Migration Letters

Volume: 21, No: S11 (2024), pp. 1333-1354

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

Towards A Resilient And Sustainable Future: Examining The Interplay Of Procurement 4.0, Process Optimization, And Environmental Uncertainty

Javed Iqbal[1] and Dr. Arfan Ali[2]

ABSTRACT

International agreements like the 2030 Agenda and scholarly research show that businesses can't keep doing what they're doing; they need to put in extra effort to make the world more sustainable. To achieve this, businesses must implement sustainable practices by adopting cutting-edge technologies to optimize their processes. The emergence of new technologies and companies' digital transformation towards these technologies is revolutionizing companies' operational and administrative processes and creating innovative digital products and services. This study aims to identify how procurement 4.0 implementation and digital transformations are related and how digital transformation impacts the intention to optimize the procurement process in achieving organizational sustainability performance. The moderating effect of environmental uncertainty is also investigated. We surveyed large-scale manufacturers in Pakistan and analyzed survey results using covariance-based structural equation modeling (SEM) through AMOS-24. The respondents of this study were 397 procurement professionals who had relevant knowledge about the understudied area. The findings of this empirical study[1] revealed the positive influence of procurement 4.0 implementation on procurement process optimization. Moreover, results confirmed the mediating role of procurement process optimization in enhancing organizational sustainability performance. Furthermore, results revealed that technological environment uncertainty significantly moderates the relationship between procurement 4.0 implementation and procurement process optimization.

Originality: *The concept of "procurement 4.0" has recently emerged and is not widely researched yet. Especially in the context of emerging economies, it is very novel. Hence, this study can contribute a lot to digitalization literature, particularly in the context of 4.0.*

Keywords: *Procurement 4.0; Industry 4.0; Process Optimization; Sustainability Performance*.

1- Introduction

Maintaining relevance and competitiveness in a dynamic global economy is increasingly challenging. Companies need to be efficient in their supply chains in order to compete effectively in today's business environment (Uusitalo, 2019). This means cutting costs, leading times, and minimizing risk. Purchasing or procurement is one area of operation in which an organization can work to remain updated with the market. Over 10% of global GDP is spent

[1.] Ph. D Scholar National Business School, The University of Faisalabad, Faisalabad, Punjab, Pakistan https://orcid.org/0000-0001-6355-6338

[2.] Assistant Professor, National Business School, The University of Faisalabad, Faisalabad, Punjab, Pakistan.

on procurement, making it a significant component of many businesses (Uusitalo, 2019). Historically, the procurement function has entailed manual procedures like sourcing, documentation, and negotiating. However, technological advancements and the growing digitalization trend have led to substantial changes in the procurement process. Procuring things has been an important part of business for hundreds of years. Initially, it mainly focused on local and regional trade and frequently used barter systems. Formal procurement procedures, including written contracts and transactions, arose as economies evolved (Ghadge et al., 2020). Throughout history, numerous industries have undergone various stages of development. One may generally categorize these shifts in the industry into four primary periods that correlate to the four different revolutions in the industrial sector (Schwab, 2017). There was a steady progression of improvement between each disruptive shift. Industry and procurement innovation can be categorized into four waves: 1.0, 2.0, 3.0, and 4.0 (Domingo Galindo, 2016). The transition from manual labor to mechanized manufacturing in this industry occurred during the latter part of the 17th century in the United Kingdom, known as Industry 1.0 (Tomassetti et al., 2011). It was a shift from relying on agrarian practices and physical labor to relying on industrial manufacturing and transportation machinery and instruments. James Watt's invention of the steam engine in 1782 played a significant role in the success of this revolution (Smith, 2009). Regarding procurement, this era resulted in a decrease in the influence of distance due to the mechanization of transportation. Prior to that period, procurement predominantly relied on local suppliers. When it came to procurement, the majority of the enterprises were operated by individual proprietors or partners (Althabatah et al., 2023). The procurement process involved inward and outward activities, which relied on a push delivery approach. Products were distributed from the producing side to the retail location. The manufacturers determine the output level according to the market's past ordering patterns. The period known as the Second Industrial Revolution (industry 2.0) was distinguished by several significant breakthroughs, with the foremost being the advent of electricity, closely followed by the development of the telegraph. These technological advancements facilitated significant progress in the fields of transportation and communication. Materials like copper, aluminum, and steel started to play a bigger role in manufacturing goods and machinery (Lauren Cottle, 2023). Emerging industries demanded specialized knowledge in mechanics, electrical, chemical science, and engineering from purchasers. Organizations began receiving support from professional buyers equipped with fresh expertise and knowledge (Nicoletti, 2020). The procurement process adopted the 'push' delivery strategy to acquire commodities in bulk while warehouses were automated. The intra-plant transportation of commodities relied on forklifts, typically equipped with electric motors, operated by personnel (De Looze et al., 2016). Materials and completed goods were carried over great distances by trains and ships (White, 2011). The period known as the third industrial revolution (industry 3.0) was characterized by the advent of the computer, a technology that featured a clear distinction between its software and hardware components (Rifkin, 2011). This facilitated significant adaptability, several technological advancements, and the implementation of entirely novel solutions. The numerically controlled machines possess the requisite adaptability for efficient mass manufacturing. These devices are equipped with computer systems that have memory and are capable of being controlled and programmed using numerical instructions (Rifkin, 2011). The first industrial robot was created in the United States in 1961 by Joseph Engelberger (Engelberger, 2012). Several software programs were created to facilitate procurement management. Enterprise resource planning (ERP), warehouse management systems (WMS), transportation management systems (TMS), and other ICT solutions are a few examples of modern software programs. Subsequently, e-procurement started to proliferate, enabling the implementation of a comprehensive information and communication technology system to facilitate procurement. The utilization of computer programs for managing and controlling procurement procedures facilitated all this development (Nicoletti & Nicoletti, 2018). The term 'industry 4.0' was coined in 2011 by a consortium of corporate, political, and academic professionals to propose a strategy for enhancing the competitiveness of the German industry (Schwab, 2017). The notion has been endorsed by the German government, which has said that it is an essential component of Germany's "High-Tech Strategy 2020" plan. Subsequently, the working group associated with Industry 4.0 (I4.0) created the initial suggestions for its implementation, which were released in April 2013 (Hermann et al., 2016). The advent of networks for communication, especially the Internet, heralded the onset of a profound transformation. The Fourth Industrial Revolution has been triggered by the integration of IoT, innovative software applications, and machine automation in production (Kagermann et al., 2013). I4.0 refers to the integration of the manufacturing process and information and communication technology (ICT) (Skilton & Hovsepian, 2018). I4.0 comprises the integration of the IoT (Internet of Things), IoP (the Internet of People), and the IoE (Internet of Everything) (Hermann et al., 2016). Modern ICT is a fundamental concept of I4.0. In reality, information and communication technology has long contributed to the procurement process management (Skilton & Hovsepian, 2018). The term electronic procurement, often known as e-procurement, has been thoroughly defined, and its framework has been meticulously outlined (Nicoletti, 2013). I4.0 and procurement 4.0 are both closely connected initiatives. The digital transformation that enables the fourth industrial revolution is the basis of this initiative. The phenomenon is still lacking a thorough definition. According to some researchers, it's a process that will result in fully automated and networked industrial production (Stock & Seliger, 2016). The conventional approach to supply chain management has seen substantial changes as a result of the fourth industrial revolution. I4.0 technologies, like artificial intelligence (AI) and the Internet of Things (IoT), have helped businesses operate more efficiently by applying them to various supply chain activities. The value chain starts with the purchasing function. Its effectiveness will depend on how well the company integrates its environmental goals, purchasing practices, and sustainability initiatives (Carter et al., 2000; Sepehri et al., 2021). Procurement is a crucial part of supply chain management, which opens up new possibilities for supply chains to become more efficient and successful. An environmentally friendly supply chain includes planning the product, buying materials, making it, delivering it to customers, and managing the product's end-of-life (Ghosh et al., 2021; Ramirez-Peña, Sotano et al., 2020). On the other hand, a sustainable supply chain is well-coordinated and considers the economic, social, and environmental factors as foundations (Ramirez-Peña et al., 2020). By integrating these aspects with critical inter-organizational business systems, we can better manage the information, material, and capital flows involved in sourcing, manufacturing, and distributing goods and services in a way that satisfies stakeholders and boosts long-term profitability (Ramirez-Peña et al., 2020). I4.0 technologies may impact all three aspects of sustainability, including design, production, safety, economic effectiveness, conserving energy, and protecting the environment (Ramirez-Peña et al., 2020). Cloud systems, for instance, can be used to create sustainable procurement by considering many sustainability-related elements, including social and environmental concerns, the cost of disposing of waste, and the carbon footprint (Singh et al., 2018). The convergence of I4.0, procurement 4.0, and sustainability performance establishes an intricate framework that empowers businesses to attain their sustainability objectives with enhanced efficacy and efficiency. Organizations may optimize their manufacturing processes, cut down on waste, and adopt more sustainable sourcing practices using the features of I4.0 and procurement 4.0. Moreover, using advanced statistics and data-driven conclusions in I4.0 and procurement 4.0 can assist businesses in precisely monitoring and evaluating their sustainable performance. This facilitates enhanced decision-making and the capacity to pinpoint areas that require improvements (Rejeb & Appolloni, 2022). In an ever-evolving technology landscape, the challenge is to leverage the advantages of emerging technologies to promote sustainable organizational practices and foster competitiveness and innovation. With the use of cutting-edge technologies, Procurement 4.0

