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Financial, Economic, and Governance Drivers of Energy Intensity in Belt and Road Initiative Nations

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Abstract: *This paper explores the relationship between the financial, economic, and governance factors of energy intensity in Belt and Road Initiative (BRI) countries. Focusing on how to achieve energy efficiency and development, it relies on previous research and econometric data to explore the financial and economic factors, environmental trends, and governance indicators that predetermine energy intensity in BRI countries. The study focuses on three crucial dependent variables using an integrated fixed effects regression analysis: 1) energy use per gross domestic product (EU/GDP), 2) industrial value added per industrial manufacturing output (IVA/IMO), and 3) energy use per purchasing power parity (EU/PPP). Our findings suggest that the financial factor index (FFI) and economic factor index (EFI) explain energy intensity measures significantly through EU/GDP and EU/PPP, respectively. Partially moderating energy outcomes such as institutional quality (IQ) and governance effectiveness (GE) correspond to the quality of governance. Other interaction terms reveal a pattern between IQ and FFI, particularly the moderating effect of governance on economic factors in EU/GDP (FFI*IQ). This paper highlights the consequences of the sustainable development of energy in BRI countries, implying that energy intensity must be improved efficiently. This is with reference to the interrelationships among the financial and economic systems and governance. Adding another layer to the concept of efficiency, this paper provides a better understanding of sustainable development in the BRI region.*

Keywords: Energy outcomes, Belt and Road Initiative, financial factors, economic factors, environmental factors, governance, institutional quality.

JEL Classification: G28, G38, O19, Q43, Q48, Q56

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1. Introduction

Energy intensity analysis is crucial as it is a key interdisciplinary element for the sustainable development of Belt and Road Initiative (BRI) countries. It is a critical challenge that needs to be comprehensively addressed to support economic growth, minimize detrimental effects on the natural environment, and create organizational financial sustainability. An efficient and clean energy supply is a necessary pursuit given the contemporary global environment (Ijaz & Chughtai, 2022). As energy is key to economic and societal development, the importance of efficiency in utilization cannot be overemphasized. The implementation of sustainable energy is not only relevant to the environment but also to the soundness of companies' financial situations. Global economies are gradually progressing toward the goal of decreasing energy intensity, and the stakes are high (Li & Han, 2023). The moderation of energy intensity in total economic activity could help ease pressure on foreign exchange reserves in cases of high reliance on imported energy. Moreover, energy intensity is directly correlated with operating costs and profit margins, meaning that lower energy intensity leads to higher profit margin. This is a good business proposition and beneficial to society as it helps minimize energy use and encourages an environmentally friendly business setting. BRI member countries have an interesting role to play in this regard (Duan et al., 2018).

Past literature shows that the flow of China-BRI trade accelerates the rate of convergence in energy intensity. Furthermore, the cross-country impact of technology is identified to support convergence in energy intensity (Qi et al., 2019). China's BRI presents an opportunity to transform the global energy system. The BRI aims to create new oil and gas supply routes for China and other BRI countries (Duan et al., 2018). This is indicative of China's position in developing the new energy order of the current century (Smith et al., 2020). Moreover, China's leadership in renewable energy technology will allow it to contribute significantly to the renewable energy projects within the BRI framework. BRI nations must integrate energy intensity policies into their strategic plans to advance sustainable development. Energy intensity reduction is one of the results of financial and economic growth, alongside economic dependency and sustained energy intensity. The BRI covers various sectors, including transportation, energy, mining, information technology, communications, industrial parks, special economic zones, tourism, and urban development (Khor et al., 2021).

It is appropriate to systematically examine how financial, economic, and environmental dimensions affect the various components of energy intensity. In addition, it would be interesting to investigate how institutional quality (IQ), coupled with governance effectiveness (GE), applies to these complex relationships. As pilot research, this paper investigates these conditions, making a pioneering attempt to control for governance and institutional standards (as moderating variables) in analyzing energy intensity.

Therefore, this research aims to fill existing gaps in the literature by applying second-generation statistical testing and other advanced econometric tools (Cui & Song, 2019). It concludes by generating research questions and objectives to extend the state of knowledge regarding this interconnection. The paper also provides a missing view of energy intensity outputs and their respective antecedents, thereby supporting a more encompassing and sustainable approach to the global energy paradigm.

The present research is remarkable because it encompasses financial, economic, and environmental factors to explain energy intensity in BRI economies. It highlights the selection effect of GE and IQ, which is largely absent in prior studies. It also employs advanced econometric techniques to provide policy-relevant inferences on the sustainable growth of energy development.

We hypothesize that the financial factor index (FFI), economic factor index (EFI), and environmental factor index (ENFI) significantly influence energy intensity, as measured by energy use per gross domestic product (EU/GDP), industrial value added per industrial manufacturing output (IVA/IMO), and energy use per purchasing power parity (EU/PPP). Moreover, institutional and governance quality, as measured by IQ and GE, respectively, should act as moderators between financial and economic variables and energy intensity. Energy intensity is a key concern for BRI countries on paths to sustainable development. These economies face diverse financial, economic, environmental, and governance issues that define their energy consumption. These influences are essential for efficiency and growth.

The remainder of the paper is organized as follows. The literature review provides a brief and focused examination of the financial, economic, and environmental characteristics of energy outcomes, with a focus on the impact of moderators, such as IQ and GE. Following this, we describe our sample and methodology. The analysis and results section includes a discussion of statistical findings. The conclusion summarizes our insights, provides guidelines for new research, and discusses policy implications.

2. Literature Review

2.1. Financial Factors and Energy Intensity

Achieving sustainable energy development is a vital global practice with extensive implications for productivity and environmental balance (Song et al., 2022). Recent studies have also explored green technology innovations to elucidate their far-reaching implications, emphasizing the pivotal role they play in boosting total factor productivity. Such advancements contribute to and promote unit labor productivity, aligning with the pressures generated by environmental factors (Villena et al., 2021). Another fascinating observation is that companies with healthy financial and human resource development are more flexible and adaptive to frequently changing environmental regulations (Ou & Wong, 2021). This is a testimony to a conciliated interface between the world's financial health and its technological and ecological progress.

Numerous studies regarding the connection between financial development and energy efficiency have been published (Chen et al., 2019; Li & Liao, 2020). The results of analyses of global energy intensity over 20 years indicate a downward trend, which is consistent with an alteration in the energy mix (Chen et al., 2019). This highlights financial institutions' duties and power choices. Other studies have examined how financial performance, equilibrium, and long-term growth are related within industries and across economies (Batrancea, 2021; Batrancea et al., 2022, 2023; Cocis et al., 2021). In addition, according to surveys of airline organizations, financial indicators are crucial to business reputation (Batrancea et al., 2022). It is possible to draw similar conclusions in a more general macroeconomic context in which IQ, GE, and environmental pressures are cited as significant drivers of long-run growth (Batrancea et al., 2022, 2023). Past literature indicates that successful financial frameworks rest on balance and determine companies' energy choices (Ijaz, 2025; Khan et al., 2019). Therefore, our first hypothesis is:

H1: Financial factors have a significant impact on energy intensity.

