Journal of Innovation & Knowledge 7 (2022) 100244

Journal of Innovation & Knowledge

https://www.journals.elsevier.com/journal-of-innovation-and-knowledge

Green knowledge management: Scale development and validation

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ARTICLE INFO

Article History:
Received 18 February 2022
Accepted 5 August 2022
Available online 18 August 2022

Keywords:
Green knowledge management
Instrument development
Green knowledge acquisition
Green knowledge application
Green knowledge sharing
Green knowledge storage
Green knowledge creation

JEL Codes:
D8
L25
M10
M14
O3

ABSTRACT

Considering a sharp decline in the quality and quantity of natural resources, many organizations are claiming to adopt eco-friendly practices. This study develops and validates the green knowledge management (GKM) scale to understand how effectively firms adhere to GKM practices in their operations. The authors followed a mixed-method approach where interviews with industry experts and an extensive literature review helped researchers develop items for GKM's constructs. It was then followed by empirical validation of the proposed scale by collecting data from the manufacturing and services firms. Twenty-seven items were classified in five dimensions of GKM: green knowledge acquisition, green knowledge sharing, green knowledge storage, green knowledge application, and green knowledge creation. The findings were supported by reliability, convergent and discriminant validity, unidimensionality, and related tests. This research can be considered as the pioneer in the GKM domain that has developed and validated its constructs. It can help researchers get a head start in the GKM field, and research in the green knowledge domain will be aided by this instrument, providing a framework for future research.

Introduction

Knowledge is an intangible and abstract asset free from the tangible world and plays an essential role in the smooth functioning of firms (Fu et al., 2022). Considering the dynamic nature of the business world (Kumari et al., 2021), it is commonly believed that firms that could manage the knowledge embedded in their operations would lead others (Aamir et al., 2021), and failure to do so can overturn the game (Shahzad et al., 2020). Knowledge also has changed the traditional approach to competition (Chamba-Rueda et al., 2021), particularly in the industrial world where natural resources were considered a principal asset (Abbas & Dogan, 2022) and have been replaced it with the intellectual asset (Habib et al., 2019; Pan et al., 2022). For this reason, many researchers have termed the current period an era of knowledge management (KM).

Green knowledge management (GKM) is a novel concept of KM aiming to integrate green or environmental aspects into all dimensions of KM. One of the critical criteria for a firm commitment to GKM practices is how such practices impact organizational green performance and how such practices can benefit the natural environment. In the current globalized market, as recommended by the United Nations, eco-friendly practices and information extend beyond the single organization to all stakeholders (UNDP, 2021). Since GKM is a recent phenomenon, the literature lacks to provide any study that adequately covers all dimensions of KM with a particular focus on the natural environment under one umbrella. The instrument by Darroch (2003) is currently considered the most popular among researchers for KM practices. However, it concentrates only on three dimensions: knowledge dissemination, acquisition, and sensitivity to knowledge scale. Wang et al. (2008) proposed an instrument for KM orientation with four factors: organizational memory, knowledge absorption, knowledge sharing, and knowledge receptivity.

The need for green knowledge has increased significantly based on environmental challenges. The current study aims to shed light on the rarely explored concept of GKM by developing and validating an instrument for GKM by following a mix-method approach where quantitative and qualitative methods are integrated. In the qualitative approach, along with a literature review, interviews were

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https://doi.org/10.1016/j.jik.2022.100244
2444-569X/

conducted, which helped authors understand the five factors of GKM, leading to the development of items. Hinkin's (Hinkin, 1998) guidelines were followed in the quantitative approach to validate the proposed scale. The quantitative data were analyzed following exploratory and confirmatory factor analyses. The proposed instrument is expected to serve as a foundation for future empirical studies relating to GKM. It would also help the related stakeholders, such as organizational leaders and users, evaluate the overall effectiveness of their KM system, specifically concerning the natural environment. The following sections discuss the literature relevant to GKM, explain the study's methodology, analyze the data analysis and result, discuss the results, highlight the implications, and conclude the study.

Review of literature

Knowledge management

Knowledge, entrepreneurship, and innovation have long been recognized as the foundations of economic growth and competitiveness (Piñeiro-Chousa et al., 2020). Particularly new studies highlight the significant impact of combining these factors on the economy, environment, and society, which are the critical components of the United Nations Sustainable Development Goals (UNDP, 2021). These three domains are interlinked and support each other. For instance, knowledge facilitates individuals and organizations to boost their innovation capabilities (Chamba-Rueda et al., 2021). In return, this improved innovation quality helps firms improve their performance (Chaithanapat et al., 2022). Nonaka (1991) stated that organizational emphasis on how they obtain, preserve, transmit, and use knowledge is a key component of organizations' knowledge-based view (KBV) that helps them build their resource-based view. Knowledge, according to KBV, is the most valuable strategic resource an organization can have.

