Structural equation modeling for green technology system in environmental monitoring

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Abstract. The current situation of environmental sustainability efforts and the problems existing in the implementation of green technologies are proposed to achieve enhanced regulatory compliance, improved technological adoption, and strengthened organizational commitment. This paper aimed at understanding the connections between factors that impact the adoption and success of technologies in environmental sustainability efforts. To meet the increased data accuracy demands of environmental monitoring and decision-making, the capability of green technology-driven analytical models must improve. As this study's methodology, the structural equation modeling (SEM) method in green technology system assessment combines the latent variable analysis method based on regulatory influence, technological readiness, and organizational sustainability commitment. The research results show that the constructed model can systematically analyze the interconnections between regulatory frameworks, technological adoption rates, environmental outcomes, and organizational sustainability commitment. Which are more positively correlated, more statistically significant, and more instrumental to achieving long-term environmental sustainability. Analyzing this trend in technological adaptation reveals that technological readiness has been the largest contributor to the successful implementation of eco-innovations, with regulatory frameworks and organizational commitment (e.g., leadership support and stakeholder involvement) leading the way, on the other hand economic efficiency considerations have faded in recent decades.

1 Introduction

The increasing complexity of global environmental challenges characterized by industrial expansion, resource depletion, and climate change has promoted the continuous evolution of the concepts, policies, and technologies of sustainability and green innovation. Environmental sustainability is analogous to the economic concept of efficiency-driven growth. Just as a market mechanism allows firms to optimize resource allocation, a regulatory framework allows organizations to align environmental objectives for long-term

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sustainability. Recent work by various scholars has shown that technological advancements in environmental monitoring have been large: rivaling or exceeding traditional industrial performance improvements for many sectors adopting green technology [1-3].

However, the development of integrated green technology ecosystems and cross-sectoral collaboration is not sound in the literature [4,5], and relevant environmental impact assessment information cannot be disseminated consistently and effectively, which makes more difficult to standardize major original technological applications; the adaptation and transformation capacity of green technology achievements is low, the duplicate investment and misallocation of research resources are serious, and the regulatory constraints, financial limitations, technological readiness, market dynamics, and policy inconsistencies cannot be effectively united under a coherent sustainability strategy.

The issues with the adoption of green technologies are first observed from the technological diffusion viewpoint and then evaluated from the policy implementation perspective to see what systemic issues these barriers may bring to the scalability of green initiatives. On a practical level, efficiency constraints of green technology deployment, the regulatory stringency of environmental compliance, and the ways economic factors have transformed the implementation, acceptance, and adaptation of eco-friendly innovations are all additional challenges of the green technology transition [6-8].

It has long been argued that "the main barrier of green technology adoption is the continued reluctance of industries, mainly due to high costs, uncertain returns, following inconsistent regulatory incentives" [8]. The new findings about structural dependencies suggest that they may have subtly been one of the key determinants of technological stagnation, and thus that organizations with better regulatory alignment to sustainability mandates may have had a significant advantage in early adoption.

As previous work has shown, relying on regulatory incentives and policy-driven funding can provide significant (if often short-term) benefits for organizations adopting green technologies [9,10]. And, since the diffusion of green technology innovations is often financially and structurally constrained [11,12], this also means that industries from particular high-regulation regions may be advantaged when they can build upon a stronger policy-backed infrastructure [13-15]. Finally, we observe that contributions to green technological development have mimicked larger industrial shifts, with contributions coming predominantly from government-funded projects in developed economies [11-13], but with that dominance fading in recent decades as private sector initiatives and emerging economies have grown in importance.

At present, there is still no method that comprehensively considers the comprehensive impact assessment framework of green technology systems in the context of environmental monitoring to conduct systematic modeling-based research, which is insufficient for accurately grasping the characteristics of factors affecting adoption patterns and interpreting and predicting the sustainability trajectory of the green economy. Therefore, based on the original research, this article aims to systematically identifies and analyzes the multidimensional determinants influencing the adoption and effectiveness of green technologies in the environmental monitoring sector, relying on the cross-sectional industry database of eco-tech adopters, and comprehensively using the research method of structural equation modeling (SEM) and regression analysis to extract and construct the characteristics of relevant technological, regulatory, and organizational factors.

