DRIVERS OF GREEN INNOVATION IN NIGERIA: EVIDENCE FROM GOVERNANCE QUALITY

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ABSTRACT
Governance as a multidimensional concept provides a framework for evaluating the effectiveness of utilization of human, material and even natural resources, including innovations in a country. Therefore, in exploring the nexus between governance quality and green innovation in Nigeria, Pearson correlation and Toda-Yamamoto causality techniques were applied to the annual time series data obtained from the World Bank's Worldwide Governance Indicators and World Development Indicators during the period, 1996-2023. Empirical evidence from Pearson correlation test indicates that, except rule of law, and voice and accountability which are negatively correlated with green innovation, the other four indicators of governance quality (control of corruption, government effectiveness, regulatory quality, and political stability) are positively correlated with green innovation in Nigeria. Furthermore, Toda-Yamamoto causality analysis reveals the existence of a unidirectional causality flow from regulatory quality to green innovation in Nigeria. However, causality runs from green innovation to control of corruption in Nigeria. The study concludes that regulatory quality is a driver of green innovation in Nigeria. There is therefore the need to improve regulatory quality in order to stimulate the level of green innovation in the country. Also, control of corruption as a governance quality could also be enhanced when there is a higher level of green innovations in Nigeria.
Keywords: *Governance Quality, Green Finance, Green Innovations, Institutional Quality, Regulatory Quality, & WGI.*

1. Introduction

Inefficient energy consumption increases emissions and ultimately degrades the ecology (Lin et al., 2023). The ecological equilibrium is distorted by human activities and this constitutes a challenge to environmental sustainability. It has been argued that environmental degradation and climate change pose significant threats to ecosystems, biodiversity and human health (Peñalosa &

Kleine-Rueschkamp, 2024). However, the adoption of the concept and mindset towards green innovation contributed to a competitive advantage for firms (Chavira et al., 2023). In achieving the goals of sustainable development set by the United Nations (UN), it is necessary to address environmental issues and implement cleaner production, which can be achieved through the application of green technologies (Maljugić & Taboroši, 2024).

Green technological innovations, and government effectiveness have significantly promoted social development through higher employment opportunities (Yikun et al., 2023). Furthermore, green innovation stimulates sustainable economic development through the reduction of carbon emissions and climate change, supply of clean energy, and increasing agricultural production (Mabhanda, 2024). Also, green innovation combines the two national strategies of innovation-driven and green development, which bring economic and environmental rewards at the same time (Lu, 2019) and it also improves corporate environmental performance with governance practices and environmental policy pressure playing moderating role (Batool et al., 2025; Ha & Nguyen, 2022). According to Hakim and Shafi (2020), incorporating green innovation enhances the economic and social performance through cost, waste reduction and other inefficiencies; it also attracts new customers; it can improve the market position of a company by giving it an edge over its competitors (Akpan & Uford, 2024); and companies can create breakthroughs by contributing to environmental causes and groups or by raising awareness among the consumers.

According to Nwogbo and Ighodalo (2021), governance involves the institutionalization of due process and transparency in the management of public resources, and monitoring the realization of the goals of development. Governance is also considered as a key tool for evaluating the effectiveness of the use of human and material resources to facilitate both national and organizational growth and development (Agwanwo & Bello, 2019; Atairet, & Ndaeyo, 2022). Public governance quality is six-dimensional issues of: political stability and absence of violence/terrorism, voice and accountability, government effectiveness, regulatory quality, control of corruption and the rule of law (Kaufmann et al., 2010).

A key component of green innovation is its contribution to sustainable development as it seeks economic development that achieves an environmental balance and specifically, green innovation is directly related to the environmental dimension of sustainability (Guinot et al., 2022). Green innovation is currently thought of as a new approach that allows organizations to continuously enhance their production and business efficiency while maintaining sustainable development, lowering raw material prices, preserving the natural, and providing more value to their operations (Ha & Nguyen, 2022; Francis, Attih & Uford, 2025). Despite this, the field of green innovation is still in its infancy (Hakim & Shafi, 2020). Against this backdrop, this study sought to explore the nexus between governance quality and green innovation in Nigeria through the lens of the six-dimensional Worldwide Governance Indicators (WGI). Therefore, the specific objectives of the study were to: (i). assess the impact of rule of law on green innovation in Nigeria; (ii). examine the impact of control of corruption on green innovation in Nigeria; (iii). evaluate the impact of regulatory quality on green innovation in Nigeria; (iv). determine the impact of government effectiveness on green innovation in Nigeria; (v). examine the impact of voice and accountability on green innovation in Nigeria; and (vi). assess the impact of political stability and absence of violence/terrorism on green innovation in Nigeria.

