The Impact of Total Quality Management on Green Performance: The Mediating Role of Green Innovation

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DOI: https://doi.org/10.47772/IJRISS.2025.91100472

Received: 21 November 2025; Accepted: 28 November 2025; Published: 19 December 2025

ABSTRACT

The current environment is characterized by complexity and uncertainty, requiring companies to develop new strategic choices and management approaches to remain competitive and fulfill their responsibilities to all stakeholders. Today, customers, investors, and stakeholders are increasingly demanding greater transparency and responsibility from companies, particularly regarding their green practices. Total Quality Management (TQM) and Green Innovation (GI) are considered strategic orientations for adapting to environmental changes and achieving green performance (GP). However, there is a gap in the literature regarding the study of the relationships among these three concepts in a single analysis. To address this gap, we proposed a conceptual model and formulated research hypotheses. The aim of this research is to analyze the relationships between TQM, GI, and GP in the context of an emerging country, namely Tunisia. More specifically, this study highlights the mediating effect of GI between TQM and GP. A questionnaire was administered to top managers of 105 certified manufacturing companies in Tunisia. The data were analyzed using structural equation modeling (SEM) with the PLS approach to examine the effects of TQM on GI and GP. The results demonstrate that TQM positively affects both GI and GP. Additionally, GI positively influences GP. Furthermore, the findings indicate that GI partially mediates the relationship between TQM and GP. This study provides valuable guidance to practitioners on improving green performance by integrating TQM practices and green innovation into their business operations. It encourages managers to understand the potential connection between TQM and green innovation and to leverage this relationship as a catalyst for achieving sustainable performance and gaining a competitive advantage.

Keywords: Total quality management (TQM), green innovation (GI), Green performance (GP).

INTRODUCTION

Manufacturing companies remain a key factor contributing to environmental problems such as natural resource depletion, climate change, and pollution (Aftab et al., 2023). Recently, the scope of Total Quality Management (TQM) has been broadened to include dimensions beyond the organization's internal structure, such as the incorporation of social responsibility and environmental policies (Tasleem et al., 2019). It is a management system that focuses on continuous improvement, aiming to use resources effectively, reduce costs, and optimize human effort (Abbes, 2019). The relationships between TQM practices and green performance (GP) have been studied by many researchers within distinctive contexts, leading to mixed results, calling for more research studies (Akanmu et al., 2023). However, Albloushi et al. (2023) suggest the existence of a positive link between TQM and CSP. On the other hand, Makhlouf et al. (2023) report that there is a negative relationship between TQM and GP. Green innovation is considered a mechanism to lead firms' success in the long term (Aftab et al., 2023). Green innovation is considered a key factor that can help companies introduce environmentally friendly processes, technologies, products, and methods into production operations in order to protect the natural environment (Chang, 2011). This approach is essential for meeting sustainable development challenges and is often considered a key driver of business performance (Le, 2022; Albloushi et al., 2023). The studies that

examined the link between GI and GP reveal a controversial relationship with mixed and inconclusive results (Chang, 2011; Przychodzen et al., 2018; Padilla-Lozano & Collazzo, 2022). The literature addressing the relationship between TQM and GP reveals significant gaps in specifying the causal links among these variables, particularly in developing countries (Abbas, 2020). Consequently, it is essential to examine the interrelationship between TQM, GI, and GP within a unified analytical framework.

Therefore, the current study aims to answer the following research questions:

1. What is the effect of TQM practices on GP?

2. Does GI mediate the relationship between TQM and GP?

This paper is organized into six sections. The second section presents the literature review and develops the hypotheses. The research methodology is outlined in the third section. The fourth and fifth sections present and discuss the results. Finally, the conclusion, implications, and limitations are presented in the last section.

THEORETICAL FRAMEWORK AND DEVELOPMENT OF RESEARCH HYPOTHESES

TQM and green performance

TQM is a relevant factor that enables companies to achieve their green performance goals (Abbes, 2020). It is a management system that focuses on continuous improvement, aiming to use resources effectively, reduce costs, and optimize human effort. According to Shafiq et al. (2019), TQM is a tool that can help companies improve the quality of their products and services, reduce defect rates, and enhance customer satisfaction. Zhang et al. (2020) stated that the successful implementation of TQM has the potential to achieve performance across the three pillars of the triple bottom line (TBL) economic, social, and environmental. According to Qasrawi et al. (2017), integrating corporate sustainability (CS)with quality management can significantly enhance firms' performance in all TBL pillars. Abbas (2020) investigated the relationship between TQM in the Pakistani manufacturing and service sectors. The results revealed a positive relationship between TQM and corporate sustainability. Hassis et al. (2023) reported that TQM has a significant impact on CS in the Palestinian context using a sequential mixed-method research technique. In contrast, the study by Makhlouf et al. (2023) showed a negative relationship between TQM and CS in the Chinese industry. Aquilani et al. (2016) reported that TQM practices help organizations achieve sustainable development (SD).

