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Pioneering Sustainability: Insights from the Integrative Role of Knowledge Management Processes and Technological Innovation

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Abstract: This paper examines the quantitative relationship between knowledge management and technological innovation and their influence on sustainable development. Organizations have increasingly focused on knowledge management processes, recognizing their importance for maintaining competitiveness and sustainability. The purpose of our study was to shed light on the impact of knowledge management processes on a firm's sustainability and innovation. Specifically, we investigated the relationship between knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application and their effects on product/service innovation, process innovation, radical innovation, and incremental innovation. Using data from 272 questionnaires completed by top managers from companies operating in Greece, we provide strong evidence of a positive relationship between knowledge acquisition, storage, and application on product innovation whereas knowledge acquisition, storage, and transfer have a statistically significant effect on process innovation. Furthermore, we found a strong positive relationship between knowledge transfer and radical innovation. Finally, all four knowledge management processes have a strong positive impact on incremental innovation. The strength of these statistically significant results is reinforced by the magnitude of the corresponding estimated coefficients. The robustness of our results was further confirmed through the estimation of a Structural Equation Model (SEM) with the application of the Partial Least Squares (PLS) technique.

Keywords: knowledge management; knowledge management processes; technological innovation; sustainable development

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1. Introduction

Knowledge management is defined as the process of managing all the knowledge related to the business environment and an organization's performance [1–3]. Knowledge management is essential to business strategy and can improve product and service development in a wide range of companies while it provides a mixture of techniques that enables managers to absorb knowledge in an efficient manner, particularly those involved in the structural and organizational scopes of corporations [4]. Moreover, Santoro et al. [5] argue that knowledge management could be seen as a long-term process since its performance affects several areas of a firm. It is a resource that demands articulation and attention, covering all departments of an organization. Teece [6] argues that "the modern corporation, as it accepts the challenges of the new knowledge-based economy, will need to evolve into a knowledge-generating, knowledge-integrating and knowledge protection organization". Recently, knowledge management has begun to gain recognition from organizations as a significant element for improving organizational performance, increasing their market share, and enhancing their competitive advantage and sustainability. Knowledge management is also considered as a significant organizational input in systematically identifying, creating, applying, and disseminating critical knowledge. Several recent literature survey papers published in 2023 and 2024 examined the research output on knowledge management in relation to several other concepts such as leadership, technological innovation, organizational performance, and a firm's performance among others. These studies covered a period of 20 to 30 years, and they recorded that research on different aspects of knowledge had increased year by year and had reached a peak in the period 2022–2024 (see, for example, [7–16]). Furthermore, given that a firm's management seeks to achieve increased organizational performance, attention to the flow of information should be given within the business environment. Thus, knowledge management encompasses technology, information, and resources. It also covers innovation, strategy, performance, and other corporate attributes [17,18].

Durst and Zieba [19] argue that knowledge management greatly supports organizations' efforts towards sustainability. Additionally, Durst and Zieba [19] and Rao [20], among others, also argue that knowledge management is relevant to all organizations' structure, as well as for small businesses, for which comparative advantage is of upmost importance. Within this framework, Perez-Lopez and Alegre [8] argue that the implementation of knowledge management can be considered an integrated part of a firm's strategic pillars, along with conventional factors such as brand name, asset management, and financial equity, which will further enhance a firm's performance. Drucker [21] underlines that knowledge has been considered an alternative to capital, labor, materials, and equipment and is expected to become a crucial element in the production process. Drucker [21] also argues that knowledge resources will substantially contribute to an increased firm's competitive advantage in product markets. Zack [22] and Van Opstal and Hugé [23] also consider knowledge management processes to be crucial for a firm's growth and sustainable development.

In the last decade, top-level managers have come to understand that efficient knowledge management can improve risk management and a firm's overall performance [24]. Therefore, it is crucial for leaders to provide an appropriate business environment, adequate resources, and robust knowledge management, raising the question of how to measure the impact on organizational performance [10]. This argument has also been put forward by Subramaniam and Youndt [25], who underline that in the era of the knowledge-based economy, resources and competencies are considered crucial both to succeed in a dynamic and competitive environment as well as to promote sustainability.

Innovation is a multidimensional concept that encompasses the organizational and procedural elements of a corporation, aiming to improve a firm's performance in terms of production efficiency or cost reduction [11]. Moreover, Harryson [26] argues that openness to innovation signals a firm's willingness to change and restructure, which will lead to obtaining a competitive advantage through the development of new ideas and the adoption of new technologies in the production process. In her seminal work, Penrose [27] sets the roots for the dynamic approach of a firm that is based on the resource-based theory of firms. Thus, the relationship between knowledge management and innovation has been placed at the forefront among management objectives. Innovating firms need sophisticated knowledge management that focuses on the special requirements of interactive knowledge and the four dimensions of knowledge management [28]. The literature on organizational innovation has developed four types of innovation, namely (a) product innovation, which refers to a new product or service; (b) process innovation, which refers to a new production process technology; (c) radical innovation which entails something qualitatively new and/or a breakthrough; and (d) incremental innovation, which involves small step-by step improvements, or continuous innovation [29–31]. The extant literature on innovation further argues that different types of innovation are necessary for understanding and identifying organizations [28].

The present paper investigates the relationship between knowledge management processes and innovation from a holistic perspective. Using a survey including 272 top executives, we develop our methodology to analyze our underlined research hypotheses. To the best of our knowledge, ours was the first study that provided robust evidence of a positive relationship between knowledge management and innovation. We contribute to the ongoing discussion on the impact of knowledge management processes on innovation by examining a set of research hypotheses that attempt to shed light on whether a statistically significant positive relationship exists between knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application for each of the four innovation types discussed above (see, for example, [11,13–16]). Evidence of a positive statistically significant relationship further implies a positive effect of knowledge management on a firm's performance, which has been well documented in the knowledge management literature.

In a nutshell, several important findings stem from our analysis. We provide strong evidence for the existence of a positive relationship between knowledge acquisition, knowledge storage, and knowledge application on product innovation whereas knowledge acquisition, knowledge storage, and knowledge transfer have shown to have a statistically significant effect on process innovation. Furthermore, we find that there is a strong positive relationship between knowledge transfer and radical innovation. Finally, all four knowledge management processes have a strong positive impact on incremental innovation. In addition to the qualitative results, we also examine the quantitative strengths of the positive relationships between knowledge management processes and the four types of innovation. Thus, based on the estimated coefficients for all statistically significant cases, we argue that the strength of each of these relationships is quite significant. Finally, we conduct robustness analysis through the estimation of a Structural Equation Model with the Partial Least Squares approach (PLS-SEM). The PLS-SEM results confirm the results obtained through the baseline OLS regressions. These findings are in line with the results of previous studies that also examined the relationships between different dimensions of knowledge management, technological innovation, and a firm's performance (see, for example, [7,12,28,32]). Our results have significant implications for both academics and managers in designing and implementing knowledge management processes to achieve higher levels of innovation, efficiency, and sustainability.