2. Literature Review

2.1 Conceptual Review

2.1.1 Green Innovation

Green innovation comprises of various terms such as, eco-innovation, environmental innovation, eco-technologies, green technologies (Hakim & Shafi, 2020). Green innovation is defined as an innovation activity in which a business gathers and applies outside knowledge to facilitate innovation activities or takes knowledge to external markets to earn money (Takalo & Tooranloo, 2021; as cited in Chavira et al., 2023). Green innovation encompasses the development and deployment of technologies, processes, and practices that aim to reduce environment harm (Losacker et al., 2023 as cited in Peñalosa & Kleine-Rueschkamp, 2024). Green innovation has gradually gained recognition not only as a powerful tool in promoting sustainable economic development but also as a contributor to the reduction of carbon emissions in a context where there is an increasing demand for and use of clean energy (Mabhannda, 2024). Thus, green innovation is essential for achieving cleaner environments and this could boost sustainable and competitive businesses and address the challenges caused by climate change (Mabhanda, 2024). Green innovations involve technology developments that substantially decrease carbon dioxide emissions and mitigate environmental risks (Pat-Natson et al., 2024). Green innovation also known as green technology innovation, refers to technological innovation that considers environmental considerations and typically has the dual features of economic development and energy conservation with emission reduction (Bakarim et al., 2024).

Green innovation with regards to organisations are the innovative activities of organisation adopting the software and hardware that is related to green goods, services and processes which include prevention of toxic waste, conservation of energy and protecting the environment through recycling waste materials and responsible management of the environment (Hakim & Shafi, 2020). Green Innovation is referred to as the innovation that comprise of new or improved processes, practices, systems and products that benefit the environment and contribute to environmental sustainability (Hakim & Shafi, 2020). Furthermore, green innovation is defined as a contemporary and noble method for managing processes and manufacturing that may reduce environmental concerns and pollution while minimizing negative effects on resources and energy usage (Wasiq et al., 2023). Green innovation is a type of innovation where businesses try to use resources more efficiently and use less energy, and employ cutting-edge techniques to accomplish the twin objectives of economic and environmental performance (Xie et al., 2019, Etuk, Uford & Udonde, 2023).

Green innovation is the use of creative or technological solutions to reduce negative environmental impacts and maximize sustainability and anything that ranges from development of new renewable energy source to the creation of more efficient way of materials recycling (Njoku et al., 2023). Green innovation is the development and dissemination of items, hardware, and frameworks used to safeguard normal living spaces and assets while lowering the negative environmental repercussions of human activities and it is carried out in a green environment: green image, green innovation, green pursuit, green product innovation, green process innovation, green procurement, eco-plan and pooling, and green construction (Chukwukadiba & Nnamani, 2023). Green innovation is an invention that focuses on waste reduction, pollution prevention, and environmental management systems (Abubakar et al., 2022). Green innovation can categorize into three sections involving green process, green product, and green management (Ha & Nguyen,

2022). In another perspective, technological innovation, product innovation, institutional innovation, and environmental innovation are the basic classifications of green innovation (Li et al., 2022).

2.1.2 Governance Indicators

Governance sometimes called institutional quality, includes the quality of laws and the strength of enforcement agents, also ensure that firms are complying with environmental regulations (Tawiah et al., 2021). Governance is popularly gauged by the six-dimensional indicators developed by the World Bank as the Worldwide Governance Indicators (WGI) comprising of government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, voice and accountability, and control of corruption (Kaufman et al., 2010).