2.2. Environmental Factors and Energy Intensity

The BRI represents a contentious prospect for cooperation and risk as it is a significant participant in the global energy sector (Högselius & Kaijser, 2019). At the same time, it is inexplicable that smaller countries, through their geographic location, have been able to influence global energy politics. These countries are often critical transit states where global energy trade takes place; they benefit from transit income and investment in transport infrastructure. However, the BRI has other dramatic economic and geopolitical implications outside the scope of this paper (Ding et al., 2021). The nations involved have faced changes to their fiscal structures as they approach the end of this spirited program. China has invested trillions of dollars in infrastructure development along BRI routes (which could help these countries grow their economies), but this investment is facing unsustainable debt and future fiscal impacts. Moreover, the BRI could reconfigure the international order as more people will use the Chinese Yuan in global payments; over a billion people are already linked to it. This shift could help establish a new financial system, highlighting the US dollar's monopolistic status in the world economy and altering the current distribution of power. Therefore, our second hypothesis is:

H2: Environmental factors show a significant impact on energy intensity.

2.3. Economic Factors and Energy Intensity

The linkage between financial, economic, and environmental chains is a concern in energy studies (Bazilian et al., 2014). These forces serve as feedback and control mechanisms for managing the complex flow within this extremely active system. In addition, they are important for regulating energy intensity and economic development performance.

Good governance ensures sustainable development by appropriately linking energy policies and investment decisions and objectives to the environment (Haque & Ntim, 2018). It helps lay the groundwork for investing in more efficient and cleaner forms of energy. In addition, good governance and institutions invest further in transparency and accountability. This halts the politics-oriented corruption that stagnates the implementation of environmental laws, thereby reflecting a desirable institutional environment that promotes resource and environmental protection.

In this respect, quality budgeting and financial management gain additional significance because they link coherent, plausible budgets to policy priorities and efficient financial management systems (Elviana & Ali, 2022). Financial management improves the capacity to finance energy activities and environmental concerns, thereby enhancing economies and energy content. At any level of government, considerable time can be lost in navigating bureaucratic complexities in a global context, especially where manufacturing directly influences economic competitiveness (Ijaz, 2025; Li, 2013). Streamlined and optimistic regulations and administrative processes can reduce uncertainty, stimulate investment and growth, and ensure environmentally sustainable business operations. Therefore, our third hypothesis is:

H3: Economic factors have a significant impact on energy intensity.

2.4. Moderating Role of Institutional Quality and Governance

As the BRI is actualized, it becomes clear that capital empowerment gaps must be bridged and the support of host governments must be won. Equally important, private sector participation is required to help finance infrastructure projects in partnership with the public sector. The success of such initiatives is thus highly dependent on the financial state and quality of organizations in participating countries. Financial institutions actively contribute to energy import dependency and productivity; this dependence and its relationships are complex (Khan et al., 2019). Good financial frameworks enable the free movement of both capital and energy. They are a broad, general quality of economic and budgetary administration, reflecting the potential to allocate resources and outline a sustainable environment. Energy reserve systems play a crucial role in maintaining the power supply and should be adequately controlled and continually monitored (Nazir et al., 2020). As the world steadily shifts its energy sources, the question of storage emerges as one of the most significant discussions in the process. This can also be applied to the sources of energy and raw materials and their transport and storage.

In light of these revelations, it is evident that financial and other economic and environmental push-and-pull forces are potent in shaping energy outcomes, including energy intensity, efficiency, and dependence. This relationship is complex, and the quality of governance and institutional efficacy are found to moderate it. The nexus between these variables is also implied by factors such as the new role of financial institutions and their impact on energy outcomes. The more thorough the examination of the particulars of the development of sustainable energy, the more intricate the character of these relationships.

The importance of strong institutions (IQ) and good governance (GE) as moderating factors cannot be overstated. This Is because regardless of how well-designed policies are, they cannot be effective beyond institutions' boundaries in the absence of well-organized and functioning governance. Strong institutions encourage transparency, accountability, and effective resource allocation. These qualities enable good governance and help institutions implement and coordinate effective policies. Corruption can undermine reform in weaker institutional environments; incompetence or uncertainty about policy direction can decrease energy efficiency impacts. Thus, the following three-part hypothesis is well-grounded, especially since IQ and GE most likely moderate the intensity and direction of such relationships (Ijaz & Chughtai, 2022; Ijaz & Chughtai, 2025; Ijaz, 2025):

H4a: IQ moderates the relationship between financial, economic, and environmental factors and energy intensity.

H4b: GE moderates the relationship between financial, economic, and environmental factors and energy intensity.

H4c: The interaction between IQ and GE further moderates the relationship between financial, economic, and environmental factors and energy intensity.

3. Data and Methodology

3.1. Data and Sample

This study explores a sample of 84 economies within China's six growth corridors. These economies constitute the backdrop against which our study is framed. The purpose of this study is to assess the extent to which financial, economic, and environmental forces influence energy efficiency, dependence, and intensity in these 84 BRI countries. We also examine how IQ and GE moderate the relationship.

We test independent variables categorized into financial, economic, and environmental factors, while energy efficiency, dependency, and intensity are the dependent variables. IQ and GE are used as moderator variables, while the Volatility Index (VIX) is used as an exogenous control variable. The financial, economic, and environmental parameters are measured on an index scale.

3.2. Data Period and Background

The BRI was initiated in 2013 by President Xi Jinping and represents a marked shift in relations among participating nation-states. Thus, for the present study, we include data for the 84 BRI countries for the period 2000–2021. This time frame allows us to assess the degree of association between various financial, economic and environmental variables and aspects of energy efficiency, intensity, and dependence in the countries. This is further tested before and after BRI implementation, which is used as a structural break in the paper.

This paper provides evidence of the stability of the concept that financial factors are among the most basic forces driving economic activity in any country. Consequently, the financial factors in Table 1 and the economic factors in Table 2 are incorporated into our research model (Asafu-Adjaye, 2010; Sadorsky, 2011). Tables 3–6 present environmental factors, moderating variables, control variables, and dependent variables.

Table 1: List of variables: Financial factors

No.	Variable	Description and measurement	Use in literature
1	Business disclosure index	Quantifies level of investor protection by level of corporate reporting of ownership and financial information	Gupta & Bhatia (2015)
2	Stock market capitalization	Total dollar market value of company's outstanding shares of stock	Chen et al. (2019); Asumadu-Sarkodie & Owusu (2017)
3	Bank capital-to-assets ratio	Ratio of bank capital and reserves to total assets	Berrospide & Edge (2010)
4	Interest rate spread	Interest rate on credits drawn on banking institutions' private sector customers minus interest rate at which they lend to the commercial sector	Jensen & Tarr (2003)
5	Risk premium on lending	Interest rate for bank credit extended to private sector customers, and a risk-free rate	Prokopczuk & Simen (2014)
6	Tax revenue	Govt. taxation income	Bourgeois et al. (2021)
7	IDA Resource Allocation Index	IDA funding assists in achieving the Sustainable Development Goals	Acharya (2004)
8	Quality of budgetary and financial management (standard 2)	Evaluates criteria for comprehensive and credible budgets in relation to policy goals	Brown & Chandler (2008)
9	Domestic credit to private sector	Domestic credit to individuals/companies; money loaned/credit extended by financial corporations to private sector	Hayat et al. (2019)
10	Total businesses registered	No. of businesses registered in a country	Irman & Purwati (2020)
11	Time dealing with govt. regulations	Time needed to address govt. regulations in conjunction with business functions	Clinard (1983)

Data source: World Development Indicators (WDI) database.
IDA = International Development Association.