The remainder of the paper is organized as follows. Section 2 presents the literature on knowledge management and innovation. In Section 3, we develop our hypotheses, and in Section 4, we present our research methodology. Section 5 provides the data and sample selection and presents and discusses our empirical findings whereas in Section 6, we present our summary, concluding remarks, policy implications, and future research suggestions.

2. Literature Review

The importance of the link between business environment and knowledge management capability in business model innovation has attracted the interest of both academics and practitioners, leading to the growth of the relevant literature, as reflected in several survey papers [11–16]. The evolving business environment requires a re-conceptualization of knowledge management in order to facilitate the business model innovation necessary for gaining a sustainable competitive advantage [33]. The intricate relationship between business environment dynamics and knowledge management capabilities could define and enhance business model innovation. The business environment is a combination of economic, social, technological, and competitive factors shaping the context in which organizations identify new opportunities or challenges. Additionally, the growing globalization of business operations presents vast opportunities for the development of innovative business models [34]. Therefore, knowledge management capability facilitates the acquisition, storage, transfer, and application of knowledge, enhancing the competence of businesses to get in-depth environmental insights effectively [35]. Knowledge-intensive companies are better placed to adapt and innovate their business models in line with the demanding business environment [36]. This synergy not only fosters innovation but also provides a competitive edge as businesses that excel in integrating environmental cues with robust knowledge management systems are better positioned to innovate and succeed.

Various definitions of knowledge management have been suggested in the extant literature. Alavi and Leidner [37] and Wiig [38] among others focus on several knowledge management processes such as the creation, diffusion, storage, and application of existing or new knowledge, emphasizing the management of existing knowledge. Moreover, Wiig [38] argues that the aim of knowledge management is to "maximize the enterprise's knowledge related effectiveness and returns from its knowledge assets, and to renew them constantly". However, Despres and Chauvel [39] underline that the definition of knowledge management has caused substantial controversy in the relevant literature. Martensson [40] distinguishes between information and knowledge, arguing that information is commonly considered a component of knowledge. Maier and Hadrich [41] argue that knowledge is a much broader concept that encompasses information-based beliefs. Furthermore, Martins et al. [42] argue that organizational knowledge consists of corporate expertise and common understandings, sharing several features similar to personal knowledge. Awan [43] and Rehman et al. [44] suggest that organizational learning is connected to activities and is developed internally in the firm through information and social interaction, leading to increasing growth capabilities, and that this type of knowledge is the foundation of knowledge management. According to Ammirato et al. [45], knowledge management is considered the comprehensive process of identifying, organizing, transferring, and utilizing information and skills. Recently, Ferreira et al. [46] conducted a survey documenting that 92.2% of business owners believe that the adoption of knowledge management can improve employee learning and organizational growth while 66.2% believe that knowledge management help them improve teamwork. Ode and Ayavoo [47] show that 50% of knowledge initiatives fail because companies need the implementation of a well-developed knowledge management approach.

The relationship between knowledge management processes and innovation has been discussed in the literature, starting with the seminal work by Schumpeter [48], who argued that innovation results from the combination of a firm's existing knowledge assets to create new knowledge. Aydin and Dude [49] showed that the exploration and exploitation of knowledge contribute to the firm's innovation and, through this, to the improvement of competitive advantage. Liao and Chuang [50] found support for the impact of knowledge management on the speed and activity of innovation. Darroch and McNaughton [51] examined the relationship between knowledge management and different types of innovation and found evidence that different knowledge management processes impact the speed, quality, and quantity of innovation success.

Hall and Andriani [52] focused on exploration and exploitation of knowledge management as the main drivers of a firm's innovative capability. Darroch [24] found further evidence that knowledge dissemination has a positive impact on innovation success. Nonaka [53] provided an analysis of the significant impact that knowledge creation and acquisition has on a firm's innovation and competitiveness. Moreover, Borghini [54] argued that there is a close link between the organization's knowledge and its capacity to innovate. Tseng [55] argued that it is important to measure knowledge management's contributions to a firm's performance. Di Vaio et al. [11] provided support on the interplay between knowledge management and digital transformation whereas Ghezza and Cavallo [56] and Gupta and Bose [57] highlighted the important correlation between knowledge management and its application in different company departments.

An extensive strand in the literature examines the influence of different knowledge management processes on various types of innovation. According to Marvel [58] and Molina-Morales et al. [59], knowledge acquisition directly enhances new product development and significantly improves existing services while knowledge application facilitates practical implementation in product development. This leads to innovative products that meet new market demands or enhance the user experience. Furthermore, knowledge storage enables organizations to optimize, increasing efficiency and reducing costs [60,61]. On the other hand, knowledge transfer across departments can uncover more efficient production techniques or distribution methods, enhancing overall process innovation.

Both knowledge acquisition and application play vital roles in radical and product/service innovation as they support the development of revolutionary products or substantial enhancements to existing ones [62]. On the other hand, knowledge storage and transfer play important roles in the context of process and incremental innovations since both are based on the improvement of the existing practices and extensive product development [59,60]. Meanwhile, incremental innovation is based on the improvement of products and services in continuous terms, which, again, depends on knowledge storage and transfer [61].

The present paper provides the first study within this literature that examined the existence of a significant positive relationship between four knowledge management processes, namely knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application, for product innovation, process innovation, radical innovation, and incremental innovation.

3. Research Hypotheses

Knowledge acquisition refers to the ability of an organization to identify, acquire, and accumulate knowledge either internally or externally, which is essential for its business [63,64]. This process requires the capacity to create knowledge and allocate it to products, services, systems, and the organization itself [65]. Knowledge acquisition leads to the creation of ideas and actions aimed at producing new concepts or topics [64,66]. Furthermore, knowledge acquisition is related to a firm's ability to generate new ideas and solutions related to the different dimensions of its operations, ranging from managerial processes to the designing and production of products/services along with its technological advancements [67].

During the stage of knowledge acquisition, information is either created internally by knowledge workers or obtained externally through outsourcing or purchases from external sources. At this stage, mechanisms include self-reporting, documentation, programming, and the required information systems and networks [68]. Knowledge may also be acquired through interactions between management and employees, in-house training, and exchanges with customers, suppliers, and employees from other departments of the corporation.

Knowledge storage refers to the storage of knowledge with the use of technologies for managing databases and data saving [69]. Organizations should establish the necessary infrastructure to store knowledge and experiences in a suitable manner, to ensure the updating of their organizational memory, and to develop security technologies to restrict access to their knowledge [70]. Specifically, organizational memory includes both the individual memory (observation, experiences, and the individual's own activities) as well as the common knowledge and the interactions, the organizational culture, and the information databases (both internal and external).

