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# Corporate Environmental Performance: Green Knowledge Management's and Green Technology Innovation's Impact

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## Chronicle

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## Abstract

It is necessary for firms to explore such methods to comply with growing regulatory duties or requirements to adapt and implement environmental friendly operations that enhance their organizational capabilities and give them competitive advantage in the market. Nowadays researchers are showing great interest in focusing or investigating the impact of using green practices in organization to know their positive outcomes. So in order to respond in this expanding field of research, this study aims to investigate the impact of effective use of green knowledge management (GKM) and green technology innovation (GTI) capabilities on corporate environmental performance (CEP), using resource commitment (RC) as a moderator. This research is quantitative research in which data is gathered from 202 respondents through survey by distributing questionnaire in manufacturing sector Peshawar. The questionnaire is adapted from previous study which was bases on 5-point Likert scale. Smart PLS software is used for analysis. Through analysis, we came to know that increasing the activities of green technology innovation helps on the improvement of corporate environmental performance through the help of green knowledge management. The results also shows that resource commitment increases the positive outcomes of green knowledge management and green technology innovation on corporate environmental performance, showing that organizations that uses sufficient resources in efficient way to introduce sustainable green practices in organization can improve their organizational environment. The results also give managerial implications for manufacturers and policymakers who wants to introduce green practices and to utilize green technologies within their organization to enhance their corporate environmental performance (CEP).

**Keywords:** Green Knowledge Management, Green Technology Innovation, Corporate Environmental Performance, Sustainability



## INTRODUCTION

The world we live in today, green knowledge management and green technology innovations is crucial during all spheres of life. Every sector, whether it be the corporate or education sectors, must embrace ecologically sustainable practices in this quickly evolving economy. The goal of this study is to learn more about how technology may have a positive influence on the environment. It also represents a new green knowledge approach to how organizations perform in terms of environmental preservation. While green technology innovation aids developing and implementing green technologies on the basis of ideas or knowledge shared by green knowledge sharing, green knowledge management provides ideas and knowledge on how to use sustainable environmental practices. The overall study aims to determine connection between green knowledge management and new green technologies.

# BACKGROUND OF THE STUDY

In accordance with natural theory based on resources of organizations, firms must strengthen their ties to their external natural environment to gain advantageous financial results through the adoption of environmentally sustainable practices. Organizations can improve the performance of the environment and continuously upgrade their edge over the competition by adopting these perspectives (Rehman et al., 2021). Numerous environmental problems, such as climate change, sanitary problems, pollution, greenhouse effects, energy consumption, etc., are becoming more and more urgent as a result of businesses disregarding environmental regulations. Researchers found that there is a conflict that needs to be resolved between economic development and environmental preservation in a study they conducted in China (Fu et al., 2022).

Corporate sustainability, a green strategy that aids in maintaining various environmental components so that their operations can continue, is said to be the most crucial and essential pillar of success for organizations (Shahzad, Qu, Ur Rehman, et al., 2020).Numerous studies have shown that organizations that update their organizational cultures using sustainable environmental practices will succeed, whereas those that do not consider or follow economic or environmental aspects will fail (Shahzad, Qu, Ur Rehman, et al., 2020). Every organization needs technology to run its various operations in this competitive era, so green technology innovation will assist organizations in resolving their technological problems or modernizing their technologies (Fu et al., 2022).

Different industries, groups, and societies have become increasingly concerned with social issues and environmental concerns in recent decades, and they are working to find environmentally friendly solutions. Organizations or societies address social or environmental problems through the exchange of green knowledge, and use innovative green technology to solve or attempt to solve those problems (Albort-morant et al., 2018). In accordance with (Alavi et al., 2005), the organization who embrace or implement knowledge management practices see significant benefits in the form of more motivated employees, better decision-making, improved work systems, and other areas.

Every industry or organization needs to modernize its operations by implementing green initiatives that will benefit both the external and internal environments of an organization. However, problem is that organizations don't understand how to implement green strategies, how to address problems, or how to get desired results from doing so. To determine or examine how green technology innovation and knowledge management affect corporate environmental performance.

Among the primary objectives of research are as below:

- To investigate the relationship between corporate environmental performance and green knowledge management
- To examine challenges and opportunities that will arise while adopting green knowledge management and green technology innovation in the green sector.
- To analyze and understand the impact of green knowledge management and green technology innovation on corporate environmental performance.

## Significance of the study

In today's businesses or industries, the study "Impact of Green Knowledge Management and Green Technology Innovation on Corporate Environmental

Performance" is crucial. Researchers are thus motivated to learn about environmental sustainability also the importance of knowledge management for enhancing business performance through their studies on knowledge sharing and innovation in green technologies (Zandi et al., 2019). The following factors may be used to illustrate the importance of researching "Impact of Green Knowledge Management and Green Technology Innovation on Corporate Environment Performance":

- One aspect which is Environmental Sustainability that highlights the importance of this study since it emphasizes the significant contribution of natural resources, including minerals and other physical inputs, to the industrial process (Goodland, 2017).
- Going green can boost business performance and help it to compete with others. Previous studies have demonstrated that organizations or businesses with high pollution levels and even high levels of productivity have poor environmental performance since adopting a greener lifestyle may improve their operations, performance, and a variety of other activities while also boosting their competitiveness. When businesses adopt environmentally friendly practices, there are obvious differences between them (D. Zhang & Du, 2020).
- Technology innovation and knowledge management are other elements that highlight the importance of this study. In this competitive era, technology innovation is a necessity for organizations, so knowledge management is emerging as a key concept. Knowledge management aids organizations in enhancing their performances and innovations, whether those innovations are technological or not. As a result, both are interrelated and dependent on one another in order to function (Darroch & Mcnaughton, 2002).

