Effects of Regulatory Quality and Political Stability on Sustainable Competitiveness in the EU: The Mediating Role of Environmental Innovations

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Abstract: With rising environmental challenges, the role of policymakers in promoting eco-innovation has become increasingly critical. This study examines how political stability and regulatory quality influence environmental innovation and sustainable competitiveness in the European Union. Using Partial Least Squares Structural Equation Modeling (PLS-SEM) on panel data from 27 EU countries (2017–2022), the study investigates both direct and indirect effects of governance quality. The findings indicate that political stability and regulatory quality significantly enhance eco-innovation, which mediates their impact on sustainable competitiveness. A stable and predictable regulatory environment reduces uncertainty, supports investment in green technologies, and fosters private sector engagement in sustainability initiatives. These results highlight the strategic role of governance in enabling eco-innovation and advancing sustainable economic growth. The study offers practical insights for policymakers seeking to strengthen governance mechanisms—such as regulatory predictability and mission-oriented innovation policies—to create favorable conditions for eco-innovation and long-term competitiveness.

Keywords: Sustainability, Eco-Innovation, Sustainable Competitiveness, Policy Measures, Regulatory Mechanisms

1. Introduction

The increasing urgency of environmental challenges has prompted the European Union (EU) to emphasize the integration of long-term economic competitiveness with environmental sustainability. Frameworks such as the European Green Deal, the Industrial Strategy, and the Fit for 55 packages identify eco-innovation as a key driver of this transition. However, despite rising investments in green technologies, significant differences persist among member states in the implementation and diffusion of sustainable innovation.

A major explanatory factor for this divergence lies in governance quality, particularly political stability and regulatory effectiveness. Stable and predictable governance systems are widely seen as essential for reducing uncertainty, encouraging investment, and creating the conditions necessary for eco-innovation and competitiveness. Yet many existing studies consider governance, innovation, and competitiveness in isolation, which limits the understanding of their systemic interactions.

This study is motivated by the need to better understand how governance quality affects sustainable competitiveness in the EU, especially through its impact on eco-innovation. While prior research has highlighted the individual importance of governance and innovation for economic and environmental outcomes, comprehensive empirical analyses that integrate these relationships remain limited. Addressing this gap is critical for identifying how institutional settings can support the green transition and strengthen national competitiveness.

This paper therefore examines the relationship between governance quality, eco-innovation, and sustainable competitiveness in EU countries, considering both direct and indirect pathways. Governance quality is operationalized through indicators of political stability and regulatory quality, while eco-innovation is treated as a mediating factor that translates institutional conditions into economic and environmental performance. The analysis employs Partial Least Squares Structural Equation Modeling (PLS-SEM) on panel data from 27 EU countries over the period 2017–2022.

By exploring both the direct and indirect effects, this study provides new insights into the institutional factors shaping the green transition in the EU. The findings aim to inform policymakers and practitioners seeking to design governance frameworks that are aligned with sustainability objectives under conditions of regulatory and technological uncertainty.

RQ: *How does governance quality influence sustainable competitiveness in EU countries, and to what extent is this relationship mediated by eco-innovation?*

The remainder of this paper is structured as follows: Section 2 reviews relevant literature; Section 3 describes the data and methods; Section 4 presents the empirical results; Section 5 discusses the findings; and Section 6 concludes with implications and suggestions for future research.

2. Literature Review

The relationship between governance quality, eco-innovation, and sustainable competitiveness is grounded in well-established institutional and innovation theories. According to North (1990), institutions — including formal rules, regulations, and informal norms — shape the incentives and constraints faced by economic actors, thereby influencing investment decisions and innovation dynamics. A stable and predictable institutional environment reduces uncertainty and fosters long-term commitments to technological change (Acemoglu et al., 2005; Kaufmann et al., 2009).

