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Navigating Kazakhstan's Sustainable Economic Future: A Study of Tech Innovation, Infrastructure, and Resource Management

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Abstract: In a quest to illuminate Kazakhstan's economic horizon within a sustainable context, this study delved into the complex interplay of sustainable tech innovation, investment in sustainable infrastructure, and natural resource management. The study assesses the potential for green economy development by introducing the adoption of sustainable practices as the mediator and corporate social responsibility as the moderator in the examined relationships. We employed a cluster sampling technique, focusing on government sector employees in Kazakhstan. The choice of this sector stemmed from its pivotal role in shaping national policies. A time-lagged approach was incorporated, collecting data at two distinct time points to capture the dynamic evolution of green initiatives over time. As the data unfolded, sustainable tech innovation, investment in sustainable infrastructure, and natural resource management emerged as significant predictors for adopting environmentally responsible practices leading to green economy development. This development process, we found, was further augmented by the moderating influence of corporate social responsibility. Hence, our findings contribute both practical and theoretical insights to the discourse on sustainable economic development. In addressing the intricate interplay of technological, infrastructural, and resource-related factors, this study provides guidance for Kazakhstan's ongoing transition towards a more sustainable and resilient economic trajectory.

Keywords: green economy development; sustainable tech innovation; infrastructure investment; natural resource management; sustainable practice adoption; corporate social responsibility

1. Introduction

In an era marked by unprecedented global challenges related to climate change, resource depletion, and environmental degradation, nations are compelled to reevaluate their economic paradigms (Ngo and Ngo 2023). The intricate tapestry of global economic development now requires a profound shift towards sustainable practices. Sustainable practices refer to actions and behaviors that aim to meet the needs of the present without compromising the ability of future generations to meet their own needs (Mansoor and Paul 2022). These practices are typically focused on preserving the environment, fostering social responsibility, and ensuring economic viability over the long term (Saleh et al. 2023). The pursuit of sustainability has become a guiding principle, steering nations toward a harmonious integration of economic growth, environmental stewardship, and social responsibility (de Oliveira et al. 2023). This paradigm shift reflects an acknowledgment of the interconnectedness between economic activities and the well-being of the planet and its inhabitants (Marín-Rodríguez et al. 2023). Sustainable development encapsulates the idea that progress must not only be measured by economic metrics but also by its impact on ecosystems and communities (Kvasha et al. 2023). It calls for innovative solutions,

international cooperation, and a collective commitment to forge a path that ensures a balanced and resilient future for generations to come (Ferraz 2023). As nations navigate these challenges, the imperative to strike a delicate balance between prosperity and preservation becomes increasingly apparent, shaping the trajectory of global progress (Veretennikova and Selezneva 2023).

Positioned strategically at the crossroads of Europe and Asia, Kazakhstan stands as a nation endowed with vast natural resources, offering both opportunities and challenges (Radelyuk et al. 2023). As the global community grapples with the imperative of transitioning towards more sustainable practices, Kazakhstan faces a pivotal juncture in determining the trajectory of its economic future (Safonova and Perfilova 2023). Kazakhstan's economic narrative has long been intertwined with the extraction and export of natural resources, particularly in the domains of oil, gas, and minerals (Safonova and Perfilova 2023). While this has fueled economic growth and positioned the country as a key player in the global energy market, it has also underscored the need for a paradigm shift. Moreover, Kazakhstan, being a country where corruption levels are relatively high, presents a pertinent context for examining this issue. The prevalence of corruption may adversely affect economic activities within the government sector, potentially resulting in underinvestment in sustainable research and development (RandD) initiatives as well as infrastructure projects. The environmental repercussions of resource-intensive industries and the growing specter of climate change have prompted a recalibration of development strategies (Kolluru et al. 2023). At the heart of this recalibration is the concept of a green economy, a model that seeks to harmonize economic development with ecological sustainability. The imperative for Kazakhstan to embark on this journey is rooted in global trends and deeply intertwined with the country's socio-economic fabric. This research endeavors to dissect the multifaceted components that can shape Kazakhstan's green economic future, focusing on sustainable tech innovation, infrastructure investment, and resource management.

Technological innovation is a foundation for transformative change in the contemporary landscape (Kvasha et al. 2023). Sustainable tech innovation, emphasizing eco-friendly solutions and resource efficiency, emerges as a key driver for countries seeking to balance economic progress with environmental preservation while minimizing ecological footprints (Shen et al. 2022). Simultaneously, infrastructure investment plays a pivotal role in shaping a nation's economic trajectory (Mhlanga 2021). Sustainable infrastructure, characterized by investments in green energy projects, smart cities, and resilient urban planning, contributes to environmental sustainability and bolsters economic resilience (Du et al. 2022). Kazakhstan's ability to strategically channel its investments into sustainable infrastructure will undoubtedly influence the nation's capacity to build a resilient and eco-friendly economic foundation. Moreover, the prudent management of natural resources remains a building block in the sustainable development narrative (Alreahi et al. 2022). For nations rich in minerals, energy, and agricultural resources, the sustainable stewardship of these assets is imperative for long-term viability (Udushirinwa et al. 2023).

Moreover, understanding the factors influencing the adoption of sustainable practices and their outcomes is crucial for envisioning a green economic future (M. Shahzad et al. 2022; Yacob and Peter 2022). Hence, in the current study, the adoption of sustainable practices serves as a mediator that translates theoretical concepts into tangible economic outcomes. This dynamic relationship underscores the complex interplay between environmental consciousness and economic prosperity. As nations grapple with the imperative to embrace sustainability, recognizing the role of sustainable practices as a transformative agent becomes paramount (Bag et al. 2021). The adoption of such practices not only reflects a commitment to ecological responsibility but also holds the potential to drive positive economic shifts (Jansson et al. 2017). Furthermore, by elucidating the mechanisms through which the adoption of sustainable practices influences economic development, the study aims to provide actionable insights for diverse economies.

While the existing literature acknowledges the importance of sustainable practices and their impact on economic development (Akbar et al. 2020; Bag et al. 2021; Teixeira et al.