presents a revolutionary method that improves sustainability, agility, and efficiency. However, combining the concepts of procurement 4.0 with process optimization and long-term organizational success is still difficult, especially regarding the unpredictability of the technology environment. The current study proposes a framework based on current research that connects procurement 4.0 to demonstrate how it improves process optimization, leading to organizational sustainability performance. The empirical study on procurement 4.0 holds significant academic and practical importance, providing valuable insights and innovations that assist scholarly comprehension and real-world implementation. In terms of theoretical contributions, the study has the potential to broaden the existing body of knowledge about operations management, supply chain management, and procurement areas. Procurement 4.0 research has the potential to close gaps in the fields of economics, management, and technology, resulting in multidisciplinary academic interactions. The current study on procurement 4.0 contributes to advancing knowledge, encourages interdisciplinary cooperation, stimulates business innovation, improves operational efficiency, provides insights for making strategic decisions, supports professional growth, and advocates for sustainable procurement practices and corporate social responsibility (CSR). As a result, this study possesses academic and practical significance. At its core, research into procurement 4.0 might have far-reaching effects on theory and practice by illuminating the digital revolution in procurement and outlining best practices for implementing it to provide long-term, potentially sustainable advantages. This study aims to investigate the role that procurement 4.0 plays in optimizing the procurement process to achieve improved sustainability performance. Despite its limited scholarly attention, the significance of procurement 4.0 to the manufacturing industry is evident. This study aims to increase our understanding of procurement 4.0 by examining how digitization and sustainability work together in uncertain technological environments. This study will make a unique contribution by creating a framework that combines the fundamental concepts of I4.0 with environmentally friendly purchasing practices. This framework will show how companies can use new technologies to improve their purchasing processes, enhance their overall business performance, and remain responsible to society and the environment in a world where technology is constantly changing.

2- Theoretical Underpinning

2.1. Dynamic Capability View Theory (DCV)

The current study is grounded on the Dynamic Capability View Theory (Teece, 2007; Teece et al., 1997). The dynamic capabilities viewpoint is a modern way of looking at firms in changing environments and how to generate long-term competitive advantage. According to Bag et al. (2020) and Breidbach et al. (2015), managers tend to reorganize internal capabilities and develop external capabilities with important stakeholders to achieve a long-term competitive advantage. As a result, the use of dynamic skills might be advantageous in this context. It is possible to view procurement 4.0 solutions as a limited resource that can assist organizations in establishing dynamic capabilities in this uncertain business climate. These solutions can help organizations reduce uncertainty by increasing visibility and optimizing processes (Bag et al., 2020; Breidbach et al., 2015). According to the DCV, an organization must adapt to changing environments to stay competitive. Based on this principle, organizations must be able to reorganize resources, adapt to ecological changes, and innovate to maintain a competitive edge. Implementing the DCV is of the utmost importance in procurement 4.0. Adopting the DCV enables organizations to improve procurement processes by adapting and modifying them (Ramírez-Peña et al., 2020). This requires optimizing procurement processes, fostering supplier cooperation, and enhancing decision-making through modern technologies, including blockchain and artificial intelligence (AI). Furthermore, to capitalize on emergent market opportunities and implement sustainable procurement practices, organizations must cultivate a capability to promptly recognize and capitalize on such prospects within the procurement domain. Using the DCV in procurement 4.0 ensures organizations adapt to changing market trends and consumer needs. The DCV highlights the ability of an organization to methodically and strategically adjust and rejuvenate its capacities to address ever-changing situations effectively. Within the framework of procurement 4.0, DCV holds significant importance as it implies that companies must cultivate the ability to use innovative technologies and enhance the efficiency and effectiveness of their procurement operations. Implementing DCV in procurement 4.0 necessitates organizations proactively allocate resources to educating and equipping their purchasing professionals. Organizations may establish a robust digital infrastructure to provide seamless communication, complete visibility, and optimal efficiency across the supply chain. Khushalani and Woodcock (2018) suggest that a procurement department of the next generation may prioritize strategically investing in digital capabilities, emphasizing fostering skill and culture development using a combination of adult learning and eLearning solutions. The DCV highlights how crucial it is for a company to react and adjust to changing circumstances, which is especially important when implementing procurement 4.0. According to this approach, firms must constantly evaluate their capacities and resources to spot new possibilities and modify their procurement strategy. Organizations can use this theory to mold their procurement operations, allowing them to exploit upcoming technology and optimize supply chain procedures. By doing this, they'll be able to stay ahead of the competition in the procurement market and successfully negotiate the challenges of digitization. Regarding procurement 4.0, the DCV is helpful since it helps businesses build skills essential for surviving and thriving in a dynamic and unpredictable world (Chang & Lin, 2010). To successfully implement procurement 4.0, organizations must follow the DCV principles, which allow them to adapt to unpredictable markets, adopt new technology, and optimize their procurement procedures for optimal value generation and operational effectiveness (Palmer & Gupta, 2011). The integration of DCV with Procurement 4.0 encompasses more than mere technological adoption. It necessitates establishing management capabilities, process efficiency standards, and strategic accomplishments that align with the transformation's objectives (Ramírez-Peña et al., 2020). Implementing dynamic capabilities is imperative for effectively managing digital technologies, which are increasingly significant in enabling collaboration and real-time communication throughout supply chains. The DCV emphasizes how crucial it is to continually evaluate and modify procurement strategies to keep them in line with transformations in the external environment when implementing procurement 4.0. This enables businesses to use innovative technologies and build the skills to meet procurement sustainability goals.

