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RESEARCH ARTICLE

Mechanism of knowledge management process towards minimizing manufacturing risk under green technology implementation: an empirical assessment

Sajjad Alam[1] · Jianhua Zhang[1] · Naveed Khan[2] · Ahmad Ali[3]

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Abstract
Given the critical importance of green technology implementation (GTI) is important for production process improvement and an eco-friendly environment. The present study investigates the connection between GTI and the knowledge management (KM) process to minimize manufacturing risk. This research also validates that an assured combination of green implementation and KM can lead to minimizing manufacturing risk. The sample data (153) was taken from those manufacturing companies that utilize green technologies. Smart PLS 3.2.9 analyzes the relationship between certain variables of GTI and the KM process. Furthermore, fuzzy set qualitative comparative analysis (fsQCA) is used for a combined configurational approach to examine manufacturing risk minimization. The study's outcome validated that green implementation positively correlated with KM to minimize production risk. fsQCA approach, KM, and green implementation outcome indicated that production risks are minimized. This study contributes to bridging research gaps in the literature and advances understanding of the interrelationship between green implementation and KM processes to minimize manufacturing risk. In addition, research is vital to combine direct and configurational methodologies to highlight two distinct facets of green implementation and the KM process for minimizing manufacturing risk.

Keywords Green technology implementation · Knowledge management process · Minimizing risk · Manufacturing process

Introduction

Since the globalization of industrial society, economic development and growth of traditional manufacturing civilizations around the globe have brought negative environmental effects. The industrial society and ecological system lead to a sharp contradiction between humans and the environment. Deprived management, low-level resources, and a polluting environment have endangered human life and created manufacturing problems. However, in the landscape of business-changing environments, such as technological development, globalization, and reshaping the business atmosphere, manufacturing firms have pressure from society to adopt emerging sustainability technologies to minimize manufacturing substances (Alam et al. 2022). To minimize manufacturing disruption, sharing knowledge processes regarding limitations in the right place and time reduces manufacturing risks. Therefore, the industrial civilization's set of thinking and rigid mode of application should be abandoned. In this scenario, manufacturing firms are deeply interested in sustainable technologies to reduce waste, create

Responsible Editor: Arshian Sharif

✉ Sajjad Alam
Sajjadalam01@yahoo.com

Jianhua Zhang
tjzhangjianhua@163.com

Naveed Khan
naveedkhan@hanyang.ac.kr

Ahmad Ali
aali_forever@hotmail.com

1 School of Management, Zhengzhou University, Zhengzhou, China

2 School of Business Administration, Hanyang University, Seoul, South Korea

3 School of Electronics and Information Engineering, Hebei University of Technology, Tianjin, China

a friendly environment, and generate more energy to produce manufacturing goods (Huiling and Dan 2020). Sustainable green adoption should construct an eco-friendly environment that does not jeopardize employee life and manufacturing quality. To solve the environmental snags affected by rapid economic growth, the government and society must build sustainable industries with ecological technologies (Zeng et al. 2021). In this construct, the researcher enthusiastically examines whether there is any connection between green technology implementation (GTI) and sharing knowledge management (KM) process to minimize manufacturing risk.

Although, the GTI and risk process focuses on opportunities and risks that align with the manufacturing strategies in the social, environmental, and governance (Manab and Aziz 2019). With government and regulatory compliance in corporate requirements, most manufacturing firms have started implementing green technology in risk management (Aziz et al. 2016). The successful implementation of green technology with risk management requires knowledge to understand risk in the early stage of the manufacturing process (Manab and Aziz 2019). The KM process supports GTI practices that handle green innovation challenges (Shahzad et al. 2020). KM process helps manufacturing firms control emerging risks (Rodriguez and Edwards 2014). Banks E (2012) identified the risk culture, which reflects the inner sensibility of employees' regular thoughts and actions. This cultural risk can be minimized through knowledge sharing. Risk identification cultural gaps are getting broader with overlooked emerging risks and other non-quantifiable ones in manufacturing firms. Hence, the substantial risk gaps may affect the survival of an employee in the manufacturing firm (Althonayan et al. 2011). Knowledge sharing plays a vital role in controlling risk and providing a better understanding to address the risk associated with environmental complexities in manufacturing firms (Hsu et al. 2014). Risk-taking on an individual basis typically fails to anticipate those risks that create uncertainty in manufacturing firms (Butler et al. 2011).

Nevertheless, the connection between green technology and the KM approaches towards minimizing manufacturing risks in the production department to the dictated primary need for investigation on such association to provide a new outcome. Therefore, few researchers have investigated such a link. The question is how this study is different from others or added to past literature. The scholar studied green technology and KM approaches from different perspectives; attention has been paid inadequately to examining GTI impacts associated with the KM process to minimize manufacturing risk. Although, such a connection has been neglected in past studies. The present study examines the green process related to minimizing manufacturing risk based on improving employee knowledge efficiency in the production process. Various scholars examined such connections between KM and the green process in the recent past. In this construct, Caglar and Ulug (2022) focused on the role of government and energy efficiency R&D budgets in the green transformation process. The study by Liu and Nie (2022) investigated the mechanism of green technology innovation and environmental regulation of green finance by coupling coordination. Moreover, the study by Caglar et al. (2022), a sustainable environment development plan for BRICS, examines the asymmetric effect of natural resources on CO_2.

Although, the lack of theoretical and empirical research based on KM and the green adoption to minimize manufacturing risk is more significant for policymakers and experts. In this connection, the current approach addresses intended theoretical gaps to develop the concept of minimizing manufacturing risk in developing countries. Prior literature highlighted risk identification in the different sectors, which allows me to examine manufacturing risk under green implementation. The current paper addresses the GTI and KM process gap to analyze manufacturing risk. Moreover, the present study combined various dimensions of green technology with the knowledge process to improve employee knowledge efficiency to reduce manufacturing risk. Therefore, the key objective of this research numerous dimensions of GTI (communication, learning, environmental, managerial green network) linking with KM (acquisition, sharing, utilization) process that could improve employee knowledge efficiency to minimize manufacturing risk. These variables are selected because they are primarily associated with prior literature and the manufacturing industry. Under this enthusiasm, the goals of this research are twofold. First, analysis of the green adoption and KM approaches that may validate effective communication to improve multi-tier employees enable a manufacturing process to decrease manufacturing risk. The second one is to recognize a specific measurement that emphasizes the inter-manufacturing learning process that may improve employee knowledge efficiency to curtail production risk. Thirdly, this study is founded on a resource-based view and KM theory that provides a lens for minimizing production risk based on enlightening employee knowledge influence. To highlight the specific objective of this work is a set of the following research question.

RQ1. The GTI (green communication, green learning, green environment, green managerial) affects the KM process (a) acquisition, (b) sharing, (c) and utilization in the production houses to minimize manufacturing risk.
RQ2. Is there a direct effect on the KM process (acquisition, sharing, and utilization) increasing the knowledge efficiency of employees to minimize production risk (KMMR)?
RQ3. What are numerous pathways to increase employee knowledge efficiency to minimize manufacturing risk(KMMR)?

