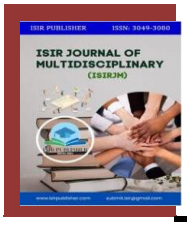

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Green Finance, Energy Transition and Governance Quality: A Structural Framework for Sustainable Development in Emerging and OECD Economies

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Abstract

This paper develops a structural framework integrating energy-intensive growth, renewable energy transition, environmental taxation, green bonds, corruption control, and AI-enabled policy modelling as determinants of sustainable development. Drawing exclusively on recent empirical and theoretical contributions in energy economics, sustainable finance, governance studies and policy modelling, the study proposes a multidimensional model linking renewable energy adoption, open market conditions, environmental fiscal instruments, and financial innovation to long-term sustainable growth.

Building upon evidence from developing countries, OECD economies, and G7 nations, the article synthesizes findings on energy transition pathways, corruption and domestic savings, green bond resilience during market turmoil, and AI-enhanced policy modelling. The proposed framework demonstrates that sustainable development is contingent not only upon renewable energy penetration but also upon governance quality, institutional transparency, and financial market sophistication.

The paper concludes with policy implications for emerging and advanced economies aiming to accelerate energy transition while ensuring financial stability and inclusive economic growth.

Keywords: *green finance, renewable energy, environmental taxation, corruption, governance, AI policy modelling, sustainable development*

INTRODUCTION

The contemporary debate on sustainable development has reached a point at which fragmentary analytical approaches no longer suffice. The question is no longer whether renewable energy contributes to environmental improvement, nor whether green finance instruments mitigate market volatility, nor even whether corruption undermines sustainable investment. Each of these problems has already been addressed within distinct empirical and theoretical traditions. The decisive challenge today consists in reconstructing the structural interdependence among these variables and in articulating a coherent theoretical framework capable of integrating energy transition, fiscal instruments, financial resilience, institutional quality and digital policy capacity into a unified architecture of sustainable development.

The empirical literature on energy-intensive growth and renewable transition has provided substantial evidence that structural transformation of energy systems is indispensable for long-term sustainability. Bekun et al. (2025), analysing developing countries under open market conditions, demonstrate that renewable energy consumption moderates the environmental externalities of energy-intensive growth, yet the transition pathways remain nonlinear and threshold-dependent. Their findings reveal that trade openness and energy structure interact dynamically, suggesting that sustainability cannot be reduced to a simple substitution effect between fossil and renewable sources. Similarly, Adebayo et al. (2025), focusing on G7 economies, show that technological innovation and renewable energy consumption significantly contribute to achieving sustainable development objectives, thereby embedding energy transition within a broader innovation-driven growth paradigm. The environmental dimension is further complicated by the evidence presented by Haseeb et al. (2021), who demonstrate that structural ecological disturbances intensify climate degradation processes in Asian economies, thus reinforcing the systemic character of environmental vulnerability.

Yet energy transition alone does not exhaust the problem. The fiscal dimension of sustainability introduces an additional structural layer. Staniewski et al. (2024), in a comparative analysis of Organisation for Economic Co-operation and Development countries, demonstrate that environmental taxation exerts a statistically significant influence on carbon

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emission reduction when coupled with sustainable environmental technologies. Their findings move the debate beyond the dichotomy between regulation and market forces and reveal that fiscal instruments operate as catalytic mechanisms when embedded within technological ecosystems. Sustainable development, therefore, appears as a fiscal–technological nexus rather than a purely technological transformation.

Parallel to the evolution of energy and fiscal research, the literature on sustainable finance has advanced the understanding of financial market resilience in the context of environmental transition. Meo et al. (2025) provide evidence that green bonds display relative stability during periods of market turmoil, which positions them as potential stabilisers of sustainable capital flows. This resilience suggests that the financial architecture of sustainability must be conceptualised not merely as an ethical reorientation of capital markets but as a structural reconfiguration of risk allocation mechanisms. Dos Santos et al. (2022) argue that innovation, governance and sustainable growth must be analysed conjointly, thereby situating financial instruments within a broader governance ecosystem.

However, the capacity of financial systems to support sustainable transition is inseparable from institutional quality. The literature on corruption and domestic savings provides a critical counterpoint to overly optimistic financial narratives. Abu and Staniewski (2019) identify structural determinants of corruption across estimation techniques, while Abu and Staniewski (2022) demonstrate empirically that corruption negatively affects domestic savings mobilisation in Nigeria. Since domestic savings constitute a fundamental source of investment capital, institutional fragility directly undermines the financial basis of sustainable development. Ruiz Estrada et al. (2018), by introducing a composite development index linking socio-economic dynamics and corruption, further underscore the systemic implications of governance failure. Sustainable development, therefore, cannot be theorised independently of institutional integrity.