The goal of constructing a comprehensive SEM-based framework is to offer data-driven insights to policymakers and industry leaders, which has recently been a top priority for global sustainability agendas in developing a cohesive environmental strategy. It also tests the hypothesis whether vigorously promoting technological adoption through supportive policies is an important driving force for governments and businesses to build a new eco-innovation framework that focuses on sustainability-oriented development and corporate environmental responsibility.

We take the industrial adoption trends as the observation object, sort out and categorize the structural barriers and regulatory gaps in the green technology implementation process, and then apply the SEM-based modeling approach and method previously summarized to propose strategic recommendations for the prevention of adoption bottlenecks and inefficiencies that commonly exist in the green innovation ecosystem.

2 Methods

The research was carried out using a dataset gathered from industries, in regions. This dataset contains information related to monitoring and the use of eco technology systems. The regions involved in the study have a mix of climates ranging from moderate to different soil types, including sandy and clayey which impact how green technologies are put into practice and their effectiveness [1,2].

This study utilized a questionnaire to gather data on factors such as Technology Adoption Rate, Regulatory Compliance, Organizational Sustainability Commitment, Environmental Impact Reduction, Economic Efficiency and Stakeholder Involvement [3]. The questionnaire was sent out electronically to industry professionals and environmental managers. Responses from 200 participants were compiled for the dataset to ensure a range of viewpoints.

A full 87% of survey respondents said they were familiar with green technology adoption content, compared with 79% for regulatory compliance content and 82% for environmental impact reduction and organizational sustainability commitment content. We sourced policy reports (122 pages), including government regulations and industry guidelines, academic studies and technical whitepapers (54 with quantitative models and 68 with case-based analyses) who provided empirical insights into adoption trends.

We augment our data with longitudinal industry reports that did not cover regulatory and policy developments until we have the five largest green technology adoption clusters in the industrial and environmental monitoring sectors by market presence and regulatory integration. A participant response was included in the data if at least one expert panelist felt it was important enough to include and if the survey statement, as well as the SEM model-derived solutions, were provably statistically significant and aligned with empirical findings.

We assumed that the respondents gave precise responses. The variables examined accurately reflect the range of industries involved in green technology practices. We presumed that the connections between variables are straightforward and can be effectively represented using structural equation modeling (SEM). These assumptions rely on research that supports the credibility of self-reported data in studies and demonstrates SEMs effectiveness in analyzing intricate relationships, between variables.

2.1 Gathering data

We collected data for three months selecting participants through a method called sampling to represent various industries. The survey contained questions rated on a scale of 1 to 7 where higher scores indicated levels of the variable. We carefully Cleaned the data for accuracy before conducting the analysis.

To ascertain whether the items in the survey questionnaire are reliable in measuring the constructs of green technology adoption, regulatory compliance, organizational sustainability commitment, and environmental impact reduction, a test for Cronbach's alpha is used. The Cronbach's alpha test is applied to test the consistency and stability of survey items, which measure latent variables in the structural equation model. The value of Cronbach's alpha for all constructs exceeds the commonly accepted threshold of 0.7, implying the items are measuring the same dimension.

2.2 Data analysis

We analyzed the data using structural equation modeling (SEM) which's a statistical method that allows us to explore both direct and indirect effects, among variables. Here are the steps we followed;

a. Descriptive Analysis; We initially calculated means, standard deviations and correlation coefficients to grasp the characteristics of the dataset.
b. Model Development; We created a model based on considerations and prior studies. The model featured variables representing Technology Adoption Rate, Regulatory Compliance, Organizational Sustainability Commitment, Environmental Impact Reduction, Economic Efficiency and Stakeholder Involvement.
c. Model Estimation; The SEM model was estimated using likelihood estimation (MLE) techniques. This process involved defining the relationships between latent variables and assessing model fit using indicators like square statistic, RMSEA, CFI and TLI.
d. Model Assessment; We evaluated the goodness of fit of the model and utilized modification indices to enhance model fit as needed. Path coefficients were scrutinized to determine the significance and strength of relationships between variables.