Multiple people have defined KM from different viewpoints; however, definitions by Davenport (1994), Nonaka and Takeuchi (1995), and Bennett and Gabriel (1999) are the most popular in the literature. Davenport (1994) defined KM as a systematic process of acquiring, sharing, and effectively using knowledge. Nonaka and Takeuchi (1995) defined KM as a process through which tacit knowledge is converted into explicit knowledge to flow within the organization freely. Any knowledge that is in written form is termed as explicit knowledge (Abbas & Sağsan, 2019). Such knowledge can be articulated, transferred, verbalized, or codified. Contrarily, tacit knowledge is unwritten and hidden knowledge in people's minds. They further stated that an organization's capacity to effectively execute its operations by reducing rework, speeding up operational activities, and implementing best practices could be improved using KM techniques, which are meticulously planned and implemented. Bennett and Gabriel (1999) linked KM with the firm's acquisition, dissemination, and use of knowledge. Moreover, all components are interrelated and dependent on each other.

To maximize a company's knowledge economy, KM takes a rigorous approach. Information technology, organizational structures, human resources practices, culture, etc., all play their roles (Zbuchea et al., 2019). Numerous frameworks of KM suggest that a structure for KM must have enabling factors and processes. The framework of knowledge must have a clear understanding of operations (Bernal et al., 2022). Organizations' enabling mechanisms to evaluate knowledge utilization continuously are known as KM enablers. In previous research, KM processes have been labeled either exploitative or explorative (Gonzalez & de Melo, 2018; Liu, 2006). In knowledge exploration, activities including research and development (R&D) and knowledge creation are generally referred (Centobelli et al., 2019). R&D activities can create new knowledge through internal firm initiatives known as knowledge creation activities (Chamba-Rueda et al., 2021). This could include developing new content or replacing old material in the organization's knowledge pool (Khan & Abbas, 2022; Li et al., 2018). Some studies have linked knowledge creation to innovation (Alshanty & Emeagwali, 2019; Goyal et al., 2020). On the other side, practices like knowledge application, storage, transfer, and application are all included under the umbrella term of knowledge exploitation (Abubakar et al., 2019).

Green knowledge management

During the preceding few years, the debate about environmental issues has gained much attention. Credit goes to ecologists for their continuous efforts to create awareness about dwindling natural resources (Kumar & Barua, 2022) and the damage caused to the natural environment because of the rapid consumption of resources by businesses worldwide (Lehmann et al., 2022). Because of improved environmental information, there has been increased pressure from stakeholders on the business community concerning the protection of non-human nature and the integration of environmental concerns in their operations and human societies (Abbas, 2020a). With the publication of the United Nations' Brundtland Commission (UN, 1987) report, businesses have started shifting their focus on sustainable development. They are trying to integrate the knowledge pertaining to nature and society into new concepts and theories (Song et al., 2020). Green knowledge is not solely about information relating to a natural condition; it has a broad spectrum of how we should react to that situation and consider following a more sustainable environmental, social, and economic development path.

Since it is an intangible asset, green knowledge cannot be managed like other resources. Firms that fail to systematically study the technical and cultural aspects of GKM experience issues rather than benefits (Zbuchea et al., 2019). Wang et al. (2020) stated that green knowledge is essential for individual and organizational green creative performance. Moreover, individuals' green learning orientation leads to firms' new eco-knowledge, which ultimately results in new ideas, thoughts, and solutions, leading to new products, technology, and services. If a firm wants maximum benefits from GKM, it must execute it as a system by involving all stakeholders so that decisions can be made on what to discard, continue, and improve.

The literature review indicates that GKM can be termed as a system of five components, i.e., green knowledge acquisition, green knowledge storage, green knowledge sharing, green knowledge application, and green knowledge creation. Green knowledge acquisition relates to a firm's acquisition, extraction, and organization of knowledge relating to environmental protection (Aboelmaged & Hashem, 2019). So ecological resources and technology can be enriched to protect the natural environment (Wang et al., 2020). Individuals can acquire knowledge from internal and external channels and relate it to different issues. However, according to Abbas and Sağsan (2019), most workers obtain knowledge from colleagues and team members (internal sources). The acquired knowledge is immediately shared with the relevant authorities or stored for future use. It is evident from the existing literature that when firms learn by creating or acquiring knowledge, they also forget it since they lose the trail of some essential aspects (Maravilhas & Martins, 2019). For this reason, firms must have an efficient mechanism to store knowledge in an organized fashion so that it can easily be retrieved for future use. Some studies, such as Zbuchea et al. (2019), termed this phenomenon as organizational memory, an integral part of effective KM.