In the context of environmental and sustainability transitions, eco-innovation systems underscore the critical role of governance structures in shaping innovation outcomes. Eco-innovation is often driven by a combination of regulatory push and market pull mechanisms, which together create favorable conditions for firms and industries to develop and adopt environmentally beneficial innovations (Rennings, 2000; Borghesi et al., 2015). Hojnik et al. (2022) and Zhao et al. (2022) emphasize that governance quality, through the design and implementation of coherent policies, directly supports the diffusion of eco-innovations.

This perspective aligns with the Porter hypothesis, which argues that well-designed environmental regulations can stimulate innovation that partially or fully offsets compliance costs, ultimately enhancing competitiveness (Porter & van der Linde, 1995). More recent contributions by Blind (2016) and Ghisetti & Quatraro (2017) extend this logic by demonstrating that regulatory quality, flexibility, and predictability are essential for transforming compliance obligations into drivers of technological advancement.

The linkage between eco-innovation and sustainable competitiveness is also highlighted by studies focusing on resource efficiency, green value creation, and the broader impacts of environmental innovation on national and firm-level performance. Cainelli et al. (2015) and Filippetti & Archibugi (2011) show that eco-innovation not only contributes to environmental goals but also enhances productivity and long-term competitiveness. Mazzucato (2018) further underscores the importance of mission-oriented policies that align public investments and regulatory frameworks with sustainability objectives, fostering innovation ecosystems capable of addressing systemic challenges.

Taken together, these theoretical insights provide a solid foundation for investigating how governance quality influences sustainable competitiveness, particularly through its effects on eco-innovation. By integrating these streams of literature, this study seeks to fill an important empirical gap and offer a nuanced understanding of the institutional mechanisms underpinning the green transition in the EU.

3. Data and Method

The empirical investigation is based on a panel dataset covering all 27 EU member states over the period 2017–2022. This timeframe captures both the lead-up to and early phases of policy implementation associated with the European Green Deal and related sustainability initiatives.

Data were drawn from internationally recognized and methodologically harmonized sources, including Eurostat, the World Bank's Worldwide Governance Indicators (WGI), the OECD Statistics Database, and the V-Dem Institute. These sources are widely used in comparative research and ensure high levels of consistency, transparency, and comparability across countries and over time (Prokop & Hájek, 2023; Giglio et al., 2023).

The conceptual model includes three latent constructs—Governance Quality, Eco-Innovation, and Sustainable Competitiveness—which are operationalized using composite indicators derived from established theoretical and empirical literature, particularly institutional theory, eco-innovation system frameworks, and sustainability performance metrics. To improve explanatory validity and account for country-level heterogeneity, we also include control variables reflecting national economic capacity and R&D intensity. Table 1 provides a full overview of all constructs, indicators, units of measurement, and data sources.

Table 1: Description of variables

Latent Variable	Indicator	Description	Unit of measurement	References
Government (GOV)	PSB	Political stability	range from (-2.5;2.5)	World Bank
	RGQ	Regulatory quality		
Eco-innovation (ECO)	ECA	Eco-innovation related academic publications	score	OECD Statistics, Eurostat
	ECP	Eco-innovation related patent	score	OECD Statistics,Eurostat
	VAE	Gross value added in environmental goods and services sector	% of GDP	Eurostat
Sustainable Competitiveness (SC)	REI	Resource Intensity	score (0-100)	OECDStatistics, Eurostat
	SUC	Sustainable competitiveness	score (0-100)	Eurostat
Control variables (CV)	GNI	Gross National Income	US dollar per capita, PPP	World Bank
	R&D	R&D expenditure	Euro per Inhabitant	Eurostat

The analytical strategy employs Partial Least Squares Structural Equation Modeling (PLS-SEM), estimated in SmartPLS 4. This method is particularly appropriate for models with complex causal relationships, latent variables, and mediating effects, as well as for datasets that may not meet multivariate normality assumptions (Hair et al., 2019; Henseler et al., 2015; Hojnik et al., 2022). Moreover, PLS-SEM enables the estimation of both formative and reflective constructs and is well suited for theory development and explanatory research.