However, the researcher employed a combined technique to analyze the study goals. The existing research applied a combined approach of structural equation modelling (SEM) and fuzzy set qualitative comparative analysis (fsQCA) to investigate empirical data. The SEM is employed for the green implementation process with KM approaches. The fsQCA will be applied for a combined approach to investigate the green and KM processes to minimize manufacturing risk in production firms. The asymmetric technique (fsQCA) is a method that explores patterns statically that are not covered by the symmetric method (Douglas and Prentice 2019). The finding of fsQCA will provide a better understanding of the complete model for management to assist in identifying causal instruction that successfully primes to improve outcomes (Olya and Akhshik 2019). The net outcome model provides individuals' effects and how the different discounting combinations of factors could lead to a better result. Understanding grouping conditions (green communication process, green learning process, green environmental process, green managerial process) leads to an enhanced knowledge process (acquisition, sharing, and utilization), which has better consequences in the production industry in terms of minimizing manufacturing risk.

Literature review and hypothesis development

The present study pursues the framework based on (1) a resource-based view (RBV) and (2) a KM capability model to illustrate the connection between GTI and KM to minimize the manufacturing risk in the production houses. The RBV and KM model in manufacturing firms may improve (communication, organizational learning, green environment, and managerial network) with KM (acquisition, sharing, and utilization) processes to increase the knowledge efficiency of the employee to KMMR. Figure 1 illustrates the study outline.

RBV theory and green environment

In the recent past, the resource-based organization view (RBV) theory was initially developed for manufacturing firms to focus on the strategic management of internal weaknesses and strengths and their relationship with performance and competitiveness (Barney et al. 2011). The RBV theory can help to understand how manufacturing resources are utilized to improve production and efficiency (Savino and Shafiq 2018). The RBV theory suggests that manufacturing firms increase their competitive environment by adopting different dynamic resources (intangible and tangible). These resources refer to all tools, skills, knowledge, organizational attributes, and information enabling manufacturing firms to implement strategies that increase efficiency and production effectiveness (Barney 1991; Rehman et al. 2022). Moreover, Barney (1991) highlighted these resources as being physiognomic VRIN; (a) valuable, (b) rare, (c) inimitable, and (d) non-substitutable. The RBV theory, on the other hand, is constrained to delineate firm-level consequences and the impacts of green technology practices on environmental and green performance (Andersén 2021; Bresciani et al. 2022a, b). In this connection, Hart, (1995) responded to RBV theory and extended (NRBV) boundaries with RBV and recognized the significance of the environment and competitive theory advantage based on the manufacturing firm's association with the natural environment (Bresciani et al. 2022a, b; Rehman et al. 2021). Environmentalists and

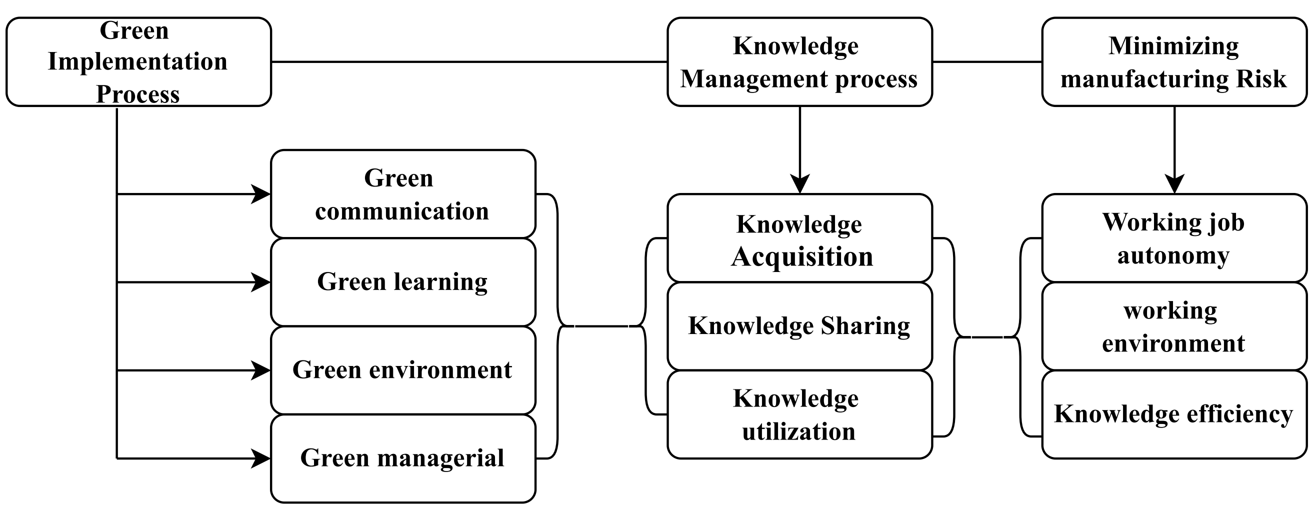

Fig. 1 Research outline

ecologists have suggested that a green culture can make manufacturing firms more affluent and increase their long-term success by implementing an NRBV (Akram et al. 2022; Shahzad et al. 2020). Hence, in the logic, if manufacturing firms adopt RBV appropriately, they improve the economy and manufacturing and minimize system failure or risk.

Correspondingly, KM resources as a dynamic force for the financial growth of manufacturing firms. Manufacturing firms spawned a knowledge-based view of the organization (Mills and Smith 2011). The competitiveness assets are determined by its ability to assimilate specific knowledge resources, which can be utilized to improve core competencies to develop sustainable and green business performance (Abbas and Sağsan 2019). The knowledge-based economy relying on green adoption and KM is the right direction towards a green culture. In this aspect, corporate green adoption improves national growth by implementing the principle of regeneration and redesigning the natural system (Awan et al. 2020). The RBV theory supports manufacturing firms' green culture with KM processes to improve green production. Recent studies suggest that sustainable green implementation with the KM process helps manufacturing firms develop green products and has minor environmental impacts. In this construct, if production companies used resources according to RBV theory and utilized knowledge resources at the right time and place, then firms improve performance.

Green communication process

Green communication technologies play a crucial role in daily life activities. Communication energy-efficient technologies are mainly developed to address the environmental impacts of traditional communication networks and systems. The green implementation process eliminates the negative influence on the operational environment (Fernando et al. 2019). In this line, Sahay and Bharti (2021) highlighted that the green communication market has been improving recently. They studied that, according to government regulations, green communication is mandatory to reduce electronic waste. Using green communication technologies increases the value of green products and maintains a strong position in the competitive market. Moreover, green communication is most suitable for energy-efficient communication to minimize resources in the different communication sectors (Sahay and Bharti 2021). Green communication's overall objectivity is to fulfill smart cities and sustainability. It would improve the quality of life, save the natural environment, and create economic and social growth (Casini 2017). Green communication helps the business in two directions. Green communication reduces the consumption and operating cost of manufacturing firms. Furthermore, the communication process improves to maximize the energy speed in the monitoring to save power consumption in manufacturing firms (Sahay and Bharti 2021). The positive construct of green communication is further utilized in the manufacturing process to investigate production risk minimization. Hence, the study uses green communication, and KM processes could increase employee knowledge efficiency to minimize manufacturing risk. Therefore, the study proposed hypotheses to investigate the minimizing the risk.