An effective KM system facilitates the flow of acquired or stored knowledge. Knowledge flows and grows within the firm since it acts as a connection between knowledge seekers and knowledge providers. Green knowledge sharing is the process of transferring or sharing green knowledge with colleagues, competitors, suppliers, or other stakeholders to develop new methods, technology, tools, and techniques that effectively offset or lessen the harmful effects of business activities on the natural environment (Song et al., 2020). This phenomenon is influenced by several factors, such as human factors, organizational culture, infrastructure and technology, reward and recognition, etc., out of which the human element is the most important (Abbas, 2020a).

Knowledge sharing is linked with knowledge application and enables workers to practice their knowledge. Green knowledge application integrates newly acquired or stored green knowledge in decision making, designing, or delivering environment-friendly products or services (Zbuchea et al., 2019). Through green knowledge applications, firms try to integrate eco-friendly technology and practices in their operations to have zero or minimum negative effects on the environment (Aboelmaged & Hashem, 2019). By applying green knowledge, organizations can introduce novel ideas, processes, and technologies to create a competitive advantage. This relates to Nonaka's (1991) statement that sharing and applying knowledge enables firms to create new knowledge and core competencies. This means knowledge sharing and application are directly related to knowledge creation. Green knowledge creation is the formation of new content, ideas, or thoughts explicitly relating to the environment based on the interaction between tacit and explicit knowledge in an individual, group, or organizational capacity. Since creating new knowledge is essential for green growth and sustainable development, dynamic organizations encourage their employees to share their knowledge to promote a knowledge-creation environment and ensure the availability of adequate resources, such as infrastructure and facilities (Wang, 2019). They also offer non-financial and financial benefits to workers who actively share their knowledge or present unique ideas or solutions (Xie et al., 2019).

Since the prime objective of this research is to develop and validate an instrument for GKM, the following sections explain the steps followed for the said purpose.

Research methodology

Research design

Considering the goal of the current research, the mixed-method technique was adopted. When conducting mixed-methods research, quantitative and qualitative techniques support each other. While qualitative and quantitative research have advantages and disadvantages, mix-method allows for developing a more context-specific instrument by balancing their respective drawbacks (McKim, 2017). An initial literature review and interviews with managers were conducted to enrich the understanding of the five studied factors of GKM. Later, this information was used to draft an instrument for measuring GKM. It was then proofread and refined by the industry and academia experts. After pilot testing, the instrument was finalized, a comprehensive survey was initiated, and the collected data were subjected to different statistical tests, such as normality, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), convergent and convergent and discriminant validity, etc. Finally, an instrument with twenty-seven items was proposed. Fig. 1 shows the scale development steps followed in accordance with Hinkin's (Hinkin, 1998) guidelines.

Data collection method

This study focuses on the managerial and non-managerial staff of services and manufacturing firms located in Turkey. In the beginning, a detailed review of the related literature was conducted, followed by content analysis and comprehensive interviews of 49 manufacturing and services industry experts (33 male and 16 female). This study followed the convenience sampling technique from the non-probability domain. Before signing up, participants were briefed on the study's overall goals, took managers' perceptions of GKM, and tried to understand how they ensure the smooth flow of green knowledge within their firms. All interviews ranged from 17 min 15 s to 32 min 16 s. Moreover, face-to-face sessions were conducted and recorded via a mobile recorder.

Analysis of qualitative data

The respondents provided qualitative information during unstructured interviews. Each question was followed with a "why" or "how" probe to get more information. After contacting 49 participants, it was noticed that their explanations were becoming repetitive and had reached a point of saturation. Thus, the authors stopped gathering more data. The recorded interviews were transcribed and later analyzed through narrative and framework analysis using a deductive reason approach through open-source coding. Abbas (2020a), Abbas et al. (2021), and Pattinson et al. (2017) also adopted a parallel technique in their investigations. The five themes of GKM, namely, green knowledge creation, green knowledge application, green knowledge sharing, green knowledge storage, and green knowledge acquisition, served as the basis for scale development.