Following recommended best practices (Hair et al., 2019; Sarstedt et al., 2020), the estimation proceeded in two main stages. First, the measurement model was evaluated to ensure the reliability and validity of all latent constructs. This included assessments of indicator loadings, internal consistency (Cronbach's alpha and composite reliability), convergent validity (Average Variance Extracted, AVE), and discriminant validity using the Fornell–Larcker criterion and the Heterotrait–Monotrait ratio (HTMT). All constructs met or closely approximated the standard thresholds, confirming the robustness of the measurement model.

Second, the structural model was assessed to examine the directional relationships among latent constructs as specified in the conceptual model. Path coefficients and their statistical significance were estimated using a bootstrapping procedure with 5,000 resamples. In addition, the model's coefficient of determination (R^2) and predictive relevance (Q^2) were calculated to assess the explanatory power and predictive accuracy of the endogenous constructs. These diagnostics provide a comprehensive understanding of how governance and innovation-related factors interact to shape sustainable competitiveness across EU countries.

The methodological framework applied in this study reflects recent advances in sustainability research and aligns with similar studies using SEM-based approaches in institutional and innovation contexts (e.g. Hojnik et al., 2022). By combining established theoretical frameworks with a structural equation modeling approach and a panel dataset covering EU countries, the study provides an empirical basis for examining governance-driven innovation dynamics.

4. Results

The analysis commenced with an assessment of the measurement model, emphasizing factor loadings, composite reliability, and average variance extracted (AVE). To establish the model's reliability and convergent validity, factor loadings were required to exceed 0.70, composite reliability to be above 0.70, and AVE to surpass the threshold of 0.50 (Richter & Tudoran, 2024). Satisfying these criteria is essential for confirming the adequacy of the measurement model prior to proceeding with the evaluation of the structural model (see Table 2). All

constructs exceeded the recommended thresholds for factor loadings (>0.70), composite reliability (>0.70), and average variance extracted (>0.50), confirming the reliability and convergent validity of the measurement model. Although the HTMT ratio between eco-innovation and sustainable competitiveness slightly exceeded the commonly cited threshold of 0.90 (HTMT = 0.903), this deviation was minimal and did not compromise the overall discriminant validity.

Table 2: Factor Loadings, Composite Reliability, AVE.

Construct	Indicators	Factors Loading	Composite Reliability	AVE
Government (GOV)	PSB	0.822	0.867	0.767
	RGQ	0.926		
Eco-Innovation (ECO)	ECP	0.820	0.834	0.626
	ECA	0.779		
	VAE	0.774		
Sustainable Competitiveness (SC)	REI	0.849	0.875	0.779
	SUC	0.915		
Control variables (VC)	GNI	0.941	0.948	0.901
	RD	0.958		

Source: Author's calculation based on SmartPLS 4 outputs

Once factor loadings, composite reliability, and AVE have been verified, the next phase in evaluating the measurement model involves confirming discriminant validity, which ensures that the constructs are empirically distinguishable. This can be assessed using the Fornell-Larcker criterion, which states that the square root of each construct's AVE should be greater than its correlations with any other construct (Hamid et al., 2017). In addition, the Heterotrait-Monotrait Ratio (HTMT) provides a more stringent test by examining inter-construct correlations, with a commonly accepted threshold of 0.85 (Dirgiatmo, 2023). Nonetheless, some researchers suggest a more lenient cutoff of 0.90 (Hamid et al., 2017). Satisfying these conditions indicates that each construct reflects a distinct concept, thereby supporting the measurement model's validity prior to structural model evaluation.