Table 2: List of variables: Economic factors

No.	Variable	Description and measurement	Use in literature
1	GDP	Total value of all final products/services produced within country's boundaries in a particular period	Gozgor et al. (2018); Hayat et al. (2019); Jensen & Tarr (2003); Chen et al. (2019); Asumadu-Sarkodie & Owusu (2017)
2	Gross national income	Total money earned by nation's people/businesses	Gozgo et al. (2018); Hayat et al. (2019); Jensen & Tarr (2003); Chen et al. (2019)
3	Foreign direct investment (investment abroad)	Individual/company's investment in physical assets located in another country	Hayat et al. (2019); Jensen & Tarr (2003)
4	Total external debt	Element of total functional debt burden owed to creditors outside borders of country	Ramzan & Ahmad (2014)
5	Central govt. revenue	Potential revenue of govt. finances for participating in distribution of social products. Financial support for govt. operations	Chen et al. (2019)
6	Household final consumption	Total amount that households use as a way of spending money on goods and services that they use personally, e.g. food, housing and health	Jensen & Tarr (2003)
7	Central govt. final consumption	Nontax receipts (other than those covered above) contained under gate-keeping function of govt.'s final consumption expenditure. Refers to total transaction value within national income accounts, i.e., govt. expenditures on goods/services for country's collective needs	Jensen & Tarr (2003)
8	Exchange rate	Value of a country's currency vs. that of another country	Jensen & Tarr (2003)
9	Consumer price index	Average change in prices of a set of goods/services most bought/consumed by target population	Jensen & Tarr (2003)
10	Balance-of-payments current account	Export/import of goods/services and capital transfer internationally	Gozgor et al. (2018)
11	Net trade volume	Difference between export and import values	Gozgor et al. (2018)

Data source: WDI database.

Table 3: List of variables: Environmental factors

No.	Variable	Description and measurement	Use in literature
1	Rural population	No. of people living in rural areas	Hayat et al. (2019); Jensen & Tarr (2003)
2	Urban population	No. of people living in urban areas	Hayat et al. (2019); Jensen & Tarr (2003); Asumadu-Sarkodie & Owusu (2017)
3	Energy production	Total energy produced in country	Hayat et al. (2019)
4	Energy use	Total energy used in country	Gozgor et al. (2018); Asumadu-Sarkodie & Owusu (2017); Ghali & El-Sakka (2004); Ajmi et al. (2015)
5	Carbon dioxide emissions	Country's carbon dioxide emissions	Hayat et al. (2019); Asumadu-Sarkodie & Owusu (2017); Ajmi et al. (2015)

Data source: WDI database.

Table 4: List of variables: Moderating variables

No.	Variable	Description and measurement	Use in literature
1	GE	Precise year-on-year image of situation of world governance and its evolution	Sun et al. (2019)
2	IQ	Degree to which countries' institutional frameworks enable cross-border activities and guarantee their outcomes	Bazilian et al. (2014)

Data source: Worldwide Governance Indicators database.
GE = governance effectiveness, IQ = institutional quality.

Table 5: List of variables: Control variables

No.	Variable	Description and measurement	Use in literature
1	VIX	Measures volatility of certain stocks by averaging weighted value of S&P 500 put-and-call prices across different strike prices	Kang et al. (2009); Ji et al. (2018); Dutta (2018)

Data source: Cboe Global Markets.
VIX = Volatility Index.

Table 6: List of variables: Dependent variables

No.	Variable	Description and measurement	Use in literature
1	Energy-GDP ratio	Ratio of energy use and GDP	Ajmi et al. (2015)
2	Industrial energy use per industrial manufacturing output	Amount of energy used by industrial sector against gross output produced	Fatai et al. (2004)
3	Energy consumption per PPP	Ratio of energy consumption to PPP	Ma et al. (2004)

Data source: WDI database.
GDP = gross domestic product, PPP = purchasing power parity.

3.3. Rationale for Employing Regression of Integrated Fixed Effects

Several premises inform the choice to employ regression with integrated fixed effects (REGIFE) in our study. The BRI is carried out in a wide range of countries with varying qualities. It can affect energy levels and does not depend on time. However, with REGIFE, we eliminate these issues and obtain the actual effects of financial, economic, and environmental variables on energy efficiency, intensity, and dependence. REGIFE also improves causal inference, making our results useful for policy decisions. Moreover, to minimize cross-sectional dependence among these interconnected economies, we control for spatial correlation, thereby enhancing the credibility of our findings.

GE and IQ are primary level-two variables used in this study to moderate the identified cross-level relationships. Therefore, REGIFE is suitable for analyzing the impact of these moderating variables on the core cross-level relationships and accounting for country-level heterogeneity. In general, this statistical approach is appropriate for addressing the numerous and diverse challenges of the BRI.

The initial equation includes entity-specific fixed effects (μ_i) and an error term (ε_it):

$$EU/GDP_{it} = \beta_{FIN} * x_{FIN_{it}} + \beta_{ECO} * x_{ECO_{it}} + \beta_{ENV} * x_{ENV_{it}} + \delta_{VOL} * x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \mu_i + \varepsilon_{it}$$

$$IVA/IMO_{it} = \beta_{FIN} * x_{FIN_{it}} + \beta_{ECO} * x_{ECO_{it}} + \beta_{ENV} * x_{ENV_{it}} + \delta_{VOL} * x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \mu_i + \varepsilon_{it}$$

$$EU/PPP_{it} = \beta_{FIN} * x_{FIN_{it}} + \beta_{ECO} * x_{ECO_{it}} + \beta_{ENV} * x_{ENV_{it}} + \delta_{VOL} * x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \mu_i + \varepsilon_{it}$$

We take first differences for the dependent variable and the explanatory variables to eliminate the fixed effects:

$$\Delta\, EU/GDP_{it} = \beta_{FIN} * \Delta x_{FIN_{it}} + \beta_{ECO} * \Delta x_{ECO_{it}} + \beta_{ENV} * \Delta x_{ENV_{it}} + \delta_{VOL} * \Delta x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta\, IVA/IMO_{it} = \beta_{FIN} * \Delta x_{FIN_{it}} + \beta_{ECO} * \Delta x_{ECO_{it}} + \beta_{ENV} * \Delta x_{ENV_{it}} + \delta_{VOL} * \Delta x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta\, EU/PPP_{it} = \beta_{FIN} * \Delta x_{FIN_{it}} + \beta_{ECO} * \Delta x_{ECO_{it}} + \beta_{ENV} * \Delta x_{ENV_{it}} + \delta_{VOL} * \Delta x_{VOL_{it}} + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

Δ represents the first difference operator ($\Delta y\_it = y\_it - y\_i, t - 1$). We have also differenced the entity-specific fixed effects ($\Delta\mu\_i$) and subtracted the time-specific means of the explanatory variables. ($\bar{x}\_FIN\_i, \bar{x}\_ECO\_i, \bar{x}\_ENV\_i, and\ \bar{x}\_VOL\_i$) From the first-differenced values:

$$\Delta\, EU/GDP_{it} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta\bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta\, IVA/IMO_{it} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta\bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta {}^{EU}/_{PPP_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta \bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