H1. Under the technology implementation, green communication process has a significant impact on the knowledge management (KM) process on (a) acquisition, (b) sharing, and (c) utilization to minimize manufacturing risk.

Green learning process

The green learning process and KM research studies are still pintsize. The present study still needs to address the green learning and KM process to minimize manufacturing risk. In manufacturing firms, learning orientation has explored the effect on ambidextrous innovation (Sheng and Chien 2016). Firms should simultaneously focus on exploratory and exploitative green innovation to engage and meet environmental challenges. The exploitative green innovation is applying existing knowledge of environmental abilities and processes to improve green design and products (Chen et al. 2014). The exploratory green innovation focuses on new information about environmental knowledge, skills, and processes to create a green product and market. Green learning is the shared value of managing manufacturing firms in acquiring green knowledge (D'Angelo and Presutti 2019). It embodies the manufacturing firm's commitment and facilitates green innovation in the following ways. The shared green learning influences the manufacturing firm's right direction of employee attitude towards acquiring new tools and skills (Huang and Li 2017) and promotes employee enthusiasm and initiative in green innovation participation (Chen et al. 2020). Green learning tends to examine environmental changes, and employees can encourage proactive thinking (Nasution et al. 2011). Green learning has a solid orientation to green manufacturing identity, reinforcing the manufacturing firm's environmental vision (Song et al. 2019). Green learning assimilates environmental knowledge about customers and the market to facilitate manufacturing firms' exploitation of green innovation. In this logic, the current study utilized a connection of green learning and the KM process with new novel thoughts to nurture exploratory minimizing manufacturing risk. Hence, in this connection, the following hypothesis is put forward.

H2. Under the technology implementation, green learning has a significant impact on the Knowledge management (KM) process (a) acquisition, (b) sharing, and (c) utilization to minimize manufacturing risk.

Green environmental process

A green environmental process is vital for businesses to realize ecological development (De Marchi and Grandinetti 2013). It means explicating or applying the new production process in manufacturing firms to reduce pollution with relevant dynamics (Inoue et al. 2013). The study focuses on green environmental KM drivers to increase employee knowledge efficiency and minimize manufacturing risk. The past literature suggests that green corporate environmental attention in manufacturing firms is based on external and internal factors; its established institutional environment and financial resources influence green environmental responsibility and process (Falavigna and Ippoliti 2022; Huang and Lei 2021). The study by Tucker (2007) highlighted that process improvement is redesigning work schedules with the systematic participation of frontline employees. Green process research identified by several scholars has shown that organizational initiatives in process improvement are connected to upgraded manufacturing firm performance (Jacobs et al. 2015). Caglar's (2022) study highlighted that green environmental processes improve financial development and environmental quality. Numerous scholars have investigated that government regulation and stakeholder pressure trigger manufacturing firms to improve the production process (Guo et al. 2019). A researcher has identified green environmental technology forms, such as pollution control, production, eco-friendly prevention, pollution prevention, and recirculation (Xing et al. 2019). The green environment and KM process mechanisms are further analyzed to examine manufacturing risk-minimizing in the production houses. In this linking, the current study put forward the hypothesis:

H3. Under the technology implementation, (Green environmental performance) has a significant impact on the Knowledge management (KM) process (a) acquisition, (b) sharing, and (c) utilization to minimize risk.

Green managerial process

Green environmental awareness needs high-level green consciousness that embodies life, ethics, values, and ecological necessities (Yang and Liu 2021). The corporate managerial process with green consumption realizes that strategic cooperative behaviors may involve environmental issues (Xue and Yi 2016). They studied the production and development of green products for environmental protection in achieving the dual purpose of being environmentally clean and maintaining the social image of sustainable development. In this appearance, corporate managerial green environmental awareness and strategic intelligence have been enhanced recently. The narrative of the word green environment alarms for environmental conversion and health. The researcher believes that business managers with green environmental awareness processes tend to adhere the active provision and an open, enlightened attitude (Yang and Liu 2021). It helps manufacturing firms to integrate information resources, engrosses the knowledge to assist green technology innovation, and actively endorses the formation and implementation of products with green innovation strategies. The green environmental awareness of the managerial process encourages manufacturing firms to have a solid sense of environmental responsibility, encourages the manufacturing firms to develop an awareness of the environment, environmental governance, and protection, and promotes the development of green technology manufacturing innovation from outside and inside (Gao et al. 2020a, 2020b). In this scenario, the current study investigates the green managerial process and KM approaches to minimize manufacturing risk in the production process. Hence hypothesis put forward:

H4. Under the technology implementation, green managerial process has a significant impact on the knowledge management (KM) process (a) acquisition, (b) sharing, and (c) utilization.

KM process and minimizing manufacturing risk

The theory of the knowledge-based view largely depends on manufacturing firms' resource-based view to incorporate knowledge assets that are crucial and unique and have an inadequacy in nature (Grant 1996). However, manufacturing risk management is typically grounded in the classical decision theory, where risk is the macro-level that reflects the variety of possible outcomes, such as likelihoods and their particular values (March and Shapira 1987). Knowledge sharing can increase objectivity through proper training for each individual to proceed with risk indexes in the same way and provide better understanding and tools for the nature of risk in each individual (Massingham 2010). The study of Zainuddin et al. 2022b, a examines operational risk management more conscious in the business process due to the COVID-19 pandemic. They studied the black box of risk management practices and well behavior of management officers, executives and monitored the risk process. Operational risk management processes are examined in the organizational practices in the Malaysian enterprise (Zainuddin et al. 2022a, b). They examined strong leadership and external consultants' diagnostic and measured the risk culture process. Risk information and knowledge are important indicators of environmental and health risks. The study by Ahmad et al. 2019 examines the lack of technical knowledge and information related to pesticide use based on environmental and health risks. Moreover, El Khatib and Ali (2022) examine knowledge risk, organizational performance, and sustainability. The study outcome indicated that knowledge risk reduces the sustainability of firms. Organizational performance mediates the association between sustainability and risk in manufacturing firms. Knowledge risk management's effect on organizational performance, innovativeness, sustainability, and agility are tested by Durst et al. 2019. The outcome showed that knowledge risk management positively affects organizational success, such as sustainability, innovativeness, growth, and agility.