Knowledge transfer is defined as the process of exchanging formal or informal knowledge between two factors. During this process, the first factor intentionally obtains and utilizes knowledge provided by the second factor. By the term "factor" we can identify an individual, a group, or an organizational unit within the specific organization or across multiple organizations [71,72]. Furthermore, knowledge management involves the exchange of knowledge between individuals, enabling the recipient to apply or upgrade the obtained knowledge within a new knowledge framework [73]. Argote and Ingram [74] define knowledge transfer as the process through which a unit (such as a team, department, or division) is influenced by another's experience. Knowledge transfer actions allow the members of the organization to share, diffuse, and copy information, transmitting it to the appropriate organizational positions to achieve the optimal use of the firm's existing knowledge. To this end, the organization must establish communication channels, which may be formal or informal and personal or nonpersonal [75]. According to Bergeron [68], for the value of information to increase and the exchange of knowledge to be facilitated, this information must be freely transmitted within the organization, preferably in person, through various channels and support mechanisms.

Finally, knowledge application is a crucial element for knowledge management in order to be assured that the revealed knowledge is applied in a productive way for the benefit of the organization [76]. Knowledge application requires the use of knowledge for decision making, acting, and solving problems within an organization [70]. Knowledge application is defined as the incorporation of knowledge generated from different sources, used to develop organizational ability through different mechanisms based on conventional processes, norms, or decision making for certain situations [77]. Moreover, the knowledge that emerges should be understood, distributed, and applied within a closed circular flow. As Sabherwal and Becerra-Fernandez [78] underline, knowledge application systems support the processes employed by individuals to utilize other individuals' knowledge.

Furthermore, Drucker [21] defines innovation as the process that adds value to existing factors of production by enhancing economic capacity, leading to the ability to create new wealth. Furthermore, the OECD [79] defines innovation as the process through which a new idea is transformed into a new product or service that could be supplied to the goods market or as an intermediate input to a new production method or service provision. Schumpeter [48] suggests and analyzes different types of innovation, such as the introduction of a new product, the alteration of existing products, entry into a new market, potential changes in an existing industry, and the development of new sources of raw materials.

Innovation varies according to its objective, duration, and organizational impact. It is often distinguished into several categories: product/service innovation, process innovation, radical innovation, and incremental innovation [80]. Product/service innovation involves introducing new products and services and upgrading existing ones [81,82]. This type of innovation could encompass changes in the designing of the product/services that could significantly alter their use or characteristics [79]. Process innovation is defined as the application or upgrade of production methods or distribution channels that consist of significant changes in techniques, infrastructure, and software [79]. Additionally, process innovation enhances both efficiency and productivity as well as quality while reducing the cost [83,84]. Dewar and Dutton [85] consider two important distinct types of innovation: radical and incremental. According to Chandy and Tellis [86], the significant transformation of existing products, services, or technologies often makes the dominant business plans and the technologies product/services obsolete. Therefore, radical innovation has the potential to significantly alter existing products and services [25]. Ettlie [87] defines incremental innovation as the process that upgrades existing products, services, or technologies and enhances the capabilities of dominant business models and technologies concerning the products/services offered. Consequently, incremental innovation is the process through which innovations that improve, refine, and strengthen existing products and services are developed [25].

Given the four dimensions of knowledge management and the four types of innovation, we continue with the development of the research hypotheses. Our conceptual model investigates the direct impact of these knowledge management processes on each type of innovation, namely (a) product/service innovation, (b) process innovation, (c) radical innovation, and (d) incremental innovation (Figure 1).

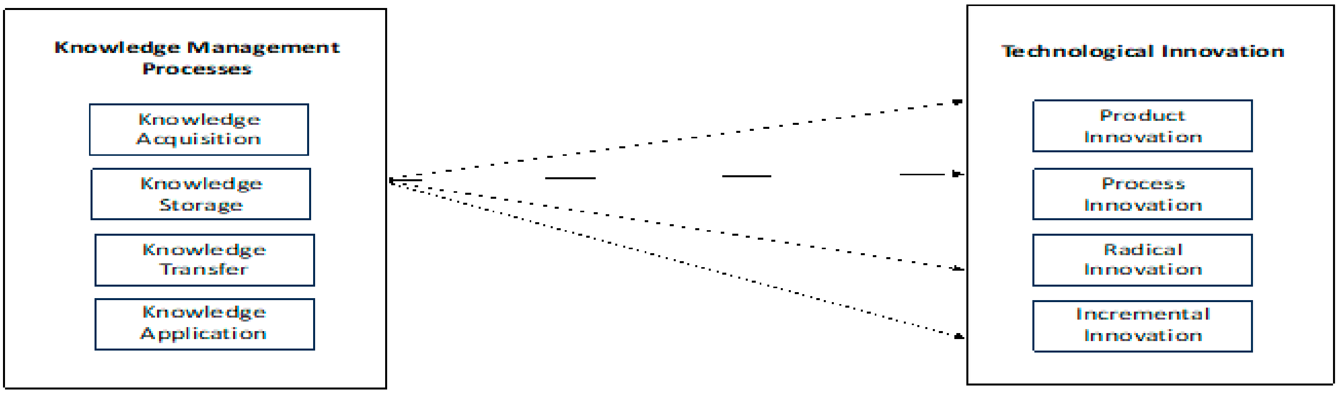

Figure 1. Conceptual framework.

3.1. The Effect of Knowledge Management Processes on Product/Service Innovation

The first group of research hypotheses that are investigated in the present analysis examines whether knowledge management processes have a significant and positive impact on product/service innovation (IN). The relevant hypotheses are formulated as follows:

H1a. *Knowledge acquisition (AP) has a significant positive impact on product/service innovation (IN).*

H1b. *Knowledge storage (SP) has a significant positive impact on product/service innovation (IN).*

H1c. *Knowledge transfer (TP) has a significant positive impact on product/service innovation (IN).*

H1d. *Knowledge application (APP) has a significant positive impact on product/service innovation (IN).*

3.2. The Effect of Knowledge Management Processes on Process Innovation

We next examine whether knowledge management processes have a significant and positive impact on process innovation (IP). The relevant research hypotheses are formulated as follows:

H2a. *Knowledge acquisition (AP) has a significant positive impact on process innovation (IP).*

H2b. *Knowledge storage (SP) has a significant positive impact on process innovation (IP).*

H2c. *Knowledge transfer (TP) has a significant positive impact on process innovation (IP).*

H2d. *Knowledge application (APP) has a significant positive impact on process innovation (IP).*

3.3. The Effect of Knowledge Management Processes on Radical Innovation

Then, we investigate whether knowledge management processes have a significant and positive impact on radical innovation (RIC):

H3a. *Knowledge acquisition (AP) has a significant positive impact on radical innovation (RIC).*