Instrument development

Items for the instrument were generated following Hinkin's Hinkin, 1998 recommendations (see Fig. 1). The initial items of the scale were developed based on interviews' findings and content analysis of the related literature. Experts in the field of education reviewed the

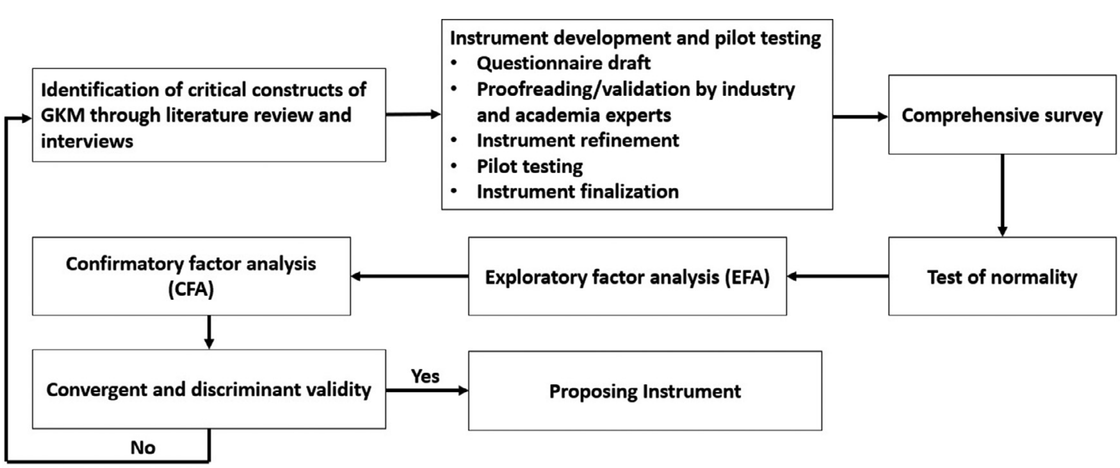

Fig. 1. Steps followed to develop the instrument.

initial questionnaire draft, mainly in the KM and management information system (MIS), and managers of potential respondents' firms for contextual and content validity, and minor language changes were made by considering their comments. There were five to seven items in each dimension. Two sections of instruments were created where 34 items (which were reduced to 27 during EFA, details of which are given in the EFA section) about various aspects of GKM were measured on a seven-point Likert scale (1 representing strongly disagree and seven representing strongly agree). Second, respondents' demographic information was included in this section. The revised questionnaire was pilot tested using 49 responses to ensure internal consistency and contextual accuracy. The initial responses indicated studied constructs' internal consistency ranged from 0.81 to 0.863 and adequately matched Hair et al.'s (2010) minimum suggested value of 0.7. Abbas, (2020b) also followed similar approach in his study.

Questionnaire administration

Based on the pilot test's results, a comprehensive survey was initiated in which manufacturing and services firms were focused on having, or have applied, or aiming to apply for ISO 14001 certificate. The questionnaire was shared with the managerial and non-managerial staff of different firms through self-administration, courier, and e-mail, depending on the preferences of persons by assuming that they would have a critical role in the flow of information throughout their firms. Out of six-hundred and eighty-one (681) distributed questionnaires, three-hundred and eighteen (318) responses were received. However, sixteen responses were incomplete, and three hundred and two (302) responses were found useable for the study. Table 1 contains the demographic details of the respondents.

Data analysis

SPSS v.25 was used to analyze the collected data statistically. The initial data screening initiated the data analysis process to confirm the normality since the abnormal data can reduce variables' correlation. Initially, 14 outliers were screened during the outliers screening process. Subsequently, R^2 presented a value of 0.910, confirming the normality of the data (Abdullah, 2006). Following this, correlation among variables was tested, which helped researchers ensure data appropriateness for supplementary analyses. Visual inspection of the correlation matrix confirmed statistically significant values and disclosed significant correlations at $p = 0.1$.

Hair et al. (2010) said that before performing factor analysis, one must ensure the non-existence of multicollinearity, adequacy of sample size, and common method bias (CMB). The sample adequacy was analyzed through the Kaiser-Meyer-Olkin test (KMO), which indicated a value of 0.897, adequately complying with the 0.6 minimum suggested value by Kaiser and Rice (1974). The variance inflation factor (VIF) helped the authors to examine the multicollinearity aspect, which showed a value of 2.91 and adequately complied with Hair et al.'s (2010) maximum value of 4. Finally, Harman's single factor test facilitated the authors to figure out the CMB issue, indicated 36.72% contribution for a single factor, and fulfilled Podsakoff et al.'s (2012) maximum value of 50% for a single factor. The initial results provided confidence to authors concerning the suitability of data for factor analysis.

Table 1
Demographic profile of respondents.