Knowledge sharing plays a crucial role in minimizing new risks and providing a better understanding of addressing risk in terms of environmental complexity in manufacturing firms (Hsu et al. 2014). The risk judgment on an individual basis typically fails to anticipate those hazards, which creates ambiguity (Butler et al. 2011). The environmental complexity problem manifests in individuals not knowing enough about the risk to anticipate its probability and consequence. The environmental difficulty generates uncertainty in manufacturing firms. The proper knowledge sharing with individuals along the spectrum of ambiguity towards certainty makes risk a learnable rather than a completely random event (Alam et al. 2019). The stakeholder demand from manufacturing firms takes responsibility for the incredible impacts on their operations, environment, and society (Manab and Aziz 2019). Despite such concern, few studies claim that social risk management, which is an extension of enterprise risk management approaches, may help manufacturing firms address the growing green and environmental risk that affects the company's survival (Alam et al. 2019). The study by Lai et al. (2013) investigated the KM's role in integrating the green environment and enterprise resources management process. They studied that an effective KM process helps manufacturing firms gain a green solid competitive advantage and react to impending risks in the external environment. Indeed, manufacturing firms can achieve long-term business success by implementing KM approaches in the production process to meet the expectation of stakeholders. Hence, it can be concluded from existing literature that KM is crucial for manufacturing firms to survive in a long-run business environment (Palermo et al. 2017). The current study investigates the knowledge-sharing process in manufacturing firms to improve employee knowledge efficiency to minimize manufacturing risk. Therefore, such connections are tested to examine KM and GTI in manufacturing companies.

H5. A. The knowledge management process (acquisition) significantly affects the knowledge efficiency of an employee to minimize manufacturing risk.

H5. B. The knowledge management process (sharing) significantly affects the knowledge efficiency of an employee to minimize manufacturing risk.

H5. C. The knowledge management process (utilization) significantly affects the knowledge efficiency of an employee to minimize manufacturing risk.

Asymmetric modelling

The measuring of direct association of green implementation process, KM, through an asymmetric technique using fcQCA. Researchers investigate different causal relationships through green implementation and KM processes that improve employee knowledge efficiency to minimize manufacturing risk. The pattern of fcQCA lies beyond applying the linear additive method, and the precision of fcQCA is bettered than the linear additive approach (de Rooij et al. 2019). Investigation of fcQCA is a crucial factor according to knowledge literature. The fcQCA loosens trajectory, which helps to determine the configuration of possible outcomes. The consequence of fcQCA identifies simultaneously to see whether the factors are fruitful, unfavorable, or immaterial towards the efficiency of employees' knowledge to minimize manufacturing risks. In this connection, it is expected that much of a diverse set of factors increase employee knowledge efficiency to minimize manufacturing risk. All drivers have an essential role in allowing management to configure desired outcomes in the manufacturing process. The fcQCA outcome will provide a clear picture of the net outcome of equifinality. Hence this point, researchers put forward the hypothesis:

H6. A varied combination of GTI (communication, learning, environmental, managerial) and KM process (acquisition, sharing, utilization) is associated with increased knowledge efficiency of employees to minimize manufacturing risk.

Material and methods

The public and private listed manufacturing firms in Zhengzhou City are connected to participating in existing research. The public and private firms perform a critical role in the day-to-day business activities in the production houses. The examination is superfluous to improve addition, and their perspective will bid crucial understanding into the research construct. The collection of data applied the survey method. The convenience sampling method is employed, and the researcher broadly used it in knowledge studies for higher response. The 250 questionnaires were distributed in the production houses. The number of questionnaires received was 168 from manufacturing houses; 14 incomplete questionnaires were discarded, which ticked feedback of 62%. The questionnaire's target personnel are administration staff and manufacturing house employees. The design of the questionnaire followed up the forward and back-translation procedure. After that, forwarded to expert personnel in the field of KM and green technologies.

Common method variance bias

The most significant concern in questionnaire study is common method variance (CMV) bais. There is a possibility in the data regarding CBM issues or problems in the survey (Elrehail et al. 2021; Kraus et al. 2020). This problem occurred when survey data were taken from a single source (Patwary et al. 2022; Sun et al. 2022). We used SPSS IBM 25 to examine the "Harman single-factor test," as (Harman 1976) suggested. To examine the existence of CMV among constructs. The outcome computed based on principal axis factoring, and extraction technique has shown 37 unique factors. The analysis accounted that 40.122% is less than 40% (Kraus et al. 2020). Moreover, we also examine the collinearity test (VIF) (Muhammad et al. 2021) run in the Smart PLS 3.2.9. All the VIF scores are lower than the cutoff values of 5, which clearly indicates there is no problem (Muhammad et al. 2022a, b) with the common method bias in the model.

Research modelling

The current study used asymmetric and symmetric analysis. The symmetric association assumption includes the high/low of the dependent variable that is usually connected with the independent variable high/low variables. These variables are equally mandatory and essential for the possible outcome of low/high endogenous variables (Skarmeas et al. 2014). The asymmetric association specifies that high values of the standard exogenous variables predict high standard criterion values. This is because the criterion of the high value may cause prediction variables to have a low value (Woodside 2013). It supposes the possibility of more than one group with a causal setting that yields the same outcome. The current study used PLS-SEM analysis for symmetrical analysis; it's appropriate for a suitable model which cannot accurately result from covariance-based (SEM) (Ringle et al. 2012).

PLS-SEM examination net effect exogenous variables on the model of symmetrical analysis outcome. The asymmetrical approach (fsQCA) measures the causal framework that describes the complex conditions (green process contributes to minimizing manufacturing risk). The fsQCA is used for the combined green process approach and KM to minimize production risk. The asymmetric advantage solution allows the investigator to analyze merged variables into the required formation and appropriate specific fundamental influence (Rihoux and Ragin 2009). PLS-SEM outcomes are augmented via fsQCA to understand variables' interrelated structures better. The fsQCA examination supports the net outcome of PLS-SEM by classifying the integrated KM dimension for attaining a positive outcome of knowledge efficiency (Sahibzada et al. 2020).

Measurement

The existing study adapted 37 measurement scales questionnaire, including a demographic study, to investigate the research objectives. According to the study aims, the current study accommodates changes in a green process setting in the adapted questionnaire. The research construct employed a Likert scale from 1 strongly disagree to 5 strongly agree. All the item scales and explanations are shown in Table 1.

Results and discussions

This study applied symmetric (PLS-SEM) and asymmetric (fsQCA) techniques to investigate a deeper understanding of GTI impacts, KM processes, and minimizing manufacturing risk strategy. However, the partial least square (PLS-SEM) is

Table 1 Measurement item

Variables	Dimension	Item	Source
Green implementation process	Green communication	3	(Sahibzada et al. 2019)
	Green learning development	4	(Sahibzada et al. 2019)
	Green environmental	3	(Ferris 1982)
	Green managerial	3	(Rao 2002; Rao and Holt 2005)
Knowledge management process	Acquisition	3	(Huang and Li 2009)
	Sharing	4	(Bryant 2005)
	Utilization	5	(Chang Lee et al. 2005; Huang and Li 2009)
Increasing knowledge efficiency to minimize risk	Working job autonomy	3	(Morgeson and Humphrey 2006)
	Cultural diversity and working environment knowledge & core efficiency	3	(Hillary 2004; Jabbour and de Sousa Jabbour 2016)
		3	(Kehbila et al. 2009; Younis et al. 2016)
			(Zhu et al. 2013),

applied for several features to analyze the conceptual model. Firstly, its outcome performs regression when estimating and examining the mediation influence. Secondly, its measurement account for error and accurately estimates the mediation effect. Thirdly, it's employed for theoretical and primary studies when the conditions of data normality using (PLS-SEM) (Hair et al. 2013). The construct of (PLS-SEM) and the fsQCA were used to employ profound results and determine the satisfactory configuration of causal amalgamation in green implementation and KM components to minimize risk. The established measurement model analyzes the validity and contrast of their components (Hair 2006). The factor loading alpha coefficient composite reliability (CR) and average variance extracted values (AVE) are found to be satisfied at 0.50 (AVE) and 0.70 (CR) as per the suggestion of (Hair et al. (2016). Tables 2 and 3, respectively, show reliability and convergent validity.