## LITERATURE REVIEW

Going green is essential for organizational success as well as environmental sustainability and preservation, as it is obvious. Going green is now a crucial component of any business or organization that wants to increase its growth. According to earlier research, employing green practices, innovation in green knowledge management and green technology in a proper manner moves an organization towards a more environmentally conscious mindset and helps to foster a positive culture or environment that improves environmental performance of corporations (Nisar et al., 2021a). According to a study, innovations in green technology can improve a company's performance, reputation, promote organization brand, sustainability development, and economic or environmental benefits in addition to effectively controlling or reducing environmental issues like pollution, energy consumption, and petrol emissions, etc. (Sun & Sun, 2021). Manufacturers are curious about the development of new and effective GKM strategies to increase the capabilities of GTI in an organization. If GTI capabilities are increased CEP will be improved and CEP goals will be achieved.

### Recourse-Based-View of Firms

Nearly all studies adopt a resource-based perspective of businesses on innovation, whether it be in terms of products or technologies. Recourse-Based View (RBV) is particularly organization-centric, and businesses pursuing environmental sustainability have been using RBV's NRBV (point of natural resource-based view). Taking a point natural resource-based approach of Firms emphasizes the utilization of natural resources by organizations in their processes or operations, which gives them a competitive edge, financial rewards, and environmental protection (Anders, 2021).

Several articles of research have conceptually tied Knowledge-based viewpoint (KBV) versus RBV, Intellectual capital is defined as a source of value an unmatched resource and significant an engine for growth and productivity (Yong et al., 2019). According to KBV, an organization's primary responsibility is to develop or adapt such information and practices for its personnel so that they would perform better and help it stand out from competing organizations (Duarte Alonso et al., 2022). As a result, in order to improve or increase a company's environmental performance, green technology innovation (GTI) depends entirely on the knowledge that is shared by their organizations' green knowledge management (GKM). This research provides an analysis foundation for the Constructs used in various ways in the study and enables the use of these two add-ons to the RBV theory (NRBV and KBV) to comprehend various green business concepts.

## Variables of the Study

Variables cam be defined as a quantifiable element. It will transform complex ideas into simple way that can be easily measured (Buchler, 2019). Variables that are used in the study is green knowledge management (GKM), green technology innovation (GTI), corporate environmental performance (CEP) and resource commitment (RC). Where GKM is independent variable, GTI is dependent variable, CEP is mediator and RC is moderator. All these variables are explained one by one as follow.

## Green Knowledge Management

The expectations and needs of consumers and stakeholders have increased in this modern era, and their preferences or demands are shifting towards being more environmentally friendly, so it is important for organizations to stay current in order to be aware of these changes. Green knowledge management, which enables organizations to transform their goods into sustainable and environmentally friendly ones, may make all of this feasible (Park & Chan, 2019).To succeed in and maintain GKM, an organization must first be mature enough to know where to gather accurate data, how to use it, and how to manage it. This is only possible with the cooperation of the stakeholders in the organization (S. Wang & Wang, 2020). This explains the RBV concept, according to which organizations with high levels of expertise and the capacity to share and manage environmental knowledge can more easily create environmentally friendly ideas and products while also helping to create a sustainable environment (Soto-acosta et al., 2018).

## Green Technology Innovation

Green innovation is a proactive response that improves organizational performance, supports sustainable consumption, and strengthens the environmental sustainability. These environmentally friendly concepts learned from GKM are put into practice through green technology innovation. Considering NRBV (Singh et al., 2020), GTI participates in this process by influencing corporate environmental performance (CEP) (Tu et al., 2020) by using the knowledge from GKM. Previous studies of researchers shows in their findings that if you are having effective or productive GKM, it will give a positive result in the form of beneficial GTI, as it helps the organization to adopt a new green culture and to innovate in their technologies in to green technologies because going green helps organization to reduce their wastes, use of energy, emission of gases and many other things that effect the environment negatively (Benabdellah et al., 2021). So it is proved from many studies and researches

that effective GKM and productive GTI is an important tool for those organizations who wants to improve or to enhance the performance of their organizational environment. GKM and GTI can also be found helpful to improve, to enhance and to promote the organizational products, process, services, methodologies and any initiative if a company wants to take (Biscotti et al., 2018).

## Corporate Environment Performance

Organizations that compete with their rivals using different strategies will prevail in the market in today's world of competition. According to studies, businesses with great environmental performance would have a competitive edge and experience rapid growth (GhanaWeb Politics, 2016). By using green practices or methods, such as pollution control and gas emission reduction, organizations may enhance their environmental performance (Zheng et al., 2020). According to studies and earlier research, CEP is shown as a positive consequences or effect of an organization pursuing sustainability in their operations, products, services, and other areas. To put it another way, CEP is the firm's positive side that gives the company a competitive advantage by addressing environmental sustainability (Song et al., 2018). NRBV theory states, the CEP is the most crucial pillar or factor for organizations that want to succeed and improve their environmental performance because it meets the need for ecological development and aids in gaining the trust of stakeholders (Vanalle et al., 2017).