3- Literature Review & Hypotheses Development

3.1. Procurement 4.0 implementation and organizational sustainability performance.

The conventional approach to supply chain management has seen substantial changes as a result of the 4th industrial revolution (Jahani et al., 2021). I4.0 technologies, like AI and IoT, have helped businesses to operate more efficiently by applying them to various supply chain activities. Procurement is one of the most important parts of supply chain management, and it can open up new ways for chains to be more effective and efficient. Procurement operation management is one of the most critical supply chain processes directly impacting the organization's performance (Jahani et al., 2021). The application of I4.0 in purchasing has recently increased, making procurement more efficient. The term "procurement 4.0" describes incorporating digital technology for improved performance and efficiency in the procurement process. "Procurement 4.0" is a component of I4.0 that enables dynamic and rapid communication and coordination outside organizational barriers (Glas & Kleemann, 2016). It also presents the concept of connecting all supply chain upstream partners. Some applications and techniques highlighted by procurement technologies include electronic procurement, electronic contract management, and electronic sourcing/procurement. Procurement managers can benefit from I4.0 technologies such as "Contract Management Systems (CMS), Artificial Intelligence (AI), Internet of Things (IoT), Big Data Analytics (BDA), Cloud Computing (CC), Blockchain, Cyber-Physical Systems (CPS), Robotics, procure-to-pay systems, simulation, ERP systems, and Smart Manufacturing" etc. These technologies can assist procurement managers in overcoming challenges related to procurement (Glas & Kleemann, 2016; Osmonbekov & Johnston, 2018; Gottge et al., 2020; Jahani et al., 2021). The abovementioned I4.0 technologies like AI, IoT, BDA, CC, CMS, Robotics, and blockchain facilitate organizations in making procurement decisions that are more sustainable and well-informed. These tools can minimize environmental effects, cut costs, and increase efficiency in the procurement process (Flechsig et al., 2022). Procurement 4.0 also lets organizations make their supply chains more open and easy to track, ensuring that environmentally friendly practices are implemented throughout the purchasing process. Procurement 4.0 can significantly improve an organization's sustainability performance by facilitating more transparent supply chains, better use of available resources, and more environmentally friendly purchasing decisions (Asha'ari & Daud, 2019). Furthermore, procurement 4.0 may help reduce waste and carbon emissions by allowing businesses to manage and monitor their purchasing operations, highlight improvement areas, and implement more environmentally friendly strategies (Bag et al., 2020). As a result, implementing procurement 4.0 can help organizations accomplish their sustainability objectives and improve their performance in the social, economic, and environmental domains. Based on the above discussion, we can hypothesize that:

H_1: There is a significant relationship between procurement 4.0 implementation and organizational sustainability performance.

3.2. Procurement 4.0 implementation and procurement process optimization.

Technological advancements facilitated by procurement 4.0 can potentially optimize the procurement process by offering real-time data. The firm's business and operations strategies, on which the procurement strategy is predicated, may have an additional impact on optimizing the procurement process (Bag et al., 2021). The requirement for immediate and accurate information to improve visibility in manufacturing processes necessitates using interactive procurement infrastructure, encouraging vendors and buyers to optimize their procurement processes (Bag et al., 2020). The most effective procurement 4.0 implementation involves the integration of process automation and optimization through the application of the "Lean and Digitize" approach (Nicoletti, 2016). This method is beneficial, as evidenced by its successful implementation in numerous firms. When implementing digital transformation, organizations frequently overlook the significance of process improvement, particularly regarding the partners and individuals impacted by the transition, who are crucial counterparts. Implementing procurement 4.0 necessitates a shift in the organization's culture. It is important to streamline and expedite the management of procurement processes by integrating them and making them simpler. Motivating the internal personnel responsible for procurement processes to adopt the new procurement 4.0 techniques is crucial to ensure its successful implementation. Using automation and cutting-edge technologies, procurement 4.0 implementation may significantly enhance the efficiency of the procurement process. The procurement process can be significantly improved in a number of ways through the implementation of Procurement 4.0. Using the potential of digitization, procurement 4.0 makes procurement processes more proactive, less manual, and significantly more well-informed, eventually resulting in substantial improvements in productivity, management of risks, and value generation. Considering all these advantages of procurement 4.0 implementation, organizations have a great intention to optimize their procurement processes. Based on the above discussion, we predict that:

H_2: There is a significant relationship between procurement 4.0 implementation and procurement process optimization.

3.3. Procurement process optimization and sustainability performance

Sustainability performance and procurement process optimization are strongly related, and advancements in one area frequently have positive effects on the other (Bag et al., 2020; Waaly et al., 2018). An organization's overall sustainability performance depends greatly on how well its procurement process works. Organizations must prioritize optimizing their procurement process to improve sustainable performance. Automating procurement procedures can help businesses be more socially and environmentally responsible, reduce waste, and use less energy. By integrating sustainable procurement methods, organizations can guarantee that their purchase decisions are consistent with their sustainability objectives and principles (Ruparathna, 2013). Organizations can lessen their impact on the environment and make positive social and economic impacts by incorporating sustainability factors into procurement processes (Song et al., 2017). Procurement process optimization involves sustainable practices that enhance organizational sustainability performance (Brewer & Arnette, 2017). These practices include sustainable sourcing, supplier selection, evaluation, collaboration, and engagement; assessment of product lifecycle and design; cost saving and resource conservation; and compliance initiatives. Sustainable sourcing can be added to an organization's procurement strategy by optimizing the procurement processes (Arora et al., 2020). Improving sustainable performance throughout the supply chain requires procurement optimization. Companies can positively impact the environment and society while improving their operations and getting ahead of the competition by considering sustainability when selecting suppliers, working with them, sourcing goods, making sure they follow sustainability standards, and looking for ways to save costs (Bag et al., 2020). Based on the above discussion, we hypothesize that:

H_3: The optimization of the procurement process has a positive impact on organizational sustainability performance.

3.4. The mediating role of procurement process optimization

The digital revolution of procurement 4.0 and the intention of improved sustainability performance throughout organizations are interconnected through procurement process optimization (Bag et al., 2020, 2021). As organizations want to include sustainable practices in their business strategies, the importance of procurement process optimization evolves progressively more important. With the help of technological innovations, procurement 4.0 aims to digitalize and automate the procurement process and build a more responsive, transparent, and effective supply chain (Handfield et al., 2019). Optimizing the purchase process entails coordinating these technology advancements with environmentally friendly purchasing practices. Its main objective is to improve procurement processes to further contribute to sustainable development and improve financial performance (Bag et al., 2020). Through procurement process optimization, organizations may guarantee that the materials and suppliers they select meet social and environmental criteria while simultaneously cutting costs and improving operational effectiveness (Bag et al., 2020). In the link between procurement 4.0 activities and sustainability performance, procurement process optimization plays a vital role as a mediator (Munir et al., 2023). Sustainable procurement is made possible by procurement 4.0 initiatives, which offer the necessary technological foundation and skills. However, real sustainability results are achieved through the optimization of procurement processes. First, optimizing the buying process makes sustainability efforts more efficient and effective by reducing the amount of waste and making the best use of resources (Bag et al., 2021). Organizations can contribute to environmental sustainability by optimizing resource allocation, cutting waste, and minimizing carbon footprint by simplifying procurement operations. Furthermore, process optimization enhances the ability to make smart choices and effectively manage risks in sustainability-related initiatives (Bag et al., 2020, 2021). Procurement process optimization facilitates the transformation regarding procurement 4.0 and demonstrates a commitment to improving sustainability performance (Munir et al., 2023). By implementing procurement process optimization, companies achieve financial advantages and significantly contribute to environmental sustainability and social responsibility, eventually promoting a sustainable future (Bag et al., 2020; Carter et al., 2000). Therefore, we can hypothesize that:

H4: Procurement process optimization mediates the relationship between procurement 4.0 implementation and organizational sustainability performance.