2022), there is a notable lack of comprehensive studies that integrate diverse sustainability initiatives within governmental settings (Saleh et al. 2023; Yavuz et al. 2023). This study fills this void by offering a holistic examination of how innovation, infrastructure investment, and resource management collectively influence the adoption of sustainable practices and, consequently, contribute to developing a green economy in governmental operations. Moreover, a gap exists in understanding the obscure relationships among sustainable initiatives and their impact on economic development in the specific context of government sectors. The current literature often emphasizes sustainability in corporate settings, neglecting the unique challenges and opportunities within governmental operations (Saleh et al. 2023; Suriyankietkaew et al. 2022). This study addresses the contextual gap by focusing on the specific dynamics of government sectors, providing insights into how sustainable practices are adopted and contribute to the broader goal of a green economy. Additionally, corporate social responsibility (CSR) acknowledges the distinctive socio-economic responsibilities of government sectors and highlights their potential to enhance the positive outcomes of sustainability initiatives (Xue et al. 2022). Given the serious environmental issues and human rights concerns in Kazakhstan, it is pertinent to explore the prevalence and scope of corporate social responsibility (CSR) initiatives within such a social context. The study underscores the need for collaborative efforts in shaping a sustainable future by recognizing the symbiotic relationship between governmental actions and corporate social responsibility. This approach expands the scope of sustainable practices beyond individual entities, emphasizing the citizens' and government's collective responsibility.

To achieve this, this research employed a cluster sampling technique to ensure a diverse and representative selection of participants from various departments across different government sectors in Kazakhstan. Furthermore, considering the socio-economic challenges and international scrutiny surrounding environmental and human rights issues in Kazakhstan, examining the extent of CSR adoption becomes imperative. Therefore, incorporating CSR into empirical hypotheses allows for a comprehensive analysis of its role in addressing socio-environmental challenges and promoting sustainable development in Kazakhstan. The integration of CSR as a moderating influence amplifies the impact of sustainable practices, fostering a holistic approach that aligns with economic development. Hence, the primary aim of this research is to address the following main research questions (RQs):

- What is the impact of sustainable tech innovation, investment in sustainable infrastructure, and natural resource management on the development of a green economy?
- How does the adoption of sustainable practices directly influence the development of a green economy?
- What is the mediating role of sustainable practice adoption in the relationships between sustainable tech innovation, investment in sustainable infrastructure, natural resource management, and green economy development?
- How does corporate social responsibility moderate the relationship between sustainable practice adoption and green economy development?

2. Theoretical Foundation of the Study

The Innovation Diffusion Theory (IDT) provides a robust foundation for understanding the dynamics of sustainable tech innovation and its diffusion within the government. According to IDT, innovations, in this case, sustainable technologies, spread through a social system, influencing organizational practices and behaviors (Yuen et al. 2021). The positive relationship observed between sustainable technology innovation and the adoption of sustainable practices leading to green economic development aligns with the core tenets of IDT (He and Lee 2020). Governments acting as adopters of sustainable technologies can be viewed as part of a larger social system where innovative practices diffuse and become integrated into routine operations (Mansoor 2021). IDT also offers insights into the temporal aspects of innovation adoption. Moreover, the Resource-Based View (RBV) complements IDT by providing a lens through which to understand the strategic allocation

of resources, particularly financial resources invested in sustainable infrastructure (Kruesi and Bazelmans 2023). The positive association between investments in sustainable infrastructure and the adoption of sustainable practices leading to green economic development aligns with RBV's principle that strategic resources contribute to sustained competitive advantage (Collins 2021). In the context of sustainability, financial investments in eco-friendly infrastructure projects are strategic resources that enhance the organization's capability to adopt and integrate sustainable practices (Khanra et al. 2022). RBV also addresses the aspect of natural resource management. Effective natural resource management can be seen as a strategic capability that contributes to organizational success (Dubey et al. 2019). RBV emphasizes the role of unique and valuable resources in achieving a competitive advantage, and in the context of sustainability, responsible and effective natural resource management can be considered a valuable resource that influences the adoption of sustainable practices.

3. Hypothesis Development

3.1. Association of Sustainable Tech Innovation, Investment in Sustainable Infrastructure, and Natural Resource Management with Green Economy Development

Sustainable tech innovation is conceptualized as the introduction and integration of novel and environmentally friendly technologies within the government sector (M. Shahzad et al. 2022). Building on the IDT, we project a positive association between sustainable tech innovation and green economy development. The rationale stems from the premise that governments at the forefront of technological innovation are better positioned to foster sustainable practices, thereby contributing to the development of a green economy. The literature supports this notion, emphasizing the transformative impact of technological innovation on sustainability (Yacob and Peter 2022). Furthermore, investment in sustainable infrastructure is conceptualized as the strategic allocation of financial resources to projects that prioritize environmental sustainability (Mhlanga 2021). Drawing from the RBV, we posit a positive relationship between investment in sustainable infrastructure and green economy development. The RBV suggests that financial investments in sustainable projects act as strategic resources, contributing to sustained competitive advantage. This extends to the sustainability domain, suggesting that governments strategically allocating financial resources to eco-friendly infrastructure projects are more likely to contribute to the development of a green economy. Empirical evidence supports this perspective, highlighting the positive link between financial commitment to sustainability initiatives and the actual adoption of eco-friendly practices (Du et al. 2022). Simultaneously, natural resource management is conceptualized as the responsible and efficient use of natural resources within operations (Matta and Alavalapati 2006). Aligning with ecological modernization principles, we hypothesize a positive association between natural resource management and green economy development. The notion is grounded in the idea that effective resource stewardship is essential for achieving long-term environmental and economic goals. Responsible natural resource management practices are expected to positively influence the adoption of sustainable practices, contributing to the broader goal of green economic development (Farrukh et al. 2022). The literature on sustainable development emphasizes the importance of aligning economic activities with ecological sustainability (Cumming et al. 2022). Therefore, it is hypothesized that:

H1a, b, and c. *Sustainable tech innovation, investment in sustainable infrastructure, and natural resource management collectively and positively influence green economy development within the government sector.*

3.2. Association of Sustainable Tech Innovation, Investment in Sustainable Infrastructure, and Natural Resource Management with Sustainable Practice Adoption