Table 3: Heterotrait-Monotrait Ratio of Correlations

	CV	ECO	GOV	SC
CV				
ECO	0.890			
GOV	0.836	0.850		
SC	0.776	0.903	0.758	

Source: Author's calculation based on SmartPLS 4 outputs

Based on the results of the discriminant validity analysis, each construct demonstrates the highest loading on its own indicators, which is an expected and desirable outcome. However, a minor issue emerges in the HTMT values, as shown in Table 3—specifically between Sustainable Competitiveness and Eco-Innovation, where the value slightly exceeds the recommended threshold of 0.90. Despite this modest deviation, the constructs can still be regarded as sufficiently distinct, as the exceedance is minimal and does not significantly compromise the overall validity of the measurement model.

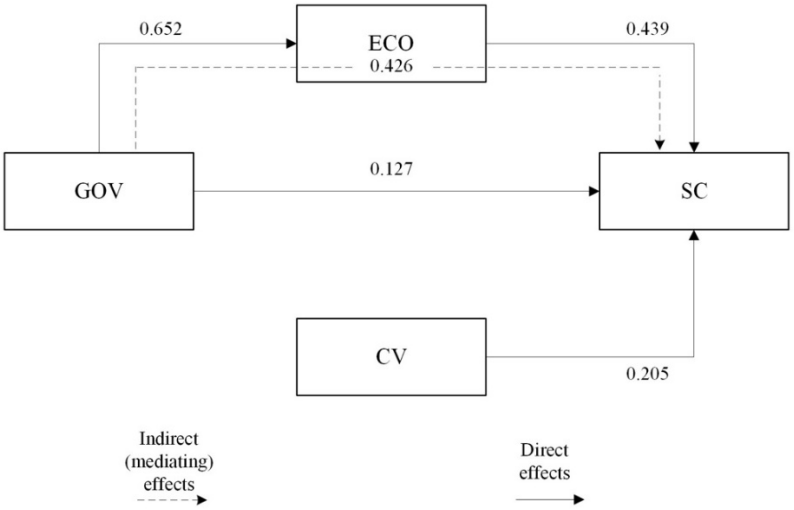

Figure 1: Research model

These findings empirically address the research question by demonstrating that governance quality, operationalized as political stability and regulatory quality, significantly impacts sustainable competitiveness both directly and through the mediating effect of eco-innovation.

The structural model results clearly address the RQ. Governance quality significantly increases eco-innovation, which in turn boosts sustainable competitiveness. The direct effect of governance on competitiveness is not significant, indicating a full mediation through eco-innovation.

5. Discussion

This study was motivated by the question of how governance quality influences sustainable competitiveness and whether eco-innovation mediates this relationship. The empirical results confirm the hypothesized direct and indirect effects, supporting the proposed conceptual framework and answering the research question. The empirical findings of this study provide preliminary findings that governance quality—captured through political stability and regulatory quality—plays a significant enabling role in fostering eco-innovation, which in turn enhances sustainable competitiveness in the European Union.

5.1 Theoretical Implications

The results suggest a full mediation effect, were governance quality influences sustainable competitiveness only indirectly through eco-innovation. This finding extends prior research by indicating that institutional quality does not directly impact economic outcomes but operates primarily through its effect on innovation dynamics. This is consistent with theoretical frameworks emphasizing the role of innovation as an intermediary channel linking governance structures to performance outcomes (Ghisetti et al., 2017). These findings are consistent with the eco-innovation system perspective, which posits that innovation outcomes, particularly in addressing environmental challenges, are strongly influenced by the institutional and policy environment. The full mediation effect observed in this study supports the view that governance structures impact sustainable competitiveness primarily by enabling eco-innovation processes (Zhao et al., 2022; Hojnik et al., 2022).

In particular, the results suggest that stable, predictable, and competent governance structures reduce uncertainty, support long-term planning, and foster commitment to environmental goals—conditions that are necessary for green innovation to flourish. This study also aligns with recent literature highlighting eco-innovation as a key mechanism through which institutional quality can affect economic and environmental performance (Giglio et al., 2021; Zhao et al., 2022; Prokop & Stejskal, 2021). By empirically examining this mediating role, our analysis complements earlier findings and offers macro-level insights into the governance–innovation–competitiveness nexus in the EU context. While prior studies have established bivariate relationships between governance and innovation (Borghesi et al., 2015), or between eco-innovation and firm-level competitiveness (Cainelli et al., 2015), few have integrated these constructs into a single empirical model. The results provide indicative support for the view that the impact of governance quality on sustainable competitiveness may be conditional on the presence of effective innovation mechanisms. In this context, eco-

innovation appears to serve as a key pathway through which institutional quality contributes to broader economic and environmental outcomes.