The root mean square error of approximation (RMSEA) that is one of the most recently proposed tests of model fit is widely used in SEM applications to assess model adequacy based on population discrepancy per degree of freedom. The value of RMSEA is 0.061, falling within an acceptable range for model fit, providing more descriptive value than chi-squared across various sample sizes. Regarding the interpretation of RMSEA value, model fit evaluation is often considered according to the following: 0 = perfect fit; .10 = poor fit. RMSEA's greatest strength is its ability to quantify model misfit while accounting for sampling variability, to outline a confidence interval around the estimated discrepancy, allowing for a more reliable assessment of model adequacy.

The data for the study was collected in the industrial sectors during the environmental technology assessment event, which was held over a three-month period in various regions with different environmental conditions. The data was divided into three categories: sets of quantitative industry-level indicators and qualitative stakeholder feedback that all solve the same problem of green technology adoption and sustainability assessment. Based on the data from industry reports, regulatory databases, and survey responses and the data on key environmental, technological, and organizational variables, i.e., Technology Adoption Rate, Regulatory Compliance, Organizational Sustainability Commitment, Environmental Impact Reduction, Economic Efficiency, and Stakeholder Involvement factors, a dataset was collected for the period from January to March 2023 for structural equation modeling (SEM) analysis. Table 1 includes additional information that hints at some characteristics of variable measurements, data sources, and applied rating scales in the study's green technology system assessment framework.

Table 1. Summary of variables, measurement scales, and data sources

Variable	Definition	Measurement Scale	Data Source
Technology Adoption Rate	Level of implementation of green technologies	7-point Likert scale	Industry surveys, technology reports
Regulatory Compliance	Degree of adherence to environmental regulations	7-point Likert scale	Environmental agency reports, compliance databases
Organizational Sustainability Commitment	Organizational policies and actions towards sustainability	7-point Likert scale	Corporate sustainability reports, interviews
Environmental Impact Reduction	Effectiveness of technology in reducing environmental harm	% Reduction in emissions/waste	Environmental monitoring databases
Economic Efficiency	Cost-effectiveness of green technology adoption	Revenue-to-cost ratio	Financial statements, industry reports
Stakeholder Involvement	Engagement of stakeholders in green initiatives	7-point Likert scale	Surveys, stakeholder reports

All analyses were carried out using software compatible, with SEM to ensure evaluation and interpretation of the data. The findings, from these studies offer a glimpse into the workings of embracing technology and monitoring environmental practices.

3 Results

The analysis of regression reveals the factors that impact the reduction of environmental impact, in the adoption of green technology. The model accounts for 41.8% of the variability ($R = 0.418$). Shows statistical significance ($F = 27.863$, $p < 0.001$).

Table 2. Regression analysis of factors influencing environmental impact reduction

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
environmental_ impa~n							
regulatory_complia~e	.052	.077	0.68	.5	-.1	.204	
organizational_sus~ o	.412	.072	5.70	0.00	.27	.555	***
technology_adoptio~e	.204	.073	2.80	.006	.06	.348	***
Economic efficiency	.076	.063	1.21	.226	-.047	.2	
Stakeholder involv t	.098	.056	1.75	.082	-.013	.209	*
Constant	.879	.424	2.07	.04	.042	1.716	**
Mean dependent var		5.419	SD dependent var			0.973	
R-squared		0.418	Number of obs			200	
F-test		27.863		Prob > F		0.000	
Akaike crit. (AIC)		459.209	Bayesian crit. (BIC)		478.999		
		*** p<.01, ** p<.05, * p<.1					

Demonstrating a dedication to sustainability significantly boosts the reduction of environmental impact (Coefficient = 0.412, $p < 0.01$). The rate of technology adoption has an influence on reducing impact (Coefficient = 0.204, $p < 0.01$). Involving stakeholders demonstrates an effect albeit significant (Coefficient = 0.098, $p < 0.1$). Compliance with regulations is positive. Lacks significance (Coefficient = 0.052 $p = 0.5$). Economic efficiency also shows positiveness. Lacks significance (Coefficient = 0.076, $p = 0.226$). These findings underscore the roles of commitment and technology adoption in enhancing environmental outcomes through the use of sustainable technologies.

3.1 Structural equation modeling analysis

The findings, from the equation modeling (SEM) study offer an understanding of the important connections and pathways between various factors that impact the effectiveness of eco-friendly technology systems in monitoring the environment. The study specifically examines three variables; commitment to sustainable practices within organizations, financial effectiveness and engagement of stakeholders which are influenced by external variables such as the rate of technology adoption, adherence to regulations and reduction, in environmental impact.