Sustainable technology innovations play a pivotal role in shaping the future of sustainable practices. Advancements in renewable energy, such as the development of efficient solar panels, energy storage solutions, and smart grid systems, enhance energy sustainability (K. Shahzad et al. 2022). Moreover, innovations in waste management and recycling

technologies promote a more circular and resource-efficient economy (Rene et al. 2021). Research shows that sustainable technology acts as an enabler for sustainable practices by providing viable alternatives to traditional, resource-intensive methods (Sarfraz et al. 2023). The integration of these innovations into various sectors accelerates the transition towards more sustainable and eco-friendly operations. Moreover, investment in sustainable infrastructure involves allocating financial resources to build and upgrade infrastructure that supports sustainable practices (Saunavaara et al. 2022; Utami 2019). For example, investing in public transportation, green buildings, and smart cities can significantly reduce carbon emissions and enhance overall resource efficiency (Sánchez-Silva and Calderón-Guevara 2022). Furthermore, research reports that sustainable infrastructure investments create an enabling environment for the adoption of sustainable practices by establishing the necessary foundations and systems that support eco-friendly technologies and behaviors (Mhlanga 2021). Moreover, effective natural resource management is intertwined with sustainable practice adoption. As the demand for resources continues to rise, responsible management becomes imperative. Sustainable forestry, water conservation, and biodiversity preservation are essential components of natural resource management (Makhloufi et al. 2022; Wanja et al. 2020). Striking a balance between resource utilization and preservation ensures the long-term viability of ecosystems and the services they provide (Farrukh et al. 2022). Hence, integrating sustainable natural resource management practices ensures the availability of resources for current and future generations, forming the backbone for sustainable development and fostering responsible consumption patterns. Therefore, we hypothesize that:

H2 a, b and c. *Sustainable tech innovation, investment in sustainable infrastructure, and natural resource management collectively and positively influence sustainable practice adoption within the government sector.*

3.3. Impact of Sustainable Practice Adoption on Green Economy Development

Sustainable practice adoption fosters eco-friendly operational strategies, resource management, and sustainable initiatives (Bag et al. 2021). This, in turn, enhances the overall economic sustainability of government operations. Empirical studies in sustainability consistently highlight the positive impact of adopting environmentally friendly practices on economic performance (Yavuz et al. 2023). Moreover, the adoption of sustainable practices often leads to increased resource efficiency and cost savings (Teixeira et al. 2022). These cost savings contribute to the economic viability and resilience of the organization. Previous research has shown that resource-efficient practices positively correlate with economic performance and competitiveness (Tumasjan et al. 2020). Previously, researchers also reported that energy efficiency supports decarbonization initiatives as significant sustainability and economic development drivers, particularly in regions like Europe (Di Foggia et al. 2022; Umair et al. 2023). Additionally, sustainable practice adoption is closely linked to innovation, providing government sectors opportunities to explore and develop new products, services, and technologies (Kuo and Chen 2018; Saleh et al. 2023). This innovation-driven approach positions organizations to capitalize on emerging green markets and participate in the growing demand for sustainable products and services. The literature on innovation and sustainability highlights the potential for organizations to gain a competitive advantage and access new market opportunities through the adoption of eco-friendly alternatives (Akbar et al. 2020; Yavuz et al. 2023). Hence, it is postulated that:

H3. *Sustainable Practice Adoption positively influences Green Economy Development within the government sector.*

3.4. Sustainable Practice Adoption as a Mediator

The adoption of resource-efficient technologies, circular economic models, and socially responsible business practices embodies the principles of green economy development. Fur-

thermore, sustainable practice adoption is considered vital in this transformative process, influencing and shaping the contours of a green economy (Karmaker et al. 2023). Research also shows that the collective adoption of sustainable practices transmits the significance of sustainable technology implementation in achieving sustainable economies (Vaisman et al. 2022). At the same time, investment in sustainable infrastructure not only addresses immediate environmental concerns but also establishes the groundwork for long-term sustainability (Hasnain and Pasha 2022; Kabir et al. 2022). It serves as a catalyst for transformative change, fostering a paradigm shift towards more eco-centric and socially inclusive economic activities. The intersection of green economy development and the adoption of sustainable practices reflects a symbiotic relationship that propels societies toward a more sustainable future. Green economy development entails restructuring economic activities to prioritize ecological integrity and social well-being (Biclar 2022; Popkova and Sergi 2023). This transformation is facilitated by the widespread adoption of sustainable practices across various sectors. The green economy flourishes as businesses and industries embrace eco-friendly technologies, resource-efficient processes, and socially responsible practices (Dou and Gao 2022; Wang et al. 2023). Additionally, natural resource management stands as a cornerstone in shaping investments that promote green economy development by ensuring the responsible use of essential resources. Natural resource management strategies, encompassing sustainable forestry, water conservation, and biodiversity preservation, create a foundation for ecological balance essential for a green economy (Benhsain and Boujrouf 2023; Farrukh et al. 2022). When embedded in investment decisions, natural resource management principles guide projects that prioritize environmental sustainability, fostering a nexus between economic growth and ecological preservation (Makhloufi et al. 2022; Rerkklang 2018). By embracing sustainable practice adoption, individuals and businesses contribute to the realization of green economy development objectives, integrating eco-friendly and resource-efficient practices into various facets of society. The current study posits that sustainable practice adoption acts as the intermediary, translating natural resource management principles into tangible actions that steer investments and economic activities toward environmentally conscious pathways. This synergy between natural resource management and sustainable practice adoption becomes a driving force in the transition to a green economy, where ecological considerations are inherent in economic development and prosperity. Hence, it is hypothesized that:

H4 a, b, and c. *Sustainable Practice Adoption mediates the relationships between Sustainable Tech Innovation, Investment in Sustainable Infrastructure, Natural Resource Management, and Green Economy Development.*