The most recent development within this intellectual landscape concerns the transformation of policy modelling itself. Ruiz Estrada, Park and Staniewski (2023) argue that artificial intelligence reshapes the architecture of policy analysis by enabling dynamic scenario construction and multidimensional modelling. In parallel, Costa Climent and Staniewski (2024) demonstrate that artificial intelligence-enabled business models generate competitive advantages through advanced data integration and predictive capacity. Although these studies do not explicitly focus on energy transition, their implications for sustainable finance and environmental governance are profound. Artificial intelligence introduces the possibility of real-time optimisation of fiscal instruments, renewable energy allocation and green bond risk assessment. Consequently, digital governance capacity emerges as an epistemic condition of sustainable transition.

Despite the richness of these contributions, the literature remains structurally fragmented. Energy economics analyses rarely integrate corruption dynamics into transition models. Sustainable finance research often abstracts from institutional fragility. Governance studies seldom incorporate environmental taxation or renewable thresholds into their explanatory frameworks. Digital policy modelling is treated as a methodological innovation rather than as a structural determinant of sustainability. The absence of a unified theoretical reconstruction constitutes the central lacuna in current scholarship.

The present article seeks to address this lacuna by reconstructing a structural conceptual framework in which renewable energy transition, environmental fiscal instruments, green bond resilience, corruption-mediated savings capacity and artificial intelligence-enabled policy modelling are interpreted as interdependent dimensions of a single systemic architecture. The principal research problem may be formulated as follows: how can the interaction between energy transition, green finance, governance quality and digital modelling capacity be theoretically integrated into a coherent structural model of sustainable development? The working thesis advanced here holds that sustainable development is not the cumulative effect of isolated policy instruments but the outcome of systemic alignment among energy structure, fiscal architecture, financial resilience mechanisms, institutional integrity and digital governance capacity.

Methodologically, the article adopts a hermeneutic-structural approach. It does not generate new empirical data but reconstructs the implicit theoretical architecture underlying the empirical findings of Bekun et al. (2025), Adebayo et al. (2025), Staniewski et al. (2024), Meo et al. (2025), Abu and Staniewski (2019, 2022), Ruiz Estrada et al. (2018, 2023) and Costa Climent and Staniewski (2024). Through comparative analytical synthesis across developing, Organisation for Economic Co-operation and Development and Group of Seven contexts, the article aims to articulate a model capable of explaining the structural coherence required for sustainable development.

The argument proceeds by first reconstructing the theoretical foundations of energy transition economics, then integrating environmental taxation and green financial resilience, subsequently analysing governance constraints and corruption dynamics, and finally incorporating artificial intelligence-enabled policy modelling as a systemic catalyst. The concluding section presents the integrated structural model and its policy implications for emerging and advanced economies.

Energy Transition as Structural Reconfiguration of Growth

The problem of energy transition cannot be reduced to a technological substitution mechanism, nor can it be adequately explained within the classical environmental Kuznets curve framework. The most recent empirical investigations suggest that the transformation of energy

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systems entails a reconfiguration of the structural logic of growth itself. Bekun et al. (2025), analysing developing economies operating under open market conditions, demonstrate that renewable energy moderates the environmental costs of energy-intensive growth, yet this moderation is conditional and nonlinear. Their threshold-based estimations reveal that the relationship between growth and emissions shifts qualitatively once renewable penetration exceeds specific structural levels. Such findings imply that renewable energy is not merely an additive corrective but a transformative variable capable of altering the growth–environment nexus.

The structural character of this transformation becomes clearer when interpreted in conjunction with Adebayo et al. (2025), who show that in Group of Seven economies technological innovation and renewable energy consumption interact to advance sustainable development goals. Renewable energy, in this context, functions not simply as a carbon-reduction instrument but as a catalyst of innovation-driven growth. Sustainability thus emerges as a systemic property of the interaction between energy composition and technological capability. The empirical results challenge reductive interpretations that isolate renewable deployment from innovation ecosystems.