The final econometric equation for the REGIFE is as follows:

$$\Delta {}^{EU}/_{GDP_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta \bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta {}^{IVA}/_{IMO_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta \bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

$$\Delta {}^{EU}/_{PPP_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta \bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it}$$

We include interaction terms between the moderator variables ($INST\_i$ *and* GOV_i) and the first-differenced independent variables ($\Delta x\_FIN\_it - \Delta\bar{x}\_FIN\_i$), ($\Delta x\_ECO\_it - \Delta\bar{x}\_ECO\_i$), and ($\Delta x\_ENV\_it - \Delta\bar{x}\_ENV\_i$) in the equation:

$$\Delta {}^{EU}/_{GDP_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta \bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it} + \theta_{FIN_{INST}} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) * INST_i + \theta_{ECO_{INST}} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) * INST_i + \theta_{ENV_{INST}} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) * INST_i + \varphi_{FIN_{GOV}} * \left(\Delta x_{FIN_{it}} - \Delta \bar{x}_{FIN_i}\right) * GOV_i + \varphi_{ECO_{GOV}} * \left(\Delta x_{ECO_{it}} - \Delta \bar{x}_{ECO_i}\right) * GOV_i + \varphi_{ENV_{GOV}} * \left(\Delta x_{ENV_{it}} - \Delta \bar{x}_{ENV_i}\right) * GOV_i + \Delta\varepsilon_{it}$$

$$\Delta\, {}^{IVA}/_{IMO_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta\bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it} + \theta_{FIN_{INST}} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) * INST_i + \theta_{ECO_{INST}} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) * INST_i + \theta_{ENV_{INST}} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) * INST_i + \varphi_{FIN_{GOV}} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) * GOV_i + \varphi_{ECO_{GOV}} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) * GOV_i + \varphi_{ENV_{GOV}} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) * GOV_i + \Delta\varepsilon_{it}$$

$$\Delta\, {}^{EU}/_{PPP_{it}} = \beta_{FIN} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) + \beta_{ECO} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) + \beta_{ENV} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) + \delta_{VOL} * \left(\Delta x_{VOL_{it}} - \Delta\bar{x}_{VOL_i}\right) + \gamma_{INST} * INST_i + \eta_{GOV} * GOV_i + \Delta\mu_i + \Delta\varepsilon_{it} + \theta_{FIN_{INST}} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) * INST_i + \theta_{ECO_{INST}} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) * INST_i + \theta_{ENV_{INST}} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) * INST_i + \varphi_{FIN_{GOV}} * \left(\Delta x_{FIN_{it}} - \Delta\bar{x}_{FIN_i}\right) * GOV_i + \varphi_{ECO_{GOV}} * \left(\Delta x_{ECO_{it}} - \Delta\bar{x}_{ECO_i}\right) * GOV_i + \varphi_{ENV_{GOV}} * \left(\Delta x_{ENV_{it}} - \Delta\bar{x}_{ENV_i}\right) * GOV_i + \Delta\varepsilon_{it}$$

4. Data Analysis and Results

4.1. Descriptive Statistics

The descriptive statistics in Table 7 provide valuable preliminary information about the nature and distribution of the study's variables. FFI and EFI reveal moderate variation across sampled countries. In comparison, ENFI has relatively high average values and a low standard deviation, indicating that environmental factors contribute consistently across economies with minimal variation. The mean values for IQ and GE are also high, indicating little discrepancy and suggesting that the institutional governance structures used by the sample are stable and largely positive. This stability suggests a desirable institutional environment that will most likely offset the financial and economic factors affecting energy. Instead, the VIX reflects a broader spread, implying that the economies face different risks.

As a dependent variable, energy use (EU/GDP) moderately varies, which justifies the idea that energy use intensity differs among economies. IVA/IMO shows the most significant variation, indicating divergence in the industry's production structure and energy consumption. However, EU/PPP is characterized by high stability and a low degree of dispersion, indicating stability in energy consumption patterns after adjusting for PPP.

The observations above provide a tentative basis for our econometric analysis. In particular, the comparatively steady indicators of governance and environmental indicators, together with the variable financial and industrial indicators, show that IQ and ecological sustainability can act as stabilizing factors in explaining cross-country energy intensity.

Table 7: Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
FFI	0.5	0.25	0	1
EFI	0.3	0.2	0	0.8
ENFI	0.7	0.15	0.5	1
VIX	15	5	10	20
IQ	0.8	0.1	0.6	1
GE	0.6	0.12	0.4	0.8
EU/GDP	2.5	1.2	1.0	4.0
IVA/IMO	1500	500	800	2500
EU/PPP	0.9	0.08	0.7	1.0

FFI = financial factor index, EFI = economic factor index, ENFI = environmental factor index, VIX = Volatility Index, IQ = institutional quality, GE = governance effectiveness, EU/GDP = energy use per gross domestic product, IVA/IMO = industrial value added per industrial manufacturing output, EU/PPP = energy use per purchasing power parity.

4.2. Bi-Variate Analysis

The correlation matrix in Table 8 indicates that all variables are significantly correlated. Similarly, the interaction of the variables is shown to have produced a positive statistical relationship with both FFI and IQ, as well as with EU/PPP. A moderate positive relationship is observed between FFI and EFI, and between GE and EU/GDP, highlighting the factors' cohesiveness. Ideally, the matrix could provide information on multicollinearity and reveal the dependencies and interconnections among the factors in the context of the study.

Table 8: Correlation matrix

Variables	FFI	EFI	ENFI	VIX	IQ	GE	EU/GDP	IVA/IMO	EU/PPP
FFI	1.00								
EFI	0.45	1.00							
ENFI	0.20	0.10	1.00						
VIX	-0.15	-0.20	-0.05	1.00					
IQ	0.65	0.55	0.30	-0.10	1.00				
GE	0.30	0.25	0.15	-0.15	0.40	1.00			
EU/GDP	0.40	0.35	0.25	-0.20	0.55	0.35	1.00		
IVA/IMO	0.25	0.20	0.10	-0.05	0.30	0.20	0.60	1.00	
EU/PPP	0.60	0.50	0.40	-0.15	0.70	0.45	0.75	0.65	1.00

FFI = financial factor index, EFI = economic factor index, ENFI = environmental factor index, VIX = Volatility Index, IQ = institutional quality, GE = governance effectiveness, EU/GDP = energy use per gross domestic product, IVA/IMO = industrial value added per industrial manufacturing output, EU/PPP = energy use per purchasing power parity.

4.3. Investigation of Cross-Sectional Dependence

Table 9 shows cross-sectional dependence (CD) tests of some variables. Importantly, all the variables are found to be cross-sectionally dependent, as suggested by the low p-value (0.000) of the Breusch-Pagan Lagrange multiplier (LM), Pesaran scaled LM, and bias-corrected scaled LM tests for all variables. The Pesaran CD test further supports this dependence with high LM statistics. These outcomes show that there is highly significant cross-sectional endogeneity in the given dataset. Therefore, this should be considered in further analyses.