3.5. Moderating role of technological environment uncertainty

Organizations' supply chain management has changed dramatically with the introduction of procurement 4.0, which incorporates cutting-edge technologies into purchasing processes (Glas & Kleemann, 2016). However, there are obstacles associated with this transition, especially in environments where technology is unpredictable (Daher et al., 2017). Organizations can streamline their processes, cut costs, and make better decisions with the help of procurement 4.0 initiatives. Due to continuous technological advancements, evolving market environments, and changing customer expectations, adopting and integrating new technologies creates procurement uncertainty (Batran et al., 2017; Li, 2022). The uncertain technological environment makes it challenging to adopt and implement procurement 4.0 technologies. Organizations may be reluctant to invest in procurement 4.0 and process optimization activities if they doubt emerging technology's effectiveness, compatibility, and long-term sustainability. Technology changes and market disruptions emerge rapidly, which makes it difficult for organizations to plan effective buying strategies (Batran et al., 2017; Uusitalo, 2019). Implementing procurement 4.0 technology requires organizations to evaluate and improve their procurement strategies, ensuring they align with the continually evolving technological environment (Bag et al., 2021). This might include offering training to employees on novel technology-based procurement techniques, allocating resources towards implementing systems that can seamlessly integrate with developing technologies and embracing a receptive mindset toward fostering innovation (Sjödin et al., 2021). Furthermore, the intention to achieve procurement efficiency in the face of technological uncertainty is also impacted by projected benefits such as enhanced traceability and transparency in the supply chain (Choi et al., 2022). For instance, blockchain technology can improve trust between stakeholders and safeguard transactions, which are important while navigating environmental uncertainty (Akaba, 2019; Gunasekara et al., 2022). Procurement 4.0 significantly impacts organizations' efforts to optimize the procurement process, especially in situations where there is uncertainty in the technological environment (Číž et al., 2021). By leveraging the cutting-edge procurement technologies emerging from procurement 4.0 initiatives, firms may stay flexible, increase productivity, and maintain their competitive edge (Bag et al., 2020, 2021; Corboș et al., 2023). We can predict on the basis of the above discussion:

H5: Technological environment uncertainty moderates the relationship between procurement 4.0 implementation and procurement process optimization.

The conceptual framework (Figure 01) has been developed to perform the empirical testing.

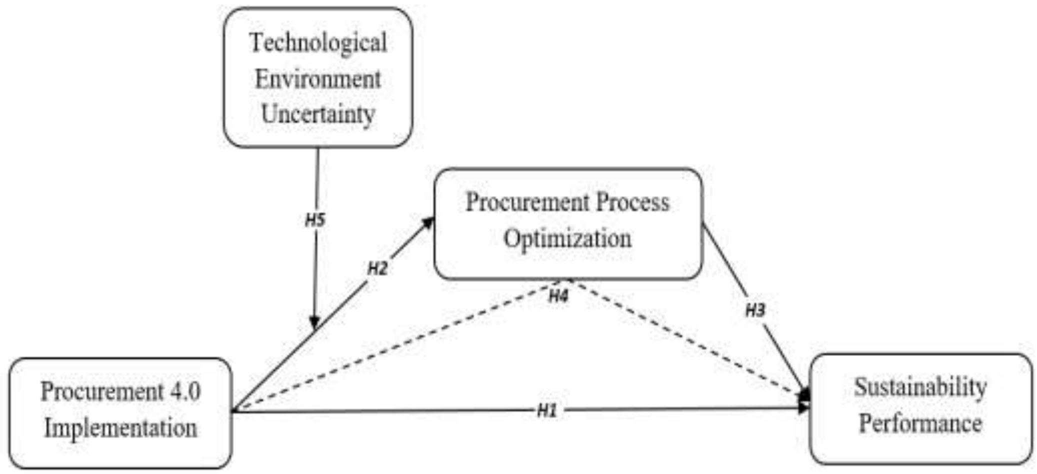

Figure 01: Hypothesized Research Model

4- Research Methods

According to Guba (1990), methodology refers to the process by which data and knowledge are produced by applying a specific theoretical framework. The present study employs the positivist research philosophy, which facilitates deriving logical conclusions to assert and validate hypothesized relationships. This philosophy was the most appropriate for our research since it adopts an essentialist perspective and assumes that reality has not yet been explored (Kreuger & Neuman, 2006). The deductive research approach is deemed the most suitable as the current study logically and systematically tests theory-based hypotheses through gathering, analyzing, and testing empirical data (Reyes, 2004). Moreover, the current research is an "explanatory research," often called "causal research," that seeks to explain the fundamental causes and effects behind observed situations. Furthermore, the current research was field research, as the research participants (procurement professionals) were contacted to fill out the questionnaire for quantitative research data. According to Brennan, Chugh, and Kline (2002), it would be field research when respondents are contacted in their natural work environment for data collection (Brennan et al., 2002). Individuals related to procurement activities in the large-scale manufacturing firms of Pakistan were the "unit of analysis" in the current study. The current study relied on "self-administered questionnaires" because of their numerous benefits, the most significant of which is that they require significantly less time to collect data.

4.1. Constructs' Operationalization

A 4-item measurement scale was adapted from the study of Kohtamäki et al. (2012) to measure procurement 4.0 implementation (Kohtamäki et al., 2012). Sample items included; "Our procurement 4.0 strategy guides our daily decision-making," "Our buying department priorities their tasks based on our procurement 4.0 strategy," and "Our buying department commits to implementing our procurement 4.0 strategy." An 8-item measurement scale was adopted from the study of Bag et al. (2020), initially developed by Bienhaus and Haddud (2018) to measure the intention to optimize the procurement process. Sample items included; "Buyers in our company have shown interest in adopting automated procurement/ supply chain processes," "Our company's intention is to integrate procurement into general management development and training programs," and "Our company's intention is to aim for agile and customer driven procurement." The current study adopted a 15-item measurement scale from the study of Arora et al., (2020) to measure organizational sustainability performance. Arora et al. (2020) measured the construct of sustainability by combining economic, environmental, and social performance indicators. Sample measurement items included; "Decrease in cost of materials purchased," "Decrease in consumption of hazardous/harmful/toxic materials," and "Improvement in occupational health and safety of employees." Technological environment uncertainty was measured using a 4-item measurement scale adopted from the study of Huo et al., (2024), initially developed by Chen and Paulraj (2004). Sample items are; "Our industry is facing a rapidly changing technology environment," "The production technology changes frequently and sufficiently," and "The rate of technology obsolescence is high in our company's industry." Except for the demographics, all latent variables were measured on a 5-point Likert-type scale where "5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, and 1 = Strongly Disagree."

4.2. Sampling and Data Collection

As the total number of large-scale firms in different manufacturing sectors was 345, it was impossible to collect data from all these firms, and the total population of the target sample was also unknown. Therefore, the study followed Krejcie and Morgan's formula for the sample section for an unknown population. According to the formula, if the population is unknown or finite, a sample size of 384 is more than enough (Krejcie & Morgan, 1970). In accordance with the guidelines that were provided by Dillman et al., (2014), a web-based survey questionnaire was developed. Before distributing the questionnaire, five procurement professionals, industry specialists, and academic experts were pretested for face and content validity. The pretest feedback helped us improve the questions' wording for clarity and interpretation. The updated questionnaire was subsequently made available online to a selected group of procurement professionals. Target respondents were approached in multiple ways, such as through personal visits, professional bodies, personal references, social platforms, professional groups, etc. A total of 1697 survey links were shared, and 397 useful responses, excluding 35 pilot study responses, were gathered, with an overall response rate of 23%.

4.3. Analytical Strategy

In the current study data, normality and descriptive statistics were conducted using Statistical Package for the Social Sciences (SPSS) version 26. Validity tests, measurements, structural model analyses, and hypotheses testing (direct and indirect effect) were made using structural equation modeling (SEM) through AMOS version 24. Moderation analyses were conducted using the Hayes process macro through SPSS-26.

4.4. Common Method Bias

Harman's one-factor test was utilized to assess the scale of the potential bias. Upon loading all items into a single-factor analysis model, a total of seven factors were identified. Notably, the initial component only accounted for 25.38 of the overall variance, which is well under 50% of the recommended cutoff criteria (Podsakoff et al., 2003). Furthermore, the factor analysis did not reveal the emergence of any general factor. Consequently, the study did not consider common method variance to be a significant problem.