3.5. Corporate Social Responsibility as a Moderator

There is a growing body of literature that underscores the interconnectedness between corporate sustainability initiatives and the broader economic landscape (Štreimikienė and Ahmed 2021). Numerous studies have demonstrated that firms embracing sustainable practices tend to contribute positively to environmental conservation and resource efficiency (Ngo and Ngo 2023). However, the extent of these contributions can be influenced by the degree of commitment to CSR. Corporations actively engaged in CSR are more likely to holistically integrate sustainable practices into their operations, fostering a more symbiotic relationship with the green economy. Empirical evidence depicts instances where firms with a robust CSR framework exhibit a more significant positive impact on green economy development than those with limited or no CSR initiatives (López-Concepción et al. 2022). Studies have indicated that CSR serves as a mechanism for ensuring that sustainable practices are not merely adopted for the sake of compliance but are deeply ingrained in the corporate culture (Huang et al. 2022; Nausheen et al. 2022). This, in turn, enhances the effectiveness and longevity of sustainable initiatives, creating a more conducive environment for the growth of a green economy. The moderation effect of CSR becomes apparent in the way it influences strategic alignment, resource allocation, and

stakeholder engagement related to sustainable practices, ultimately shaping the overall impact on green economic development. Hence, it is hypothesized that:

H5. *The relationship between sustainable practice adoption and green economy development within the government sector is contingent upon the level of corporate social responsibility, with higher levels of CSR strengthening the positive impact of sustainable practice adoption on green economy development.*

3.6. Theoretical Framework

Figure 1 encapsulates the comprehensive theoretical framework of this study, illustrating the relationships among key variables within government sectors striving for sustainable development. The three independent variables at the framework's core are sustainable tech innovation, investment in sustainable infrastructure, and natural resource management. These variables represent the proactive steps government sectors take to foster environmental sustainability. The arrows signify the direct influences of these variables on two pivotal constructs: the adoption of sustainable practices and the development of a green economy. Sustainable practice adoption, in turn, is positioned as a mediator that channels the positive impacts of independent constructs toward green economy development. Additionally, the framework introduces CSR as a moderating factor, highlighting its potential to amplify the positive influence of sustainable practice adoption on green economy development.
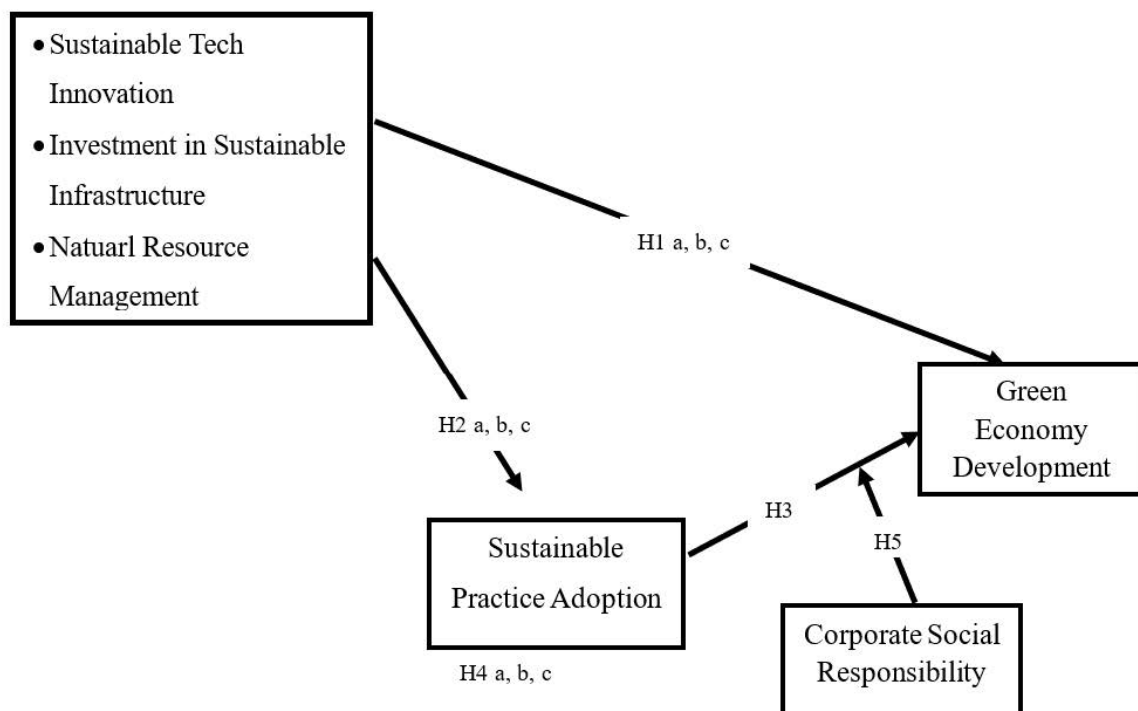

Figure 1. Theoretical framework of the study.

4. Research Methods

A quantitative research approach was adopted to explore the intricacies of project management effectiveness within the government sector. The research employed a cluster sampling technique to ensure a diverse and representative selection of participants from various departments across different government sectors in Kazakhstan. The aim was to garner valuable insights from government employees within these sectors regarding sustainable tech innovation, investment in sustainable infrastructure, natural resource management, sustainable practice adoption, and green economy development. In implementing the cluster sampling strategy, the research team initially identified a broad spectrum of

government sectors strategically. This step was crucial for ensuring comprehensive representation (Jaiswal et al. 2020). A list of potential clusters encompassing ministries, agencies, and other relevant government bodies was compiled. From this list, a random subset was selected to form the primary clusters for participant recruitment, ensuring randomness and reducing potential bias. Within each chosen cluster, multiple departments were then identified and included as sub-clusters, covering various operational facets. These included departments responsible for policy formulation, regulatory compliance, and service delivery. By adopting this two-tiered cluster approach, the study aimed to capture diverse perspectives from different departments within each sector, contributing to a well-rounded representation of the government's operational landscape.

Participants within the selected clusters were invited to participate in the study using a stratified random sampling method. This approach ensured that participants were selected proportionally from each sub-cluster, further enhancing the representativeness of the sample. The recruitment process involved clear communication of the research objectives, confidentiality assurances, and the voluntary nature of participation. Additionally, efforts were made to include participants with varying levels of experience and expertise within their respective departments to capture a comprehensive range of perspectives. To facilitate participant engagement and data collection, a combination of online surveys and in-person interviews was employed. The surveys were designed to assess participants' perspectives about study constructs. To capture a comprehensive understanding of the temporal aspects of the constructs under investigation, a time-lagged survey design was implemented. Measures for sustainable tech innovation, investment in sustainable infrastructure, natural resource management, and sustainable practice adoption were assessed at Time 1, while green economy development and corporate social responsibility were evaluated at Time 2. This temporal approach allowed for the examination of changes and relationships over time, offering a nuanced perspective on the factors influencing green economy development. The data collection process involved reaching out to a total of 590 potential respondents. In Time 1 (February 2023–May 2023), 486 individuals completed the survey, and in Time 2 (July 2023–October 2023), 425 respondents provided their insights, culminating in the final response rate calculation. Subsequently, a series of statistical techniques, including regression analysis and factor analysis, were applied to analyze the collected data, ensuring a robust examination of the dynamics of project management effectiveness within the government sector.