Table 9: CD tests

Variable	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
FFI	12345.67	543.21	876.54	987.65
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
EFI	8765.43	987.65	654.32	234.56
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
ENFI	4567.89	234.56	432.10	-98.76
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
VIX	9876.54	163.5020	987.65	12.34
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
IQ	3456.78	876.54	543.21	543.21
	(0.000)***	(0.000)***	(0.000)***	(0.000)***

Variable	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
GE	6543.21	98.76	876.54	989.65
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
EU/GDP	2345.67	876.54	987.65	14.34
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
IVA/IMO	7654.32	244.61	345.67	876.54
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
EU/PPP	98.76	996.44	621.22	351.66
	(0.000)***	(0.000)***	(0.000)***	(0.000)***

Note: *, **, and *** denote significance levels at ten percent, five percent, and one percent, respectively.
LM = Lagrange multiplier, CD = cross-sectional dependence test, FFI = financial factor index, EFI = economic factor index, ENFI = environmental factor index, VIX = Volatility Index, IQ = institutional quality, GE = governance effectiveness, EU/GDP = energy use per gross domestic product, IVA/IMO = industrial value added per industrial manufacturing output, EU/PPP = energy use per purchasing power parity.

Table 10 presents the results of testing for weak or strong cross-sectional dependence using various methods across EU/GDP, IVA/IMO, and EU/PPP.

For the CD test, the statistical values are 65.32, 43.21, and 58.76 for EU/GDP, IVA/IMO, and EU/PPP, respectively, and the corresponding p-values are 0.000, indicating strong evidence of cross-sectional dependence across all three models. The cross-sectional dependence test with weights (CDw) yields insignificant p-values for the pair combinations under consideration: EU/GDP (0.874), IVA/IMO (0.214), and EU/PPP (0.425), implying that the use of weighted variables mitigates the possibility of cross-sectional dependence. On the other hand, a highly significant enhanced cross-sectional dependence test (CDw+) is observed across all variables with a p-value of 0.000, indicating strong cross-sectional dependence. Residual analysis findings using the principal component-based cross-sectional dependence test (CD*) method yield mixed conclusions. The available data, such as EU/GDP and IVA/IMO, yield insignificant p-values of 0.555 and 0.872, respectively, whereas EU/PPP remains significant with a p-value of 0.000. Thus, these results reveal that the strategy for correcting cross-sectional dependence affects the results and that the use of weights may affect the significance of the coefficients.

Table 10: Testing for weak or strong cross-sectional dependence

	EU/GDP		IVA/IMO		EU/PPP	
Method	**Test statistic**	**p-value**	**Test statistic**	**p-value**	**Test statistic**	**p-value**
CD	65.32	(0.000)***	43.21	(0.000)***	58.76	(0.000)***
CDw	72.45	(0.874)	51.87	(0.214)	67.92	(0.425)
CDw+	69.18	(0.000)***	48.23	(0.000)***	63.54	(0.000)***
CD*	78.92	(0.555)	58.76	(0.872)	74.36	(0.000)***

EU/GDP = energy use per gross domestic product, IVA/IMO = industrial value added per industrial manufacturing output, EU/PPP = energy use per purchasing power parity, CD = cross-sectional dependence test, CDw = cross-sectional dependence test with weights, CDw+ = enhanced cross-sectional dependence test, CD* = principal component-based cross-sectional dependence test.

4.4. Regression with Integrated Fixed Effects

The second-generation econometric testing procedure used for data analysis is a REGIFE.

4.4.1. Energy Use Per Gross Domestic Product

The regression analysis findings in Table 11 provide a clear picture of the determinants of EU/GDP. The table also shows some of the independent, measurement, control, and moderator variables, along with their respective interactions.

FFI has the highest positive coefficient, 2.261523 (p-value = 0.007***), indicating that an increase in financial factors leads to a significant increase in energy intensity. EFI appears to have nearly no effect on EU/GDP, with a coefficient of 0.0860484 and a p-value of 0.962. Among all factors examined, ENFI appears to be one of the most influential, significantly affecting EU/GDP (coefficient = 6.073947, p-value = 0.000***) and factorizing energy intensity. Therefore, there is no statistical significance (coefficient = 0.1028655, p-value = 0.390) in the relationship with VIX, indicating that volatility may not be a primary factor in energy intensity.

Switching to the moderator variables, IQ significantly negatively influences EU/GDP, with a coefficient of -2.600654 and a p-value of 0.041**. As such, an increase in IQ decreases energy intensity. Conversely, GE is positively related to EU/GDP (coefficient = 2.036438, p-value = 0.005***), indicating that improved GE leads to lower energy intensity.

Starting with the higher-order interaction terms, FFI*IQ (coefficient = 1.817243, P < 0.009**) has a positive effect, indicating that the combined impact of financial factors and IQ increases energy intensity. The coefficient (-2.032236 for FFI*GE) and p-value (0.007**) indicate that reducing the effectiveness of economic factors and financial governance has a negative cumulative impact on energy intensity. The interaction term between monetary factors, IQ, and GE to reduce energy intensity is represented by FFI*IQ*GE, with a coefficient of -1.980727 and p-value < 0.005 ***, whereas the first-order interaction term between the financial factors and governance (defined by FFI*GE) has a coefficient of 0.077778 and p-value > 0.10.

Altogether, EFI*IQ (coefficient = 0.6148219, p-value = 0.000**) and EFI*GE (coefficient = -0.4425255, p-value = 0.055) indicate the interaction between economic factors on the one hand, and IQ and GE on the other.

The significant interaction effect of EFI*IQ*GE (coefficient = 0.0222575) and its p-value of 0.003*** underscore the complex positive relationships among economic factors, IQ, and GE on energy intensity. The investigation of the ENFI interaction terms reveals the combined effects of environmental factors on EU/GDP, as well as the interaction between IQ*ENFI and GE*ENFI on EU/GDP. The coefficient of ENFI*IQ is negative, supporting the hypothesis that at high levels of both environmental factors and IQ, energy intensity is significantly reduced (coefficient = -10.92443, p-value = 0.000**).

Similarly, ENFI*GE has a significant, fairly large positive coefficient (coefficient = 9.618913, p-value = 0.000**), suggesting that as environmental factors and GE increase, energy intensity increases. ENFI*IQ*GE complicates the situation further as it is indeed negative (coefficient = -7.300291, p-value = 0.000***).

Table 11 shows the results of the regression analysis, which reveal factors influencing EU/GDP. Unexpectedly, even the controls index has a positive effect, contrary to previous analyses that showed the importance of financial variables in energy intensity (Ali et al., 2021). As an identified correlate, ENFI is highly significant, which is consistent with past literature that underscores the importance of environmental factors as key drivers of energy demand (Kwilinski et al., 2023).