Table 1 summarizes the description of the six dimensions of public governance indicators according to Worldwide Governance Indicators

Table 1: Governance Indicators

Indicators	Description
Rule of Law	This reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
Voice and Accountability	This reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.
Control of Corruption	This reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as capture of the state by elites and private interests
Government Effectiveness	This reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
Political Stability and Absence of Violence/Terrorism	This measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism
Regulatory Quality	This reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

Source: Kaufmann et al. (2010)

2.2 Theoretical Framework

2.2.1 The Institutional Theory of Governance

The institutional theory postulated by Meyer and Rowan (1977) regards governance as the processes by which structures, schemes, rules, norms, and routines, become established as authoritative guidelines for social behavior. Governance quality emphasizes the role of institutions in the management and control of the affairs as well as resources of a country in order to make the

organisations and the society better. The theory relates to the institutional framework within which economic agents interact with one another in an economy influences economic development (Alexiou et al., 2014 as cited in Utile et al., 2021). The institutional theory of governance is thus a socio-political theory that deals with the manner in which rules, norms, culture, policies and regulations are established and managed by a higher authority as authoritative guidelines for social behavior within an ecosystem (Ndugbu et al., 2024). This theory is essential for understanding the institutional determinants of green innovation in Nigeria through the lens of public governance indicators.

2.3 Empirical Review

Salihi et al. (2024) examined the effect green innovation capacity and firm value creation with regards to environmental governance based on a study of 74 companies traded in the Nigerian Stock Exchange for years 2012–2021. The findings shows that the more a company recognizes the importance of governance, environment, and economic governance, the higher the tendencies for companies to have capacities in green innovation and the higher the tendencies for companies to create a valued firm. However, in the study governance dimension was not found to affect the inclination to create firm value.

Okufemi (2024) examined the determinants of green economy in Nigeria. The study employed primary data and six hundred questionnaires (600) were collected. This study adopted a multi-stage random sampling technique in the selection of the sample. The study employed OLS regression to analyse the determinants of green economy in Nigeria. The study revealed that the major determinants of the adoption of green economy in Nigeria during the study period are income level; marital status; age; educational level; type of occupation and family type. It was also confirmed that gender does not determine the adoption of green economy in Nigeria.

Zhang and Chen (2023) used the number of green patent applications and green patent citations measure corporate green innovation and analyze the micro-green effects of the ESG score system using the panel fixed effects models to Chinese listed A-shares in Shanghai and Shenzhen from 2010–2019 as our research sample. The study found that ESG positively affects corporate green innovation; the higher the ESG evaluation, the more it improves firms' green innovation performance. The promotion effect is reflected quantitatively and qualitatively and remains valid after several robustness tests.

Stucki and Woerter (2012), based on a comprehensive data set comprising 13 countries, 22 industries and a period of 30 years, investigated the impact of internal and external knowledge pools of both green and 'other than green' technologies on green patent activities. The study found that the internal green knowledge stock is positively related to green patent activities with a considerably large marginal value. The country's green knowledge stock and the green knowledge stock of the same industry in other countries are also positively related with industries' green patent activities, although with a significantly lower marginal value. External 'other than green' knowledge stocks are negatively related with green inventions.

2.4 Conceptual Framework

The conceptual framework of public governance determinants of green innovation is depicted in Fig.1