Particulars	Details	Participants	Percentage
Industry	Manufacturing	139	46.03%
	Services	163	53.97%
Status of Organization	Public	112	37.09%
	Private	166	54.97%
	Semi-Government	24	7.95%
Gender	Male	176	58.28%
	Female	111	36.75%
	Prefer not to disclose	15	4.97%
Years of Experience	Less than 15 years	119	39.40%
	Less than 20 years	154	50.99%
	20 years or above	29	9.60%

Exploratory factor analysis

EFA was carried out after it was confirmed that the data were suitable for factor analysis. The "Varimax" rotation technique was used in conjunction with "principal component analysis." Parallel analyses were performed for scale development using EFA and CFA. Following Hinkin's (Hinkin, 1998) criteria, overall data were divided into two subsamples. EFA was performed to understand the underlying relationship between the studied variables and condense the items. Moreover, items loading 0.4 or above on a single factor and an inter-item correlation of 0.4 or above were retained (Churchill, 1979). Table 2 lists items developed after reviewing the literature and interviewing 49 industry experts. The initial list of items not categorized across KM components was subjected to EFA. During the EFA, seven items were removed, out of which four indicated poor loading, and three represented high cross-loading. The initial screening resulted in the five factors corresponding to the GKM components. The initially screened scale indicated 27 items (five items each for knowledge acquisition, knowledge storage, and knowledge creation, and six for knowledge application and sharing.). The final extracted factors explained 71.191% of the variance and complied with Molina et al.'s (2007) minimum suggested value of 50%. Once the unidimensionality was established, the authors examined the reliability and internal consistency. The Cronbach's alpha (α) indicated a value of 0.892, which effectively complied with Lance et al.'s (2006) minimum suggested value of 0.7.

The EFA of GKM presented five items for green knowledge acquisition, explaining 59.3% of the variance with 0.836 Cronbach's alpha value (see Table 3). The items loading ranged from 0.576 to 0.874. The factor analysis of green knowledge storage explained 60.2% of the variance along with 0.884 Cronbach's alpha value and five items with 0.528 to 0.783-factor loadings. The theme of green knowledge sharing contained six items loading from 0.499 to 0.815. This factor explained 61.3% of the variance with 0.867 Cronbach's alpha value. Similarly, the theme of green knowledge applications presented six items with loading ranging from 0.669 to 0.792. This factor explained 62.2% of the variance and 0.837 Cronbach's alpha value. Finally, green knowledge creation contained five items with loading ranging from 0.556 to 0.641. Moreover, this theme explained 57.1% of the variance and 0.893 Cronbach's alpha value.

Confirmatory factor analysis

Higher-order CFA was performed to ensure that the obtained factorial structure was stable. CFA enables researchers to evaluate the robustness and model fit. The authors performed CFA through AMOS v.25. The chi-square (χ^2) to the degree of freedom indicated a value of 1.722 that meets Bagozzi and Yi's (1988) and Byrne's (1989) ideal values of less than 3 and 2, respectively. The root means square error of approximation (RMSEA) indicated a value of 0.059 and complied with Hair et al.'s (2010) maximum suggested value of 0.08.

Similarly, the calculated standardized root means residual (SRMR) value of 0.0492 proposed the close fit of the model since it efficiently relates to Hu and Bentler's (1998) recommended value of less than 0.1. The other model fit indices values, such as goodness of fit index (GFI), adjusted goodness of fit index (AGFI), normative fit index (NFI), comparative fit index (CFI), and Tucker-Lewis's index, were also found just close to the recommended value. The details of these

Table 2
Proposed instrument, items loading, and factors loading.

Particulars	Items Loading
Knowledge Acquisition	
My organization regularly acquires information about environment-friendly products and processes/services from external stakeholders (e.g., customers and suppliers)	0.663
My organization regularly acquires information about environment-friendly products and processes/services from internal stakeholders (e.g., management and staff)	0.576
My organization regularly arranges training sessions for employees to develop their knowledge about environment-friendly products and processes/services	0.742
We have a well-developed information system through which employees can acquire the required information	0.874
My organization encourages and supports the employees to acquire knowledge about environment-friendly products and processes/services	0.676
Knowledge Storage	
My organization has sufficient information about environment-friendly products and processes/services	0.775
We have an excellent information system to manage information regarding environment-friendly products and processes/services	0.683
It is easy to retrieve information about a specific problem from our information system	0.783
We have comprehensive information about our competitors and the impact of their operations on the natural environment	0.528
Even if any person leaves, our information system keeps their best knowledge	0.714
Knowledge Sharing	
People within our organization regularly interact with each other to discuss different environmental developments and share knowledge	0.584
We have a well-organized system through which we can share knowledge and learn from each other	0.687
We are provided with the latest equipment and technology to obtain and share the knowledge	0.815
My organization recognizes and rewards the employees sharing innovative ideas and information to improve the process for the protection of the natural environment	0.506
My organization regularly share the latest environmental knowledge and market trends with its employees through e-mail, training sessions, and workshops	0.499
We regularly share information and knowledge related to the natural environment with our customers, suppliers, and other stakeholders	0.675
Knowledge Application	
My organization fully comply with environmental regulations in its operations	0.739
My organization ensures the application of acquired knowledge to produce environment-friendly products and services	0.693
We use the knowledge obtained from our experiences and mistakes to improve our environmental performance	0.669
We use the acquired knowledge to develop our environment-friendly business strategies	0.792
We have strong commitments to implementing environment-friendly strategies	0.783
Knowledge Creation	
My organization uses existing information to create environment-friendly products and services	0.567
The management encourages debates and discussions to create new knowledge	0.556
Employees proposing new ideas, knowledge, and solutions are highly appreciated and rewarded by the management	0.641
We use to collaborate with other firms to create environment-friendly products or processes/services	0.592
We regularly evaluate new ideas for further refinement	0.602