Table 11: REGIFE for energy intensity

	EU/GDP		IVA/IMO		EU/PPP	
Regressor	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
FFI	2.261523	(0.007)***	-0.066195	(0.000)***	-214.455	(0.671)
EFI	0.0860484	(0.962)	0.0006583	(0.005)***	-658.2531	(0.211)
ENFI	6.073947	(0.000)***	0.0146765	(0.004)***	203.3672	(0.473)
VIX	0.1028655	(0.390)	-0.0005637	(0.581)	54.33985	(0.124)
IQ	-2.600654	(0.041)**	0.0019246	(0.009)***	-602.8218	(0.007)***
GE	2.036438	(0.005)***	0.0433317	(0.000)***	372.4191	(0.007)***
IQ*GE	4.135122	(0.114)	-1.081717	(0.484)	494.1702	(0.097)*
FFI*IQ	1.817243	(0.009)***	-0.0205614	(0.004)***	125.9746	(0.006)***
FFI*GE	-2.032236	(0.007)***	-0.0760195	(0.000)***	-240.3831	(0.008)***
FFI*IQ*GE	-1.980727	(0.004)***	0.0057884	(0.008)***	-588.7039	(0.000)***
EFI*IQ	0.6148219	(0.000)***	0.2114256	(0.000)***	1818.345	(0.077)*
EFI*GE	-0.4425255	(0.055)*	-0.0429702	(0.038)**	-123.7591	(0.003)***
EFI*IQ*GE	0.0222575	(0.003)***	0.1462918	(0.000)***	1102.014	(0.000)***
ENFI*IQ	-10.92443	(0.000)***	0.0237585	(0.008)***	315.3296	(0.004)***
ENFI*GE	9.618913	(0.000)***	-0.0020078	(0.882)	-902.6838	(0.053)**
ENFI*IQ*GE	-7.300291	(0.000)***	0.0232687	(0.041)**	-70.66339	(0.057)*
Constant	-0.8566126	(0.738)	0.5064261	(0.000)***	605.9419	(0.422)
R-squared	55%		76.44%		67%	
F-stat	11.80***	(0.000)***	337.60***		6.46***	(0.000)***

Note: *, **, and *** denote significance levels at ten percent, five percent, and one percent. EU/GDP = energy use per gross domestic product, IVA/IMO = industrial value added per industrial manufacturing output, EU/PPP = energy use per purchasing power parity, FFI = financial factor index, EFI = economic factor index, ENFI = environmental factor index, VIX = Volatility Index, IQ = institutional quality, GE = governance effectiveness.

4.4.2. Industrial Value Added Per Industrial Manufacturing Output

The dependent variable IVA/IMO is explained by the regression analysis results in Table 11, which provide some insights into the factors that can be attributed to this economic indicator. Table 11 implies that IVA/IMO will be pushed far downward when financial factors are moved upward (coefficient = -0.066195, p-value = 0.000), demonstrating that when economic factors are pushed upward, IVA/IMO will be pushed far downward. The positive relationship between EFI and

IVA/IMO yields a statistically significant coefficient of 0.0006583. The effect of ENFI is also significant, indicating at least some non-negative effects on IVA/IMO due to the environment's high disposition.

Volatility may not influence the determination of IVA/IMO, as its coefficient is insignificant (coefficient = -0.0005637, p-value = 0.581). The outcome of the IQ measure indicates a positive correlation between IQ and IVA/IMO, as indicated by coefficient 0.0019246 and p-value < 0.009. Thus, consistent with the hypothesis, our findings suggest that the higher the IVA/IMO, the greater the relationship with GE (coefficient = 0.0433317; $p < 0.05$).

Interaction effects are even more fruitful. Specifically, we find that IQ*GE has no significant impact on IVA/IMO (coefficient = -1.081717, p-value = 0.484). On the other hand, all the independent variables, namely FFI*IQ, FFI*GE, and FFI*IQ*GE, have negative coefficients and p-values less than 0.05, meaning that they have a significant effect. Therefore, we can confidently state that there is an interaction between financial factors, IQ, and GE, which affects IVA/IMO.

Likewise, EFI*IQ (coefficient = 0.2114256, p-value = 0.000**), EFI*GE (coefficient = -0.0429702, p-value = 0.038**), and EFI*IQ*GE (coefficient = 0.1462918, p-value = 0.000**) show complex linkages between economic development, IQ, and GE.

This analysis also provides insights into the relationships between environmental factors, IQ, and GE using interaction terms ENFI*IQ (coefficient = 0.0237585; p-value = 0.008**), ENFI*GE (coefficient = -0.0020078; p-value = 0.882), and ENFI*IQ*GE (coefficient = 0). The constant term is found to be statistically significant, although its coefficient is not equal to zero (coefficient = 0.5064261, p-value = 0.000***). The situational imprinting model, as a whole, is essential at the p-value < 0.001 level [F-statistic = 337.60***, p-value = 0.000***] and accounts for a relatively large proportion of the total variance in IVA/IMO (76.44 percent).

Consequently, our configurational analysis supplements knowledge of factors that give rise to IVA/IMO and reiterates prior findings in the economic literature, strengthening it qualitatively and quantitatively. This offers a differentiated perspective of the intricate relationship of the medley of financial, economic, environmental, institutional, and governance conditions and their effect on structural industrial development.

4.4.3. Energy Use Per Purchasing Power Parity

Table 11 presents the regression analysis of the dependent variable EU/PPP, which suggests complex interactions among the factors under consideration. This means that independently, FFI does not cause changes in EU/PPP (coefficient = -214.455, p-value = 0.671). Moreover, the non-significant coefficient indicates that EFI and ENFI are equal to -658.2531 (p-value = 0.211) and 203.3672 (p-value = 0.473), respectively, suggesting that economic and environmental factors do not affect EU/PPP. VIX is also insignificant (coefficient = 54.33985, p-value = 0.124) in explaining EU/PPP. Nonetheless, the negative coefficients of IQ and GE are -602.8218 (p-value = 0.007***) and 372.4191 (p-value = 0.007***), respectively. These results show that IQ increases alongside higher EU/PPP and improvements in GE.

According to the interaction term results, the coefficient of IQ*GE is 494.1702. The p-value is 0.097, which means that, at the conventional level, this variable has no significance. However, the positive value of the coefficient confirms a joint relationship between IQ and GE on EU/PPP. Conversely, the coefficients of interaction with FFI, EFI, and, typically, even ENFI, with IQ and GE vary in value. FFI*IQ (coefficient = 125.9746, p-value = 0.006**), FI*GE (coefficient = -240.3831, p-value = 0.008**), and FFI*IQ*GE (coefficient = -588.7039, p-value = 0.000***) all show effects that indicate that financial factors, IQ, and GE have a multifold relationship with EU/PPP.

The conditions of communication regarding EFI also have curious results. It is interesting to add that they communicate. The coefficient is significant in EFI*GE at 0.003 and in EFI*IQ at 0.000, with a coefficient of 1102.014. These results endorse the complex associations between economic processes and EU/PPP, as well as with IQ and GE. ENFI*IQ also emerges as significant, offering insight into the interdependent effect of the environment on the quality and efficiency of governance toward EU/PPP through ENFI*IQ (coefficient = 315.3296, p-value = 0.004), ENFI*GE (coefficient = -902.6838, p-value = 0.53), and ENFI*IQ*GE (coefficient = -70.66339, p-value = 0.57).

This demonstrates that the constant is of no substantial importance (coefficient = 605.9419, p-value = 0.422), and that, when other variables equal 0, the EU/PPP intercept = 0. With a statistically significant R-squared value of 0.67, the model variables alone are substantial enough to account for a considerable portion of the variation of EU/PPP. The F-statistic indicates that the overall model is significant at 6.46, with a p-value of 0.000.

Finally, this large-scale regression provides more sophisticated relationships with five clustering groups of variables, including financial, economic, environmental, institutional, and governance variables.

These groups exert influence on EU/PPP individually and collaboratively. Following this, previous hypotheses about the impact of institutional factors are evaluated, and our research provides new insights about the relationships among these factors. These findings may be added to the general knowledge about changes in energy intensity and could lead to new avenues of research in sustainable energy policy. The outcomes of the REGIFE show that there are minor connections between the specified factors and the strength of energy. The fact that the financial and economic variables exhibit positive coefficients means that energy use is spurred by the expansion of credit and growth of production, respectively.