H3b. *Knowledge storage (SP) has a significant positive impact on radical innovation (RIC).*

H3c. *Knowledge transfer (TP) has a significant positive impact on radical innovation (RIC).*

H3d. *Knowledge application (APP) has a significant positive impact on radical innovation (RIC).*

3.4. The Effect of Knowledge Management Processes on Incremental Innovation

Finally, we examine whether knowledge management processes have a significant and positive impact on incremental innovation (IIC):

H4a. *Knowledge acquisition (AP) has a significant positive impact on incremental innovation (IIC).*

H4b. *Knowledge storage (SP) has a significant positive impact on incremental innovation (IIC).*

H4c. *Knowledge transfer (TP) has a significant positive impact on incremental innovation (IIC).*

H4d. *Knowledge application (APP) has a significant positive impact on incremental innovation (IIC).*

4. Methodology

An appropriately designed questionnaire to measure innovation and knowledge management processes was addressed to Chief Executive Officers (CEOs) in Greek medium and large enterprises. CEOs hold the highest strategic decision-making roles, providing a comprehensive overview of both the operational and strategic aspects of their organizations. Their insights are crucial for understanding strategic initiatives such as innovation and knowledge management, having a broader, holistic, perspective that encompasses various dimensions of business operations. This makes them best placed to assess how well innovation and knowledge management processes have been integrated with business operations and how those processes impact organizational performance.

Greece has exhibited the highest percentage of reported innovative enterprises in the European Union—27 for the 2018–2020 period. Greece has undergone significant economic changes and challenges over the past decade, including a severe financial crisis and subsequent recovery efforts, providing a fertile ground for studying the implications of knowledge management and innovation. Moreover, Greece has a diverse economy with significant contributions from sectors like tourism and shipping, allowing for the exploration of the above-mentioned relationships across different industries. These factors make Greece an intriguing and relevant case study for examining how innovation and knowledge management contribute to business performance and sustainability.

Of the total number of questionnaires sent out, 272 were received by the CEOs and were considered suitable, with a response rate of 21%. In this study, all dimensions of innovation and knowledge management were measured on a five-point Likert scale. Knowledge management was measured through four processes: knowledge acquisition was based on Lee et al. [88] while knowledge storage, transfer, and application were evaluated with questions based on Donate and de Pablo [89]. Innovation was captured by four dimensions [73]. Process and product/service innovation were evaluated with questions based on Prajogo and Sohal [90] while incremental (INC) and radical (RAD) innovation were based on Subramaniam and Youdt [25] (see Appendix A). Finally, the sector of the economy that each firm operated (SECTOR), the number of years of operation (AGE), and the number of employees (N) were used as control variables.

5. Empirical Analysis and Results

Table 1 reports the results from our regression analysis to investigate the validity of the research hypotheses H1a, H1b, H1c, and H1d, which examine the impact of knowledge management processes on product/service innovation. Specifically, the null hypothesis for each research hypotheses posits that there is no statistically positive impact of each knowledge management process on product/service innovation against the alternative hypothesis that there is a statistically positive impact. We employ the Ordinary Least Squares (OLS) method with robust standard errors. In addition, to ensure the robustness of our results, the standard errors are bootstrapped over 1000 replications and this method is applied for all subsequent OLS estimations. The results show that the coefficient of knowledge acquisition is statistically significant at the 1% significance level, with a positive sign and a magnitude of 0.268. Therefore, we confirm H1a, indicating that knowledge acquisition has a positive and significant impact on product/service innovation. The coefficient for knowledge storage is also positively signed and statistically significant at the 5% critical value, with a magnitude of 0.155, confirming H1b and implying that knowledge storage has a positive and statistically significant impact on product/service innovation. The coefficient for knowledge transfer, however, has a positive sign and a magnitude of 0.0053 but it is not statistically significant at any conventional significance level, and therefore, we argue that we are unable to reject the null hypothesis that knowledge transfer has no positive impact on product/service innovation. Finally, the coefficient for knowledge application is positively signed with a magnitude of 0.119 while it is statistically significant at the 10% level of significance. Therefore, we conclude that knowledge application has a positive and statistically significant impact on product/service innovation. Regarding the control variables, we find that the production sector (SECTOR) and the years of the firm's operation (AGE) are not statistically significant at the 5% significance level whereas the number of employees (N) is statically significant at the 5% critical value.

Table 1. Effects of Knowledge Acquisition, Transfer, Storage, and Application on Product Innovation (IN).

Variable	Coefficient	Standard Error	Statistical Significance (t-Stat)	*p*-Value
AP	0.267593	0.066910	3.999320 ***	0.0001
SP	0.155100	0.066043	2.348474 **	0.0196
TP	0.005258	0.067948	0.077385	0.9384
APP	0.119125	0.068092	1.749470 *	0.0814
Sector	−0.100553	0.094904	−1.059533	0.2903
N	−0.050882	0.068871	−0.738805	0.4607
Age	0.001425	0.002386	0.597197	0.5509
Constant	0.365677	0.347490	1.052338	0.2936
R-Squared	0.214757			
Adjusted R-Squared	0.193936			
F-statistic (*p*-value)	10.31452 (0.000)			
Durbin–Watson stat	1.817614			
Ramsey F-statistic (*p*-value)	1.77 (0.185)			
Homoscedasticity White (*p*-value)	32.37 (0.59)			
Normality Jarque–Bera (Jarque–Bera) (*p*-value)	1.87 (0.393)			
Breusch–Godfrey LM Test (*p*-value)	1.39 (0.25)			

This table displays estimates of the Ordinary Least Square (OLS) regression procedures of four dimensions of Knowledge and other control variables on Product Innovation (dependent variable) based on 272 questionnaires. IN: Product Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application; Sector: the sector that the company operates (primary, secondary, and tertiary sector); N: the number of employees; Age: the number of years elapsed since the company's foundation. *, **, and *** indicate two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 1 also provides a battery of diagnostic tests to evaluate the appropriateness of the estimated model. The F-statistic is statistically significant with a *p*-value of 0.0000, leading us to conclude that the model is appropriate. Additionally, the adjusted coefficient of determination is 19.3%, which is sufficient for this type of analysis. The Ramsey RESET test, with a *p*-value of 0.185, was not statistically significant, and therefore, we cannot reject the null hypothesis of linearity. The null hypothesis of homoskedasticity was tested using the White test, reported with a *p*-value of 0.59, indicating no statistical significance, and thus, we cannot reject the null hypothesis of homoskedasticity. The Durbin–Watson test was used to test the null hypothesis of no serial correlation in the residuals with a value of 1.817; therefore, we are unable to reject the null hypothesis of autocorrelation in the residuals. The absence of serial correlation was further supported by the Breusch–Godfrey test. Multicollinearity was examined using the variance inflation factor, and the results, showing a value well below 10, confirm that there is no evidence of multicollinearity. Finally, the Jarque–Bera test, with a p-value of 0.393, was not statistically significant, allowing us to conclude that we cannot reject the null hypothesis of normality in the distribution of residuals. Hence, we conclude that our model specification is appropriate for our analysis.