4.1. Demographic Characteristics

Engaging government employees from various departments across different sectors in Kazakhstan, the study ensured a comprehensive representation of the workforce. The participants included both genders, with 59.3% male and 40.7% female respondents. The age distribution among respondents varied, covering a wide range of age groups. Approximately 30.2% were early-career professionals, while 40.3% fell within the mid-career range, and 29.5% represented individuals with extensive experience. Educational backgrounds of the participants were diverse, with 15.4% holding undergraduate degrees, 25.6% and 32.3% possessing graduate and postgraduate degrees, respectively, and 26.7% having professional certifications. Professional roles within the government departments covered a wide spectrum, with 25.6% involved in policy formulation, 29.2% in regulatory compliance, and 45.2% in service delivery. This diversity in roles ensured that the research captured insights from individuals with different responsibilities and perspectives, shedding light on the multifaceted nature of project management within the government. The participants were distributed across different hierarchical levels within their respective departments, showcasing a balanced representation. Approximately 22% held entry-level positions, 43% occupied mid-level roles, and 35% were in managerial and leadership positions. This stratification enabled a thorough examination of how perceptions and experiences of project management effectiveness varied across organizational levels.

4.2. Study Measures

Sustainable Tech Innovation was measured with 5 items from Omri (2020) and Vaisman et al. (2022). The measures include the adoption of clean energy technologies, eco-friendly manufacturing processes, and waste reduction technologies. Investment in Sustainable Infrastructure was measured with 5 items from Du et al. (2022) and Mhlanga (2021). The scale quantifies the level of financial investment directed towards sustainable infrastructure projects, encompassing renewable energy, green building initiatives, and eco-friendly transportation systems. Natural Resource Management was measured with 6 items from Matta and Alavalapati (2006). It assesses the organization's efforts in natural resource conservation, including water, energy, and raw materials. Sample items ask participants to rate the effectiveness of water conservation initiatives and the significance of the organizational efforts to minimize energy consumption in daily operations. Sustainable Practice Adoption was measured with 6 items from Zhang and Yang (2016). Sample items include questions about the effectiveness of communication and the integration of sustainability practices into daily operations. Sample questions also inquire about employee involvement in suggesting and implementing sustainability initiatives and the effectiveness of internal communication regarding sustainability practices. Sustainable Economy Development was measured with 11 items from Choudhary and Sangwan (2019) and Teixeira et al. (2022). Sample items include questions about the extent of the organization's contribution to green job creation and the importance placed on fostering environmentally friendly employment opportunities. Finally, Corporate Social Responsibility (CSR) was measured with 11 items from Liu et al. (2022). Sample items include questions about the effectiveness of CSR initiatives and the extent of engagement in philanthropic activities for community benefit.

5. Data Analysis and Results

Model Estimation: Measurement Model

The study employed SmartPLS v.4.0 to conduct an analysis of collected data. The research conducted by Sarstedt et al. (2018) underscores the utility of Partial least squares structural equation modeling (PLS-SEM) in evaluating models characterized by numerous constructs and intricate relationships, such as the conditional mediation effect of brand credibility. Partial Least Squares Structural Equation Modeling (PLS-SEM) is a statistical technique used for modeling complex relationships between observed and latent variables in a system (Sarstedt et al. 2017). PLS-SEM is a component-based approach that aims to maximize the explained variance of the endogenous latent variables. PLS-SEM allows researchers to specify and test hypotheses about the relationships between latent variables and observed variables through path modeling. Its estimation procedure involves iteratively minimizing the difference between the observed data and the predicted data using weighted linear regressions. Additionally, PLS-SEM commonly employs bootstrapping, a resampling technique, to assess the reliability and significance of estimated parameters (Hair et al. 2017). With its flexibility, PLS-SEM is well-suited for studies with small sample sizes, non-normal data, or exploratory research objectives, making it a valuable tool for researchers in various disciplines. To assess the results obtained through PLS-SEM, we adhere to the methods and standards delineated by Ringle et al. (2023). Our examination of the data presented in Table 1 reveals robust indicator reliability, with almost all outer loadings surpassing 0.7. Furthermore, the reliability of constructs, gauged through Cronbach's alpha and composite reliability, was confirmed, as both metrics exceeded 0.7 (Noor et al. 2022; Sarstedt et al. 2017). Convergent validity was established, as the average variance extracted for reflectively measured constructs surpassed 0.5.

To assess discriminant validity, Heterotrait–Monotrait (HTMT) ratios were examined, and the results, presented in Table 2, revealed that all constructs exhibited values below the threshold of 0.85 (Henseler et al. 2015). These findings affirm the distinctiveness of each construct, indicating that they are measuring different traits and not merely variations of the same underlying characteristic. The HTMT ratios provide robust evidence supporting the validity of the measurement model and reinforcing the confidence in the distinctiveness of the latent variables under study.

Table 1. Factor loadings, reliability, convergent validity, and full collinearity.