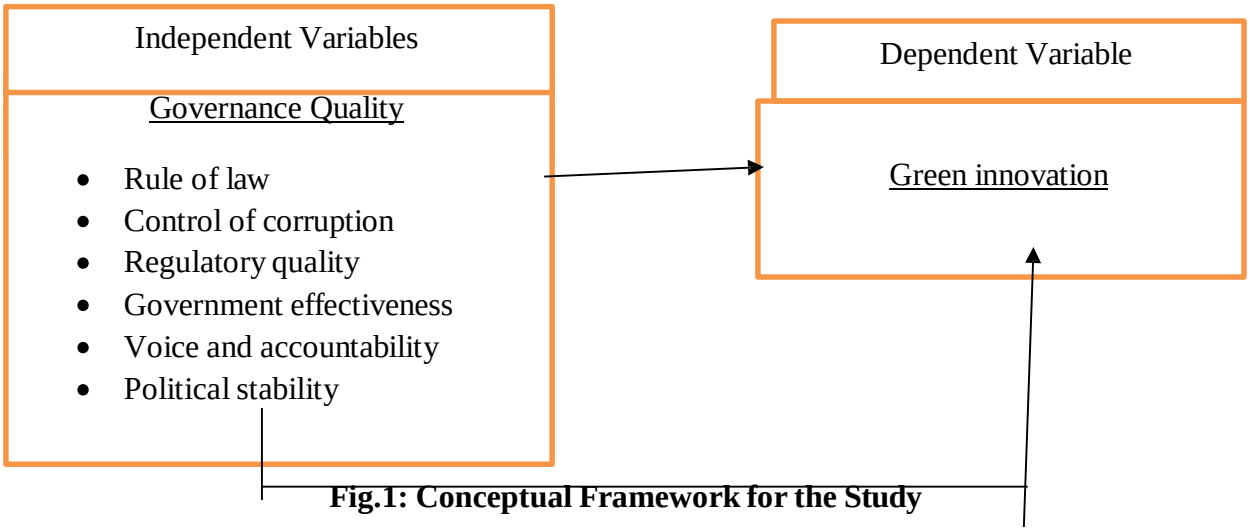

Fig.1: Conceptual Framework for the Study

Source: Authors' conceptualization, 2025

3. Methodology

In exploring the nexus between governance quality and green innovation in Nigeria, Pearson correlation test and Toda-Yamamoto causality techniques were applied to the annual time series data obtained from the World Bank's Worldwide Governance Indicators and World Development Indicators during the period, 1996-2023. The study focused on six-dimensional governance indicators documented in the Worldwide Governance Indicators as independent variables while the dependent variable is green innovation.

In line with the ex-post facto research design, secondary data in were employed in the study. The data used quantitative in nature and annual in frequency. The time series data used in the study are briefly described in Table 2.

Table 2: Measurement of Variables

Variable	Abbreviation	Measurement	Source of Data
Green innovation	GRIN	Renewable energy consumption (% of total final energy consumption)	WDI (2023)
Rule of law	RULA	Rule of law index	WGI (2023)
Political stability	POST	Political stability index	WGI (2023)
Control of corruption	COCO	Control of corruption index	WGI (2023)
Voice and accountability	VOAC	Voice and accountability index	WGI (2023)
Regulatory quality	REQU	Regulatory quality index	WGI (2023)

Government effectiveness	GOEFF	Government effectiveness index	WGI (2023)

Source: Authors' compilation from literature review, 2025.

The functional relationship between governance indicators and green innovations is specified in equation (1).

$$\square\square\square\square_t = \square_0 + \square_1\square\square\square\square_t + \square_2\square\square\square\square_t + \square_3\square\square\square\square_t + \square_4\square\square\square\square_t + \square_5\square\square\square\square_t + \square_6\square\square\square\square\square_t + \square_t \quad (1)$$

Where: $\square$ =error term; t-time in years, 1996-2023; $\square_0$ is the intercept of the model while $\square_1 - \square_6$ are the parameters of the model.

4. Results and Discussions

4.1 Correlation Analysis

Table 3: Pearson Correlation Test

	GRNINO	COC	GOVEFF	POLSTAB	REGQ	ROLAW	VOICE
GRNINO	1.0000						

COC	0.0553	1.0000					
	0.7796	-----					
GOVEFF	0.1465	-0.3630	1.0000				
	0.4568	0.0576	-----				
POLSTAB	0.4265	-0.2767	0.257536	1.0000			
	0.0236	0.1539	0.1858	-----			
REGQ	0.1910	0.5093	-0.3100	-0.2623	1.0000		
	0.3302	0.0056	0.1084	0.1774	-----		
ROLAW	-0.4012	0.7226	-0.4928	-0.3876	0.3280	1.000	
	0.0343	0.0000	0.0077	0.0415	0.0883	-----	
VOICE	-0.5995	0.0446	-0.2503	-0.6402	-0.0276	0.4404	1.000
	0.0007	0.8216	0.1988	0.0002	0.8888	0.0190	-----

Evidence from Pearson correlation test in Table 3 indicates that except rule of law and voice and accountability which are negatively correlated with green innovation, the other four indicators of governance quality (control of corruption, government effectiveness, regulatory quality, and political stability) are positively correlated with green innovation in Nigeria.