Thus, we propose the following hypothesis:

H1. TQM positively influences GP.

TQM and green innovation

TQM has been considered a key driver of green innovation (Abbas, 2020). However, the assessment of the relationship between the two has been inconclusive (Prajogo and Sohal, 2001; Castillo-Rojas et al., 2012; Manders et al., 2016). The philosophy of continuous improvement advocated by quality management may hinder firms from pursuing radical green innovations Steiber and Alange (2013). Zeng et al. (2017) argued that the adoption of TQM practices creates a conducive environment for companies to innovate, serving as a significant catalyst for green innovation. In contrast, the study by Li et al. (2018) showed a negative relationship between TQM and green innovation in the Chinese industry. Results from the study of Albloushi et al. (2023) showed that TQM significantly enhances firms' capabilities to innovate in the UAE industry. Azam et al. (2023) described green theory as providing a theoretical basis for clarifying the relationship between TQM and GI and reported that TQM practices positively impacted two aspects of GI, namely green product innovation and green process innovation, in Pakistani manufacturing firms.

Hence, we propose the following hypothesis:

H2. TQM *positively influences* GI

Green innovation and green performance

Green innovation is a powerful lever for achieving green performance(Hur et al., 2013). GI is one of the tools that involves creating environmentally friendly products, processes, and management practices in order to achieve long-term sustainability (Xie et al., 2019; Li et al., 2017). GI encompasses various areas, such as reducing resource usage and minimizing waste and pollution (Rossiter and Smith, 2018). The study by Abbas and Sagsan (2019),which focused on a sample of industrial companies in Pakistan, confirmed a positive relationship between green innovation and corporate sustainability. Asadi et al. (2020) conducted an empirical investigation based on a questionnaire administered to 183 Malaysian companies, and the findings showed that GI significantly improves green performance. Azam et al.(2023) investigated how GI affects GP in the Pakistani manufacturing sector. The authors reported that GI, including green product innovation and green process innovation, positively impacts GP. Therefore, we hypothesize that,

H3. Green innovation positively influences corporate sustainability

The indirect effects of TQM on green performance

The relationship between TQM and green performance (GP) has been extensively studied in the literature by several researchers, yet no consensus has emerged regarding the link between the two constructs (Alboushi et al., 2023 ; Makhlouf et al., 2023). As a result, some researchers have recommended that mediating variables may be essential for understanding the relationship between TQM and corporate sustainability performance (CSP). Thus, it is relevant to examine the mediating effect of green innovation (GI) in this relationship. Azam et al. (2023) argued that companies can increase their GI by implementing TQM. The study by Albloushi et al. (2023) in the UAE context showed that GI partially mediates the relationship between TQM and GP. This indicates that the efficient implementation of TQM practices can significantly enhance an organization's GI activities, which in turn positively impacts corporate sustainability. Therefore, we hypothesize that.

H.4 TQM positively influences GP through GI.