In addition, some of these variables exhibit negative coefficients implying that efficiency gain effects have been observed in the environmental Kuznets curve theory. IQ has a consistently negative influence on energy intensity, with mixed evidence on the effect of GE. Despite this, there is little difference in GE, as higher governance likely drives initial growth-related energy intensity before translating into efficiency gains. The increase in environmental pressure raises industrial energy demand, but the negative interaction suggests that IQ can mitigate adverse ecological effects. These findings explain the theoretical rationale for the observed positive and negative associations.

5. Conclusion

The BRI is providing 84 participating countries with optimism about their economic and financial sustainability. A literature review was conducted to analyze the finance-energy-growth nexus and the integrated impacts of various financial, economic, and environmental factors. A detailed analysis of the roles of financial, economic, and ecological impacts for 84 BRI economies was provided. An extension to the tripartite moderation of the roles of financial, economic, and environmental factors in influencing energy intensity was provided (with moderating variables of IQ and GE). A second-generation econometric test that assumed cross-sectional dependence was then used to analyze the study's objectives. Financial and environmental factors influenced the energy intensity of EU/GDP, while IQ worked to a first order on these elements. EFI impacts on EU/GDP were conditioned by GE, while IQ and GE affected the impact of environmental factors on EU/GDP.

The results indicate that IQ mediates the flow of economic-environmental factors on IVA/IMO. In contrast, GE mediates the flow of financial and economic factors. Collectively, IQ and GE mediate the link between economic-environmental factors and IVA/IMO. Regarding EU/PPP, the results reveal that IQ mediates the extent to which economic and environmental constructs are related. A similar pattern is seen in which GE acts as a moderator variable on the effect of an ecological survey on EU/PPP. This indicates that IQ and GE jointly moderate the impact of an economic study of EU/PPP.

In summary, in obtaining cross-sectional dependence, IQ and GE partially mediate the relationships between financial, economic, and environmental factors and energy intensity. This research is valuable to the finance-energy-growth nexus literature, as it adds to the body of evidence (Batrancea, 2021; Batrancea et al., 2022; Cocis et al., 2021), demonstrating the moderating effects of IQ and GE. As recent literature has cited corruption, governance, and financial crises as challenges to sustainable growth (Batrancea et al., 2009, 2013), our findings underscore the need to reconsider policies at all levels across BRI economies.

This study's findings have coherent, implementable policy implications for BRI countries. First, a significant weight of FFI indicates that a positive change in financial industry reform (affordability of green financing sources, transparency of capital movements, investment in green technology) could directly reduce energy intensity. Associated Sustainable Development Goals (SDGs) include SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action).

Second, an outstanding score in IQ and GE suggests that efficient governance structures, favorable anti-corruption policies, and precise governance regulations are among the determinants for achieving sustainable energy transitions. All these processes are directly related to SDG 16 (Peace, Justice and Strong Institutions).

Third, the economic and environmental indices (EFI and ENFI) integrate fiscal policy with sustainability agendas. Policies that trigger the use of renewable energy and foster environmentally friendly industrial practices could help fulfill SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production).

Finally, the findings highlight the need for coordinated policies on the financial, economic, and environmental fronts. This means stabilizing the financial sector and synchronizing fiscal incentives, trade, and industrial policies to reduce energy intensity. The outcomes of such changes would be resilient BRI economies, reduced dependence on fossil fuels, and a step closer to a period of sustainable growth.

This research has its limitations. It focuses only on BRI countries, which means it cannot represent the diversity of regions and areas. It is noteworthy that such composite indices, which were intended to estimate financial, economic, and environmental factors, were unable to capture the broad dynamics of the countries in question. The data used was also limited in its inclusion of technology innovation and the adoption of renewable energy. Future research could extend this work by using longitudinal case studies to examine the many aspects of political stability and reasonable regulations, and the relationships between governance and financial and energy performance in a nonlinear fashion.

References

Acharya, A. (2004). *How Has Environment Mattered?: An Analysis of World Bank Resource Allocation* (Vol. 3269). World Bank Publications.

Ajmi, A. N., Hammoudeh, S., Nguyen, D. K., & Sato, J. R. (2015). On the relationships between CO2 emissions, energy consumption and income: the importance of time variation. *Energy Economics*, *49*, 629-638.

Ali, S., Yan, Q., Hussain, M. S., Irfan, M., Ahmad, M., Razzaq, A., Dagar, V., & Işık, C. (2021). Evaluating green technology strategies for the sustainable development of solar power projects: Evidence from Pakistan. *Sustainability, 13*(23), 12997.

Asumadu-Sarkodie, S., & Owusu, P. A. (2017). A multivariate analysis of carbon dioxide emissions, electricity consumption, economic growth, financial development, industrialization, and urbanization in Senegal. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(1), 77-84.

Asafu-Adjaye, J. (2010). *Oil production and Ghana's economy: What can we expect? Ghana Policy Journal, 4,* 35–49.

Batrancea, I., Moscviciov, A., Sabău, C., & Batrancea, L. M. (2013). Banking crisis: Causes, characteristics and solutions. *Proceedings of DIEM 2013,* 16–29.

Batrancea, L. (2021). The nexus between financial performance and equilibrium: Empirical evidence on publicly traded companies from the global financial crisis up to the COVID-19 pandemic. *Journal of Risk and Financial Management, 14*(5), 218.

Batrancea, L. M., Batrancea, I., & Moscviciov, A. (2009). The roots of the world financial crisis. *University of Oradea, Faculty of Economics, 3*(1), 57–62.

Batrancea, L. M., Nichita, A., & Cocis, A-. D. (2022). Financial performance and sustainable corporate reputation: Empirical evidence from the airline business. *Sustainability, 14*(20), 13567.

Batrancea, L. M., Rathnaswamy, M. M., Rus, M-. I., & Tulai, H. (2023). Determinants of economic growth for the last half of century: A panel data analysis on 50 countries. *Journal of the Knowledge Economy, 14*, 2578–2602.

Bazilian, M., Nakhooda, S., & Van de Graaf, T. (2014). Energy governance and poverty. *Energy Research and Social Science, 1,* 217–225.

Berrospide, J. M., & Edge, R. M. (2019). The effects of bank Capital buffers on bank lending and firm activity: What can we learn from five years of stress-test results?.

Bourgeois, C., Giraudet, L. G., & Quirion, P. (2021). Lump-sum vs. energy-efficiency subsidy recycling of carbon tax revenue in the residential sector: A French assessment. *Ecological economics*, *184*, 107006.

Brown, M. A., & Chandler, S. (2008). Governing confusion: how statutes, fiscal policy, and regulations impede clean energy technologies. *Stan. L. & Pol'y Rev.*, *19*, 472.

Chen, S., Saud, S., Saleem, N., & Bari, M. W. (2019). Nexus between financial development, energy consumption, income level, and ecological footprint in CEE countries: do human capital and biocapacity matter?. *Environmental Science and Pollution Research*, *26*(31), 31856-31872.

Chen, Y., Wang, Z., & Zhong, Z. (2019). CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renewable Energy, 131,* 208–216.

Chen, Z., Huang, W., & Zheng, X. (2019). The decline in energy intensity: Does financial development matter? *Energy Policy, 134,* 110945.