Measurement model assessment

This research investigated the variance inflation factor (VIF), and the outcome of VIF is to determine the model collinearity concern (Muhammad et al. 2022a, b). The study (Hair et al. 2013) investigated that if the inner value is less than 5, then there is no problem in the collinearity data. The present study found that VIF inner value contrasted range from 2.431 to 3.769. Thus, it indicated that the data has no collinearity problem and the model is significant. However, the R^2, ACQ (0.488), and Q^2 values 0.354, KMMR (0.755), Q^2 0.342, R^2 SHR (0.415), and Q^2 0.226, and UTI (0.702), Q^2 0.309, which support a current model in the predictive power. The outcome of blindfolding with the omission of 7.55 in Table 4 shows the model's predictive optimistic association with an out-of-sample prediction (Q^2 values all significant and above zero (Hair et al. 2013).

Structural model assessment

In this section, the researcher's examine PLS-SEM structural model investigation. The analysis of structural model assessment involves measuring the model predictive and significance of empirical path coefficient along with confidence level. The study used a bootstrapping resampling approach 5000, sub-sampling (Hair et al. 2016), to investigate the significance of the direct relationship. The study uses a reflective construct to follow a consistent PLS bootstrapping approach. The study summarizes the outcome accompanied by hypotheses concerning the direct relationship in Table 5.

However, testing the hypothesis values shown in Table 5 and Fig. 2, the positive influence of green communication impacts on KM and KM process influences are found to be optimistic with minimizing manufacturing risk. Table 5 shows the hypothesis green communication impacts (H1a (β, − 0.195; t 2.484; $p < 0.007$), H1c, (β, − 0.131; t 1.95; $p < 0.026$) which are a positive influence on KM and KM process improve employee knowledge efficiency to minimizes the manufacturing risk; hence, H1a and H1c supported to minimizes risk. But H1b values are not supported to minimize risk (β, 0.057; t 0.591; $p = 0.277$); therefore, H1b is rejected.

Moreover, hypotheses tested whether green learning process impacts are positive to minimize the manufacturing risk. In Table 5, the hypotheses H2a (β, 0.282; t 3.107; $p < 0.001$) and H2c (β, 0.203; t 2.915; $p < 0.002$) show that influence is positive to minimize risk. The hypothesis H2b (β, 0.052; t 0.425; $p = 0.336$) is not supported to minimize the manufacturing risk. Furthermore, this study analyzes green environmental process impacts associated with the KM process to minimize manufacturing risk. Table 5 indicates that H3a (β, 0.336; t 2.842; $p < 0.002$) and H3c (β, 0.417; t 3.331; $p < 0.033$) are supported by H3a and H3c hypotheses. But H3b values are insignificant (β − 0.097; t 0.681; $p = 0.248$). Hence, H3b is rejected. In addition, this research work applied hypotheses of the green managerial process to minimize manufacturing risk. The study demonstrated that green managerial process impacts are positive and support hypotheses (H4a, H4b, and H4c).

Furthermore, the study analyzed KM's direct effect (H5 A, H5 B, and H5 C) to minimize manufacturing risk. The direct effect (H5 A (β, 0.167; t 0.168; $p < 0.039$), H5 B (β, − 0.104; t 1.731; $p < 0.042$), and H5 C (β, 0.781; t 9.002; $p < 0.019$) showed that green process influence is a positive sign to minimizing the manufacturing risk (see Table 5).

Specified direct and indirect effect

The direct and indirect specified analyses were performed to mediate the relationship between the green process, KM, and minimizing manufacturing risk. The analysis was performed via smart PLS using a bias-corrected bootstrapping approach at a 95% confidence interval (5000 iterations) (Hayes and Preacher 2010). Table 6 indicates the specific and indirect effects of green implementation, KM, and minimizing manufacturing risk. In Table 6, GCP—> KMMR (β, − 0.142; t 2.289; $p < 0.011$) and GLD—> KMMR (β, 0.21; t 3.015; $p < 0.01$) indicated a positive sign of direct effect between green process and minimizing manufacturing risk.

Moreover, the specified indirect effect in Table 6 demonstrated that fundamental values are positive for minimizing manufacturing risk. Table 6 path values such as GCP—> ACQ—> KMMR (β, − 0.033; t 1.361; $p < 0.017$) are a positive sign of an indirect approach. Furthermore, GEP—> ACQ—> KMMR (β, 0.056; t 1.477; $p = 0.071$) indicated a negative path of indirect effect.

Table 2 Validity and reliability analysis

Construct	Item	Loading	CA	CR	AVE
Knowledge acquisition			0.844	0.906	0.764
	ACQ1***	0.902			
	ACQ2***	0.908			
	ACQ3***	0.808			
Green communication process			0.813	0.888	0.727
	GCM1***	0.825			
	GCM2***	0.905			
	GCM3***	0.826			
Green environmental process			0.842	0.903	0.756
	GEP1***	0.818			
	GEP2***	0.913			
	GEP3***	0.874			
Green learning process			0.791	0.865	0.617
	GLD1***	0.806			
	GLD2***	0.845			
	GLD3***	0.787			
	GLD4***	0.696			
Green managerial process			0.742	0.851	0.657
	GMP1***	0.777			
	GMP2***	0.778			
	GMP3***	0.872			
Minimizing manufacturing risk			0.867	0.895	0.492
	KMMR1***	0.789			
	KMMR2***	0.627			
	KMMR3***	0.727			
	KMMR4***	0.750			
	KMMR4***	0.753			
	KMMR5***	0.865			
	KMMR6***	0.638			
	KMMR7***	0.612			
Knowledge sharing			0.812	0.874	0.637
	KSHR1***	0.784			
	KSHR2***	0.909			
	KSHR3***	0.801			
	KSHR4***	0.683			
Knowledge utilization			0.682	0.798	0.482
	KUTI1***	0.864			
	KUTI2***	0.729			
	KUTI3***	0.802			

*** < 0.001, alpha ≥ 0.7; CR ≥ 0.6; AVE ≥ 0.5, *KACQ* knowledge acquistem, *GCP* green communication process, *GEP* green environmental process, *GLD* green learning development, *KMMR* knowledge efficiency to minimize risk, *KSHR* knowledge sharing, *KUTI* knowledge utilization

However, the specified direct effect relationship between KM and risk is positively shown in Table 6. Nevertheless, some area relationship is not positive, as demonstrated in Table 6, such as path GLD—> ACQ—> KMMR ($P = 0.105$), GEP—> SHR—> KMMR ($P = 0.282$), and GLD—> SHR—> KMMR ($P = 0.364$). The rest of the path values significantly impact minimizing manufacturing risk.

fsQCA approach

This study employed fsQCA to examine the antecedent conditions GCP, GLP, GEP, and GMP association with the knowledge process to explain an aspect of KMMR in the manufacturing context (hypothesis 6).