In Table 2, we report the results of the regression analysis to investigate the validity of the research hypotheses H2a, H2b, H2c, and H2d, which examine the impact of knowledge management processes on process innovation. Specifically, the null hypothesis for each research hypotheses posits that there is no statistically positive impact of the knowledge management processes on process innovation, contrasted against the alternative hypothesis of a statistically positive impact. The analysis shows that the coefficient for knowledge acquisition is statistically significant at the 1% significance level, with a positive sign and a magnitude of 0.184. Therefore, we confirm H2a, i.e., that knowledge acquisition has a positive and significant impact on process innovation. The coefficient for knowledge storage is also positively signed and statistically significant at the 5% critical value with a magnitude of 0.141, confirming H2b and implying a significant positive impact on process innovation. The coefficient for knowledge transfer has a positive sign and a magnitude of 0.304 and is strongly statistically significant at any conventional significance level, and therefore, we argue that we reject the null hypothesis that knowledge transfer has no positive impact on process innovation. However, the coefficient for knowledge application is negatively signed with a magnitude of -0.014 and is not statistically significant at conventional levels, indicating that we cannot reject the null hypothesis that knowledge application has no positive impact on process innovation. Regarding the control variables, the production sector (SECTOR) and the years of the firm's operation (AGE) are not statistically significant at the 5% significance level whereas the number of employees (N) is statistically significant at the 5% critical value.

Table 2 also includes a battery of diagnostic tests to evaluate the appropriateness of the estimated model. The F-statistic is statistically significant with a p-value of 0.0000, affirming the model's appropriateness. The adjusted coefficient of determination is 23.6%, deemed sufficient for this type of analysis. The Ramsey RESET test yields a p-value of 0.537, which is not statistically significant, and therefore, we are unable to reject the null hypothesis of linearity and that the equation's functional form is correct. The White test result, with a p-value of 0.02, leads us to reject the null hypothesis of homoskedasticity at the 5% level of significance. The Durbin–Watson statistic is 1.989, and therefore, we are unable to reject the null hypothesis of no serial correlation in the residuals. The evidence of serial correlation is further confirmed by the Breusch–Godfrey test result. Multicollinearity was examined with the calculation of the variance inflation factor, which is well below 10, indicating no evidence of multicollinearity. Finally, the Jarque–Bera test result has a p-value equal of 0.360 and is not statistically significant, and therefore, we are unable to reject the null hypothesis of normality in the distribution of residuals.

Given the violation of the homoskedasticity hypothesis in the residuals of the estimated regression equation, we re-estimated the model using the Robust Least Squares (RLS) estimation technique. The results from the RLS estimation are reported in Table 3. Overall, we observe that the qualitative outcomes remain consistent. Therefore, we confirm that knowledge acquisition, knowledge storage, and knowledge transfer maintain a positive and statistically significant impact on process innovation.

Table 2. Effects of Knowledge Acquisition, Transfer, Storage, and Application on Process Innovation (IP).

Variable	Coefficient	Standard Error	Statistical Significance (t-Stat)	*p*-Value
AP	0.184812	0.067975	2.718827 ***	0.0070
SP	0.141428	0.067094	2.107909 ***	0.0360
TP	0.304334	0.069030	4.408749 ***	0.0000
APP	−0.014220	0.069176	−0.205564	0.8373
Sector	−0.170266	0.096414	−1.765987 *	0.0786
N	−0.027879	0.069968	−0.398457	0.6906
Age	0.000984	0.002424	0.406072	0.6850
Constant	0.487964	0.353021	1.382250	0.1681
R-Squared	0.255871			
Adjusted R-Squared	0.236140			
F-statistic (*p*-value)	12.96814 (0.000)			
Durbin–Watson stat	1.989711			
Ramsey F-statistic (*p*-value)	1.47 (0.537)			
Homoscedasticity White (*p*-value)	53.92 (0.02)			
Normality Jarque–Bera (Jarque–Bera) (*p*-value)	2.04 (0.360)			
Breusch–Godfrey LM Test (*p*-value)	0.312 (0.73)			

This table displays estimates of the Ordinary Least Square (OLS) regression procedures of four dimensions of Knowledge and other control variables on Process Innovation (dependent variable) based on 272 questionnaires. IP: Process Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application; Sector: the sector that the company operates (primary, secondary, and tertiary sector); N: the number of employees; Age: the number of years elapsed since the company's foundation. *, **, and *** indicate two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3. Effects of Knowledge Acquisition, Transfer, Storage, and Application on Process Innovation (IP)-Robust Least Squares.

Variable	Coefficient	Standard Error	Statistical Significance (t-Stat)	*p*-Value
AP	0.188844	0.070796	2.667416 ***	0.0076
SP	0.145334	0.069879	2.079782 **	0.0375
TP	0.320531	0.071895	4.458328 ***	0.0000
APP	−0.002652	0.072047	−0.036810	0.9706
Sector	−0.144891	0.100416	−1.442898	0.1490
N	−0.015464	0.072872	−0.212210	0.8319
Age	0.000117	0.002525	0.046334	0.9630
Constant	0.423815	0.367676	1.152688	0.2490
Adjusted R-Squared	0.236140			
Rn-squared (critical value)	92.32590 (0.000)			

This table displays estimates of the Robust Least Squares (RLS) regression procedures of four dimensions of Knowledge and other control variables on Process Innovation (dependent variable) based on 272 questionnaires. IP: Process Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application; Sector: the sector that the company operates (primary, secondary, and tertiary sector); N: the number of employees; Age: the number of years elapsed since the company's foundation. *, **, and *** indicate two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4 presents the results of the regression analysis to investigate the validity of the research hypotheses H3a, H3b, H3c, and H3d, which examine the impact of knowledge management processes on radical innovation. Specifically, the null hypothesis for each one of the research hypotheses is that there is no statistically positive impact of each one of the knowledge management processes on radical innovation against the alternative hypothesis that there is a statistically positive impact. The results indicate that the coefficient for knowledge acquisition, while positive, is not statistically significant at all conventional significance levels with a magnitude of 0.065. Therefore, we are unable to reject H3a, and thus, we argue that knowledge acquisition has no significant impact on radical innovation. Similarly, the coefficient for knowledge storage is positively signed but not statistically significant at all conventional significance levels, with a magnitude of 0.004, and therefore, we are unable to reject H3b, implying that knowledge storage does not have a statistically significant impact on radical innovation. The coefficient of knowledge transfer has a positive sign and a size of 0.408 and is strongly statistically significant at any conventional significance level, and therefore, knowledge transfer has a positive and statistically significant impact on radical innovation. However, the coefficient for knowledge application shows a negative sign with a magnitude of −0.094 and is not statistically significant at any conventional level of significance, suggesting no positive impact on radical innovation. Regarding the control variables, we find that the production sector (SECTOR), the number of employees (N), and the years of the firm's operation (AGE) are not statistically significant at the 5% significance level.