5- Data Analysis and Findings

5.1. Analysis of Data Normality

Skewness and Kurtosis statistics were utilized to test the normality of the data. Analysis of the data's normality was performed according to the recommendations made by Hair et al. (2010) and Kline (2023). Since Covariance-based SEM (using AMOS) is parametric, normal data is necessary. Therefore, it is important to evaluate the data to see whether it deviates too much from normality (Hair et al., 2010). Because the severely non-normal data may make it difficult to analyze the parameters, which could inflate the standard errors. Hair et al. (2010) define normality as the bell-shaped trend in data distribution. Both graphical and statistical approaches can be used to assess the data normality (Tabachnick & Fidell, 2007). According to Tabachnick and Fidell (2007), the statistical approach of Kurtosis and Skewness was considered for this research. Kline (2023) suggests that the maximum possible value for Kurtosis should be less than 10, and the skewness number should be less than 3. Byrne, (2013) states that data is normal if the Kurtosis values fall between -7 to +7 and the Skewness values fall between -2 and +2. Table 1 displays the skewness and kurtosis statistics. These indicate that all values are within the appropriate range and meet the cutoff criterion, indicating no data normality problem.

Moreover, in SEM, multicollinearity can be a significant problem (Hair et al., 2010). According to Hair et al. (2010), multicollinearity occurs when excessive inter-correlation among the predictor variables can be tested using the tolerance value and variance inflated factor (VIF). According to Hair et al. (2010), concerns about multicollinearity should be raised when the VIF value exceeds 5 and the tolerance value falls below 0.20. Hair et al. (2010) further state that when the correlation coefficient is 0.90 or above, it suggests that there is multicollinearity between the exogenous variables. Table 1 contains the VIF statistics, whereas table 2 represents the correlation matrix. All research variables have a maximum correlation value of 0.512, indicating no multicollinearity problem in the data (see Table 2). Furthermore, if VIF values are less than 10, as stated by Hair et al. (2010), then it can be concluded that the data have no multicollinearity problem. Table 1 shows that the greatest VIF value is 1.70, significantly lower than the criterion of 10.

Table 1: Descriptive Analysis, Test of Data Normality and Multicollinearity

Variables	Mean	SD	Skewness	Kurtosis	Tolerance	VIF
P 4.0 Implementation	3.84	0.88	-0.93	-0.19	0.59	1.70
Technological Environment Uncertainty	3.48	1.12	-0.53	-1.11	0.85	1.17
Procurement Process Optimization	3.49	1.03	-0.57	-0.91	0.59	1.70
Organizational Sustainability Performance	3.80	0.84	-1.08	0.09	-	-

N=397

Table 2: Correlation Matrix

Variables	1	2	3	4
1- P 4.0 Implementation	1			
2- Technological Environment Uncertainty	.255**	1		
3- Procurement Process Optimization	.512**	0.003	1	
4- Organizational Sustainability Performance	.238**	.329**	.257**	1

N=397; **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

5.2. Validity Analysis

Validity tests are classified into convergent and discriminant validity (Hair et al., 2010). Hair et al. (2010) recommended that validity analysis is necessary before going for hypotheses testing. The current study tested both convergent and discriminant validities, and results are shown in table 3 and table 4.

5.2.1. Convergent Validity

The convergent validity demonstrates that each item measures its own concept in a way that is consistent with the hypothesis. Several methods can determine convergent validity. Within the scope of this study, two different methodologies were examined. First, composite reliability (CR) values; second, average variance extracted (AVE) values were examined to test the convergent validity. According to the CFA results, the composite reliability values for each item in the related construct were more than 0.84 and highly significant. Hair et al. (2010) suggested that CR values for each construct should be 0.70 or higher for convergent validity. Moreover, Hair et al. (2010) also suggested that AVE should be higher than 0.50 for convergent validity. The current study CFA results reveal that AVE values for all under-study constructs are well above the threshold of 0.50, which confirms convergent validity (see table 3).

5.2.2. Discriminant Validity

Discriminant validity suggests that a particular construct in the model is indistinguishable from the others. This means that for discriminant validity, all constructs in the study model should be uniquely different from each other. The current study utilized two methods to test the discriminant validity. Firstly, following Fornell and Larcker, (1981), for confirmation of discriminant validity, the value for the square root of AVE should be greater than the construct correlation value. Secondly, Heterotrait-Monotrait Ratio (HTMT)" is also used to test discriminant validity. Table 3 presents the results of the Fornell- Larcker Criterion, which shows excellent levels of "discriminant validity" as all the values of the square root of AVE are higher than the constructs' correlation values. Table 4 presents the results of "Heterotrait-Monotrait Ratio (HTMT)" ratios, which reveal that all values are less than 0.90, which confirms excellent discriminant validity, as suggested by Henseler et al., (2015). Therefore, the study measurement model established satisfactory validity.

Table 3: Fornell-Larcker Criterion (Validity Analysis)

Variables	**CR**	**AVE**	**1**	**2**	**3**	**4**
1- Procurement 4.0 Implementation	0.84	0.56	**0.749**			
2- Procurement Process Optimization	0.90	0.54	0.588***	**0.734**		
3- Technological Environment Uncertainty	0.88	0.65	0.295***	-0.032	**0.804**	
4- Organizational Sustainability Performance	0.95	0.55	0.265***	0.224***	0.366***	**0.745**

N = 397; *** p < 0.001; Diagonal bold are square root of AVE

Table 4: Heterotrait-Monotrait Ratio (HTMT)

Variables	**1**	**2**	**3**	**4**
1- Procurement 4.0 Implementation	-			
2- Procurement Process Optimization	0.593	-		
3- Technological Environment Uncertainty	0.299	0.004	-	
4- Organizational Sustainability Performance	0.269	0.279	0.361	-

N=397

5.3. Measurement Model

Each latent variable (construct) and its corresponding indicator are tested simultaneously using the measurement model under the CFA paradigm. According to Hair et al. (2010), it demonstrates how specific sets of variables are used to operationalize various constructs. CFA results for measurement model fitness are shown in table 5, and the measurement model is shown in figure 2. Results reveal excellent model fit as all fit indexes are in the acceptable range.

Table 5: Results of the Measurement Model

Fit Indices*	Accepted Criteria	The Measurement Model Results	Accepted Yes/No
χ^2/df	χ^2/df < 3.0	2.77	Yes
RMSEA	<0.08	0.07	Yes
TLI	≥0.90	0.90	Yes
IFI	≥0.90	0.91	Yes
CFI	≥0.90	0.91	Yes
PNFI	Close to 1.0	0.765	Yes
PCFI	Close to 1.0	0.803	Yes