Table 3 Construct discriminant validity

	ACQ	GCP	GEP	GLD	GMP	KMMR	SHR	UTI
ACQ	**0.874**							
GCP	0.241	**0.853**						
GEP	0.642	0.392	**0.87**					
GLD	0.548	0.298	0.736	**0.786**				
GMP	0.462	0.617	0.492	0.215	**0.81**			
KMMR	0.686	0.394	0.687	0.529	0.603	**0.702**		
SHR	0.39	0.43	0.279	0.135	0.64	0.275	**0.798**	
UTI	0.718	0.395	0.756	0.576	0.657	0.858	0.401	**0.68**

Table 4 Coefficient and predictive relevance

Item	R^2	Item	Q^2
ACQ	0.488	ACQ	0.354
KMMR	0.755	KMMR	0.342
SHRU	0.415	SHR	0.226
TI	0.702	UTI	0.309

Calibration

The fsQCA begins with calibrating data into the fuzzy set, identifying instances as completely in, out, or within specified groups. The value of the fuzzy sets is from zero to one (Woodside 2013). The variables calibrated may be in a set either explicitly(variables category belong to a binary form (0), for non-membership (1) completely fuzzy (degree belonging variables from 0 to 1) (Skarmeas et al. 2014). The fuzzy set analyzes the calibration with three categories, 0.95 for full membership, 0.50 for crossover membership, and 0.05 for non-membership (Handrich 2000). The direct approach of data calibration was employed in this research (Rihoux and Ragin 2009). The researcher used percentile scores to select the cutoff values (Beynon et al. 2016). Thus, the study used Handrich's (2000) technique of 95% for the complete membership threshold.

Necessity condition

After the calibration is performed, the next step is to analyze whether or not the conditions are necessary and sufficient. Table 7 demonstrates the outcome of the necessary condition analysis. None of the condition's outcome values is more significant than 0.90, suggesting that none of them is necessary (Morgan 2010). It validated that neither single condition could elucidate the distinct aspect of KMMR by itself. The result is demonstrated in Table 8. Next, coverage and consistency were calculated for all configurations,

Table 5 Path coefficient and direct effect

Structural paths & hypotheses	Original sample	Sample mean	Standard deviation	*T*-statistics	*P*-values	Supported
GCP- > ACQ(H1a)	−0.195	−0.182	0.078	2.484	0.007	Yes
GCP—> SHR(H1b)	0.057	0.058	0.097	0.591	0.277	No
GCP—> UTI(H1c)	−0.131	−0.119	0.067	1.95	0.026	Yes
GLD—> ACQ(H2a)	0.282	0.279	0.091	3.107	0.001	Yes
GLD—> SHR(H2b)	0.052	0.046	0.121	0.425	0.336	No
GLD—> UTI(H2c)	0.203	0.195	0.07	2.915	0.002	Yes
GEP—> ACQ(H3a)	0.336	0.323	0.118	2.842	0.002	Yes
GEP—> SHR(H3b)	−0.097	−0.084	0.143	0.681	0.248	No
GEP—> UTI(H3c)	0.417	0.405	0.125	3.331	0.033	Yes
GMP—> ACQ(H4a)	0.356	0.366	0.104	3.435	0.012	Yes
GMP—> SHR(H4b)	0.642	0.64	0.087	7.348	0.014	Yes
GMP—> UTI(H4c)	0.489	0.493	0.111	4.403	0.021	Yes
A direct effect of hypotheses						
ACQ- > KMMR(H5 A)	0.167	0.186	0.095	1.768	0.039	Yes
SHR—> KMMR(H5 B)	−0.104	−0.112	0.06	1.731	0.042	Yes
UTI—> KMMR(H5 C)	0.781	0.772	0.087	9.002	0.019	Yes