indices are given in Table 4. Considering the results of these model-fit indices, it can be said that the studied model indicated an admirable fit to the data (Bagozzi & Yi, 1988; Hair et al., 2010).

Using discriminant and convergent validity, constructs' validity was studied. Convergent validity represents how a scale correlates with other scales measuring similar constructs (Churchill, 1979). All the five studied dimensions of GKM were found to correlate adequately, representing the existence of convergent validity. The discriminant validity was performed to ensure that the scale sufficiently differs from other scales. It was examined using Fornell and Larcker's (1981) criteria (see Table 5), which adequately confirmed the discriminant validity. Based on EFA, CFA, reliability, validity, and unidimensionality tests' findings, it is confidently said that the scale sufficiently meets the standard criteria for offering the instrument. Fig. 2 represents the confirmatory relationship between five factors corresponding to GKM and item loading.

Table 3
Reliability and validity of instrument.

Dimensions	# of Items	Cronbach's alpha[*a]	Items Loading Range	Average Variance Explained[*b]
Knowledge Acquisition	5	0.836	0.576–0.874	0.593
Knowledge Storage	5	0.884	0.528–0.783	0.602
Knowledge Sharing	6	0.867	0.499–0.815	0.613
Knowledge Application	6	0.837	0.669–0.792	0.622
Knowledge Creation	5	0.893	0.556–0.641	0.571

[*a] Cronbach's alpha value should be higher than 0.7 (Lance et al., 2006).
[*b] Average variance explained value should be higher than 0.5 (Molina et al., 2007).

Discussing the results

KM has gained wide attention in the industrial world and has been essential in designing new strategies and developing compelling products and services (Abbas & Kumari, 2021). It promotes excellence in organizational and operational processes (Antunes, de & Pinheiro, 2020). Considering environmental challenges mainly caused by industrial activities, the need for green operations and products has increased significantly. This study aimed to develop and validate an instrument that can measure GKM practices in organizations. Managers and non-managerial operational staff have a key stake in information, knowledge, and management. For the current study, their interviews were conducted to learn more about their points of view and perceptions of the topic.

The sphere of green knowledge acquisition contained five items. Sample items include: "My organization regularly acquires information about environment-friendly products and processes/services from external stakeholders (e.g., customers and suppliers)"; "My organization encourages and supports the employees to acquire knowledge about environment-friendly products and processes/services"; "My organization regularly arranges training sessions for employees to develop their knowledge about environment-friendly products and processes/services.". Items in this factor mainly focused on sources and mechanisms of knowledge acquisition by employees within and outside their organization. The study by Darroch (2003) and Abbas and Kumari (2021) also had similar items for knowledge acquisition. However, they investigated KM from a general perspective and ignored the green aspect. This sphere suggests that firms must pay attention to acquiring eco-friendly knowledge to counter the environmental degradation aspect. Organizational structure should enable employees to acquire pro-environmental knowledge from internal and external aspects. The newly acquired knowledge should be appraised objectively so that a clear understanding of the material can be created and the new information can be integrated into the framework of existing knowledge.

Similar to knowledge acquisition, the green knowledge storage theme contained five items. Sample items include: "My organization has sufficient information about environment-friendly products and processes/services"; "It is easy to retrieve information about a specific problem from our information system."; "We have an excellent information system to manage information regarding environment-friendly products and processes/services." This sphere relates to the "knowledge codification and storage" factor Lee and Wong (2015) mentioned in their study focusing on developing KM performance

Table 4
Confirmatory factor analysis results.

Particulars	χ^2/df	GFI	NFI	TLI	AGFI	CFI	SRMR	RMSEA
Recommended Values	≤3[a]	≥0.9[b]	≥0.9[b]	≥0.9[b]	≥0.9[b]	≥0.9[b]	≤0.8[c]	≤0.08[d]
Current study values	1.722	0.922	0.906	0.915	0.918	0.919	0.0492	0.059

Notes A: $\chi 2$/df: Chi-square to degree of freedom, GFI: Goodness of fit index, NFI: Normative fit index, TLI: Tucker-Lewis's index, AGFI: Adjusted goodness of fit index, CFI: Comparative fit index, RMSEA: Root mean square error of approximation, SRMR: Standardized root mean residual.
Notes B: [a]Bagozzi and Yi (1988), [b]Byrne (1989) and Bentler and Bonett (1980), [c]L. Hu and Bentler (1998), Hair et al. (2010).