## Research Gap

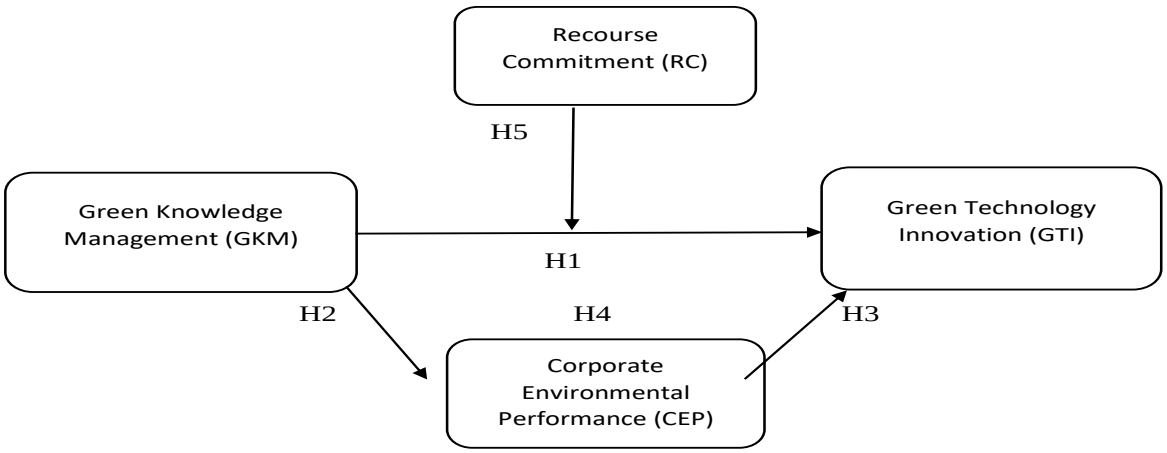
Organizations are not paying full attention towards the green sustainability. Even though environmental issues or challenges are widely known by everyone but still many organizations are not prioritizing green sustainability. Organizations focuses only in short term financial gains rather than long term environmental benefits (Flammer, 2013). According to recent studies it shows that only small amount of businesses have embraced environmental friendly practices. Studies shows that there is lack of policies to motivate organizations to implement green strategies (Markard & Rosenbloom, 2020). Among organizations, knowledge gap exists in investigation of the connection between green knowledge management and green technological innovation. There are very limited researches on impact of GKM on GTI (Chen & Chang, 2013). As there is many investigations and studies on green knowledge management and green technology innovation but separately, the relationship between these two variables are still not clearly understand or explained. Understanding these variables are necessary because they are playing significant role within an organization because without the support and knowledge of GKM, GTI cannot work properly. Studies shows that, many researchers studies focuses on GKM and GTI separately, there relationship or connection are ignored (Albort-Morant et al., 2016).

## Theoretical Model

The developing of the model of research examined contradictory data pointing to potential connections between a number of constructs, including GKM, GTI, CEP, and RC. Because of this, research that showed how GKM and GTI are related has shown that GKM serves as a messenger for GTI (Singh & El-Kassar, 2019). Numerous studies demonstrate that GTM and GTI have a favorable effect on CEP (Nisar et al., 2021a). Model proposed relative to the earlier discussion on RBV (Hsieh et al., 2019) because it aids organizations in making managerial decisions to enhance their operations during GKM and GKI activities. According to studies in the past that RC significantly

effects on GTI in green manufacturing practices, the suggested model includes RC as a moderator (J. A. Zhang & Walton, 2017).

The following model describes the research framework, in which the relationships or variables are examined and briefly explained in the following paragraphs.




## HYPOTHESIS

The organizations ability to innovate can be influenced by work environment of business (Rehman et al., 2021). Stakeholders' forces manufacturers to bring and accept green practices in their businesses, because it is now necessary for manufacturers to become sustainable as it is the need of the market (Pekovic & Bouziri, 2023). Due to the reduction of natural resources and increase in pollution, government agencies and communities are now promoting GTI in different countries (Singh & El-Kassar, 2019). GTI helps organization in making green operations and eco-friendly products for sustainability and for environmental protection which helps in reduction of gases emission, pollution and energy consumption etc. (Huang & Li, 2017). Knowledge is the important and strategic advantage for the organization that is unique and difficult to imitate, and make GKM important because it works as a messenger and work for sustainability in an organization to improve or to identify GTI and influence CEP (Shahzad, Qu, Ur Rehman, et al., 2020). According to this, we develop the following hypothesis:

**H1.** Green knowledge management (GKM) will effect green technology innovation (GTI) positively and significantly

Different manufactures are having different reasons in using GKM and GTI (Pekovic & Bouziri, 2023). As GKM and GTI are the new and trending concepts, so manufacturers have to collect primary data to get the know-how for adopting or using these concepts in their businesses and in order to reduce negative impact of the organization as of ecosystem (Kumar & Rodrigues, 2020). From studies finds that manufacturers uses different methods for getting GKM like through surveys, brain storming and the biggest priorities is to get GKM from employees engagement initiatives to make it easy to get knowledge related to environment, and this would be helpful for manufacturers because due to this GKM they will get knowledge about the unnecessary or harmful production processes which will result in the decrease of pollution wastage gases emission etc. (Abbas & Sağsan, 2019). So it is proved by the study that GTI works on the knowledge that is shared by GKM. GTI helps organizations in the development of the new innovative technologies and making their

environment green by making green products and taking care of ecosystem especially in manufacturing sector, which can give organization a competitive edge (Shahzad, Qu, Ur Rehman, et al., 2020). So GKM is having positive impact on CEP in manufacturing sector. So a hypothesis develop:

**H2.** Green knowledge management (GKM) will effect corporate environmental performance (CEP) positively and significantly

Organization that has its laws and regulations to improve their performance can lead organization to success. According to Porter's hypothesis, the organization that has strict laws and regulations can encourage innovation which leads to cost reduction and found beneficial in their financial results (Eiadat et al., 2008). So corporate environmental performance founds helpful to convert their technologies according to green practices. So the hypothesis develop:

**H3.** Corporate environmental performance (CEP) will effect green technology innovation (GTI) positively and significantly

## Corporate Environmental Performance as a mediator

Natural Resource-Based-View theory (Harts, 1995), suggests that environmental performance of a corporation explains the relation between green knowledge and green innovation. When manufacturers uses GKM effectively and efficiently the CEP of an organization will be enhanced, when CEP is improved organizational culture will be strengthen and their employees will be motivated and cooperative and will share their innovative ideas to take some initiatives (Shahzad, Qu, Zafar, et al., 2020). While adopting GTI the organization will gain competitive advantages and the efficiency of their work will also be improved which will have a direct impact on the CEP to be improved. GTI capabilities is supported by effective GKM which lead to cost reduction through reduced the use of resources and to reduced wastage. GKM is having a positive impact on CEP by advancing environmental performance, enhancing behaviors and knowledge. So greater GTI can be facilitated through higher CEP. This mediation shows that GKM influence CEP in addition to having direct impact on GTI. Those organizations that are aware of this mediating function may concentrate on their GKM which leads toward the improvement of CEP and, in turn improved their GTI. Using this perspective organizations can adopt more creative, innovative and environmentally sustainable practices. So it is clear that through the collaboration of GTI and GKM, CEP will be positively influenced. According to this, the hypothesis developed which is:

**H4.** Corporate environmental performance (CEP) is positively influenced by the mediating effects of green knowledge management (GKM) and green technology innovation (GTI)

## Recourse Commitment as a moderator

Through RBV, it is clear that resources of an organization are playing an important role (Kumar & Rodrigues, 2020), saying that using organizational resources in an appropriate way will give organization a competitive edge, GKM and GTI is also considered organization resource as it promote the performance of environment of organization (i.e. CEP) (Shahzad, Qu, Ur Rehman, et al., 2020). Through theories and previous studies, we found out that the relationship between GKM and GTI based on RC. This shows that higher degree of resource commitment results in stronger positive effect of GKM on GTI and lower degree of resource commitment results weaker effect

of GKM on GTI. High level of RC helps organizations to support green practices and to continue innovation while lower RC can make it more difficult to innovate and to develop and apply green technologies. RC helps organization in the allotment of current and new resources (Mao et al., 2016). When organizations understands the moderating effect of RC, they will help the organization in resource allocation, strategic planning and in enhancing the effectiveness of GKM. So, the hypothesis generated is:

**H5.** Green knowledge management (GKM) and green technology innovation (GTI) is positively influenced by the moderating effect of resource commitment (RC)

# RESEARCH METHODOLOGY

According to the need of this study, it is to find out that the relationship between GKM and GTI are highly influence CEP in a positive way. For the purpose of this research, data is collected through the survey of 202 manufacturers of Peshawar to know the relationship of the variables among each other. The PLS-SEM regression approach is used for the empirical assessment of the model. This approach is used because it has the capability to evaluate the theoretical representation of the concurrent equations that shows the relationship of the variables among each other and to estimate values to measure the relationship of these variables (Peugh et al., 2013). In the following subsections detailed method is explained.

## Research Type

The research is of quantitative type which is based on primary data collection because this research is based on a specific problem and the data that are collected is used for this research only.

## Data Collection

The research model is based on survey type. To answer the questions of this study data will be collected from employees, and managers working in different manufacturing sectors of Peshawar.

## Time Horizon

The research is predicted on cross sectional study. Data were collected from a single responder at a time and to gather the data it took almost one month.

## Population of the study

There are different sectors in corporation but here the researcher selects manufacturing sector because going green in manufacturing sector will highly affect CEP. The researcher is going to survey different manufacturing industries of Peshawar and distribute questionnaire to know the GKM and GKI's impact on CEP.

## Sample Size and Sampling Technique

The subset of population is known as sample which helps researchers to make conclusion that are applicable to a specified group. Raosoft sample size calculator is used to get estimate sample size, with margin of error 5%, confidence level 95%, and population size 400 and with 50% response distribution, so the recommended sample size is 197. As the sample size is known probability sampling so simple random sampling technique is used. The study were conducted in manufacturing industries of Peshawar to fulfill the requirements of the research.

## Data Analysis

The data were arranged and organized in a systematic way and to extract insight of the data, statistical techniques were used.

## Research Instrument

Smart PLS, Measurement Model, Structural Model will be used. Measurement model evaluates the connection or relation between latent variables (constructs) as well as their observed indicators. It represents the reflective or formative nature of the constructs being measured. Reflective measurement model assumes that the indictors as a result caused by underlying organize and are expected to correlate with each other. Meanwhile, model for formative measurement treats the indicator as causes of the construct and focuses on their combined influence. An overview of structural model examines relationships between the latent variables (constructs) themselves, representing the casual connections among them. It focuses on understanding the direct and indirect effects between constructs. The structural model aims to explain how the latent constructs interact with each other.

## Data collection tool

Based on this research, a questionnaire is adopted for survey to get the different responses of the respondents to know about the variables relationship. The selection of items which represents constructs of the research model in the survey is based on the previous. A Five point Likert Scale is used ranging from "strongly agree" to "strongly disagree", which will show the different attitudes of different respondents toward each item.

## Analysis

SmartPLS software was used for PLS regression to test the research model's hypothesis. There are numerous benefits of using PLS technique. Firstly, it is a good fit in order to conduct preliminary investigation or study, which is relevant to this study since, it looks at new ideation of GKA, GKM, and GTI. Because it is less impacted by inaccurate model specifications, the PLS approach may be a more general model estimator than covariance-based SEM (Barroso & Carri, 2010). Secondly, it is suitable for limited sample sizes, that is, less than 300 samples. According to (Latan & Noonan, 2017) , a number of requirements must be met in order to evaluate a SEM model using PLS. These include determining the type of interactions that exist between items and constructs, evaluating the validity and reliability of constructs, and evaluating the measurement's fit with the structural model.

## Descriptive Statistics

Here the basic information or demographic profile of the respondents are represented, including age, gender, designation and operating sectors. Demographic profile of the respondents are also given in table no 1 with frequencies.

## Age of the respondents

The questionnaire was distributed among different age groups varies from 20 years to 60 years of ages of employees, which were classified as 0-20, 21-30, 31-40, 41-50 and 51-60.

## Gender of the respondents

The questionnaire was distributed in different manufacturing organization from which 202 questionnaires were collected from respondents. As in Peshawar, females employees rate are relatively zero in manufacturing sectors. So the respondents were almost male employees.

## Designation of the respondents

The data was collected from different level of mangers and different field of workers. It includes employees of managerial level, operational level and junior level employees.