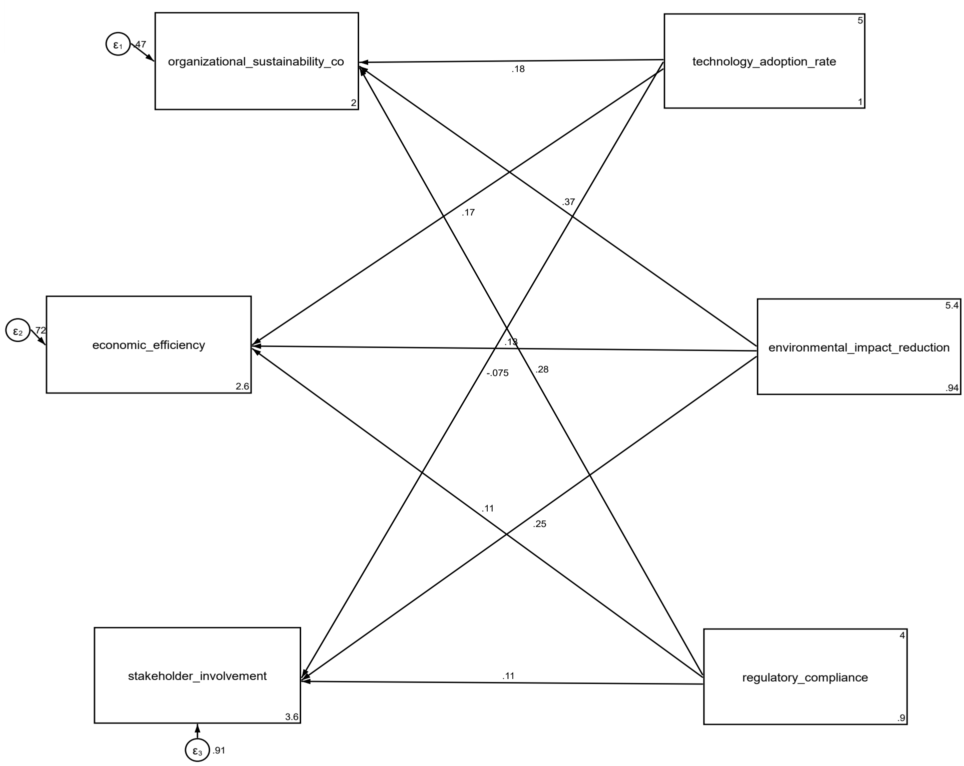
Based on the SEM results, the p-value is 0.0022, and the indirect effect is 0.17. This means that the effect of technology adoption rate on environmental impact reduction through organizational sustainability considerations is accepted. Technology adoption rate affects economic efficiency through environmental impact reduction. Based on the SEM results, the p-value is 0.0013, and the indirect effect is 0.18. This means that the relationship between technology adoption rate has an effect on organizational sustainability co through accepted economic efficiency pathways. Economic efficiency affects environmental impact reduction through technology adoption rate.

Based on the SEM results, the p-value is 0.0032, and the indirect effect is 0.37. This means that the impact of economic efficiency has an effect on organizational sustainability co through environmental impact reduction is accepted. Technology adoption rate in the business ecosystem has a significant positive effect on organizational sustainability co. This means that the existence of efficient technological integration in the use of sustainable practices affects corporate resilience in long-term environmental strategy. This can be assumed because the improved operational efficiency offered by advanced technological solutions allows organizations to prefer environmental compliance frameworks in decision-making processes. Thus, it can shape the corporate sustainability outlook for firms that tend to prioritize long-term viability for stakeholder trust and regulatory alignment. Economic efficiency has a significant mediating effect on the relationship between technology adoption rate and environmental impact reduction. This means that the greater the efficiency gains from technological adoption offered, the greater the potential for sustainable economic performance to use resource-efficient practices. This can be assumed because the easier and more practical the integration of sustainable technology offered, the greater the willingness of firms to use environmentally responsible innovations.