***Fit indices cut-off criteria by Hu and Bentler (1999), and Hair et al. (2010).**

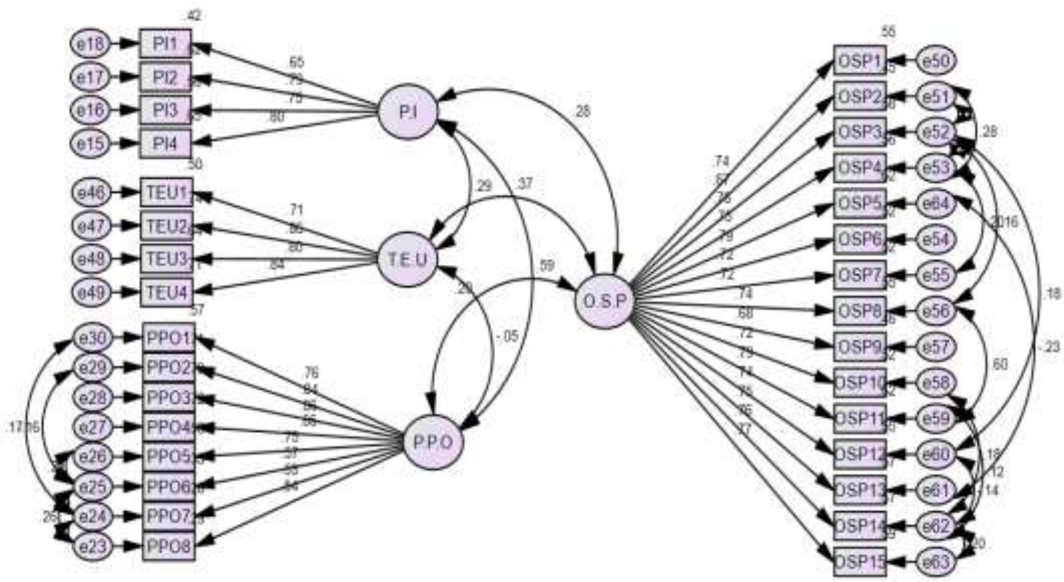

Figure 2: Measurement Model

5.4. Hypotheses Testing

The structural Equation Modeling (SEM) technique was used to test the hypotheses through AMOS-24, and the results of direct effect is shown in table 6, while the mediation effect is shown in table 7. Results reveal that procurement 4.0 implementation is positively related to organizational sustainability performance (β=0.196, P<.001). Moreover, procurement 4.0 implementation is positively related to procurement process optimization (β=0.440, P<.001). Furthermore, results indicated that procurement process optimization is positively related to organizational sustainability performance (β=0.141, P<.001). The findings lead to the acceptance of hypothesized relationships as H1, H2, and H3.

Table 6: Test of Hypotheses (Direct Effect)

Hypotheses	Structural Paths	SE.	Estimate	CR.	P
H1	Procurement Implementation → Sustainability Performance	0.04	0.196	4.58	***
H2	Procurement Implementation → Procurement Process Optimization	0.06	0.440	7.12	***
H3	Procurement Process Optimization→ Sustainability Performance	0.04	0.141	3.46	***

*****p<.001**

The mediation effect of procurement process optimization between the relationship of procurement 4.0 implementation and organizational sustainability performance is tested using SEM bootstrap indirect effect, and results are shown in table 7. Hypothesis H4 states that procurement process optimization mediates the relationship between procurement 4.0 implementation and organizational sustainability performance. Results confirm hypothesis H4 through a significant regression coefficient (β=0.09, p<.01). Moreover, there is no existence of zero in the values of CI, which are 0.043~139.

Table 7: Bootstrap Results for Mediation Effect

Hypotheses	Structural Paths	Effect	SE	LL 95%CI	UL 95%CI
H4	Procurement 4.0 Implementation → Procurement Process Optimization → Sustainability Performance	0.09	0.03	0.043	0.139

N=397; UL = Upper Limit, LL, Lower Limit, CI=Confidence Interval

5.6. Moderation Analysis

The moderation hypotheses were tested using the slop test introduced by Hayes & Preacher (2014). The current study hypothesized (H5) that the relationship between procurement 4.0 implementation and procurement process optimization is moderated by technological environment uncertainty in such a way that the relationship gets stronger when there is high environmental uncertainty. The results of the moderation effect of technological environment uncertainty in the relationship between procurement 4.0 implementation and procurement process optimization are presented in table 8. The conditional effect of 'procurement 4.0 implementation' on procurement process optimization at the values of the moderator (technological environment uncertainty) reveals that 'highest order unconditional interaction' shows significant values for R^2 change and F-statistics (R^2-change = 0.031, F=17.52, P<.001). This confirms the moderation effect. For further validation of the moderation effect, the simple slope of the relationship illustrated in figure 3 indicates that the relationship between procurement 4.0 implementation and procurement process optimization is stronger in the presence of high uncertainty as compared to low uncertainty. Hence, hypothesis H5c is also accepted.

Table 8: Procurement process optimization Predicted from procurement 4.0 implementation and technological environment uncertainty

Moderator (Technological environment uncertainty)	β	p	95% CI	
Low Uncertainty	0.350	<.001	0.182	0.518
Moderate Uncertainty	0.554	<.001	0.447	0.661
High Uncertainty	0.758	<.001	0.644	0.872
Test(s) of highest order unconditional interaction: (X*W)				
R^2 -chng = .031**				
F Statistics = 17.52				

***p<.001

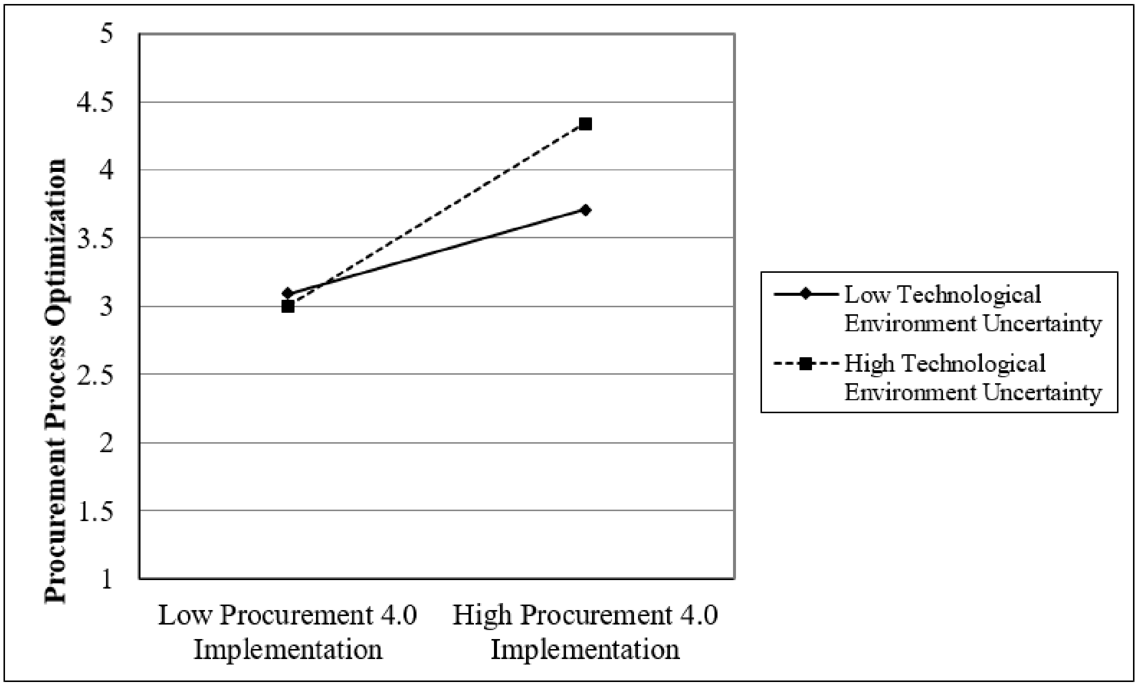

Figure 3: Moderation Graph (P4.0 Implementation*Uncertainty →Process optimization)