Table 4. Effects of Knowledge Acquisition, Transfer, Storage, and Application on Radical Innovation (RIC).

Variable	Coefficient	Standard Error	Statistical Significance (t-Stat)	*p*-Value
AP	0.064994	0.070682	0.919529	0.3587
SP	0.004607	0.069766	0.066035	0.9474
TP	0.408334	0.071779	5.688797 ***	0.0000
APP	−0.094662	0.071931	−1.316015	0.1893
Sector	0.109893	0.100254	1.096144	0.2740
N	0.000561	0.072754	0.007705	0.9939
Age	0.000766	0.002521	0.303691	0.7616
Constant	−0.309633	0.367081	−0.843501	0.3997
R-Squared	0.175014			
Adjusted R-Squared	0.153139			
F-statistic (*p*-value)	8.000766 (0.000)			
Durbin–Watson stat	1.951851			
Ramsey F-statistic (*p*-value)	0.04 (0.835)			
Homoscedasticity White (*p*-value)	32.48 (0.58)			
Normality Jarque–Bera (Jarque–Bera) (*p*-value)	4.67 (0.097)			
Breusch–Godfrey LM Test (*p*-value)	0.98 (0.37)			

This table displays estimates of the Ordinary Least Square (OLS) regression procedures of four dimensions of Knowledge and other control variables on Radical Innovation (dependent variable) based on 272 questionnaires. RIC: Radical Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application; Sector: the sector that the company operates (primary, secondary, and tertiary sector); N: the number of employees; Age: the number of years elapsed since the company's foundation. *, **, and *** indicate two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

In Table 4, we also report a battery of diagnostic tests to evaluate the appropriateness of the estimated model. The F-statistic is statistically significant with a *p*-value of 0.0000, affirming the model's suitability. The adjusted coefficient of determination is 15.3%, considered sufficient for this analysis. The Ramsey RESET test result has a *p*-value of 0.835, which is not statistically significant, and therefore, we are unable to reject the null hypothesis of linearity and that the equation's functional form is correct. The White test result, with a *p*-value of 0.58, indicates homoskedasticity, confirming the model's stability in variance of residuals. The Durbin–Watson statistic is 1.95185, suggesting no rejection of the hypothesis of no serial correlation. This finding is further supported by the Breusch–Godfrey test result. Multicollinearity was examined with the calculation of the variance inflation factor, and it was found that the value of this factor is well below 10, leading to the conclusion that there is no evidence of multicollinearity. Finally, the Jarque–Bera test result, with a *p*-value of 0.097, shows no significant departure from normality in the distribution of residuals.

Finally, in Table 5, we present the results from our regression analysis to investigate the validity of the research hypotheses H4a, H4b, H4c, and H4d, which examine the impact of knowledge management processes on incremental innovation. Specifically, the null hypothesis for each one of the research hypotheses is that there is no statistically positive impact of each one of the knowledge management processes on incremental innovation against the alternative hypothesis that there is a statistically positive impact. The analysis shows that the coefficient for knowledge acquisition is statistically significant at the 1% significance level with a positive sign and a magnitude of 0.177. Therefore, we confirm H4a that knowledge acquisition has a positive and significant impact on incremental innovation. The coefficient for knowledge storage is also positively signed and is statistically significant at the 5% critical value with a magnitude of 0.130, confirming H4b, implying that knowledge storage has a positive and statistically significant impact on incremental innovation. The coefficient for knowledge transfer is positively signed with a magnitude of 0.118 and is statistically significant at the 10% significance level, leading us to reject the null hypothesis and confirm that knowledge transfer positively impacts incremental innovation. The coefficient for knowledge application is positively signed with a magnitude of 0.286 and is statistically significant at the 1% level of significance, thus confirming that knowledge application significantly impacts incremental innovation. Regarding the control variables, we find that none of them is statistically significant at any conventional significance level.

Table 5. Effects of Knowledge Acquisition, Transfer, Storage, and Application on Incremental Innovation (IIC).

Variable	**Coefficient**	**Standard Error**	**Statistical Significance (t-Stat)**	***p*-Value**
AP	0.177055	0.064638	2.739183 ***	0.0066
SP	0.130864	0.063801	2.051146 **	0.0412
TP	0.118691	0.065641	1.808194 *	0.0717
APP	0.286552	0.065780	4.356206 ***	0.0000
Sector	0.044521	0.091681	0.485610	0.6276
N	−0.058101	0.066533	−0.873263	0.3833
Age	0.002792	0.002305	1.210973	0.2270
Constant	−0.030769	0.335692	−0.091659	0.9270
R-Squared	0.318979			
Adjusted R-Squared	0.300922			
F-statistic (*p*-value)	17.66478 (0.000)			
Durbin–Watson stat	2.028614			
Ramsey F-statistic (*p*-value)	0.02 (0.891)			
Homoscedasticity White (*p*-value)	36.95 (0.38)			
Normality Jarque–Bera (Jarque–Bera) (*p*-value)	45.60 (0.000)			
Breusch–Godfrey LM Test (*p*-value)	0.27 (0.75)			

This table displays estimates of the Ordinary Least Square (OLS) regression procedures of four dimensions of Knowledge and other control variables on Incremental Innovation (dependent variable) based on 272 questionnaires. IIC: Incremental Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application; Sector: the sector that the company operates (primary, secondary, and tertiary sector); N: the number of employees; Age: the number of years elapsed since the company's foundation. *, **, and *** indicate two-tailed statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5 also provides a battery of diagnostic tests to evaluate the appropriateness of the estimated model. The F-statistic is statistically significant with a *p*-value of 0.0000, and therefore, we conclude that the model is appropriate. In addition, the adjusted coefficient of determination is equal to 30%. The Ramsey RESET test result has a *p*-value 0.891, which is not statistically significant, and therefore, we are unable to reject the null hypothesis of linearity and that the equation's functional form is correct. The null hypothesis of homoskedasticity was tested with the use of the White test and it was reported with a *p*-value of 0.38, implying no statistical significance, and thus, we are unable to reject the null hypothesis of homoskedasticity. The Durbin–Watson test was used to test the null hypothesis of no serial correlation in the residuals, and the value of the DW statistic is equal to 2.0286, and therefore, we are unable to reject the null hypothesis of autocorrelation in the residuals. The evidence of no serial correlation in the residuals is further supported by the Breusch–Godfrey test result. Multicollinearity was examined with the calculation of the variance inflation factor, and it was found that the value of this factor is well below 10, leading to the conclusion that there is no evidence of multicollinearity. Finally, the Jarque–Bera test result has a *p*-value equal to 0.000 and is statistically significant. Therefore, we reject the null hypothesis of normality in the distribution of residuals. Nevertheless, the non-normality of the residuals does not substantially affect the statistical inference given the large sample size. Therefore, we conclude that our model specification is appropriate for our analysis.