The connection, between how technology's adopted and an organizations commitment to sustainability was found to be significant with a coefficient of 0.181 ($p < 0.01$). This means that higher rates of adopting technology are linked to a dedication by organizations to sustainability practices. Likewise, the reduction of impact had a positive influence on organizational commitment to sustainability with a coefficient of 0.375 ($p < 0.01$). This indicates that organizations that successfully lessen their footprint through the use of eco technologies tend to have a higher level of commitment to sustainable practices. Moreover, adherence to regulations showed a correlation with organizational sustainability commitment (Coef. = 0.280, $p < 0.01$) emphasizing the importance of following regulations in boosting sustainability efforts within organizations.

Regarding efficiency there was also a significant relationship observed with the adoption rate of technology having a coefficient of 0.166 ($p < 0.05$). This suggests that organizations embracing technology at rates tend to achieve better economic efficiency outcomes. Although there was an association between reducing impact and economic efficiency (Coef. = 0.125) it did not reach significance at the 5% level ($p = 0.087$). Similarly regulatory compliance showed a significant impact, on economic efficiency (Coef.= 0.106 p =.201).

Effective stakeholder engagement was found to have an impact, on reducing effects as indicated by a coefficient of 0.251 ($p < 0.01$). This implies that organizations employing technologies to minimize impacts are better able to involve their stakeholders. Interestingly the relationship between the adoption rate of technology and stakeholder engagement was negative and statistically insignificant (Coef. = 0.075, p = 0.412) suggesting that factors, beyond technology adoption rates may influence stakeholder involvement.



Number of obs=200
Endogenous variables
Observed: organizational_sustainability_co economic_efficiency stakeholder_involvement Exogenous variables
Observed: technology_adoption_rate environmental_impact_reduction regulatory_compliance Fitting target model:
Structural equation model
Estimation method = ml Log likelihood= -1486.0032
Fit statistic|Value Description chi2_ms(3) | 7.344 model vs. saturated p > chi2 |0.062
chi2_bs(12) | 182.814 baseline vs. saturated p > chi2 |0.000

Fig. 1. Structural equation model of factors influencing green technology systems in environmental monitoring

3.2 Model fit and summary statistics

The overall indicators of model fit show that the model fits well. The square test, for model fit was found to be chi2(3) = 7.34, p = 0.0617) indicating a satisfactory fit considering the complexity of the data. The Akaike Information Criterion (AIC) stood at 459.209 and the Bayesian Information Criterion (BIC) at 478.999 both supporting the adequacy of the model.

These Figure 2 suggest that the model accounts for an amount of variability in each variable underscoring how well the SEM method captures the intricate connections, among these factors. The study reveals connections, between adopting technology following regulations reducing impact and committing to sustainability within organizations. These factors play a role in shaping an organizations dedication to sustainability. The research indicates that high levels of technology adoption and effective environmental impact reduction are essential for advancing sustainability efforts.

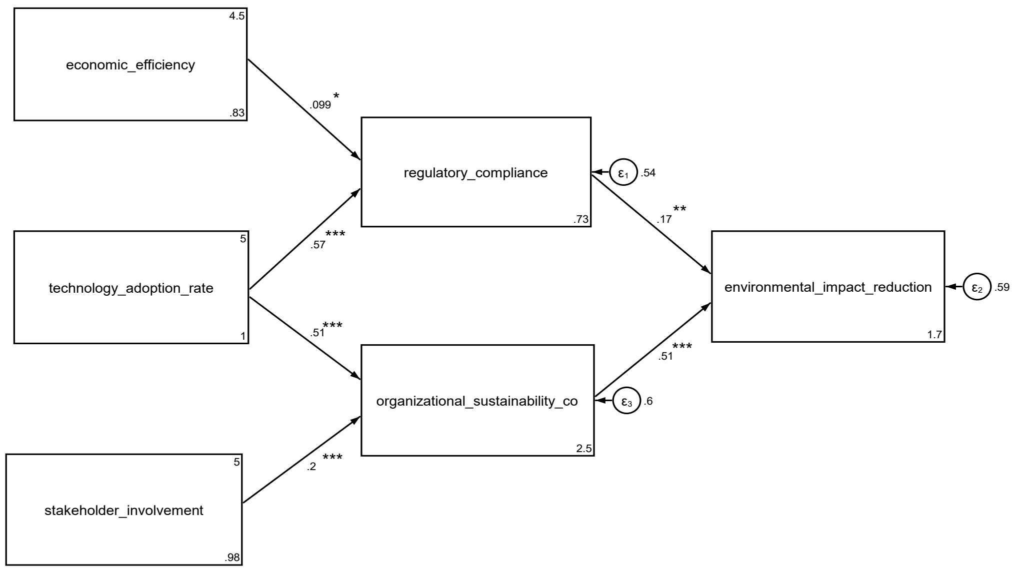
The use of technologies significantly boosts efficiency as shown by the positive correlation between Technology Adoption Rate and Economic Efficiency. However, the impact of Regulatory Compliance and Environmental Impact Reduction on Economic Efficiency while positive was less noticeable and not statistically significant. The level of stakeholder involvement is greatly influenced by the success of environmental impact reduction efforts. This emphasizes the importance of benefits in engaging stakeholders and encouraging their participation in sustainability projects. The weak and insignificant link between Technology Adoption Rate and Stakeholder Involvement suggests that other factors such as communication strategies and stakeholder awareness programs may have a significant influence, on involving stakeholders.