6- Discussion

The data results confirm the hypothesis of a positive relationship between procurement 4.0 implementation and sustainability performance. These results are well aligned with many past studies. Organizations can attain sustainability goals by adopting procurement 4.0, which encourages ethical purchasing, lowers wastage and carbon emissions, and develops partnerships with suppliers who share these values (Bag et al., 2020). Procurement 4.0 can also help organizations monitor and assess their sustainability performance by collecting information on important indicators, including emissions of greenhouse gases, water consumption, and waste production. The utilization of this data can ultimately result in improved organizational sustainability performance by highlighting areas for development and providing guidance to decision-making procedures (Bag et al., 2020, 2021). Another hypothesized relationship between procurement 4.0 implementation and the intention to optimize procurement is also tested. Results indicate a significant and positive impact of procurement 4.0 implementation and intention to optimize the procurement process. These findings are well supported by Bag et al.'s (2020) studies and Nicolette (2018; 2020). Procurement 4.0 implementation refers to the digitalization and integration of cutting-edge technology into the procurement process with the goal of improving transparency, efficiency, and strategic decision-making. Implementing Procurement 4.0 can significantly affect the goal of optimizing the procurement process (Bag et al., 2020; Nicolette, 2020). Moreover, the study of Althabatah et al. (2023) also confirms that 4.0 technologies significantly optimize the procurement process (Althabatah et al., 2023). Furthermore, Jahani et al. (2021) also established the positive impact of 4.0 technologies on the procurement process. The current study findings show that the intention to optimize the procurement process positively and significantly impacts the organizational sustainability performance. Past studies by Bag et al. (2020) and Waaly et al. (2018) also established that sustainability performance and procurement process optimization are strongly related, and advancements in one area frequently have positive effects on the other. A study by Adesanya et al., (2020) also confirms a strong relationship between procurement process optimization and sustainability. Saqib & Zhang (2021) also found that optimizing procurement processes enables organizations to make smart choices to reduce their environmental impact and improve their sustainability performance. Moreover, research by He et al., (2020) also proved that optimizing procurement makes it easier for suppliers and other partners to work together by incorporating sustainability issues in the design and development of products. Improving sustainable performance throughout the supply chain requires procurement optimization (Bag et al., 2020). Data results indicate that the intention to optimize the procurement process significantly mediates the relationship between procurement 4.0 implementation and organizational sustainability performance. Many recent studies well support these findings. For example, studies by Bag et al. (2020, 2021) proved that procurement 4.0 and the intention of improved sustainability performance throughout organizations are interconnected through procurement process optimization. The study by Handfield et al. (2019) concluded that with the help of technological innovations, procurement 4.0 aims to digitalize and automate the procurement process and build a more responsive, transparent, and effective supply chain. The study of Akaba (2019) established that procurement 4.0 initiatives improve the transparency and traceability of the whole supply chain process, which confirms that sustainability standards are followed. The current study findings are also well aligned with the research findings of Munir et al. (2023), which proved that procurement process optimization incorporates continuous improvement in processes, which track, analyze, and improve sustainability performance using data from procurement 4.0 technology. According to Munir et al. (2023), in the link between procurement 4.0 activities and sustainability performance, procurement process optimization plays a vital role as a mediator. The current study findings reveal that there is a significant moderation of technological environment uncertainty between the relationship of procurement 4.0 implementation and the intention to optimize the procurement process. Many past studies support these findings. According to the study of Daher et al. (2017), there are many obstacles associated with the transition of cutting-edge procurement 4.0 technologies, especially in unpredictable environments. Studies by Batran et al. (2017) and Li (2022) found that due to continuous advancements in technology, evolving market environments, and changing customer expectations, adopting and integrating new technologies creates procurement uncertainty. The study of Uusitalo (2019) established that procurement 4.0 significantly impacts how organizations want to optimize their purchasing operations, especially when there is uncertainty in the technological world. The study of Handfield et al. (2019) revealed that procurement 4.0 technologies facilitate organizations to be more adaptable and reactive to shifts in the technological landscape through the provision of predictive analytics and real-time data. The study of Bag et al. (2021) proved that implementing procurement 4.0 technology requires organizations to evaluate and improve their procurement strategies, ensuring they are in line with the continually evolving technological environment. Moreover, the current study findings are also supported by the study of Čížek et al. (2021), which confirms that procurement 4.0 significantly impacts organizations' efforts to optimize the procurement process, especially in situations where there is uncertainty in the technological environment.

7- Theoretical Implications

Procurement 4.0, driven by digitization and the adoption of Industry 4.0 technologies, represents a fundamental change in our understanding and conceptualization of the role of procurement in companies and the economy at large. The following are several significant theoretical implications:

Firstly, in the current study, the integration of the digitization and sustainability theories in procurement 4.0 research bridges the gap between these two historically distinct fields. Secondly, the current study offers an approach to connecting technological improvements with sustainable outcomes, enhancing integration. Advances in digital technology and conventional procurement theories are combined in hybrid models developed due to this study on procurement 4.0. This comprises methods that combine sustainability principles, automation, and data analytics to produce more effective and sustainable purchasing practices. Previous research studies, such as the one authored by Saqib and Zhang (2021) and Ahmed et al. (2024) regarding sustainable supply chains, mostly focus on conceptual frameworks for sustainability and do not use modern digital technologies (Ahmed et al., 2024; Saqib & Zhang, 2021). Thirdly, the integration of procurement 4.0 and sustainability research improves supplier relationship management (SRM) theories by integrating digital tools that increase communication, transparency, and performance evaluation. Fourthly, the current study further advances risk management theories by highlighting how digital technology can improve the detection, evaluation, and reduction of sustainability-related risks. This involves adding real-time surveillance and predictive analytics to conventional risk management systems. Fifthly, the present study enhances circular economy theories by demonstrating how digital technology enables circular economies such as reuse, recycling, and optimizing resource utilization. Lastly, this study adds to existing value-creation concepts by demonstrating how digital technology can create value by improving sustainability practices. This involves highlighting how the use of technology and sustainable practices can work together to provide value for both enterprises and stakeholders. The traditional theories of value creation mostly focused on competitive advantage and economic value. The present research investigates the incorporation of sustainable practices and innovative technologies into existing theories, thereby broadening the scope to encompass the value created by these practices and innovations.

8- Practical Implications

The convergence of procurement 4.0 with sustainability presents an enticing strategy for managers who aim to include ethical standards in their operations. To help managers for making a real difference, this emerging subject offers practical insights beyond academic frameworks. This study has implications for managers in the following ways:

Firstly, managers are advised to include procurement 4.0 technologies in their sustainability goals to improve procurement operations. This entails utilizing digital technologies like artificial intelligence (AI), blockchain, and the Internet of Things (IoT) to attain operational efficiency and sustainability objectives simultaneously. Secondly, the current study offers managers the ability to leverage advanced data analytics to make well-informed procurement decisions. This involves examining extensive databases to detect patterns, predict requirements, and improve sourcing strategy. Thirdly, implementing procurement 4.0 technologies necessitates a reassessment and restructuring of conventional procurement procedures. Procurement managers have to manage the transformation of purchasing procedures to utilize digital tools for collaboration, automation, and real-time monitoring.

Fourthly, to improve supplier relationship management, managers should make use of digital platforms. This encompasses using digital tools to enhance communication, monitor performance, and facilitate collaboration to cultivate more robust and transparent partnerships with suppliers. Fifthly, managers can proactively identify and reduce risks connected to supply chain interruptions and sustainability by utilizing digital technologies for risk management. It requires the utilization of predictive analytics to forecast potential challenges and provide contingency strategies. Sixthly, managers need to implement and monitor sustainability initiatives utilizing digital tools to assess the efficiency of their procurement operations. This entails establishing explicit sustainability objectives and using data analytics to assess performance and improvement. Seventhly, the current study offers valuable insights regarding organizational change management. Efficient change management solutions are necessary for the transformation to procurement 4.0 and sustainability. Managers must effectively guide and oversee the implementation of new technology and procedures in order to achieve successful organizational change. Lastly, managers can use digital technologies to promote equitable and inclusive sourcing processes. This involves utilizing technology to actively involve a wide range of suppliers and guarantee equitable chances during the procurement process. Inclusive sourcing, as exemplified by the work of Carter and Jennings (2004), primarily emphasizes policies and procedures but does not incorporate technology perspectives (Carter & Jennings, 2002; Hill et al., 2024; Silva & Ruel, 2022). The current study provides valuable comprehension into how digital tools can effectively support equitable and inclusive sourcing practices. It offers managers practical tactics that can be implemented to achieve this objective.