This paper brings to the surface the impact of knowledge processes on four types of innovation. Overall, our results indicate that the four knowledge management processes—knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application—significantly impact both a firm's innovative structure as well as its performance and sustainability. Specifically, knowledge acquisition, knowledge storage, knowledge transfer, and knowledge application have a significant effect on the four types of innovation under investigation: product, process, radical, and incremental.

First, our findings suggest that knowledge acquisition, knowledge storage, and knowledge application have a positive and statistically significant influence on product innovation; thus, H1a, H1b, and H1d are rejected. Moreover, the magnitude of the significant coefficients (AP, SP and APP) is substantial, implying that a one-percent increase in each of these coefficients leads to more than a one-percent increase in product innovation. Intuitively, these outcomes imply that firms that develop and implement knowledge management mechanisms will eventually observe a robust innovation track, which, in turn, will have a beneficial impact on performance and the achievement of sustainability goals. This finding aligns with previous research on knowledge management [21,75].

Second, our research shows that knowledge acquisition, knowledge storage, and knowledge transfer have a positive and statistically significant impact on process innovation; thus, H2a, H2b, and H2c are rejected. Again, the first two dimensions of knowledge management remain the baseline elements on which firms adopt process innovative business models, and this dynamic setting is reinforced by the strong positive effect of knowledge transfer on process innovation. The significant coefficients (AP, SP, and TP), especially TP, are notable—a one-percent increase in knowledge storage leads to a thirty-percent increase in process innovation, which is consistent with our theoretical priors. Our results are consistent with findings by Mardani et al. [28], Di Vaio et al. [11], Chen and Yu [12], and Idrees et al. [13]. By contrast, regarding the impact of knowledge management on radical innovation, we find that only knowledge transfer has a statistically significant influence; thus, H3c is rejected. It is important to underline that the magnitude of the TP coefficient is quite large, implying that a one-percent increase in TP will lead to a forty-percent increase in radical innovation. Intuitively, this outcome implies that firms rely substantially on knowledge transfer to develop and adopt radical innovative mechanisms. This result is in line with several previous and recent studies on the effect of knowledge management on technological innovation [29,75,76].

Finally, all four knowledge management processes have a statistically significant effect on incremental innovation; thus, H4a, H4b, H4c, and H4d are rejected. Additionally, the magnitude of the significant coefficients (AP, SP, TP, and APP) is substantial, implying that a one-percent increase in each of these coefficients leads to an increase in incremental innovation ranging from eleven to twenty-eight percent. Managers fully understand the importance of the adoption of knowledge management systems as an important resource to achieve stepwise innovation, which will lead to increased firm performance and the achievement of long-term sustainability targets.

For robustness checking, we supplement our empirical analysis by further conducting a Partial Least Squares–Structural Equation Model (PLS-SEM) analysis that further enriches and supports our baseline results. PLS-SEM is a variance-based, descriptive, and prediction-oriented approach to structural equation modelling. Furthermore, the SEM method is a second-generation multivariate data analysis method having the advantage that it can handle unobservable variables, a problem that is often encountered in management research problems. Additionally, PLS structural equation modelling is frequently employed for analyzing complex interrelationships between observed and latent variables. It allows us to incorporate all research hypotheses in a single structural model. By construction, this method involves a two-step approach. The first step requires the evaluation of the measurement model (outer model) and provides the investigation of the existence of a relationship between the observable variables and theoretical concepts. In the second step, the structural model (inner model) should be evaluated to test the extent to which the relationship specified by the suggested model is consistent with the data acquired.

Table 6 summarizes our results from the application of the PLS-SEM approach, and it is clearly shown that our research hypotheses are supported, confirming the evidence provided by the estimates of our baseline model. Specifically, it is shown that Knowledge Acquisition, Knowledge Storage, and Knowledge Application have a positive significant impact on product innovation. In the same vein, the PLS-SEM results confirm that Knowledge Acquisition, Knowledge Storage and Knowledge Transfer have a statistically significant effect on process innovation. Furthermore, as in the baseline results, only Knowledge Transfer has a positive and statistically significant influence on radical innovation. Finally, the PLS-SEM estimates confirm our baseline results since all knowledge management activities have a statistically significant positive impact on incremental innovation.

Table 6. Effect of the knowledge management processes on innovation: PLS-SEM robustness test.

Variables		Regression Weight	Standard Error	*p*-Value
IN	AP	0.334	0.124	0.007 ***
IN	SP	0.194	0.097	0.045 **
IN	TP	0.021	0.080	0.789
IN	APP	0.087	0.060	0.097 *
IP	AP	0.319	0.142	0.025 **
IP	SP	0.136	0.113	0.027 **
IP	TP	0.490	0.106	0.000 ***
IP	APP	−0.022	0.072	0.761
RIC	AP	0.113	0.162	0.485
RIC	SP	−0.092	0.133	0.488
RIC	TP	0.773	0.133	0.000 ***
RIC	APP	−0.144	0.085	0.190
IIC	AP	0.168	0.105	0.012 **
IIC	SP	0.194	0.087	0.027 **
IIC	TP	0.156	0.075	0.037 **
IIC	APP	0.241	0.058	0.000 ***

This table displays estimates of the Structural Equation Model (SEM) of four dimensions of knowledge on innovation based on 272 questionnaires. IN: Product Innovation; IP: Process Innovation; RIC: Radical Innovation; IIC: Incremental Innovation; AP: Knowledge Acquisition; SP: Knowledge Storage; TP: Knowledge Transfer; APP: Knowledge Application. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

The present study was conducted within the theoretical conceptual framework that had been developed in related studies that examined the relationships between knowledge management and innovation performance, knowledge management and leadership style, and knowledge management and digital innovation among others. Thus, our conceptual model relates to those employed by Mardani et al. [28], Di Vaio et al. [11], Andrej et al. [7], and Cordeiro et al. [14] among others. Furthermore, our results, which strongly support a positive relationship between four knowledge processes on four types of innovation, are in line with the results that similar studies like the ones mentioned above reached, although we underline that the present study was the first one that explicitly investigated the effect of knowledge management on innovation. Related studies such as those by Mardani et al. [28] and Andrej et al. [7] provide indirect evidence of the strong positive impact of knowledge management on innovation and a firm's performance.