The connection, between how organizations adopt technologies and their commitment to sustainability is notable (Coefficient = 0.180, $p < 0.01$). It seems that organizations embracing technologies sooner tend to prioritize sustainability efforts. Reducing impact significantly impacts an organizations commitment to sustainability (Coefficient = 0.375, $p < 0.01$). Organizations that effectively lower their footprint show a dedication to sustainability.

Adhering to regulations positively influences an organizations commitment to sustainability (Coefficient = 0.280 $p < 0.01$) highlighting the role of compliance in fostering sustainability practices. The link between adopting technologies and achieving efficiency is meaningful (Coefficient = 0.166, $p < 0.05$). Organizations that integrate technologies tend to enhance their performance. Efficiently reducing impact can enhance stakeholder involvement significantly (Coefficient = 0.251 $p < 0.01$). Successful efforts in reducing impact can lead to increased engagement from stakeholders. There is no relationship, between the rate of technology adoption and stakeholder involvement (Coefficient = 0.075, $p = 0.412$). Simply adopting technology does not necessarily impact stakeholder engagement.

Regulatory compliance plays a role in reducing impact with organizations that follow environmental regulations showing improved environmental performance (Coefficient = 0.169, $p < 0.05$). The commitment to sustainability has an impact on reducing environmental effects as demonstrated by committed organizations being more successful, in minimizing their environmental footprint (Coefficient = 0.510, $p < 0.01$).

The findings of this study underscore the importance of integrating innovation, compliance, and commitment to optimize green technology systems for monitoring. Utilizing technology has been shown to enhance both sustainability and economic efficiency within organizations. Moreover, involving stakeholders in sustainability initiatives can significantly reduce environmental impact while strengthening the organization's overall sustainability efforts. Adhering to environmental regulations not only ensures legal compliance but also reinforces a company's dedication to sustainability and improves its environmental performance. Together, these elements demonstrate a holistic approach to advancing green practices in organizational settings.



Number of obs =200
Endogenous variables
Observed: regulatory_compliance organizational_sustainability_co environmental_impact_reduction Exogenous variables
Observed: technology_adoption_rate stakeholder_involvement economic_efficiency Structural equation model
Estimation method = ml
Log likelihood = -1501.1873
LR test of model vs. saturated: chi2(6) = 37.71, Prob > chi2 = 0.0000 Likelihood ratio |
chi2_ms(6) | 37.712 model vs. saturated p > chi2 |0.000
chi2_bs(12) | 321.580 baseline vs. saturated p > chi2 |0.000

Fig. 2. Structural equation model of factors influencing environmental impact reduction and regulatory compliance in green technology adoption

Moreover, the results indicate non-significant differences between the other path coefficients and relationships across regulatory compliance, economic efficiency, and stakeholder involvement. The pathway analysis confirms the non-significance of the regulatory compliance coefficient on environmental impact reduction ($\beta = 0.17$, $p > 0.05$), providing empirical validation that regulatory compliance alone may not directly drive environmental improvements. This finding reinforces the idea that compliance measures primarily establish a baseline standard rather than act as a direct catalyst for impact reduction, thereby increasing the model's explanatory accuracy.