4.2 Unit Root Analysis

Table 4: Augmented Dickey-Fuller (ADF) Unit Root Test Statistics

Variables	**ADF Test In Level**		**ADF Test at First Difference**		**Integration Order**
	t-Statistic	Prob.	t-Statistic	Prob.	I(d)
GRNINO	-1.9436	0.3085	-5.368323	0.0002	I(1)
COC	-1.7275	0.4067	-4.328156	0.0023	I(1)

GOVEFF	-3.5124	0.0154			I(0)
POLSTAB	-1.8262	0.3604	-4.7812	0.0008	I(1)
REGQ	-2.4914	0.1285	-6.4335	0.0000	I(1)
ROLAW	-1.5539	0.4917	-3.3130	0.0246	I(1)
VOICE	-4.0619	0.0042			I(0)

Evidence from the ADF unit root test in Table 4 reveals that except voice and accountability, government effectiveness which are stationary in level, all other variables are stationary at first difference.

4.3 Optimum Lag Order Selection

Table 5: VAR Lag Order Selection Criteria

Endogenous variables: GRNINO COC GOVEFF POLSTAB REGQ ROLAW VOICE						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	39.1818	NA	2.18e-10	-2.3838	-2.0478	-2.2839
1	161.9623	172.8020*	1.05e-12*	-7.8490*	-5.1613*	-7.0498*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Evidence from the VAR lag order selection criteria in Table 5 reveals the optimum Lag Order Selected by all the criteria to be lag length one.

4.4 Causality Analysis

Table 6: The Toda-Yamamoto Causality Test

	GRNINO	**COC**	**GOVEFF**	**POLSTAB**
Variable	**Chi-sq[Prob.]**	**Chi-sq[Prob.]**	**Chi-sq[Prob.]**	**Chi-sq[Prob.]**
GRNINO		8.5289[0.0035]	1.6398[0.2003]	0.2254[0.6349]
COC	0.3498[0.5542]		1.9693[0.1605]	0.6089[0.4352]
GOVEFF	0.3009[0.5833]	3.5231[0.0605]		1.8979[0.1683]
POLSTAB	1.4748[0.2246]	0.0077[0.9300]	0.0717[0.7888]	
REGQ	2.8387[0.0920]	0.0595[0.8072]	0.1259[0.7226]	7.9145[0.0049]
ROLAW	0.6862[0.4074]	5.6930[0.0170]	0.1777[0.6733]	3.4144[0.0646]
VOICE	2.1562[0.1420]	0.9541[0.3287]	0.1793[0.6719]	0.0348[0.8520]
Variable	**REGQ**	**ROLAW**	**VOICE**	
	Chi-sq[Prob.]	**Chi-sq[Prob.]**	**Chi-sq[Prob.]**	
GRNINO	0.0148[0.9030]	1.8435[0.1745]	0.0007[0.9788]	
COC	0.8269[0.3631]	0.7652[0.3817]	0.0696[0.7919]	

GOVEFF	0.2709[0.6027]	4.9099[0.0267]	2.5646[0.1093]	
POLSTAB	0.5959[0.4401]	0.0004[0.9823]	0.7891[0.3743]	
REGQ		11.2993[0.0008]	18.4802[0.0000]	
ROLAW	0.097624[0.7547]		0.7548[0.3849]	
VOICE	0.863230[0.3528]	0.134821[0.7135]		

Note: Values in [ ] are the probability values.

The result of the Toda-Yamamoto causality test in Table 6 reveals the existence of a unidirectional causality flow from regulatory quality to green innovation in Nigeria. However, causality runs from green innovation to control of corruption in Nigeria.

5. Conclusions and Recommendations

In exploring the nexus between governance quality and green innovation in Nigeria, this study applied Pearson correlation and Toda-Yamamoto causality techniques to the annual time series data obtained from World Bank's Worldwide Governance Indicators and World Development Indicators during the period, 1996-2023. Empirical evidence from Pearson correlation test indicates that, except rule of law and voice and accountability which are negatively correlated with green innovation, the other four indicators of governance quality (control of corruption, government effectiveness, regulatory quality, and political stability) are positively correlated with green innovation in Nigeria. The Toda-Yamamoto causality technique reveals the existence of a unidirectional causality flow from regulatory quality to green innovation in Nigeria. However, causality runs from green innovation to control of corruption in Nigeria.

The study concludes that only regulatory quality dimension of governance quality is a driver of green innovation in Nigeria. The study underscores the need to improve regulatory quality in order to stimulate the level of green innovation in the country. It can also be inferred that the control of corruption could also be enhanced when there is a higher level of green innovations in Nigeria.

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