5.2 Managerial Implications

The results also carry important regional implications.

While the structural model was estimated on the full EU sample, regional disparities in governance quality and innovation capacity remain important considerations. The literature suggests that Eastern and Southern European countries often lag behind in both dimensions (Costantini et al., 2017). These findings underscore the need for differentiated policy approaches. In countries with weaker institutional environments, reforms aimed at improving regulatory predictability and administrative capacity may provide a critical foundation for the emergence of eco-innovation systems. This is particularly relevant in Eastern and Southern European countries, where innovation capabilities and governance effectiveness remain below the EU average (Costantini et al., 2021; D'Este et al., 2017). Conversely, in countries with more mature governance systems, policy should increasingly focus on scaling mission-oriented innovation, strengthening cross-sectoral coordination, and reducing administrative barriers—elements shown to accelerate green technology deployment (Mazzucato, 2018; Kivimaa & Kern, 2016). Another relevant dimension concerns regulatory design. It is not merely the presence of environmental regulation that matters, but also its quality, credibility, and alignment with innovation incentives. Recent studies support the view that well-designed regulation—when predictable, flexible, and innovation-friendly—can act as a stimulus rather than a constraint (Ghisetti & Quatraro, 2017). The positive association between eco-innovation and sustainable competitiveness observed in this study aligns with these findings and extends the Porter hypothesis to a macro-level, cross-country context (Blind, 2016).

In addition, the results highlight the value of academic and technological knowledge production—as measured by eco-innovation-related publications and patents—as important components of national competitiveness (Bruns et al., 2020). This observation is consistent with previous research emphasizing that innovation outcomes depend not only on input factors (such as R&D spending), but also on the effective diffusion and commercialization of scientific knowledge (Filippetti & Archibugi, 2011).

These findings support ongoing calls to strengthen science–policy–industry linkages, particularly in regions where the commercialization of public research remains limited. As shown by D'Este et al. (2017), the development of cooperative research networks, mission-driven partnerships, and international consortia—especially within frameworks like Horizon Europe—can help bridge the gap between institutional structures and innovation outcomes.

The model results indicate that institutional and innovation-related factors play a meaningful role in explaining variation in sustainable competitiveness across EU countries. This reinforces the view that governance quality plays a critical enabling role in shaping long-term sustainability outcomes. As countries around the world pursue green transitions, the capacity of governance systems to stimulate innovation may be a decisive factor in determining the success or failure of sustainability-oriented growth models. The insights provided here suggest that building institutional readiness for eco-innovation—through regulatory coherence, administrative capacity, and mission-oriented policy frameworks—is a necessary condition for achieving long-term competitive and environmental outcomes.

6. Conclusions and Implications

This study provides novel empirical evidence on the indirect mechanisms through which governance quality—captured through regulatory quality and political stability—enhances sustainable competitiveness in the European Union. By applying a PLS-SEM approach to panel data from 27 EU countries between 2017 and 2022, the analysis demonstrates that governance dimensions—specifically political stability and regulatory quality—do not exert a direct effect on competitiveness. Rather, their influence is channeled through eco-innovation, which emerges as a crucial mediating factor. The findings offer macro-level insights into the relationship between institutional quality, eco-innovation, and sustainable competitiveness in the EU context. These results empirically support the theoretical assumptions underlying the role of innovation systems in enabling eco-innovation and sustainable competitiveness (Horbach et al., 2012; Zhao et al., 2022).