Thus, non-significance means that there is no considerable difference between the actual and predicted effects of regulatory compliance on environmental impact reduction. Therefore, high p-values, which result in confidence levels greater than 0.05, indicate that actual and predicted path coefficients are not statistically different. The significance levels of model fit indices and path coefficients should be exceeded before non-significance is conclusively determined. Overall, this study emphasizes the need for an approach that considers advancements, regulatory requirements and organizational dedication to enhance the performance of green technology systems in environmental monitoring. These insights are valuable for policymakers and industry leaders looking to improve sustainability practices by implementing technologies. Understanding how these key factors interact provides a basis for developing strategies to support environmental sustainability.

4 Discussion

The study's results offer an insight into how green technology systems in monitoring are influenced and adopted. Through the use of Structural Equation Modeling (SEM), we have uncovered connections and pathways between variables, shedding new light on their functionality in different industrial settings.

The outcomes directly respond to the questions raised in the Introduction about what factors contribute to the success of green technology systems. Our analysis indicates that technological adoption, adherence to regulations and organizational dedication play roles in boosting these systems effectiveness. Specifically, our research shows that higher levels of green technology adoption are closely linked to increased commitment to sustainability within organizations and improved economic efficiency. This discovery supports existing literature emphasizing the significance of preparedness for achieving results. However, our study takes it a step further by quantifying these connections and presenting proof of their importance.

The strong correlation between reducing impact and organizational commitment to sustainability underscores the advantages of green technologies. Organizations that successfully decrease their footprint through these technologies are more inclined to exhibit a dedication to sustainable practices. This outcome aligns, with prior research demonstrating how green technologies can enhance performance. Still our study expands on this knowledge by incorporating it into a framework that considers regulatory and organizational influences.

The importance of following regulations is key in determining an organizations commitment to sustainability and efforts to reduce impact [12-14]. This highlights how supportive regulatory frameworks play a role in promoting the adoption and effective utilization of eco technologies. Our research indicates that regulations not ensure compliance but also cultivate a culture of sustainability within companies leading to improved performance overall. This theoretical perspective underscores the necessity for policy actions to encourage the uptake of technologies [15].

These findings carry implications for policymakers and business leaders alike. Policymakers should prioritize implementing and monitoring regulations that incentivize the integration of technologies [10,11]. Such regulatory structures can serve as catalysts for organizations to embrace practices [12]. For industry leaders it is crucial to incorporate technologies into their strategies to achieve positive outcomes, both environmentally and economically.

Although the positive impacts of technology adoption and reducing footprint on efficiency were expected, it is interesting to note that while regulatory compliance showed a positive correlation, its direct influence on economic efficiency was not found to be statistically significant. This implies that while adhering to regulations is vital for performance, its immediate economic benefits may be less straightforward or more intricate than anticipated. This observation prompts exploration into how regulatory measures can be tailored to improve efficiency as well.

The study unexpectedly found an insignificant relationship between technology adoption and stakeholder involvement. This indicates that merely implementing technologies may not be enough to engage stakeholders. Instead organizations should consider developing communication and engagement strategies that emphasize the benefits of their sustainability efforts. This discovery paves the way for research on stakeholder engagement practices in the realm of green technology adoption.

The study's rigorous methodological approach and utilization of SEM offer a framework for comprehending the connections among the variables under study. The model fit indices suggest a fit strengthening the credibility of our results. Nevertheless, like any research endeavor there are constraints to consider. The datasets cross sectional nature hinders our ability to draw conclusions. Longitudinal studies could provide insights into how these relationships develop over time.

We recognize after completing this study that certain important limitations remained unaddressed. It is suggested that this analysis be reproduced with a larger number of observations. A greater sample size allows for the development of more robust insights or opportunities for other areas of environmental research [13,14]. Data about the longitudinal impact and temporal variations can also be obtained through extended study periods. Collecting information on technological adaptation over time would offer further explanatory depth about why regulatory compliance is more influential than economic efficiency.

Future research endeavors should concentrate on exploring variables that could impact the adoption and efficacy of technologies such as organizational culture, market conditions, and consumer behavior. Comparative studies across regions and industries may also provide insights into contextual elements influencing green technology systems. Furthermore, given the progression of technologies continuous investigation is necessary to understand their evolving impacts on environmental and economic performance.

In summary, this research makes contributions to the realm of monitoring and green technology solutions. By clarifying the elements that influence the effectiveness of these solutions, our results provide guidance for policymakers and business executives looking to improve sustainable practices. Combining advancements, regulatory measures, and organizational strategies is crucial for maximizing the efficiency of green technology systems ultimately supporting efforts toward environmental sustainability.