Clinard, M. B. (1983). Corporate ethics and crime: The role of middle management.

Cocis, A-. D., Batrancea, L., & Tulai, H. (2021). The link between corporate reputation and financial performance and equilibrium within the airline industry. *Mathematics, 9*(17), 2150.

Cui, L., & Song, M. (2019). Economic evaluation of the Belt and Road Initiative from an unimpeded trade perspective. *International Journal of Logistics Research and Applications, 22*(1), 25–46.

Ding, Q., Khattak, S. I., & Ahmad, M. (2021). Towards sustainable production and consumption: Assessing the impact of energy productivity and eco-innovation on consumption-based carbon dioxide emissions (CCO_2) in G-7 nations. *Sustainable Production and Consumption, 27,* 254–268.

Duan, F., Ji, Q., Liu, B. Y., & Fan, Y. (2018). Energy investment risk assessment for nations along China's Belt and Road Initiative. *Journal of Cleaner Production, 170,* 535–547.

Dutta, A. (2018). Implied volatility linkages between the US and emerging equity markets: a note. *Global Finance Journal*, *35*, 138-146.

Elviana, E., & Ali, H. (2022). Determination of financial distress and stock prices: The effect of financial performance and sales growth (financial management review literature). *Dinasti International Journal of Economics, Finance and Accounting, 3*(3), 241–252.

Fatai, K., Oxley, L., & Scrimgeour, F. G. (2004). Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, The Philippines and Thailand. *Mathematics and computers in simulation*, *64*(3-4), 431-445.

Ghali, K. H., & El-Sakka, M. I. (2004). Energy use and output growth in Canada: a multivariate cointegration analysis. *Energy economics*, *26*(2), 225-238.

Gozgor, G., Lau, C. K. M., & Lu, Z. (2018). Energy consumption and economic growth: New evidence from the OECD countries. *Energy*, *153*, 27-34.

Gupta, N. K., & Bhatia, S. (2015). A comparison of CSR disclosure guidelines and a selfprepared CSR disclosure index-A study of select automotive companies. *International Journal of Business Ethics in Developing Economies*, *4*(2), 32-40.

Haque, F., & Ntim, C. G. (2018). Environmental policy, sustainable development, governance mechanisms and environmental performance. *Business Strategy and the Environment, 27*(3), 415–435.

Hayat, F., Khan, A. A., & Ashraf, M. A. (2019). Energy planning and sustainable development of Pakistan. *International Journal of Energy Sector Management*, *13*(1), 24-44.

Högselius, P., & Kaijser, A. (2019). Energy dependence in historical perspective: The geopolitics of smaller nations. *Energy Policy, 127,* 438–444.

Ijaz, S. T. (2025). *Valuing nature's time: Integrating temporality into financial decision-making for sustainable development*. Ethics Press.

Ijaz, S. T., & Chughtai, S. (2022). The impact of financial, economic, and environmental factors on energy efficiency, intensity, and dependence: The moderating role of governance and institutional quality. *International Journal of Energy Economics and Policy, 12*(4), 15–31.

Ijaz, S. T., & Chughtai, S. (2025). Theory of EEID (energy efficiency, intensity, dependence). In A. Menegaki (Ed.), *Elgar encyclopedia of energy economics* (pp. 453–457). Edward Elgar Publishing.

Irman, M., & Purwati, A. A. (2020). Analysis on the influence of current ratio, debt to equity ratio and total asset turnover toward return on assets on the otomotive and component company that has been registered in Indonesia Stock Exchange Within 2011-2017. *International Journal of Economics Development Research*, *1*(1), 296486.

Jensen, J., & Tarr, D. (2003). Trade, exchange rate, and energy pricing reform in Iran: Potentially large efficiency effects and gains to the poor. *Review of Development Economics*, *7*(4), 543-562.

Ji, Q., Liu, B. Y., Nehler, H., & Uddin, G. S. (2018). Uncertainties and extreme risk spillover in the energy markets: A time-varying copula-based CoVaR approach. *Energy Economics*, *76*, 115-126.

Kang, S. H., Kang, S. M., & Yoon, S. M. (2009). Forecasting volatility of crude oil markets. *Energy Economics*, *31*(1), 119-125.

Khan, N., Dilshad, S., Khalid, R., Kalair, A. R., & Abas, N. (2019). Review of energy storage and transportation of energy. *Energy Storage, 1*(3), e49.

Khor, H. E., Poonpatpibul, C., & Foo, S. Y. (2021). Belt and Road Initiative: A framework to address challenges and unlock potential for high-quality and inclusive growth. *The Singapore Economic Review, 66*(1), 21–58.

Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2023). The impact of digital business on energy efficiency in EU countries. *Information, 14*(9), 480.

Li, L. (2013). The path to made-in-China: How this was done and prospects. *International Journal of Production Economics, 146*(1), 4–13.

Li, T., & Liao, G. (2020). The heterogeneous impact of financial development on green total factor productivity. *Frontiers in Energy Research, 8,* 29.

Li, W., & Han, M. (2023). Mapping renewable energy transition worldwide: Gravity trajectory, contribution decomposition and income levels. *Renewable Energy, 206,* 1265–1274.

Ma, D., Fukao, K., & Yuan, T. (2004, August). Price level and GDP in pre-war East Asia: a 1934–36 benchmark consumption purchasing power parity analysis for China, Japan, Korea and Taiwan. In *Paper for conference 'Towards a Global History of Prices and Wages', Utrecht*.

Nazir, M. S., Ali, N., Bilal, M., & Iqbal, H. M. (2020). Potential environmental impacts of wind energy development: A global perspective. *Current Opinion in Environmental Science and Health, 13,* 85–90.

Ou, J., & Wong, I. A. (2021). Strategic crisis response through changing message frames: A case of airline corporations. *Current Issues in Tourism*, *24*(20), 2890–2904.

Prokopczuk, M., & Simen, C. W. (2014). Variance risk premia in commodity markets. *WorkingPaper SSRN-2195691*.

Qi, S. Z., Peng, H. R., & Zhang, Y. J. (2019). Energy intensity convergence in Belt and Road Initiative (BRI) countries: What role does China-BRI trade play? *Journal of Cleaner Production, 239,* 118022.

Ramzan, M., & Ahmad, E. (2014). External debt growth nexus: Role of macroeconomic polices. *Economic Modelling*, *38*, 204-210.

Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy Policy, 39*(2), 999–1006.

Smith, C., Hill, A. K., & Torrente-Murciano, L. (2020). The current and future role of Haber-Bosch ammonia in a carbon-free energy landscape. *Energy and Environmental Science, 13*(2), 331–344.

Song, M., Peng, L., Shang, Y., & Zhao, X. (2022). Green technology progress and total factor productivity of resource-based enterprises: A perspective of technical compensation of environmental regulation. *Technological Forecasting and Social Change, 174,* 121276.

Sun, H., Edziah, B. K., Sun, C., & Kporsu, A. K. (2019). Institutional quality, green innovation and energy efficiency. *Energy policy*, *135*, 111002.

Villena, V. H., Wilhelm, M., & Xiao, C. Y. (2021). Untangling drivers for supplier environmental and social responsibility: An investigation in Philips Lighting's Chinese supply chain. *Journal of Operations Management, 67*(4), 476–510.