The environmental fragility dimension is further deepened by Haseeb et al. (2021), who demonstrate that forest disturbance and structural ecological degradation intensify climate vulnerability in major Asian economies. Their findings reinforce the thesis that environmental systems possess feedback loops which amplify structural imbalances. When integrated with Bekun et al. (2025), this suggests that energy transition must be understood within a broader ecological matrix in which delayed structural adaptation generates cumulative degradation.

What emerges from these studies is a theoretical shift from incremental environmental correction to structural transformation. Energy transition modifies capital allocation patterns, technological trajectories and external trade dynamics. Open market conditions, as demonstrated by Bekun et al. (2025), amplify the effects of renewable transition by linking domestic energy structures to global value chains. Sustainability therefore becomes a function of systemic alignment rather than isolated policy interventions.

Environmental Taxation and the Fiscal Architecture of Sustainability

If energy transition constitutes the technological axis of sustainability, environmental taxation represents its fiscal architecture. The empirical investigation conducted by Staniewski et al. (2024) across Organisation for Economic Co-operation and Development countries demonstrates that environmental taxes significantly reduce carbon emissions when coupled with sustainable environmental technologies. Crucially, their analysis indicates that taxation alone does not suffice; it becomes effective when embedded in a technological innovation framework.

This finding challenges two classical interpretations. The first assumes that market forces alone will internalise environmental externalities through price mechanisms. The second presumes that taxation functions as a coercive corrective independent of technological capacity. The evidence presented by Staniewski et al. (2024) suggests instead that fiscal instruments operate as structural incentives within a broader innovation ecosystem. Environmental taxation thus modifies behavioural expectations and capital allocation only when technological alternatives are viable.

The interaction between fiscal instruments and technological innovation parallels the energy–innovation nexus identified by Adebayo et al. (2025). When interpreted hermeneutically, these strands of research reveal that sustainability depends upon the alignment of three structural domains: energy composition, fiscal incentives and technological capacity. Any disjunction among these domains generates inefficiencies or rebound effects.

Moreover, fiscal sustainability intersects with financial market stability. Green finance instruments must operate within predictable fiscal environments. The absence of coherent taxation frameworks undermines long-term investment planning, thereby weakening renewable transition incentives. Environmental taxation, therefore, cannot be analysed as a standalone regulatory tool; it must be conceptualised as part of a fiscal–financial continuum supporting sustainable capital flows.

Green Bonds and Financial Resilience

The financial dimension of sustainable development acquires particular significance during periods of market turbulence. Meo et al. (2025) demonstrate that green bonds exhibit resilience under conditions of financial instability, suggesting that sustainable financial instruments possess distinct risk-return characteristics. Their findings indicate that green bonds do not merely replicate conventional bond behaviour but display stabilising properties that may enhance investor confidence during crises.

This resilience must be interpreted within a broader governance context. Dos Santos et al. (2022) argue that innovation, management and governance structures determine the long-term viability of sustainable growth. Financial innovation, therefore, requires institutional frameworks capable of ensuring transparency and accountability.

The structural importance of green bonds lies not only in their capacity to finance renewable projects but in their function as signalling mechanisms. By directing capital towards environmentally certified investments, they shape market expectations and reinforce the legitimacy of sustainable transition strategies. However, their effectiveness remains contingent upon institutional integrity and corruption control.

Governance Quality and Corruption as Structural Moderators

The sustainability discourse often underestimates the corrosive impact of corruption on financial and environmental

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outcomes. Abu and Staniewski (2019) identify multiple determinants of corruption across estimation techniques, revealing its systemic entrenchment in institutional architectures. More significantly, Abu and Staniewski (2022) demonstrate empirically that corruption reduces domestic savings in Nigeria. Since domestic savings constitute a fundamental source of long-term investment capital, corruption indirectly constrains the financing capacity required for renewable transition and green infrastructure development.

Ruiz Estrada et al. (2018) further contribute to this debate by introducing a composite development index linking corruption and socio-economic variables. Their approach underscores that governance quality functions as a structural moderator of development trajectories. When interpreted alongside green bond resilience (Meo et al., 2025), a critical insight emerges: financial instruments cannot compensate for institutional fragility. Sustainable finance presupposes governance credibility.

Thus, corruption does not merely distort public procurement or regulatory enforcement; it disrupts the savings–investment cycle that underpins sustainable capital accumulation. The absence of institutional integrity transforms green finance from a structural solution into a fragile instrument vulnerable to opportunistic capture.