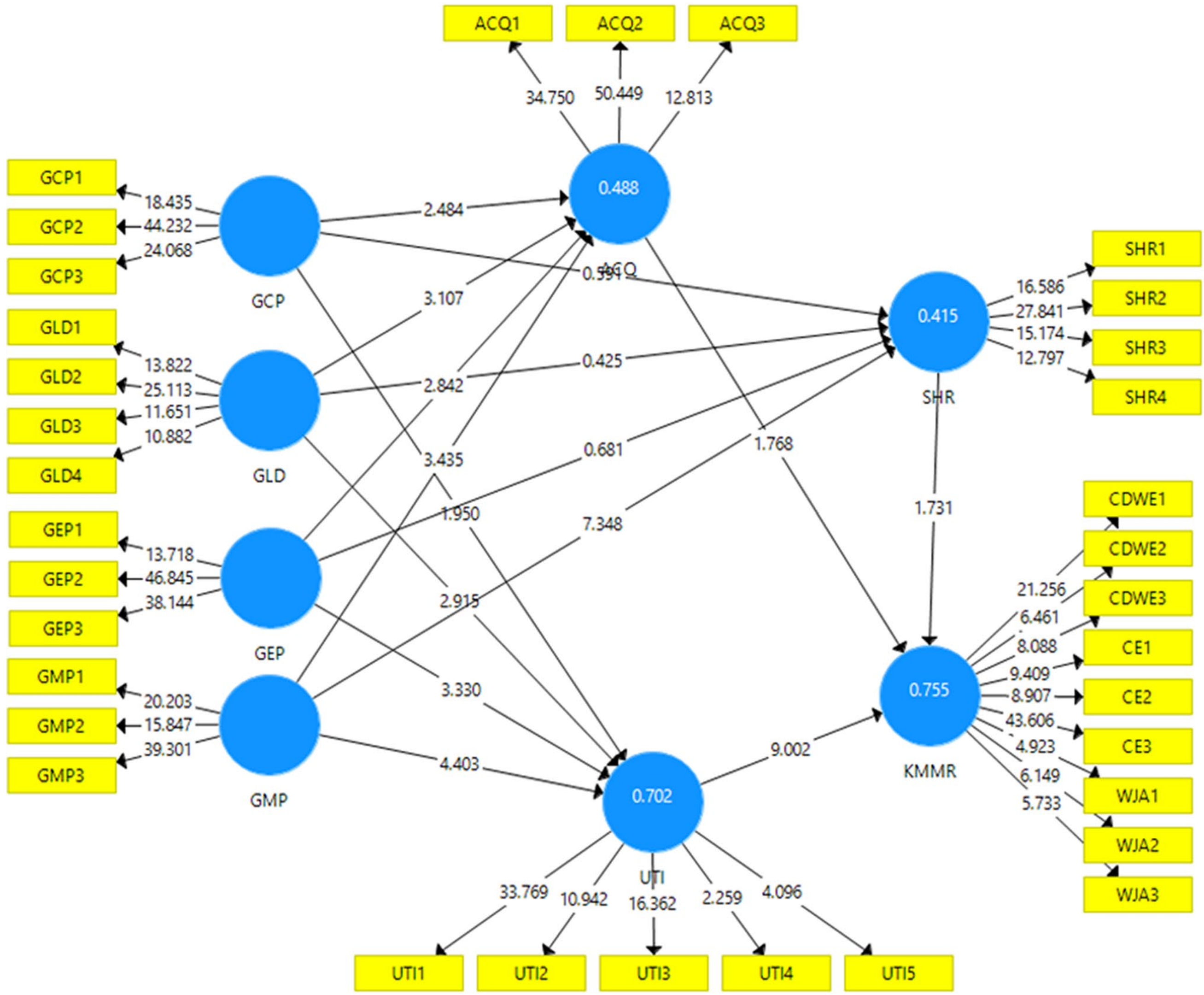

Fig. 2 Path information

with the necessary configuration that the consistency is greater than 0.8 and coverage is higher than 0.2 (Pappas and Woodside 2021). The fsQCA produces three kinds of outputs from sufficient conditions known as parsimonious, complex, and intermediate. A solution is a set of formations reinforced by large cases and follows the instructions that combination leads to a consequence (Pappas and Woodside 2021). The present study supports the intermediate solution as per the recommendation (Rasoolimanesh et al. 2021).

Solution

The fsQCA summarized the finding of KMMR using the notations of Ragin and Fiss (2008). The overall solution consistency in KMMR is 0.852; the consistency in this study is more than 0.80 (Morgan 2010). The solution of four dimensions has a unique set of conditions to identify several solutions for sufficient conditions outcome to equifinality (Fiss 2011). In this outcome, the solution supported the H6 hypothesis. In the fsQCA, all the core conditions and values are satisfied. Regarding coverage values, the fsQCA yielded the overall solution of a coverage score of 0.722 and solution consistency of 0.852. The result implies that our four causal confirmation conditions explain 72% KMMR, which both fall within a limited range of 0.25–0.90 (Morgan 2010). Hence, hypothesis 6 is supported.

Discussion

Green implementation process

This study developed a conceptual model and tested it by examining the multidimensional relationship between

Table 6 A specific direct and indirect effect

Structure path combined approach	Original sample	Sample mean	Standard deviation	*T*-statistics	*P*-values	Supported
GCP—> KMMR	−0.142	−0.13	0.061	2.289	0.011	Yes
GLD—> KMMR	0.21	0.22	0.066	3.015	0.001	Yes
GEP—> KMMR	0.392	0.375	0.106	3.698	0.021	Yes
GMP—> KMMR	0.374	0.383	0.109	3.428	0.024	Yes
Specific indirect effect						
GCP—> ACQ—> KMMR	−0.033	−0.034	0.024	1.361	0.017	Yes
GEP—> ACQ—> KMMR	0.056	0.059	0.038	1.477	0.071	No
GLD—> ACQ—> KMMR	0.047	0.055	0.038	1.256	0.105	No
GMP—> ACQ—> KMMR	0.065	0.073	0.043	1.378	0.084	Yes
GCP—> SHR—> KMMR	−0.006	−0.006	0.013	0.461	0.323	No
GEP—> SHR—> KMMR	0.014	0.007	0.017	0.578	0.282	No
GLD—> SHR—> KMMR	−0.005	−0.004	0.015	0.349	0.364	No
GMP—> SHR—> KMMR	−0.066	−0.071	0.039	1.691	0.045	Yes
GCP—> UTI—> KMMR	−0.102	−0.092	0.051	1.981	0.024	Yes
GEP—> UTI—> KMMR	0.326	0.309	0.094	3.471	0.014	Yes
GLD—> UTI—> KMMR	0.158	0.149	0.054	2.932	0.002	Yes
GMP—> UTI—> KMMR	0.381	0.384	0.108	3.526	0.012	Yes

green implementation impacts, the KM process, and three distinct facets of minimizing risk. The finding of this research contributed to the broad question; why the green implementation process is important with KM, and how does the KM impact minimize manufacturing risk? This research integrated three theoretical approaches, RBV theory (Barney 1991), knowledge management theory (Grant 1996), and classical decision theory (March and Shapira 1987), to build the framework that analyzes the relationship between multidimensional variables of the green implementation process and KM influence to minimizing the manufacturing risk. The outcome of this study was beneficial influences within multidimensional relationships, improved manufacturing performance, based on minimized risk. Manufacturing firms are compelled to improve their production performance continuously by alleviating and addressing ecological concerns.

Table 7 Necessary condition for predicating KMMR

Conditions	Consistency	Coverage (outcome of KMMR)
GCP	0.82[a]	0.804
~GCP	0.603	0.597
GLP	0.796[a]	0.762
~GLP	0.641	0.622
GEP	0.805[a]	0.781
~GEP	0.672	0.637
GMP	0.784[a]	0.771
~GMP	0.653	0.611
ACP	0.711[a]	0.652
~ACQ	0.643	0.612
SHR	0.665[a]	0.624
~SHR	0.616	0.589
UTI	0.699[a]	0.602
~UTI	0.682	0.600

~ designates the absence of a condition. [a]Meets 0.65 consistency level for usually necessary conditions

The outcome of this research suggests that the green implementation process implies that the knowledge process significantly minimizes manufacturing risk. Green communication displaced positive impacts on KMMR. Manufacturing firms with green communication perform better in managing green processes inside and outside boundaries with employees. This study's support is consistent with the broader domain of the green communication process literature (Casini 2017; Sahay and Bharti 2021). The studies emphasized the importance of green communication in encouraging employees to develop and accept new knowledge by exemplifying anticipated attitudes and stirring followers to produce and share knowledge information to minimize risk. The result of green communication and KMMR contradicts the outcome of Casini (2017), which identifies a positive relationship between green communication and manufacturing performance influence on smart cities and sustainability to improve life quality and protect the natural environment. Moreover, the study supports prior literature (Anser et al. 2021); they studied that green information communication technologies improve the production and consumption process.

Moreover, the green learning and KM process have optimistic impacts on KMMR. Green learning is positively associated with employee work attitude and performance.

The result is constant with those of (Song et al. 2019), who found that the green learning process is improve employee performance, enhance knowledge, and extend their conclusion to minimize the manufacturing risk. The outcome endorses that if the green learning process is considered an input, then employee KMMR can be achieved as the output of the learning process effort. The green learning process and knowledge management directly affect KMMR; in this view, the study postulated an indirect influence on employees' perceived green learning process subsequent to KMMR via the knowledge management process. In this linking study connected with Zhao et al. (2019), they highlighted that knowledge sharing positively impacts innovation, research and development, and product innovation. Furthermore, this research identifies the mediating relationship between employee green learning and the knowledge process to identify risk response in the manufacturing context. The study supported by Holman et al. (2012) found that the learning process improves employee engagement in innovation. But this study extends the notion by suggesting that green learning is associated with KM reflected in improving skills and knowledge to minimize the manufacturing risk in terms of employees' context.