Our results not only underscore the importance of knowledge management processes in enhancing innovation but also highlight their potential in advancing a firm's ESG goals. Effective knowledge management can lead to improved ESG performance by enhancing innovation that optimizes resource use, promotes workforce diversity, improves community relations, and ensures that best practices in corporate governance are applied across the organization. This, in turn, enhances transparency, accountability, and compliance—key elements of sound governance. Consequently, our findings suggest that integrating knowledge management into an ESG strategy not only helps in achieving operational targets but also supports broader sustainability goals.

6. Conclusions, Policy Implications, and Future Directions

The present paper aimed to develop and empirically test a conceptual model that sought to find whether four identified knowledge management processes affected each one of four types of technological innovation. Control variables, including the size, age, and sector of the firms in the sample, were incorporated to explore potential moderating effects. The conceptual model predicts that knowledge management processes within a firm have a significant positive impact on product innovation, process innovation, radical innovation, and incremental innovation. Following the extant literature on knowledge management, we developed our research hypothesis and model specification. Based on a survey, by collecting 272 questionnaires completed by top managers of medium and large Greek firms, we found strong evidence of a positive relationship between knowledge acquisition, storage, and application and product innovation. Similarly, knowledge acquisition, storage, and transfer significantly affect process innovation. Furthermore, knowledge transfer shows a strong positive relationship with radical innovation. Finally, all four knowledge management processes have a strong positive impact on incremental innovation. Furthermore, our results are robust across alternative empirical estimation methods. These results are crucial for both academics and managers in designing and implementing knowledge management processes to achieve higher innovation, efficiency, and sustainability.

Based on these findings, firms should not only implement knowledge management processes to boost innovation but also align these processes with their ESG strategies. Managers should therefore consider the benefits of knowledge management processes, both in the enhancement of innovation capabilities as well as in the support of ESG goals. By doing so, firms not only ensure compliance with regulatory requirements related to sustainability but also position themselves as leaders in corporate responsibility. Our results provide conclusions relevant to academics and practitioners. Both academics and firms are aware of the implications and dimensions of knowledge management. An important finding of our analysis is the strong evidence that knowledge management is a crucial mechanism to augment innovation, a firm's performance, and the achievement of ESG goals. Therefore, the results of this study provide an important set of tools to the managers to negotiate with stakeholders about implementing knowledge management processes not only to achieve the short-term profit maximization principle but also, and more importantly, to achieve long-term sustainability goals. Practitioners can also benefit from the robust results of our study given that it provides organizations with new insights on the positive impact of knowledge management processes on technological innovation and the appropriate ways to implement them in a firm's organizational structure. Furthermore, our findings underscore the utility and positive externalities of implementing knowledge management projects, illustrating how adoption can enhance innovation, financial soundness, process improvements, and sustainable growth.

Our findings also provide a road map for future research. First, expanding the sample to include companies from various countries could offer a more international perspective on the interplay between knowledge management processes and technological innovation alongside improving firm performance and achieving global ESG goals. Thus, the concept of knowledge management could further be analyzed aiming to provide a clearer understanding to firms' managers and other personnel who responded to a relevant survey. Moreover, the relationship between knowledge management and innovation could further be investigated in a cross-country international framework. Comparing the results of this study with other European countries would give us more information on this relationship. A further research avenue should focus on the investigation of changes in knowledge management and its application before, during, and after the COVID-19 pandemic. Second, an intertemporal analysis could provide deeper insights into the evolution of knowledge management over time. Specifically, an intertemporal investigation of the impact of knowledge management on technological innovation could possibly focus on examining how firms observe the existence of knowledge management implementation in a lifecycle as well as observing the derived advances in knowledge management over time. Finally, incorporating objective measures of firm performance, such as learning outcomes, into the questionnaire could enrich the empirical basis of our conclusions.

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Appendix A

Scale items

Knowledge Management Processes:

Knowledge Acquisition

- KM processes in our company effectively enable the creation of new knowledge from existing knowledge.
- The KM processes in our company enable the learning of useful lessons from previous work experience.
- The KM processes in our company facilitate the exchange of knowledge with other departments.
- The KM processes in our company facilitate the exchange of knowledge with other trading partners.
- The KM processes in our company enable the acquisition of knowledge of new products and services in the industry.
- The KM processes in our company facilitate the acquisition of new knowledge about competitors in the industry.

Knowledge Storage

- Organizational processes are codified and documented in manuals or other types of devices.

- There are databases that allow employees to use knowledge and experiences that have previously been loaded into the databases.
- There are phone or e-mail directories (referring to departments and sections) that can be used to find experts in specific areas.
- It is possible to access knowledge repositories, databases, and documents through some kind of internal computer network (for instance, an intranet).
- There are databases with updated information about customers.
- Databases are frequently updated.
- There are procedural guidelines, manuals, or books including problems that have been solved successfully.

Knowledge Transfer

- Information technologies (internet, intranet, e-mail, etc.) are used in order to encourage information flow and improve employees' communication.
- The firm's objectives and goals are clearly communicated to all the organizational members.
- There are frequent internal reports that inform employees about the firm's progress.
- There are well-distributed internal reports that inform employees about the firm's progress.
- There are periodical meetings in which employees are informed about the new initiatives that have been implemented.
- There are formal mechanisms that guarantee best practices to be shared in the firm (for instance, among departments or business areas).
- There are projects with interdisciplinary teams to share knowledge.
- There are employees that compile suggestions from other employees, customers, and suppliers and produce structured reports to be distributed throughout the company.
- There are communities of practices or learning groups to share knowledge and experiences.

Knowledge Application

- All the employees have access to relevant information and key knowledge within the firm.
- There are interdisciplinary teams with autonomy to apply and integrate knowledge.
- Suggestions from employees, customers, or suppliers are frequently incorporated into products/services.
- Suggestions from employees, customers, or suppliers are frequently incorporated into processes.
- Knowledge that has been created is structured in independent modules that allow for its integration or separation to create different applications and new usages.
- It is quite common to use external experts with experience on a specific subject in order to solve particular problems (acting as advisers).

<u>Innovation:</u>
Incremental innovation

- Innovations that strengthen your current products and/or services.
- Innovations that strengthen your current competencies in dominant products and/or services.
- Innovations that strengthen your current competitive position.

Radical innovation

- Innovations that make your current products and/or services redundant.
- Innovations that radically alter your current products and/or services.
- Innovations that make your current competencies in current products and/or services redundant.

Product Innovation

- The degree of novelty of our company's new products.
- The application of the most recent technological innovations in our new products.
- The pace of developing new products.
- The number of new products the company has brought to the market.

- The number of new products the company has brought to the market first.

Process innovation

- The technological capability of our company.
- The pace at which we incorporate the newest technological innovations into our processes.
- The innovativeness of the technology used in our processes.
- The frequency of changes in our processes.
- The frequency of changes in technology.

Source: Authors' own adaptation from Lee at al. [88], Donate and Sánchez de Pablo [89], Prajogo and Sohal's [90], and Subramaniam and Youndt [25].

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