Artificial Intelligence and the Epistemic Transformation of Policy Modelling

The integration of artificial intelligence into policy modelling represents a qualitative transformation of governance capacity. Ruiz Estrada, Park and Staniewski (2023) argue that artificial intelligence enables multidimensional scenario construction and dynamic simulation, thereby enhancing the analytical precision of public policy design. This epistemic expansion allows policymakers to model complex interactions among energy markets, fiscal instruments and financial systems.

Costa Climent and Staniewski (2024) demonstrate that artificial intelligence-enabled business models generate competitive advantages through predictive analytics and value optimisation. When transposed into the domain of sustainable finance, such capacities enable improved risk assessment of green bonds, optimisation of environmental tax structures and forecasting of renewable deployment outcomes.

Artificial intelligence thus functions not merely as a technological addendum but as a structural amplifier of policy coherence. It enhances the capacity to detect threshold effects identified by Bekun et al. (2025) and to simulate fiscal–technological interactions described by Staniewski et al. (2024). Sustainable development becomes, in part, an epistemic challenge: the capacity to integrate heterogeneous data streams into coherent policy architectures.

Toward an Integrated Structural Model

The hermeneutic synthesis of the literature reveals that sustainable development cannot be conceptualised as the sum of renewable energy deployment, environmental taxation, green finance instruments and anti-corruption measures. Rather, it emerges from the structural alignment of these domains within a digitally enhanced governance framework.

Renewable energy reconfigures growth dynamics (Bekun et al., 2025; Adebayo et al., 2025). Environmental taxation reshapes fiscal incentives (Staniewski et al., 2024). Green bonds stabilise sustainable capital flows (Meo et al., 2025). Governance quality conditions savings mobilisation (Abu and Staniewski, 2022; Ruiz Estrada et al., 2018). Artificial intelligence expands policy modelling capacity (Ruiz Estrada et al., 2023; Costa Climent and Staniewski, 2024). The absence of coherence among these dimensions produces structural contradictions: renewable deployment without financial resilience; fiscal incentives without technological capacity; green bonds without institutional trust; digital modelling without governance integrity.

The integrated model proposed here conceptualises sustainable development as systemic coherence across five axes: energy structure, fiscal architecture, financial resilience, institutional integrity and digital governance capacity. Each axis functions as both determinant and moderator of the others. Sustainability thus appears not as a policy objective but as a structural equilibrium state emerging from multidimensional alignment.

Policy Implications and Theoretical Contributions

The structural reconstruction undertaken in the preceding sections leads to a fundamental theoretical conclusion: sustainable development cannot be achieved through partial optimisation of isolated policy instruments. The empirical contributions of Bekun et al. (2025), Adebayo et al. (2025), Staniewski et al. (2024), Meo et al. (2025), Abu and Staniewski (2019, 2022), Ruiz Estrada et al. (2018, 2023) and Costa Climent and Staniewski (2024) collectively demonstrate that sustainability emerges only where energy transformation, fiscal architecture, financial resilience, institutional integrity and digital modelling capacity operate in structural coherence. Policy implications therefore follow not as technocratic prescriptions but as consequences of systemic interdependence.

For developing economies, the findings of Bekun et al. (2025) reveal that renewable energy moderates the environmental externalities of energy-intensive growth only under specific threshold conditions and within open market environments. This implies that renewable transition must be embedded within trade and industrial strategies rather than treated as an isolated environmental reform. Where corruption constrains domestic savings mobilisation, as demonstrated by Abu and Staniewski (2022), the financial base necessary for renewable infrastructure remains structurally insufficient. In such contexts, green bond issuance cannot substitute for institutional reform. The empirical evidence indicates that corruption reduces the domestic capacity to generate long-term investment capital, thereby undermining sustainable finance mechanisms at their foundation (Abu and Staniewski,

*Corresponding Author: **Wojciech Slomski.**

2019; Abu and Staniewski, 2022). Consequently, anti-corruption policy must be interpreted as an energy transition policy in indirect but decisive form.

In Organisation for Economic Co-operation and Development economies, the interaction between environmental taxation and technological capacity becomes decisive. Staniewski et al. (2024) demonstrate that environmental taxes reduce carbon emissions when coupled with sustainable environmental technologies. The fiscal instrument functions effectively only when innovation systems are capable of absorbing and redirecting the incentive structure. This finding resonates with the broader innovation–sustainability nexus described by Adebayo et al. (2025), who show that technological innovation amplifies the contribution of renewable energy to sustainable development objectives. The policy implication is clear: taxation without innovation capacity produces distributive friction without structural transformation, while innovation without fiscal alignment lacks directional force. Sustainable development in advanced economies therefore depends upon the synchronisation of fiscal and technological systems.