## Operating Sectors

The data was collected from different types of manufacturing sectors which includes food industries, chemical industries, metal industries, energy industries, wood industry, pharmaceutical industry, clothes industry and marble industry.

## Ownership

The data that was collected from manufacturing sectors are all privately owned organization.

**Table 1.**
**Demographic Profile of the Respondents**

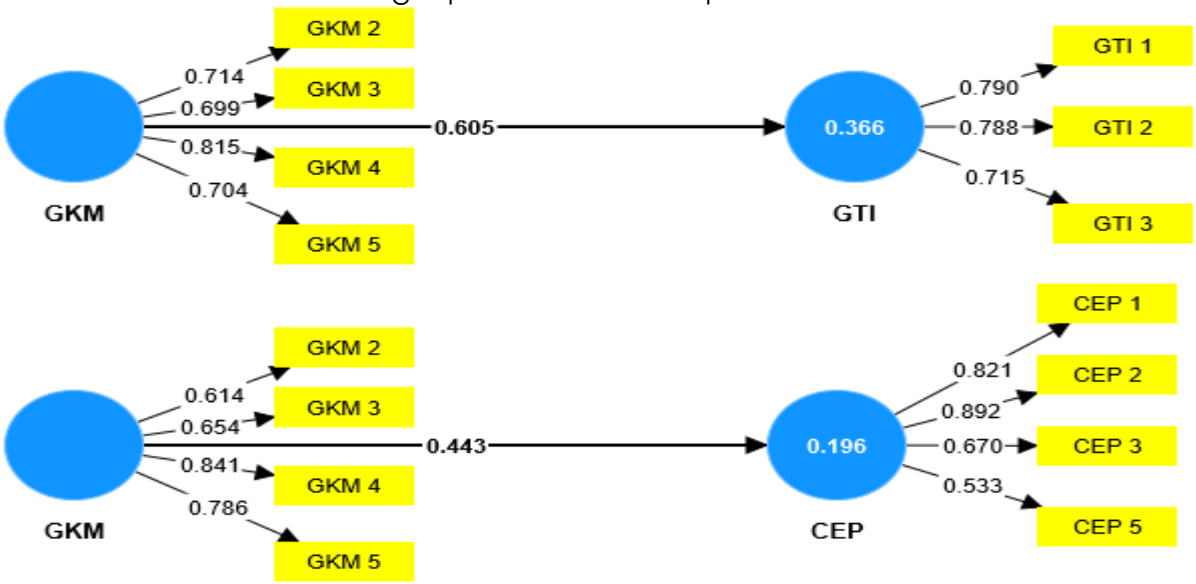
| Demographic Characteristics | Frequency (%) | Demographic Characteristics | Frequency (%) |
|---|---|---|---|
| **Designation:** | | **Operating Sectors:** | |
| General Managers | 19 (9.4%) | Energy | 46 (22.7%) |
| Project Managers | 10 (5%) | Chemicals | 60 (29.70%) |
| Operational Level Managers | 10 (5%) | Food | 10 (5%) |
| Sales & Marketing Managers | 9 (4.5%) | Metals | 11 (5.44%) |
| Employees | 154 (76.2%) | Wood | 35 (17.32%) |
| **Ownership:** | | Pharmaceutical | 17 (8.41%) |
| Private | 202 (100%) | Clothes | 13 (6.43%) |
| Public | 0 | Marble | 10 5%) |

## Structural Equation Modelling (SEM)

SEM describes and evaluates the relationship between two types of variables, that is, latent variables and observed variables. Due to the abstract character of latent variable, it is not possible to measure or observe it directly. On the other hand, observed variables are having objective facts and are easy and simpler to measure. One latent variable reflects a number of observed variables (Xiong et al., 2015). There are two primary parts of structural equation modelling, that is, structural model and multiple measurement models. To assess and understand the study model, SEM is very helpful to use. In this study, we determine structural equation model to examine and describe the relationship between green knowledge management, green technology innovation, corporate environmental performance, by evaluating the mediating role of resource commitment. For this reason, PLS-SEM is used.

## Measurement Model

The measurement model, which is also known as outer model in PLS-SEM, shows the connection between latent variables and observed variables (rectangles) (Edeh et al., 2023). Reflective measured constructs are used in measurement model. According to (Chin & Dibbern, 2010), it is preferable to have standardised loadings above 0.70. So, it is proved that all the constructs of the study are valid and reliable. Furthermore, the analysis shows that there is a positive relationship among the constructs, green knowledge management (GKM) and green technology innovation (GTI) having the path coefficient value of 0.605 and green knowledge management (GKM) and corporate environmental performance (CEP) having the path coefficient value of 0.443. Hence it is proved through the analysis that all the variables of the study are valid and reliable having a positive relationship with each other.




## Construct's Reliability and Validity

Composite reliability (CR) and average variance extracted (AVE) are used to measure the construct's reliability and validity. In previous researches and studies it is shown that if the value of Cronbach's alpha and the value of composite reliability is higher than 0.70 and if their values are below than 0.95 will be known as reliable and average variance extracted (AVE) value is higher than 0.50 will be known as valid (Ringle et al., 2020). So testing the reliability and validity of the study's constructs shows that all these variables are reliable and valid, as it is according to the significance level. In table no 1, the reliability and validity of latent variables (constructs) are shown. In which the value of composite reliability varies from 0.724 to 0.823, the value of Cronbach's alpha varies from 0.714 to 0.745 and the value of average variance extracted varies from 0.539 to 0.586.