Constructs/Items	Loading	AVE	CR	CA	FC
Sustainable Tech Innovation		0.585	0.875	0.777	1.243
STI1	0.729				
STI2	0.811				
STI3	0.770				
STI4	0.787				
STI5	0.723				
Investment in Sustainable Infrastructure		0.601	0.883	0.787	1.292
ISI1	0.719				
ISI2	0.775				
ISI3	0.808				
ISI4	0.780				
ISI5	0.791				
Natural Resource Management		0.545	0.878	0.794	1.331
NRM1	0.719				
NRM2	0.714				
NRM3	0.709				
NRM4	0.834				
NRM5	0.701				
NRM6	0.745				
Sustainable Practice Adoption		0.582	0.893	0.801	1.348
SPA1	0.720				
SPA2	0.754				
SPA3	0.715				
SPA4	0.813				
SPA5	0.793				
SPA6	0.776				
Green Economy Development		0.595	0.942	0.870	1.459
GED1	0.760				
GED2	0.784				
GED3	0.791				
GED4	0.774				
GED5	0.722				
GED6	0.727				
GED7	0.731				
GED8	0.849				
GED9	0.746				
GED10	0.793				
GED11	0.797				
Corporate Social Responsibility		0.613	0.864	0.823	1.217
CSR1	0.796				
CSR2	0.770				
CSR3	0.806				
CSR4	0.759				

Note: CR = composite reliability; AVE = average variance extracted; CA = Cronbach alpha; FC = full collinearity.

Table 2. Heterotrait–Monotrait (HTMT) ratio correlation.

Study Construct	1	2	3	4	5	6
1. Sustainable Tech Innovation	**0.764**					
2. Investment in Sustainable Infrastructure	0.534	**0.775**				
3. Natural Resource Management	0.526	0.391	**0.738**			
4. Sustainable Practice Adoption	0.425	0.444	0.507	**0.762**		
5. Green Economy Development	0.600	0.401	0.390	0.476	**0.771**	
6. Corporate Social Responsibility	0.469	0.521	0.467	0.452	0.504	**0.783**

Note: The values in bold depict the square roots of AVE.

Moreover, our examination indicates that the Variance Inflation Factor (VIF) in this study consistently stays below the established threshold of 3.33, ranging from 1.24 to 1.49. This outcome implies that multicollinearity is not an issue within our dataset, adhering to the criteria outlined by Hair and Sarstedt (2021). Following this, we utilized bootstrapping resamples, totaling 10,000 samples, in accordance with the guidance provided by Becker et al. (2023), to assess the validity of the hypotheses formulated in our study.

Our study's analysis of direct relationships has yielded noteworthy findings, demonstrating the influential role of various factors in contributing to green economy development (see Figure 1). Firstly, sustainable tech innovation exhibited a statistically significant positive impact on green economy development ($\beta = 0.203$, $p < 0.05$), indicating that organizations embracing innovative sustainable technologies are more likely to contribute positively to green economic development. Similarly, investment in sustainable infrastructure demonstrated a significant positive association with green economy development ($\beta = 0.298$, $p < 0.05$), suggesting that dedicating financial resources to sustainable infrastructure projects contributes substantially to developing a green economy. Furthermore, natural resource management displayed a statistically significant positive impact on green economy development ($\beta = 0.302$, $p < 0.05$), emphasizing the role of effective resource management in fostering environmentally sustainable economic practices. In addition, sustainable practice adoption was found to significantly influence green economy development positively ($\beta = 0.413$, $p < 0.05$), underlining the importance of integrating sustainable practices into organizational operations for broader economic benefits (See Table 3).

Table 3. Results of the structural model.

Path	Relationship	Std. β	LB	UB	Significant? ($p < 0.05$)	VIF	R^2	Q^2 Predict	Type of Mediation
Direct	H1a: STI→GED	0.203	0.120	0.336	Yes	1.24	0.612	0.309	
	H1b: ISI→GED	0.298	0.145	0.402	Yes	1.31			
	H1c: NRM→GED	0.302	0.218	0.427	Yes	1.29			
	H2a: STI→SPA	0.210	0.146	0.290	Yes	1.45	0.613	0.409	
	H2b: ISI→SPA	0.198	0.089	0.284	Yes	1.49			
	H2c: NRM→SPA	0.245	0.190	0.379	Yes	1.39			
	H3: SPA→GED	0.413	0.217	0.540	Yes	1.40			
Indirect	H4a: STI→SPA→GED	0.214	0.113	0.352	Yes				Partial
	H4b: ISI→SPA→GED	0.134	0.091	0.216	Yes				Partial
	H4c: NRM→SPA→GED	0.127	0.101	0.287	Yes				Partial
Interaction	H5: CSRx SPA→GED	0.189	0.123	0.292	Yes				
Control Variable	Age→GED	−0.034	−0.013	0.039	No				
	Gender→GED	0.033	−0.021	0.041	No				
	Education→GED	0.010	−0.001	0.015	No				
	Designation→GED	0.017	−0.012	0.029	No				
	Experience→GED	0.029	−0.019	0.038	No				

Note: STI = Sustainable Tech Innovation; ISI = Investment in Sustainable Infrastructure; NRM = Natural Resource Management; SPA = Sustainable Practice Adoption; GED = Green Economy Development; CSR = Corporate Social Responsibility. "The examination of the indirect effect involves a two-tailed test with a confidence interval at the 97.5th percentile, whereas the remaining factors are evaluated through a one-tailed test with a confidence interval at the 95th percentile".

Examining indirect relationships unveiled the mediating role of the adoption of sustainable practices in the relationships between sustainable tech innovation, investment in sustainable infrastructure, natural resource management, and green economy development. Sustainable tech innovation exhibited a significant positive indirect effect on green economy development through sustainable practice adoption ($\beta = 0.214$, $p < 0.05$). Similarly, investment in sustainable infrastructure and natural resource management also demonstrated positive indirect effects on green economy development through sustainable practice adoption, with respective β values of 0.134 ($p < 0.05$) and 0.127 ($p < 0.05$). These findings underscore the significance of incorporating sustainable practice adoption as a pivotal mediator in the relationship between sustainable initiatives and the overall development of a green economy.

Moreover, the study explored the interaction effect between corporate social responsibility (CSR) and sustainable practice adoption in influencing green economy development. The results indicated a significant positive interaction effect ($\beta = 0.189$, $p < 0.05$), highlighting the amplified positive impact on green economy development when corporate social responsibility initiatives are coupled with widespread sustainable practice adoption within an organization. In terms of control variables, including age, gender, education, designation, and experience, no significant direct impacts on green economy development were observed. This suggests that the observed relationships between sustainable initiatives and green economy development remain robust even when considering demographic and professional characteristics.