The resilience of green bonds during market turbulence, documented by Meo et al. (2025), introduces an additional dimension for both developing and advanced economies. Financial stability during crises becomes a precondition for uninterrupted renewable investment. However, green bonds derive credibility from governance quality. Ruiz Estrada et al. (2018) demonstrate that corruption and socio-economic distortions erode development performance. If governance fragility persists, green financial instruments risk becoming speculative rather than transformative tools. Thus, financial innovation presupposes institutional reliability. The systemic insight here is that sustainable finance cannot function independently of governance architecture.

The contribution of artificial intelligence to policy modelling further modifies the policy landscape. Ruiz Estrada, Park and Staniewski (2023) argue that artificial intelligence enhances the capacity to simulate complex economic interactions and construct multidimensional scenarios. When interpreted within the context of energy transition and green finance, artificial intelligence becomes a structural amplifier of policy coherence. It allows policymakers to model threshold effects in renewable deployment identified by Bekun et al. (2025), to optimise environmental taxation mechanisms described by Staniewski et al. (2024), and to assess financial risk patterns associated with green bonds as analysed by Meo et al. (2025). Costa Climent and Staniewski (2024) show that artificial intelligence-enabled models enhance value creation and strategic optimisation. Transposed into public policy, this capacity reduces epistemic fragmentation and increases systemic alignment.

The theoretical contribution of this article lies in reframing sustainable development as structural equilibrium rather than policy accumulation. Existing empirical research has tended to analyse renewable energy, fiscal instruments, corruption and financial innovation as discrete determinants. The hermeneutic synthesis advanced here demonstrates that these variables form an interdependent architecture. Renewable transition modifies growth trajectories; fiscal instruments reconfigure incentives; green bonds stabilise capital flows; governance quality conditions savings mobilisation; artificial intelligence enhances modelling precision. None of these dimensions is sufficient in isolation. Sustainability emerges only when they converge within a coherent institutional and epistemic framework.

This structural interpretation also clarifies the asymmetry between developing and advanced economies. In developing contexts, governance fragility and savings constraints represent primary bottlenecks (Abu and Staniewski, 2022). In advanced economies, the challenge concerns optimisation and coordination among sophisticated fiscal, technological and financial systems (Staniewski et al., 2024; Meo et al., 2025). Artificial intelligence operates as a cross-contextual integrator capable of reducing modelling gaps (Ruiz Estrada et al., 2023). Thus, while policy priorities differ, the structural logic remains constant: systemic alignment determines sustainable outcomes.

The integrated model proposed here therefore redefines the concept of green transition. It is not solely an environmental project but a reorganisation of economic architecture. It entails reallocation of capital, redesign of fiscal incentives, reinforcement of institutional integrity and enhancement of digital governance capacities. Sustainable development, in this perspective, becomes a condition of structural coherence across energy, finance, governance and epistemology.

Conclusion

The literature examined in this study converges toward a central insight: sustainability cannot be conceptualised as a linear progression from fossil dependence to renewable adoption. Rather, it represents a systemic transformation requiring multidimensional coordination. Empirical evidence from developing countries (Bekun et al., 2025), Group of Seven economies (Adebayo et al., 2025), Organisation for Economic Co-operation and Development contexts (Staniewski et al., 2024), financial markets under stress (Meo et al., 2025), and corruption-affected economies (Abu and Staniewski, 2019, 2022; Ruiz Estrada et al., 2018) collectively indicates that energy transition, fiscal design, financial resilience and institutional quality are structurally inseparable.

Artificial intelligence-enabled policy modelling (Ruiz Estrada et al., 2023; Costa Climent and Staniewski, 2024) introduces a new dimension by expanding the epistemic capacity required to manage this complexity. Sustainable development thus becomes not only a material transformation but also a cognitive and institutional one.

The theoretical reconstruction advanced here proposes that sustainable development is a state of systemic equilibrium emerging from the alignment of renewable energy transition, environmental taxation, green financial resilience, governance integrity and digital modelling capacity. Where one dimension

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lags, structural imbalance persists. Where coherence is achieved, sustainability becomes self-reinforcing.

Future research may empirically operationalise this integrated framework through panel modelling or structural equation analysis across heterogeneous economic contexts. Yet even without additional data, the hermeneutic synthesis of existing scholarship demonstrates that the path toward sustainability lies not in isolated interventions but in architectural coherence.

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