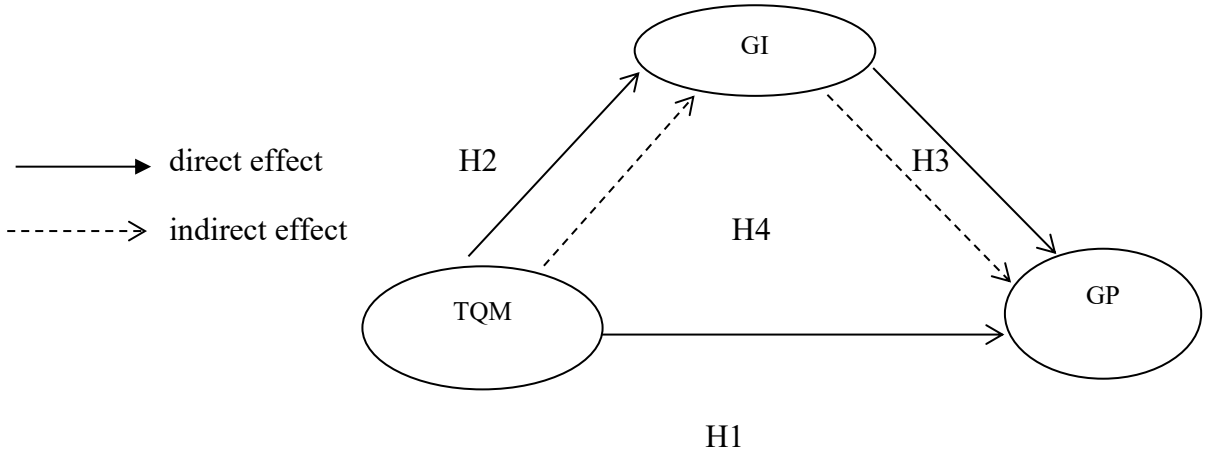

Figure 1. A conceptual model on the relationship between TQM, GI and GP

RESEARCH METHODOLOGY

Sample and Data collection

The study sample in the current research consists of certified manufacturing industries in Tunisia. We selected the list of the target population from the Tunisian Industry Portal. Data were collected using a survey questionnaire covering TQM, GI, and GP. We contacted and then sent a questionnaire to 345 certified manufacturing companies. The questionnaire was administered by email to top management. We received 121 questionnaires; however, only 105 were retained due to missing and/or doubtful responses. Table 1 summarizes the respondents' and industries' profiles.

Table 1. Demographics results

Descriptions	Characteristics	Values	Percentage %
Number of employees	<50	14	13.3
	50-199	25	23.8
	200-500	46	43.8
	More than 500	20	19.1
Gender	Female	7	6.7
	Male	98	93.3
Age	20-29	8	7.6
	30-39	41	39
	40-49	42	40
	More than 50	14	13.3
Job experience	Less than 3 years	12	11.4
	3 to 5years	33	31.4
	6 to 10 years	19	18.1
	More than 10 years	41	39.1

Ethical Consideration

During the research,ethical standards were strictly followed.To ensure confidentiality, participants were informed that all responses they provided would remain strictly confidential and be used exclusively for academic purposes. They were also informed that their participation was voluntary and that they could withdraw from the study at any time without any negative consequence. Furtheremore, no data that could personally identify the participants was collected.

Variable measurement

In this study, six TQM practices were considered: leadership, strategic planning, customer focus, human resource management, process management, and information and analysis, as these are the most widely cited in the literature (chaher et Lakhal,2024 ; Abbes, 2021). To measure the TQM dimensions, we used the scales developed by Abbas and Kumari (2021) and Chaher and Lakhal (2024). Strategic planning, customer focus, human resource management, process management, and information and analysis were each measured using five items, while leadership was measured using four items. Green performance was assessed using five items adapted from Yu et al. (2017), Roscoe et al. (2019), and Singh et al. (2020). The green innovation dimension—namely green product innovation and green process innovation—was measured using four items each, based on the scale developed by Chen et al. (2006).

RESULTS

The collected data were analyzed using partial least squares structural equation modeling (PLS-SEM).

Assessment of the the measurement model

In accordance with Hair et al. (2019), measurement model reliability was assessed using Cronbach's alpha and composite reliability (CR). Table 1 confirms that all values exceed the recommended threshold of 0.7 (Hair et al., 2018). Furthermore, validity was established through the examination of factor loadings, convergent validity, and discriminant validity. Table 1 demonstrates that all factor loadings exceed the 0.7 cutoff suggested by Hair et al. (2018), confirming that each item has a strong correlation with its corresponding construct.

Average Variance Extracted (AVE) was used to evaluate convergent validity. The findings reveal that all AVE values exceed the threshold of 0.5, as suggested by Fornell and Larcker (1981), confirming convergent validity.