Table 5
Discriminant validity.

Dimension	Knowledge Acquisition	Knowledge Storage	Knowledge Sharing	Knowledge Application	Knowledge Creation
Knowledge Acquisition	**0.77**				
Knowledge Storage	0.626	**0.776**			
Knowledge Sharing	0.593	0.621	**0.783**		
Knowledge Application	0.558	0.559	0.656	**0.789**	
Knowledge Creation	0.622	0.663	0.613	0.611	***0.756***

measurement. This domain suggests that once a firm has acquired green knowledge, it must have an effective system to store, retrieve and use it whenever required.

The green knowledge-sharing dimension contained six items. Sample items include: "People within our organization regularly interact with each other to discuss different environmental developments and share knowledge"; "We have a well-organized system through which we can share knowledge and learn from each other"; "My organization regularly shares the latest environmental knowledge and market trends with its employees through e-mail, training sessions, and workshops." This sphere relates to Song et al.'s (2020) study highlighting the importance of green knowledge sharing for green innovation. In their study, Lee and Wong (2015) termed this dimension as knowledge transfer and sharing. Items in this theme focused on tools, methods, policies, and practices at individual and organizational levels for sharing environment-friendly knowledge to achieve environmental sustainability goals. Knowledge sharing facilitates a multidirectional flow of knowledge and activates tacit knowledge, which is essential for knowledge appraisal and reception.

Similarly, the theme of green knowledge applications presented six items. Sample items include: "My organization ensures the application of acquired knowledge to produce environment-friendly products and services."; "We use the knowledge obtained from our experiences and mistakes to improve our environmental performance"; "We use the acquired knowledge to develop our environment-friendly business strategies." The items of this sphere match with Lee and Wong's (2015) dimension, i.e., knowledge application and utilization. Businesses can enjoy a long-term competitive advantage by applying knowledge to new and vastly improved services and products, organizational production activities, practices, and innovation. Firms can take green knowledge application as a strategic tool that can strengthen their abilities to perform better than their competitors from an environmental perspective and enjoy more loyal customers (Contreras-Barraza et al., 2021).

Finally, green knowledge creation contained five items. The sample items include: "My organization uses existing information to create environment-friendly products and services"; "We use to collaborate with other firms to create environment-friendly products or processes/services"; "We regularly evaluate new ideas for further refinement." Items in this sphere relate to Heeseok and Byounggu's (2003) and Lee and Wong's (2015) studies. They highlighted the importance of creating new knowledge in achieving competitive advantage and smooth functioning of the organizations. Businesses can enjoy a long-term competitive edge by applying knowledge to new and vastly improved services and products, organizational production activities, practices, and innovation (Ode & Ayavoo, 2020). For this reason, many organizations take it as a strategic tool that strengthens their abilities to perform better than their competitors (Contreras-Barraza et al., 2021).

This systematically constructed and validated GKM construct can serve as a basis for researchers examining the effects of GKM on enhancing core competencies and green performance. Numerous theoretical works emphasize the significance of the environmental performance. However, progress has been hampered by inadequate scale for a company's GKM operations. Studies by Darroch (Darroch, 2003) and Lee and Wong (2015) have sought to address KM processes systematically; nevertheless, their work focused on KM from a general perspective. In this work, the model fit of the GKM scale was investigated and reported systematically. In addition, the authors adhere to the advanced scaling approach suggested by Hinking (1998), and the results of scale dimensionality, reliability, and validity were satisfactory, giving a solid foundation for future research. In addition, the GKM scale can motivate future research to develop alternative metrics for GKM or revalidate the GKM scale in various industry or organizational contexts.

Conclusion

In the current dynamic business environment, businesses are encountering multiple challenges. Customers are more informed about products' attributes and substitutes; firms are experiencing increasing competition, environmental degradation issues force firms to follow environment-friendly practices, etc. These elements have significantly increased the importance of pro-environmental and knowledge-based activities. This study focuses on integrating KM concepts with environmental concerns and is among the pioneer studies establishing an instrument that concentrates explicitly on organizational knowledge-based pro-environmental activities. Following a holistic approach where qualitative and quantitative techniques support each other, a five-factor instrument for GKM is proposed with twenty-seven items.

The model of GKM can provide managers and practitioners with detailed guidelines on how to implement an effective GKM system. Organizations can use it as a checklist to ensure nothing is overlooked when creating their green measurement model. It is difficult to improve if errors and weaknesses are not identified. Therefore, businesses committed to environmental protection and promotion must use a sound model to evaluate their GKM performance, providing accurate and constructive information on what should be continued, improved, or discarded to implement GKM systems. On the other hand, this paper can help researchers get a head start in this field. Research in the green knowledge domain will be aided by this instrument, which provides a framework for future research.