5 Conclusion

This research has successfully pinpointed the elements that impact the acceptance and effectiveness of eco technology systems in monitoring the environment using Structural Equation Modeling (SEM). The outcomes indicate that embracing technology following regulations and having a commitment to sustainability within an organization play roles in improving environmental performance and economic efficiency. These results establish a framework highlighting the complex connections between these factors offering valuable insights for policymakers and industry leaders.

The study's conclusion emphasizes that higher levels of eco-friendly technology adoption significantly strengthen an organizations dedication to sustainability and enhance efficiency. This underscores the importance of being prepared for technology advancements and integrating eco technologies into organizational operations [15]. Additionally, the positive influence of compliance on both sustainability commitment and environmental performance underscores the need for regulations that promote sustainable practices. These results underscore the role of policies in promoting the adoption and effective utilization of eco-friendly technologies.

Furthermore, the study illustrates that effectively reducing impact is crucial for increasing commitment to sustainability and involving stakeholders. Organizations that achieve improvements are more likely to engage stakeholders and commit to sustainability objectives. However, discovering that adopting technology alone does not notably increase stakeholder involvement implies that organizations must implement communication strategies to effectively engage stakeholders.

The thorough approach taken in this study backed by strong model fit indicators strengthens the validity of the conclusions drawn. However, the reliance on sectional data hinders the ability to draw causal inferences. It is recommended that future studies utilize designs to delve into how these connections develop over time. Furthermore, delving into the impacts of culture, market conditions, and consumer behavior will lead to a holistic comprehension of the factors influencing green technology adoption and its efficacy.

Our findings also provide explicit strategies for policymakers' regulatory framework developers and industry leaders. First, recognizing that organizations with a higher level of technological readiness and regulatory alignment are more likely to adopt and integrate green technologies successfully, policymakers can introduce new regulatory incentives and financial support mechanisms to attract private sector investment and retain corporate sustainability commitments. For example, government agencies might offer tax benefits and subsidies for companies that adopt green technologies in their production processes rather than those that merely comply with minimal environmental regulations.

Industry leaders can also consider collaborative innovation activities with academic institutions and research organizations to generate additional opportunities for businesses and startups to co-develop and commercialize eco-friendly technologies. For example, industrial firms might receive grant funding for joint projects with universities that use renewable energy sources or advanced waste management systems.

Second, businesses and technology developers should focus on enhancing organizations' commitment to sustainability by introducing more customized green technology solutions to encourage long-term adoption, increase return on investment, and improve operational efficiency. For example, providing preferential financing programs to users with demonstrated environmental performance improvements could increase those organizations' willingness to invest further in sustainable innovations and expand their green initiatives. Other engagement strategies—for example, allowing corporate partners to co-develop environmental-friendly solutions, share sustainability data, and assist smaller enterprises in transitioning to green practices—may engage stakeholders socially and thereby increase their perceived environmental responsibility.

Third, our study identifies regulatory consistency, technological feasibility, and organizational leadership commitment as key drivers of companies' long-term engagement with green technology adoption. Therefore, policymakers and industry decision-makers should ensure that businesses' sustainability investments and the regulatory support the government provides continually exceed market uncertainties. Initiatives to this end might include gathering real-time industry feedback via stakeholder consultations, analyzing environmental impact metrics from pilot projects to understand barriers to green technology adoption (or scalability challenges), and devising adaptive policy frameworks to fulfill (or solve) those regulatory inefficiencies (or investment risks).

Future research should prioritize investigating the lasting effects of green technology adoption on economic performance through studies. It is also imperative to explore how organizational culture, market conditions, and consumer behavior shape technology uptake and effectiveness. Comparative analyses spanning regions and industries can shed light on elements impacting green technology system performance. Examining the influence of emerging technologies like intelligence and Internet of Things (IoT) on sustainability practices and outcomes will yield valuable insights.

To sum up, this study presents contributions to monitoring and green technology systems. By outlining drivers behind these systems success our findings provide insights, for enhancing sustainability practices and optimizing green technology system performance. The convergence of regulatory and organizational aspects plays a role, in driving forward global initiatives for environmental sustainability. This research sets a groundwork for studies in this critical field.

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