Table 2. Reliability and convergent validity analysis

Constructs	No. of items	Cronbach's Alpha	Factor Loading	Composite Reliability	AVE
Leadership	LD1	0.903	0.842	0.932	0.775
	LD 2		0.895		
	LD3		0.910		
	LD5		0.873		
Information and analysis	IA1	0.888	0.764	0.918	0.693
	IA2		0.853		
	IA3		0.829		
	IA4		0.844		
	IA5		0.867		
Policy and strategy	PS1	0.849	0.776	0.894	0.630
	PS2		0.771		
	PS3		0.732		
	PS4		0.895		
	PS5		0.873		
Process management	PM1	0.878	0.814	0.911	0.672
	PM2		0.791		
	PM3		0.861		
	PM4		0.823		
	PM5		0.809		
Human resource management	HRM1	0.865	0.808	0.903	0.651
	HRM2		0.865		

	HRM3		0.712		
	HRM4		0.845		
	HRM5		0.797		
Customer focus	CS1	0.859	0.855	0.904	0.702
	CS2		0.793		
	CS3		0.870		
	CS4		0.832		
Green product innovation	GPI1	0.902	0.893	0.932	0.773
	GPI2		0.876		
	GPI3		0.914		
	GPI4		0.887		
Green performance	GP1	0.870	0.876	0.906	0.659
	GP2		0.773		
	GP3		0.788		
	GP4		0817		
	GP5		0.802		
Green Process Innovation	GPRI1	0.814	0.768	0.872	0.642
	GPRI2		0.829		
	GPRI3		0.786		
	GPRI4		0.820		

The Fornell and Larcker criterion and the HTMT ratio are generally used to evaluate discriminant validity (Hair et al., 2014). According to Fornell and Larcker (1981), to establish discriminant validity, the square root of the AVE of each construct should be greater than its correlation with any other construct in the model ;According to Hair et al. (2019), the HTMT ratio should be below the threshold of 0.90 to confirm discriminant validity.

Tableau 3. Fornelle-Larcker criterion analysis

	CS	**GP**	**GPI**	**GPRI**	**LD**	**MP**	**IA**	**PS**	**RH**
CS	0,838								
GP	0,214	0,812							
GPI	0,238	0,329	0,879						
GPRI	0,316	0,552	0,329	0,801					
LD	0,180	0,414	0,230	0,404	0,880				

MP	0,207	0,504	0,270	0,448	0,670	0,820			
IA	0,210	0,509	0,180	0,414	0,490	0,729	0,832		
PS	0,289	0,461	0,195	0,406	0,602	0,648	0,602	0,794	
HRM	0,195	0,532	0,257	0,455	0,606	0,733	0,705	0,647	0,807

Notes : LD : Leadership; CS : Customer Focus; GPI : Green Product Innovation; GPRI : Green Process Innovation; MP : Process Management;
PS : Politics and Strategy; IA : Information and Analysis; HRM : Human Resources Management; GP : Green Performance

Tableau 4. HTMT Ratio

	CS	**GP**	**GPI**	**GPRI**	**LDSH**	**MP**	**IA**	**PS**	**HRM**
CS									
GP	0,242								
GPRI	0,382	0,651	0,368						
LDSH	0,199	0,462	0,252	0,471					
MP	0,234	0,578	0,302	0,534	0,749				
IA	0,238	0,577	0,202	0,493	0,546	0,826			
PS	0,329	0,533	0,224	0,492	0,682	0,743	0,687		
HRM	0,224	0,605	0,285	0,542	0,668	0,826	0,793	0,743	

Structurel Model

The coefficient of determination (R^2) and the cross-validated redundancy (Q^2) were checked to evaluate the path model's predictive accuracy. Chin et al. (1998) suggested that an the R^2 values of 0.26, 0.13, and 0.02 indicate substantial, moderate, and weak relevance , respectively. According to Hair et al. (2014), a Q^2 value greater than 0is considered satisfactory. The data in Table 5 indicate that TQM and GI together are responsible for 42% of the variation in GP.

Table 5. Coefficient of determination (R^2)

	R Square	**R Square Adjusted**	**Résults**
GI	0. 341	0.334	substantial
GP	0.420	0.409	substantial

Table 4 show that Q2 Values for all endogenous construct exceeding zero indicating that the path model meets predictive relevance.

Table 6. Cross-validated redundancy(Q^2)

Variables endogènes	**Q2**	**Résultat**
GI	0,103	Significatif
GP	0,270	Significatif

In the end, a bootstrapping procedure was conducted to test the direct and indirect relationships between TQM, GI, and GP. The results reveal a positive and significant relationship between TQM and GP ($\beta = 0.413$; T =

4.433; $p < 0.001$), confirming Hypothesis 1. Additionally, a positive relationship was found between TQM and GI ($\beta = 0.491$; $T = 7.958$; $p < 0.001$), supporting Hypothesis 2. The results also indicate a positive and significant relationship between GI and GP ($\beta = 0.336$; $T = 3.662$; $p < 0.01$), confirming Hypothesis 3. Finally, regarding the mediation hypothesis, the results show that TQM has an indirect effect on GP through the mediating role of GI ($\beta = 0.165$; $T = 2.905$; $p < 0.01$).