In Figure 2, a heightened perception of green economic development among government employees is evident, attributed to the interactive impact of the adoption of sustainable practices and corporate social responsibility. Significantly, lines corresponding to higher CSR values demonstrate a more pronounced upward trend, indicating a stronger positive influence on projected green economic development compared to lines associated with lower CSR values. The visual representation underscores the amplifying effect of CSR in conjunction with sustainable practice adoption, emphasizing its role in fostering positive perceptions of sustainable economic initiatives among government personnel.
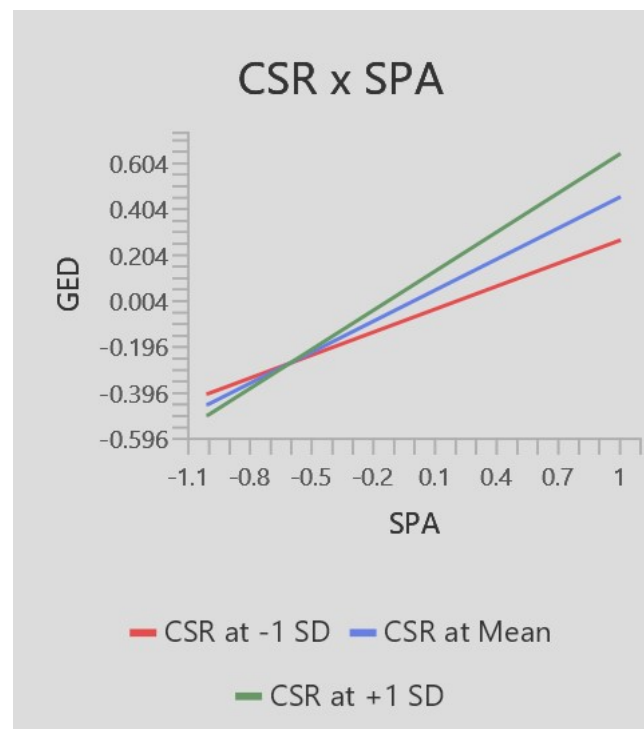

Figure 2. Simple slope analysis of the two-way interaction effect CSR $\times$ SPA on GED.

6. Discussion

The direct relationships examined in this study shed light on the significant impact of various sustainability factors on green economic development within the government sector. Results revealed the positive influence of sustainable tech innovation on GED, aligning with the past literature emphasizing the pivotal role of technological innovation in driving environmental sustainability (Omri 2020). Similarly, the results showed the positive effect of investment in sustainable infrastructure on GED, which is consistent with research highlighting the importance of eco-friendly infrastructure for fostering sustainable economic growth (Du et al. 2022). Furthermore, the positive relationship between natural resource management and GED supports the notion that effective resource conservation contributes to broader economic sustainability (Liu et al. 2020; Renwick et al. 2016). The

direct association between sustainable practice adoption and GED underscores the practical significance of integrating sustainable measures into organizational operations. The findings collectively affirm the critical role of these direct relationships in shaping perceptions and actions toward green economic development within the government sector.

The relationship between sustainable tech innovation and the adoption of sustainable practices signifies the pivotal role of technological advancements in driving the adoption of sustainable practices within government operations. In our study, the positive relationship suggests that the likelihood of adopting environmentally conscious practices increases as government entities embrace and integrate innovative sustainable technologies. This finding aligns with the prior literature emphasizing the transformative influence of technological innovation on sustainability practices (Al-Rahmi et al. 2020). Organizations at the forefront of technological innovation are well-positioned to lead in the adoption of sustainable practices, contributing to a more environmentally conscious approach to governance. Moreover, in our study, the positive relationship suggests that as governments invest in sustainable infrastructure projects, there is a corresponding increase in the adoption of sustainable practices. This resonates with research emphasizing the link between financial commitment to sustainability initiatives and the actual adoption of eco-friendly practices within organizations (Sánchez-Silva and Calderón-Guevara 2022). The findings imply that financial investments in sustainable infrastructure act as catalysts for broader organizational shifts toward sustainability. Additionally, the relationship between natural resource management and sustainable practice adoption underscores the significance of effective resource stewardship in influencing the adoption of sustainable practices. NRM involves responsible and efficient use of natural resources, minimizing waste and environmental impact (Makhloufi et al. 2022). The positive association in our study indicates that as governments prioritize and effectively manage natural resources, there is a subsequent increase in the adoption of sustainable practices. This aligns with the principles of sustainable development, emphasizing the importance of responsible resource use in achieving long-term environmental and economic goals.

Moving to the indirect relationships, the mediating role of SPA in the links between STI, ISI, NRM, and GED adds depth to our understanding. By influencing SPA, sustainable tech innovation indirectly contributes to GED, suggesting that the positive effects of innovation are, in part, realized through adopting sustainable practices. This resonates with studies highlighting the transformative potential of innovation in fostering sustainability (Hayat et al. 2020). Similarly, the indirect impact of ISI and NRM on GED through SPA emphasizes the importance of sustainable practices as a mechanism through which investment in infrastructure and effective resource management translates into broader economic sustainability. The examination of the interaction effect between corporate social responsibility (CSR) and SPA provides nuanced insights. The positive interaction effect implies that the impact on GED is amplified when CSR initiatives are coupled with the widespread adoption of sustainable practices. This finding aligns with literature emphasizing the complementary nature of CSR and sustainability practices in driving positive environmental and social outcomes (Guo et al. 2021). The study contributes by highlighting the synergistic potential of combining CSR efforts with the adoption of sustainable practices to foster green economic development within the government sector.