The findings confirm that well-structured and predictable governance systems create an enabling environment for innovation aligned with environmental objectives. In particular, the mediating effect of eco-innovation—measured via patents, academic output, and gross value added in the environmental goods and services sector—

suggests that improvements in governance establish necessary institutional preconditions for innovation to flourish. This aligns with the conclusions of Prokop and Stejskal (2021), who emphasize the catalytic role of policy-induced innovation in converting governance capacities into economic performance outcomes. Based on these insights, the study formulates a set of actionable implications for two principal stakeholder groups: policymakers and firms.

From a policy perspective, five priority areas can be identified. First, ensuring long-term regulatory predictability is essential for reducing uncertainty and enhancing investor confidence in green technologies (Giglio et al., 2021; Borghesi et al., 2015). Second, public innovation funding should be strategically oriented toward mission-driven research that addresses systemic sustainability challenges, in line with recommendations by Mazzucato (2018). Third, green public procurement (GPP) should be employed as a strategic demand-side instrument to create lead markets for eco-innovations, particularly in sectors such as energy, construction, and transport (Edler & Georghiou, 2007). Fourth, institutional capacities for designing, monitoring, and implementing green regulations must be strengthened, especially in Eastern and Southern European regions where administrative constraints persist (Prokop et al., 2023; Costantini et al., 2017). Fifth, international collaboration through programs like Horizon Europe and alignment with the European Green Deal objectives are essential for scaling innovation and policy coherence across member states (Kivimaa & Kern, 2016).

At the firm level, several strategic responses are recommended. Companies should integrate environmental innovation into long-term planning and recognize environmental regulation as a potential source of competitive advantage rather than a constraint. Early adoption of green innovations often leads to first-mover benefits in emerging markets (Porter & van der Linde, 1995; Del Río et al., 2017). Firms are also encouraged to engage in cooperative R&D with universities and public research institutions, which can lower costs and improve access to advanced technologies (Cainelli et al., 2015; Horbach, 2008). Investing in long-term green technologies enhances not only compliance but also resilience, brand value, and adaptability (Costantini et al., 2017; Popp et al., 2020). Moreover, companies should develop robust internal systems for environmental reporting and governance, aligning with CSRD and ESG frameworks to meet growing expectations from investors and regulators (Sullivan & Gouldson, 2017). Lastly, proactive engagement in regulatory dialogues enables firms to anticipate compliance trends and contribute to shaping more effective and innovation-friendly policies (Johnstone et al., 2010).

7. Limitations and Future Research

While this study provides initial insights into the role of institutional quality in shaping sustainable competitiveness, several limitations should be acknowledged. First, the composite indicators used to measure eco-innovation—although widely adopted in cross-country analyses (Ghisetti & Quatraro, 2017)—may not fully capture qualitative attributes of innovation, such as their transformative capacity, environmental effectiveness, or technological novelty. Second, although the model includes relevant control variables and follows a theoretically informed structure, the possibility of reverse causality between governance quality and competitiveness cannot be fully ruled out, particularly in the absence of dynamic modeling (Hojnik et al., 2022).

Future research could benefit from the application of panel-based causal inference methods, such as system-GMM or difference-in-differences designs, to address endogeneity and better capture feedback dynamics over time (Bun & Kleibergen, 2021; Arkhangelsky & Imbens, 2023). Additionally, recent studies employing qualitative comparative analysis (QCA) have demonstrated its effectiveness in uncovering how various configurations of institutional, technological, and environmental factors influence green innovation outcomes across different national contexts (Liu H., 2025). Such approaches would enrich our understanding of institutional diversity and its implications for sustainability transitions.

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Ethics Declaration

This research did not involve human participants, personal data collection, or experiments requiring ethical approval. Therefore, ethical clearance was not required for the purposes of this study.

AI Declaration

AI tools were used solely for translation purposes. No AI tools were involved in the generation, analysis, or interpretation of the research content. The scientific content and conclusions remain the sole work of the author.

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