Table 7. Hypothesis testing.

	Hypothesis	**Constructs**	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**	**Hypothesis Decision**
Direct effect	H1	TQM → GP	0,413	0,403	0,093	4 .433	**0,000**	Accepted
	H2	TQM → GI	0,491	0,500	0,062	7.958	**0,000**	Accepted
	H3	GI → GP	0,336	0,352	0,092	3.662	**0,002**	Accepted
Mediation	H4	TQM → GI → GP	0,165	0,178	0,057	2.905	**0,004**	Partial Mediation

DISCUSSION

The aim of this study is to analyze the effect of TQM on GP through the mediating role of GI. The results show that TQM has a positive relationship with GP. This finding is consistent with the study of Abbas (2020) which confirmed that the implementation of TQM practices promotes green performance. Furthermore, the results indicate a positive relationship between TQM and GI. This finding aligns with the study of Nazarian et al. (2025), which demonstrated that TQM is a pivotal factor in enhancing green innovation in Pakistani manufacturing companies. However, this result contradicts the findings of Li (2018), who reported that TQM has no significant effect on GI.TQM is based on a set of principles, including continuous improvement, customer focus, employee involvement, and leadership, which can enhance a company's capacity to foster a culture oriented toward green innovation (GI) and corporate sustainability. The results also show that GI has a positive effect on GP. This finding is consistent with the study by Hussain et al. (2022), which suggests that GI can promote environmental, social, and economic sustainability in manufacturing companies in the UAE. Finally, the results of this empirical study illustrate that TQM has an indirect effect on GP through the mediating role of GI. The introduction of GI as a mediating variable strengthens the impact of TQM on GP. These results are consistent with the findings of Albloushi et al. (2023) in the UAE context, which showed that GI partially mediates the relationship between TQM and GP. Overall, the findings of the current study indicate that adopting TQM practices enables companies to promote green innovation, which, in turn, contributes to achieving green performance.

CONCLUSION

The main aim of this study is to analyze the relationship between TQM GI and GP in developing country context. The findings showed that TQM positively associate with GI and GP. Additionally, the study shows that GI positively influences GP. Furthermore, the results indicate that GI partially mediates the association between TQM and GP

Theoretical contribution

This study contributes to the current literature in several ways. First, this study provides a conceptual model to examine the relationship between TQM, GI and GP, by explaining the path of this relationship. Second, the conceptual model highlights the mediating effect of GI between TQM and GP

Managerial contribution

This research provides managerial contributions. It encourages managers to understand the potential connection between TQM and green innovation and to leverage this relationship as a catalyst for enhancing the GI of their companies. The study highlights the importance of TQM in promoting green innovation and corporate sustainability. Businesses are encouraged to adopt a comprehensive set of TQM practices—such as continuous improvement, top management commitment, employee involvement, and evidence-based decision-making—to foster a culture that supports green innovation and achieves long-term sustainability goals. Furthermore, this research emphasizes the significant role of green innovation in enhancing green performance. Managers are encouraged to actively integrate green innovation into operational activities, such as the use of eco-efficient technologies, green materials innovation, waste-reduction practices, and energy-efficient processes. By incorporating these green practices into daily operations, managers can strengthen their organizations' social, economic, and environmental sustainability. Finally, the study urges managers to consider TQM and GI as strategic investments that contribute to sustainable development and provide a competitive advantage

Limitations and Future Perspectives

This study has certaines limitations. First, the sample size was relatively small (105 companies). Future research could test this model on a larger sample to enhance the generalizability of the results. Second, a cross-sectional design was employed. Future studies are encouraged to adopt a longitudinal approach to more accurately examine the causal relationships between total quality management, green innovation, and green performance over time. Finally, although this study focused on certified manufacturing companies located in Tunisia, future research could explore other industries or regions to assess whether the findings hold across different contexts. Additionally, other potential mediators, such as green entrepreneurial orientation or green knowledge management, could be investigated in the relationship between TQM and GP.

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