**Table1.**

**Construct reliability and Validity**

| Constructs | Cronbach's alpha | CR (rho_a) | CR (rho_c) | AVE |
|---|---|---|---|---|
| GKM | 0.714 | 0.724 | 0.823 | 0.539 |
| GTI | 0.745 | 0.746 | 0.809 | 0.586 |

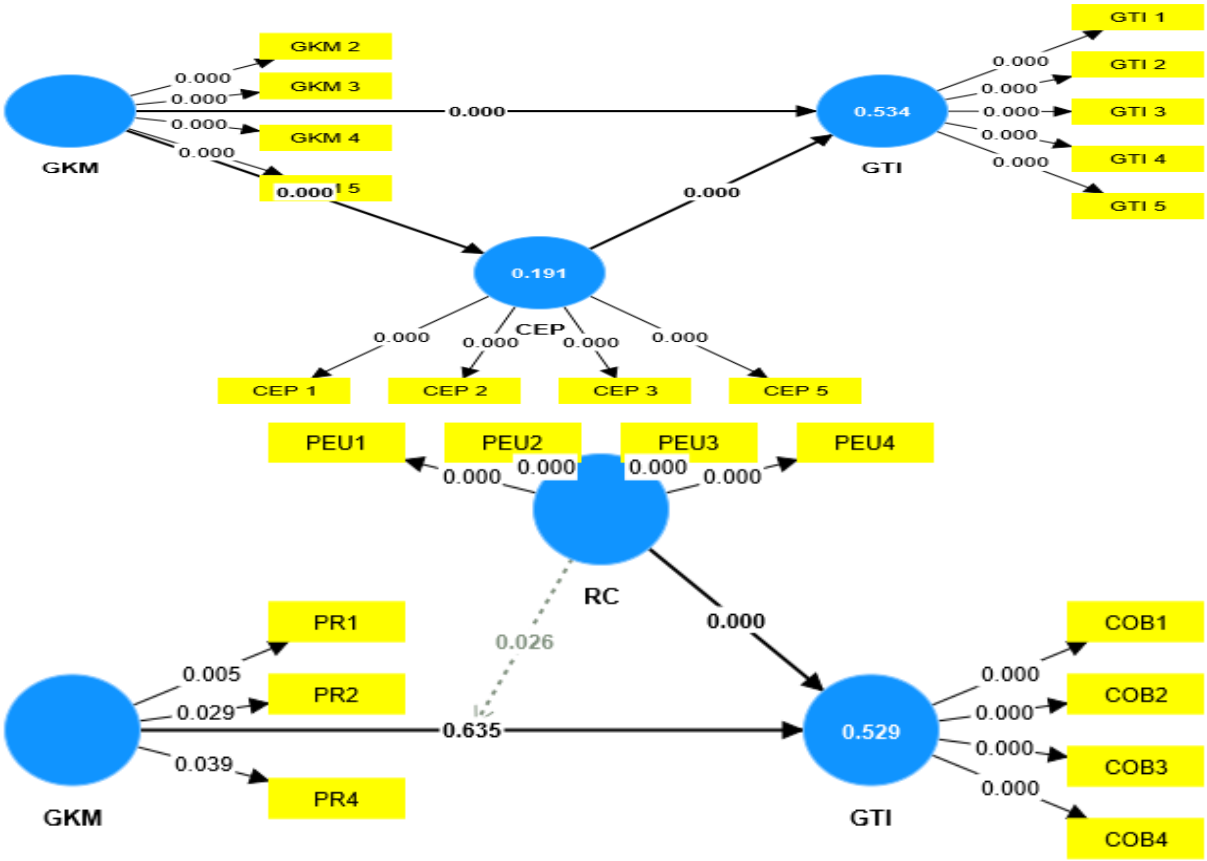
In table no 2, the construct's CEP and GKM reliability and validity explained. In which the value of composite reliability varies from 0.735 to 0.825, the value of Cronbach's alpha varies from 0.708 to 0.714 and the value of average variance extracted varies from 0.532 to 0.55.

**Table 2.**

| Constructs | Cronbach's alpha | CR (rho_a) | CR (rho_c) | AVE |
|---|---|---|---|---|
| CEP | 0.708 | 0.735 | 0.825 | 0.55 |
| GKM | 0.714 | 0.761 | 0.817 | 0.532 |

### Structural Model

The structural model, which is also known as inner model of PLS-SEM, connects the constructs with each other through a pathway (in circle or oval form) that often represent hypothesis. In simple words, structural model is the connection between constructs or latent variables (Edeh et al., 2023). After evaluating measurement model, the suggested hypothesis were tested, by measuring the standard deviation of the parameter estimations between the constructs and examining the p-values, which shows the significance level of 0.05.




## Hypothesis Testing

For hypothesis testing we use three methods, that is, direct analysis, indirect analysis and moderation analysis. During analysis, hypothesis from H1 to H5 all are supported. As the significance level of p-values, according to the researchers, is 0.05 and all of the p-values during hypothesis testing is below the significance level 0.05. Table no 3 shows the path assessments results of SEM model by using SmartPLS software to show the significance level of direct effects of GKM on measures of GTI and CEP, supported and confirming H1 and H2. It shows that GKM had a great positive effect on GTI and CEP. The result also indicates that manufacturers are having effective GKM that is playing a great role in helping organization to innovate and making eco-friendly

products and to improve and to upgrade their CEP. The finding also shows the direct effects of CEP on measure of GTI, supported and confirming H3. It also indicates that manufacturers having positive CEP directly affect GTI positively and can be found helpful for innovating eco-products.

**Table 3.**
**Direct analysis**

| Hypothesis | Path Assessments | Original sample (O) | Sample mean (M) | Standard Deviation (SD) | T values | P values | Results |
|---|---|---|---|---|---|---|---|
| H1 | GKM -> GTI | 0.612 | 0.617 | 0.049 | 12.613 | 0 | Supported |
| H2 | GKM -> CEP | 0.437 | 0.44 | 0.055 | 7.895 | 0 | Supported |
| H3 | CEP -> GTI | 0.445 | 0.452 | 0.049 | 9.163 | 0 | Supported |

Table no 4 shows that CEP is playing a mediating role between the association or relationship of GKM and GTI. The analysis supported or confirming H4 as there p-value is low than a significance level of 0.05. The findings shows that manufacturers that is having positive CEP in an organization can positively effect GKM and GTI. Because if the organization are having well managed CEP their employees will work on GKM and GTI properly and the organization will be able to make eco-friendly products and will take initiatives to innovate and to boost their organization.