6.1. Theoretical Implications

The positive and significant results for sustainable tech innovation and investment in sustainable infrastructure directly influencing green economy development affirm the pivotal role of innovation in fostering sustainable economic outcomes. This supports and extends the innovation diffusion theory, suggesting that government sectors embracing innovative sustainable technologies and investing in eco-friendly infrastructure are more likely to contribute to the development of a green economy. The study provides empirical evidence that innovation serves as a catalyst for broader economic sustainability. The findings of this study underscore the pivotal role of innovation in fostering overall eco-

nomic sustainability. Specifically, the observed positive impact of investment in sustainable infrastructure on the adoption of eco-friendly practices is consistent with the tenets of the Resource-Based View (RBV). This perspective highlights the strategic significance of financial investments in sustainable initiatives, which serve as valuable resources facilitating the adoption of environmentally conscious practices. This extends the RBV into the domain of sustainability, highlighting that organizations strategically allocating financial resources to sustainable infrastructure projects enhance their capability to adopt and integrate sustainable practices. The positive relationship between natural resource management and the adoption of sustainable practices (spa) underscores the importance of responsible resource stewardship in influencing the adoption of sustainable practices. This finding aligns with ecological modernization theories, emphasizing the harmonization of economic activities with ecological sustainability. Effective natural resource management is identified as a valuable resource that influences the integration of eco-friendly practices within the government sector. The partial mediation effects observed in the indirect paths (H4a, H4b, H4c) suggest that while sustainable practice adoption partially mediates the relationship between sustainable tech innovation, investment in sustainable infrastructure, natural resource management, and green economy development, there are additional factors contributing to the overall impact. This nuanced understanding adds depth to existing theoretical frameworks, emphasizing that the pathway from sustainable initiatives to economic development is multifaceted and involves complex interactions. The significant interaction effect of CSR $\times$ SPA highlights the moderating role of CSR in influencing the relationship between sustainable practice adoption and green economy development. This supports the notion that when CSR initiatives are coupled with widespread adoption of sustainable practices, there is an amplified positive impact on economic development. This finding extends theoretical perspectives on the synergistic effects of CSR and sustainability practices, emphasizing their collective influence on economic outcomes.

6.2. Practical Implications

The practical implications derived from the study's results offer actionable insights for policymakers, organizational leaders, and practitioners aiming to enhance sustainability within the government sector. Government entities should strategically invest in innovative, sustainable technologies and eco-friendly infrastructure projects. This not only aligns with environmental goals but also positions organizations for long-term economic sustainability. Policymakers can design incentive structures to encourage such investments, fostering a culture of innovation and sustainability within the public sector. The positive link between natural resource management and Sustainable Practice Adoption underscores the importance of responsible resource stewardship. Practical implications suggest that governments should prioritize effective NRM practices. This includes efficient use of natural resources, waste reduction strategies, and environmentally responsible policies. Implementing NRM practices enhances the likelihood of integrating sustainable practices into routine operations. The partial mediation effects indicate that while adopting sustainable practices plays a crucial role, additional factors influence the relationship between sustainable initiatives and economic development. Organizations are encouraged to embrace comprehensive sustainability strategies that integrate technological innovation, substantial investments in infrastructure, and conscientious management of resources across their operations. This holistic approach is essential for fostering long-term environmental stewardship, resilience, and competitive advantage in today's dynamic business landscape.

This involves a comprehensive approach that addresses the multifaceted nature of sustainability within the government sector. The interaction effect between CSR and the adoption of sustainable practices highlights the potential for amplified positive impacts on economic development when CSR initiatives are coupled with the widespread adoption of sustainable practices. Practitioners and leaders should recognize the synergies between CSR and sustainability and strive to integrate these initiatives cohesively. This involves aligning CSR efforts with the organization's sustainability goals, reinforcing a positive

impact on economic outcomes. Given the dynamic nature of sustainability initiatives and their influence on economic development, organizations should continuously monitor and adapt. Regular assessments of the effectiveness of sustainable initiatives, resource management practices, and the integration of CSR can inform adaptive strategies. Policymakers and leaders should remain agile in responding to changing environmental and economic conditions.

6.3. Limitations

While the study contributes valuable insights to the understanding of sustainability dynamics within the government sector, several limitations should be considered. The study focused on a specific geographic context (e.g., Kazakhstan), and the findings may not be fully generalizable to other regions with different socio-economic, cultural, and political contexts. Future research should explore diverse settings to enhance the external validity of the results. The reliance on self-reported data introduces the potential for common method bias and subjectivity. Future research could incorporate objective measures or triangulate findings with alternative data sources to enhance the reliability of the results. While the study considered relevant demographic variables as control factors, other unexplored variables may influence the relationships examined. Future research should explore additional factors that may contribute to or moderate the observed relationships. The study identified partial mediation effects and an interaction effect, suggesting the presence of nuanced relationships. However, the specific mechanisms driving these effects were not profoundly explored. Future research should delve into the intricacies of these mediation and moderation processes to provide a more comprehensive understanding. The study primarily utilized quantitative methods. Future research could adopt a mixed-methods approach to provide a more holistic understanding of sustainability initiatives within the government sector, incorporating qualitative insights and stakeholders' perspectives. Investigating external factors and contingencies that may influence the observed relationships, such as regulatory environments, public opinion, and global economic trends, would provide a more comprehensive understanding of the contextual influences on sustainability initiatives.

7. Conclusions

This study contributes to advancing our understanding of sustainability dynamics within the government sector and offers valuable insights for theory, practice, and policy. Sustainability has emerged as a critical imperative for governments worldwide, necessitating a deeper understanding of its implications for economic development. The existing literature acknowledges the importance of sustainable practices in driving economic growth, yet there remains a notable gap in comprehensive studies integrating diverse sustainability initiatives within governmental settings. This study aims to fill this void by examining the impact of sustainability factors on green economic development (GED) within the government sector. A quantitative research approach was adopted to explore the intricacies of sustainability factors' impact on GED within the government sector. The study employed a cluster sampling technique to ensure a diverse and representative selection of participants from various departments across different government sectors. Structural Equation Modeling (SEM) was utilized to analyze the relationships between sustainable tech innovation, investment in sustainable infrastructure, natural resource management, sustainable practice adoption, and GED. Bootstrapping was employed to assess the reliability and significance of estimated parameters. The findings of this study illuminate the significant impact of various sustainability factors on GED within the government sector. The positive influence of sustainable tech innovation, investment in sustainable infrastructure, and natural resource management on GED underscores the importance of integrating sustainability measures into governmental operations. Furthermore, the mediating role of sustainable practice adoption highlights the pathways through which these factors contribute to economic sustainability. Hence, this research provides a foundation for informed decision making and strategic interventions to promote environmental stewardship and resilience within

governmental operations. Despite limitations, this study contributes to advancing our understanding of sustainability and green economic development, paving the way for sustainable governance practices and long-term economic prosperity.

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