The green environmental process is prominent in its infrequent practicable authentication of manufacturing performance and minimization risk. In the study's finding, green environmental and KM processes significantly impact minimizing manufacturing risk. In the green environment, manufacturing firms are responsible for internal and external institutional environmental processes to update employees on related matters with KMMR. The study supports the past literature by Falavigna and Ippoliti (2022); they studied that internal and external environments are vital influences on the green process. Additionally, a green environment consolidates different resources to alleviate the green environment influence, allowing them to recognize and capitalize on KMMR possibilities (Zhou et al. 2018). However, the green managerial process tends to provide environmental awareness that allows employees to provision and enlighten their behavior (Yang and Liu 2021). It is helpful for manufacturing firms to assimilate information resources, engross the KM to assist the green implementation process, and actively endorse implementation and information of production under the green process. Moreover, studies are associated with the literature of Khan and Liu (2022) on effective environmental processes that improve human resources management to achieve innovation and performance based on emission reduction.

Table 8 Result of the intermediate solution

Raw coverage	0.531	0.514	0.402
Unique coverage	0.021	0.017	0.010
Consistency	0.887	0.842	0.806
Solution coverage	0.722		
Solution consistency	0.852		

Knowledge management process

The KM processes' outcome revealed the current research's positive influence on the three-dimension (ACQ-KMMR, SHR-KMMR, and UTI-KMMR) relationship with KMMR. The finding of the knowledge process demonstrates that participating in manufacturing firms allocated sufficient time and resources to developing employees' new skills and knowledge that substantially improved to minimize risk. The outcome of the present study explains that the administration should add and share knowledge information about the creation of new ideas, sustainability, and to minimizing manufacturing risk. The result of this study support verifying prior research (Shehzad et al. 2022). The study by Tseng et al. (2018) articulates that knowledge sharing is a crucial tool for employees to cooperate and continually maintain development throughout manufacturing firms. The contextual examination exposed the positive association between green implementation and the KM process with an aspect of KMMR. This implies that green implementation and knowledge processes are essential for all manufacturing processes to improve performance based on reduce risk.

fsQCA

We assume that none of the terms that are neither green implementation dimensions nor knowledge management is sufficient to explain the high level of KMMR on their own. The most robust solution for high-level KMMR (see Table 7) demonstrated that 53% of feedback in our sample reduces manufacturing risk. The outcome indicated that the survey respondent affirms that manufacturing performance can achieve the target dimension of KMMR with a combination of green implementation and knowledge management. The analysis of fsQCA identifies that green implementation and KM are core dimensions for minimizing risk. The result is valuable and supports past literature in terms of green process performance (Shehzad et al. 2022). The equifinality existence is progressively getting impetus in the past literature in the field of management (Fiss 2011); in this view, our research support that green implementation and KM processes are a higher degree to reduce manufacturing risk. The outcome of this study endorsed the notion that there are several paths to improve employee performance, emphasizing the need to develop fsQCA in the knowledge and green literature (Cabrilo and Dahms 2018).

Implication

Theortical contribution

This study highlighted the connection between GTI, KM, and minimizing manufacturing risk. Theoretically, the present study expands based on the green theory and KM model to mitigate risk. This model builds on three theories, RBV, KM, and classical decision theory, giving insight into a new relationship that fills the research gap by theoretical context. This study improved employee awareness to minimize manufacturing risk through such a theoretical contribution.

Methodological contributions

The study emphasized a trend of a methodological standpoint to combine PLS-SEM and fsQCA to understand manufacturing processes and their problems. fsQCA examines manufacturing likelihoods, and their connection is more thorough than the symmetric technique (Ling 2013). These two methods provide new sight for policymakers and researchers to minimize manufacturing risk by implementing PLS-SEM and fsQCA techniques. Thus, its enriching green process and KM literature identify multiple configurations to improve manufacturing performance and minimize risk.

Practical implication

This study has several implications for manufacturing firms and policymakers. Firstly, the study develops a model for firms to improve their manufacturing performance with eco-friendly products based on minimizing manufacturing risk and employee knowledge efficiency improvement. When production risks are minimized, then manufacturing processes are improved. The expert and policymaker should realize the importance of sharing knowledge processes are crucial in risk mitigation and creating a platform for increasing employee knowledge, sustainability and improving production performance. Thirdly, the present research urges senior administration and policymakers to add sustainable practices and effective adoption of knowledge sharing, acquisition, and application in their production plant to improve employee inner satisfaction while working for more production. Finally, this study highlights the positive role of green implementation in assisting manufacturing firms to achieve a competitive position in the market based on employee satisfaction and knowledge sharing in productivity improvement. Green adoption enables firms to implement new technologies that allow employees to learn new skills and knowledge creating high-quality products with a green tag. Additionally, the study is vital for small and midsize firms to implement such a model to improve performance and minimize production risk.

Conclusion, limitation, and future work

This study examined the complicated features of green implementation (communication, learning, environmental, and managerial) and KM processes to minimize manufacturing risk (KMMR). The empirical outcome in the context of manufacturing companies validated that production risks are minimized based on the theoretical contribution. The survey data are analyzed through symmetric and asymmetric techniques. The symmetric result identifies that green implementation directly influences the knowledge process, and the knowledge process directly impacts on minimize manufacturing risk. The asymmetric approach (fsQCA) presented a clear connection of equifinality of risk minimization in the production process. The study's outcome revealed that various dimensions could improve manufacturing performance and minimize risk based on knowledge sharing.

Although the current work is based on a comprehensive examination, it has several limitations that point to future research directions. Firstly, the study used a cross-sectional analysis to analyze the relationship between certain dimensions. A longitudinal study would solve this matter and permit the amalgamation of the outcome. Secondly, this study analyzes the connection between various variables to control manufacturing risk without considerating the moderating influence or moderating role of manufacturing size, support, and agility. Future studies investigate moderating effects in terms of minimizing risk. The future study also adds knowledge application to investigate comparing private and public firms to minimize risk impacts and their performance. Thus, the literature on green implementation that has increased performance and control risk will be highlighted.

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Author contribution All authors contributed to the study's conception and design. Study design and analysis by SA and JZ. NK and AI helped in the data collection and analysis. The first draft of the manuscript was written by SA, and JZ further monitored the work for improvement. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability The data and materials presented in this study are available in the article. Further information is available upon request from the corresponding author.

Declarations

Ethical approval This study was drawn only on behalf of such connections for policymakers and experts. Nevertheless, the applicable institutional and governmental ethical regulations concerning the use of data collection.

Consent to participate All authors consent to participate in this work.

Consent for publication All authors consent to publish.

Competing interests The authors declare no competing interests.

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