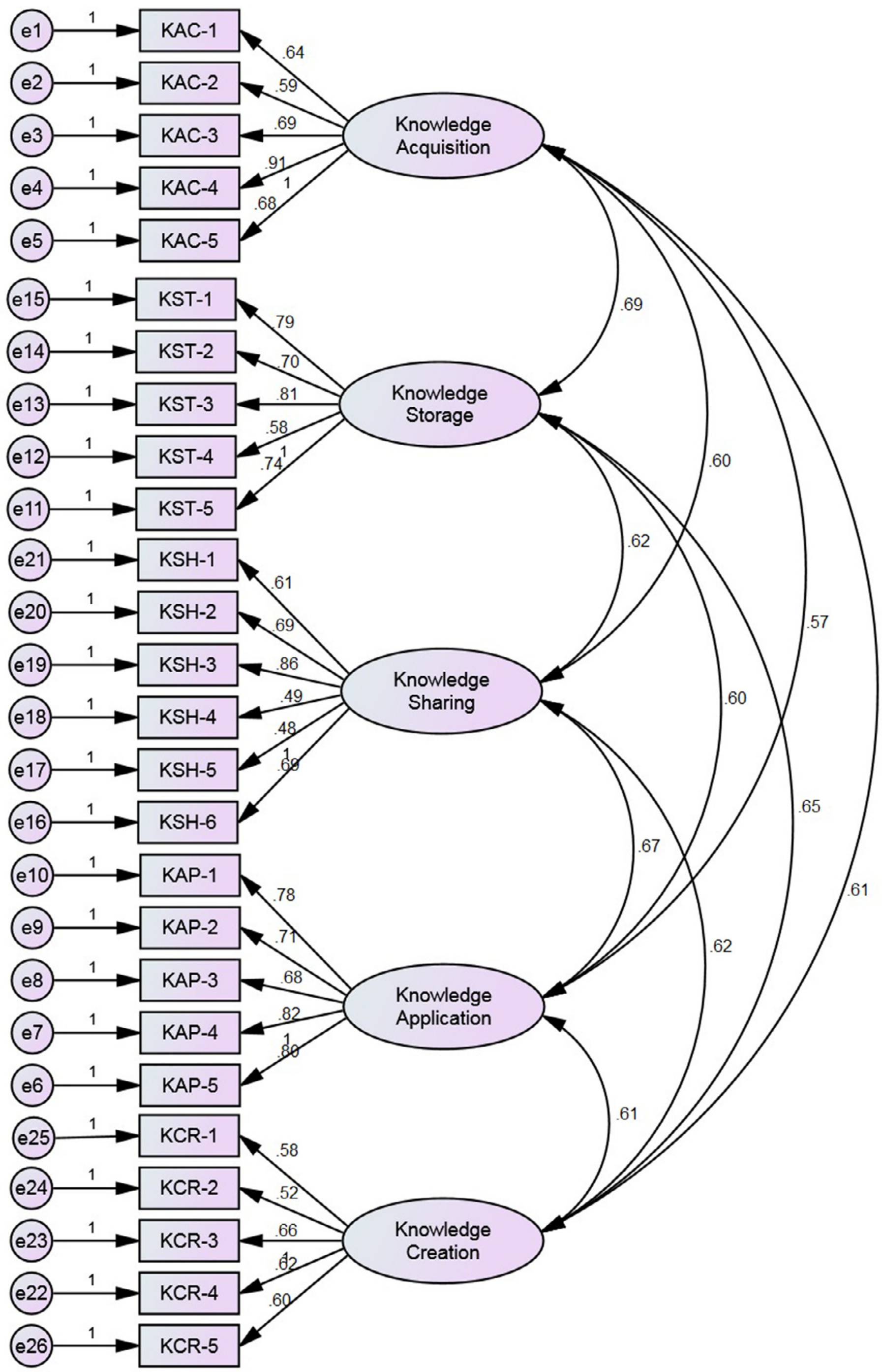

Fig. 2. Confirmatory factor analysis.

This study also has a few limitations. For instance, the authors focused only on manufacturing and services firms located within Turkey for the current research. Future studies should expand the scope of this model by validating this instrument in other regions. Researchers also suggest investigating the GKM relationship with variables such as green innovation, economic performance, environmental recovery, etc. This research also has a limited sample of 302 operationalized responses. More robust analyses can be performed in future studies by increasing the sample size.

Declaration of Competing Interest

The author declares no conflict of interest

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