**Table 4.**
**Indirect Analysis**

| Hypothesis | Path Assessments | Original sample (O) | Sample mean (M) | Standard Deviation (SD) | T values | P values | Results |
|---|---|---|---|---|---|---|---|
| H4 | GKM -> CEP -> GTI | 0.194 | 0.199 | 0.034 | 5.682 | 0 | Supported |

## Test of Moderation

As discussed, the study included moderation effect on the evaluation of the association or relationship between GKM and GTI. The results shows that RC is strongly moderate the relationship of GKM and GTI which is confirming H5, with numerical data as evidence.

**Table 5.**
**Moderation Analysis**

| Hypothesis | Path Assessments | Original sample (O) | Sample mean (M) | Standard Deviation (SD) | T values | P values | Results |
|---|---|---|---|---|---|---|---|
| H5 | RC x GKM -> GTI | 0.063 | 0.053 | 0.028 | 2.233 | 0.026 | Supported |

# DISCUSSION

This research helps in expanding the application or scope of RBV and their theoretical extensions, that is, KBV and NRBV by conceptualizing GKM which helps to better understand while taking decisions regarding GTI activities in an organization. The research model that has been suggested is based on incomplete data that is collected by previous researchers (Abbas & Sağsan, 2019; J. Wang et al., 2020) – has made it possible for this study to show that environmental decision making can enhance company ability to handle green information and improve organizational capacity to innovate and to take initiative of making eco-friendly products and process. The results also supports the fact that the organization or manufacturers that are having technical resources, there know how and thinking capabilities to manage green information helps to reduce the level of risks related to the environment in which

they work or operate their business. The conceptually included GKM and GTI helps the research to contributes a new theoretical view on knowledge management and environmental management, which leads to help the administrators or manufacturers to transform their businesses in environmental friendly businesses, away from pollutions by going green. The first hypothesis is confirmed during hypothesis testing which is, green knowledge management effect green technology innovation positively. This means that organizations or manufacturers that are using the capabilities of green knowledge management effectively and efficiently will impact directly on the innovation of green technology, positively. Previous studies shows that knowledge production or generation increase the ability of organization to generate new ideas or concepts and to innovate their technologies (Al Yami & Ajmal, 2019). The second hypothesis is, green knowledge management effect corporate environmental performance positively, which is confirmed during analysis. This means that organization uses the knowledge that is collected through green knowledge management can help the organization to address risk and issues and to resolve their issues by taking appropriate action in time which lead towards the improvement of the corporate environmental performance. Green knowledge management works as an initiator that help organization to initiate and to improve their environmental performance (Shahzad, Qu, Ur Rehman, et al., 2020).

The third hypothesis is, corporate environmental performance effect green technology innovation positively, which is confirmed during analysis. Corporate environmental performance can also have the direct impact on the innovation of green technology within an organization because if the environmental performance of an organization is supportive and cooperative then manufacturer will be able to innovate their technologies to utilize their capabilities. Technologies can improve the mistakes or issues that are arising in the environment of the organization. The laws and regulations that are used within the organizations are found helpful not only in the improvement of organization, it also helps organizations to encourage themselves to innovate (Abu Seman et al., 2019). The fourth hypothesis is confirmed during hypothesis testing which is, corporate environmental performance is positively influenced by the mediating effect of green knowledge management and green technology innovation.

This is clear from the above statements also that manufacturers if use green knowledge management effectively to increase the capabilities of green technology innovation can positively influence the corporate environmental performance to improved which will be found helpful in achieving organizational strategic goals or objectives easily. The study also finds that the process of green knowledge management is helpful in the process of technology innovation which make the environment of an organization better (Shahzad, Qu, Zafar, et al., 2020). The fifth hypothesis which is also confirmed during hypothesis testing is that, green knowledge management and green technology innovation is positively influenced by the moderating effect of resource commitment. This is clear from the findings that those organizations or manufacturers which invest their resources in introducing these green practices in their organization culture will positively impact their organization. Because without resources organization will be unable to collect accurate data through green knowledge management and will be unable to innovate their green technologies. The ability to innovate and to generate new ideas for innovation is enhanced by the creation of or by generating new knowledge, so the organization need to invest sufficient resources to this endeavour (Abbas & Sağsan, 2019).

## THEORETICAL CONTRIBUTIONS

The study's findings shows that there is a strong and positive connection between GKM and GTI (H1). Because the organization cannot work on their GTI without the knowledge that is obtained by GKM. Due to GKM, the massive data is collected from the environment which is then visualising, analysing, evaluating, structuring for organization to improve their GTI capabilities. Without GKM company is unable to keep their selves up-to-date from the emerging risks in the environment in which they operate and GKM can be found helpful to reduce environmental complexities of GTI. This idea supports the result that is related to H1, which supports the theoretical hypothesis that manufacturer's GTI capabilities are positively impacted by the successful implementation of GKM (Abbas & Sağsan, 2019; Zhou et al., 2020). Thus, the current study offers a unique addition considering environmental factors related to the effect of GKM as an analytical tool and creative precursor towards the organizational synthesis of GTI.

## MANAGERIAL IMPLICATIONS

The findings of the study imply various consequences for manufacturers and administrators to use in their manufacturing industries. First, the administrators and policy makers can establish a visionary environmental management for their organizations by utilizing their technical capabilities to cover the whole manufacturing value chain (Biscotti et al., 2018; Frondel et al., 2008). Manufacturers can use their GKM capacity to innovate and for new evaluations in their business, can get instant access to new data, and can support sustainability through the execution of green policies. When a company runs with green policies and promote eco-friendly products and process, can get number of advantages or benefits. Second, the findings recommended that company should invest in their technology to improve company's infrastructure and to increase their technological capacity, to support GKM and GTI, which is considering important factors in their manufacturing operations and can also helpful in increasing their environmental knowledge (Mao et al., 2016). If the company invests according to their company's vision and mission they will get benefited. The data that is collected through GKM and GTI, if gathered and used appropriately by the manufacturer will be found helpful and effective for company (Benzidia et al., 2021; Nimmagadda et al., 2018). Manufacturers are also advised to make such environment or management to watch careful their company's assets and sensitive data in order to protect them.

In industrial settings where there are many participants, GKM helps to effectively communicate with them about green policies and interests, through which their GTI activities or capabilities could improve due to which they will be able to improve their organizational environment and design. When organization runs with the perspective of 'going green' are having a positive impact on their image and reputation (Papa et al., 2021). Therefore, to improve organizational capabilities, introducing green practices, evaluating organizational environment, to find out area of improvement within an organization, managers should make daily conversations and arrange meetings with their teams or employees (Sahoo et al., 2023). After this, the organization will be able to set desirable goals for introducing green practices, will know the process of how to get that goal, and will be able to achieve their goals effectively and efficiently. Due to this their organizational image will greatly impact which will impress their stakeholders and their industrial network to promote green practices in their organization as well, which is also a great achievement to protect

environment. Those manufacturing industries which really want to introduce green practices in their organizations or want to adopt green practices, must have to invest on their GKM activities, whereas GTI activities needs a large amount of fund more than GKM. Because according to these findings, it is proved that thinking about adopting of green strategy within an organization is not suitable until the company transform their ideas into technological innovation and increase their competencies to develop some social capabilities (Huang & Li, 2017). According to this study, RC works as a moderator between GKM and GTI which effects CEP of the organization, so the manufacturers have to invest on their technological innovation with greater RC, could improve their CEP positively. This is because, valid data will lead GKM successful (Ashrafi et al., 2019), if GKM is successfully obtained it will promote GTI (Singh & El-Kassar, 2019) through which CEP will be automatically improved.

In today's such in competitive market, where manufacturers want to produce goods or products according to the public demand and also want to produce eco-friendly products in low budget or limited resources where inflation rate is also high, they must have to invest or use the available resources only on the top priorities of all the time (Wu, 2017). Sometimes high budget or number of resources are not just enough to get success or desirable results, mangers must have to understand that using available resources in a proper way will lead them toward success. To get these results manufacturers first have to do resource management in their organization and records several criteria, like how much human capital you have and what are their capabilities, what are your capacity for process work, how much resources and time you have to complete the project. Manufacturers must have to monitor all these things for resource management. In the next step the mangers must have to set short-term goals for themselves and should move towards the achievement of the organizational objectives which is important. During the establishment of these steps, issues should be mentioned.

In order to establish these steps the seniors or mangers make sure their team or employees: (1) high value work is prioritised according to the available resources to increase the utilisation of resources (2) make sure the available resources is according to the strategical goal (3) make sure the actual progress is monitored and given time is also tracking. When these short-term strategies are achieved, the mangers or manufacturers must have to move toward next step which is now to establish long-term goals or strategies then the previous one. Mangers must have to motivate their human capital for their progress of achieving those goals and for continuous improvement, and recognize their efforts and reward those who works above the expectations. Manufacturers or managers must have to evaluate their actual work with the desirable work to improve their capacity and to know about the usage of organizational resources.

Establishing a culture in an organization which is continuously improving through the appropriate use of allocation of resources will enhance organization ability to improve GKM and GTI through the achievement of their short-term goals which will automatically lead towards the achievement of long-term goals or strategies of improving CEP. This research strongly recommended the functional implementation of proactive environment related to resource management system in order to achieve strategic objectives related to GKM and GTI (Anders, 2021; Nisar et al., 2021b). The suggested strategy for building proactive green orientation that might be found accountable and sustainable by creating new department within an organization with other organizations like HR, marketing, R&D etc. Finally, in the light

of regulatory requirements, manufacturers must be aware of the necessity to mobilise all of their assets either funds or resources to transform establish industrial techniques into paradigms that are compatible and ecologically sustainable (J. A. Zhang & Walton, 2017). Because of this it is become more and more important to implement strategic objectives and initiatives inside in an organizations (Konadu et al., 2020). Therefore, manufacturers should take advantage from this chance to secure or to protect the organizational culture through tools (introducing green practices and trainings etc.) which will help them in achieving and making challenging environment for others.

## LIMITATIONS

Every research has some limitations due to the shortage of time and budget. First, the data is collected from Peshawar manufacturing sectors only. Second, the data which is collected are having a large number of employees which gives the same result. Third, the study is cross sectional design, due to which it is not possible to observe changes with the passage of time.

## FUTURE DIRECTION

In future the researcher might need to explore the relationship of the variables that how they interact with each other over the time will be find helpful to get more accurate result. The researcher should collect data from other cities as well to get more detail because this research is having limited data. In future the researcher, if possible, collect data from mangers and from top management to know the relationship of variables better. The researcher should also plan to collect data from a wide range of stakeholders including investors, suppliers, and customers etc. to get more comprehensive understanding of the potential and difficulties associated with the green practices implementation. This research focuses only on manufacturing sectors of Peshawar in future the researcher might need to investigate other sectors of Peshawar and in other regions or cities as well to know the outcomes of the study. In order to monitor or observe changes in GKM, GTI and CEP with the lengthy time period, the researcher will design longitudinal approach for future investigation. The researcher should plan for future to investigate how Block Chain, Artificial Intelligence (AI), Digital Finance and other cutting-edge technologies might improve GKM and GTI which will help us to know that how the technology advancement may support these productive sustainable practices.

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