9- Study Limitations and Future Research Directions

The current study has some limitations that provide opportunities for future research studies in the context of procurement 4.0, digitalization, process automation, and sustainability. The current study ignores risks associated with procurement 4.0 implementation, including supply chain interruptions, cybersecurity threats, and privacy concerns. Further investigation is required to examine efficient methods for managing risks. With modern technologies such as AI, ML, and BDA in procurement, it becomes essential to tackle ethical issues, biases, and transparency concerns, which need further investigation. The current research mostly concentrates on procurement 4.0 within large companies; however, there is a lack of comprehension regarding its implementation and influence on small and medium-sized enterprises (SMEs). The current study is dedicated to examining the buyer's perspective; there is a lack of awareness regarding the impact of procurement 4.0 on suppliers. Potential research might investigate how suppliers adjust to digital procurement platforms, the significance of buyer-supplier relationships, and their collaboration for attaining shared benefits. Cultural norms, legislative systems, and institutional frameworks impact procurement processes. There are gaps in the current research regarding how cultural characteristics and institutional contexts influence the adoption and success of procurement 4.0 technologies across different nations and industry sectors.

10- Conclusion

The study's main objective was to investigate how procurement 4.0 implementation impacts organizational sustainability performance directly and indirectly through the mediation of intention to optimize the procurement process. Moreover, the study investigates the moderating role of technological environment uncertainty in the relationship between procurement 4.0 implementation and the intention to optimize the procurement process. The proposed model was tested on a sample of 397 management-level procurement and supply chain professionals of 345 large-scale Pakistani manufacturing firms to achieve the study objectives. The study findings reveal that procurement 4.0 implementation significantly influences organizational sustainability performance. Moreover, results reveal that the intention to optimize the procurement process significantly mediates the relationship between procurement 4.0 implementation and sustainability performance. The study findings indicate that procurement process optimization significantly impacts overall organizational sustainability performance. Furthermore, the study results also proved that in the presence of technological environment uncertainty, procurement 4.0 implementation significantly impacts buyers' intention to optimize the procurement process.

References

Adesanya, A., Yang, B., Bin Iqdara, F. W., & Yang, Y. (2020). Improving sustainability performance through supplier relationship management in the tobacco industry. Supply Chain Management: An International Journal, 25(4), 413–426.

Ahmed, H., Al Bashar, M., Taher, M. A., & Rahman, M. A. (2024). Innovative Approaches To Sustainable Supply Chain Management In The Manufacturing Industry: A Systematic Literature Review. Global Mainstream Journal of Innovation, Engineering & Emerging Technology, 3(02), 1–13.

Akaba, T. I. (2019). A framework for the adoption of a blockchain-based e-procurement system: a case study of Nigeria. Tallinn University of Technology: Tallinn, Estonia.

Althabatah, A., Yaqot, M., Menezes, B., & Kerbache, L. (2023). Transformative Procurement Trends: Integrating Industry 4.0 Technologies for Enhanced Procurement Processes. Logistics, 7(3), 63.

Arora, A., Arora, A. S., Sivakumar, K., & Burke, G. (2020). Strategic sustainable purchasing, environmental collaboration, and organizational sustainability performance: the moderating role of supply base size. Supply Chain Management: An International Journal, 25(6), 709–728.

Asha'ari, M. J., & Daud, S. (2019). Sustainable procurement and corporate sustainability performance: the moderating role of organisation age. International Journal of Environmental Technology and Management, 22(4–5), 330–351.

Bag, S., Dhamija, P., Gupta, S., & Sivarajah, U. (2021). Examining the role of procurement 4.0 towards remanufacturing operations and circular economy. Production Planning and Control, 32(16), 1368–1383. https://doi.org/10.1080/09537287.2020.1817602

Bag, S., Wood, L. C., Mangla, S. K., & Luthra, S. (2020). Procurement 4.0 and its implications on business process performance in a circular economy. Resources, Conservation and Recycling, 152. https://doi.org/10.1016/j.resconrec.2019.104502

Batran, A., Erben, A., Schulz, R., & Sperl, F. (2017). Procurement 4.0: A survival guide in a digital, disruptive world. Campus Verlag.

Bienhaus, F., & Haddud, A. (2018). Procurement 4.0: factors influencing the digitisation of procurement and supply chains. Business Process Management Journal.

Breidbach, C. F., Reefke, H., & Wood, L. C. (2015). Investigating the formation of service supply chains. The Service Industries Journal, 35(1–2), 5–23.

Brennan, A., Chugh, J. S., & Kline, T. (2002). Traditional versus open office design: A longitudinal field study. Environment and Behavior, 34(3), 279–299.

Brewer, B., & Arnette, A. N. (2017). Design for procurement: What procurement driven design initiatives result in environmental and economic performance improvement? Journal of Purchasing and Supply Management, 23(1), 28–39.

Byrne, B. M. (2013). Structural equation modeling with Mplus: Basic concepts, applications, and programming. routledge.

Carter, C. R., & Jennings, M. M. (2002). Logistics social responsibility: an integrative framework. Journal of Business Logistics, 23(1), 145–180.

Carter, C. R., Kale, R., & Grimm, C. M. (2000). Environmental purchasing and firm performance: an empirical investigation. Transportation Research Part E: Logistics and Transportation Review, 36(3), 219–228.

Chen, I. J., & Paulraj, A. (2004). Towards a theory of supply chain management: the constructs and measurements. Journal of Operations Management, 22(2), 119–150.

Choi, T., Kumar, S., Yue, X., & Chan, H. (2022). Disruptive technologies and operations management in the Industry 4.0 era and beyond. Production and Operations Management, 31(1), 9–31.

Číž, J., Krechovská, M., & Palacká, A. (2021). Procurement Transformation in Digital World. SHS Web of Conferences, 115, 1002.
Corboş, R.-A., Bunea, O.-I., & Jiroveanu, D.-C. (2023). The Effects of Strategic Procurement 4.0 Performance on Organizational Competitiveness in the Circular Economy. Logistics, 7(1), 13.
Daher, M., Ruiz-Huidobro, R., Chmielewski, J., & Jayaraj, V. (2017). Digital Procurement New Capabilities from Disruptive Technologies. Deloitte Development LLC. https://www2. deloitte. com/content/dam/Deloitte ….
De Looze, M. P., Bosch, T., Krause, F., Stadler, K. S., & O'sullivan, L. W. (2016). Exoskeletons for industrial application and their potential effects on physical work load. Ergonomics, 59(5), 671–681.
Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method. John Wiley & Sons.
Domingo Galindo, L. (2016). The challenges of logistics 4.0 for the supply chain management and the information technology. NTNU.
Engelberger, J. F. (2012). Robotics in practice: management and applications of industrial robots. Springer Science & Business Media.
Flechsig, C., Anslinger, F., & Lasch, R. (2022). Robotic Process Automation in purchasing and supply management: A multiple case study on potentials, barriers, and implementation. Journal of Purchasing and Supply Management, 28(1), 100718.
Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50.
Ghadge, A., Er Kara, M., Moradlou, H., & Goswami, M. (2020). The impact of Industry 4.0 implementation on supply chains. Journal of Manufacturing Technology Management, 31(4), 669–686.
Ghosh, P. K., Manna, A. K., Dey, J. K., & Kar, S. (2021). Supply chain coordination model for green product with different payment strategies: A game theoretic approach. Journal of Cleaner Production, 290, 125734.
Glas, A. H., & Kleemann, F. C. (2016). The impact of industry 4.0 on procurement and supply management: A conceptual and qualitative analysis. International Journal of Business and Management Invention, 5(6), 55–66.
Gottge, S., Menzel, T., & Forslund, H. (2020). Industry 4.0 technologies in the purchasing process. Industrial Management & Data Systems, 120(4), 730–748.
Guba, E. G. (1990). The paradigm dialog. Alternative Paradigms Conference, Mar, 1989, Indiana u, School of Education, San Francisco, ca, Us.
Gunasekara, H. G., Sridarran, P., & Rajaratnam, D. (2022). Effective use of blockchain technology for facilities management procurement process. Journal of Facilities Management, 20(3), 452–468.
Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (2010). Multivariate Data Analysis New Jersey. Pearson Education London, UK.
Handfield, R., Jeong, S., & Choi, T. (2019). Emerging procurement technology: data analytics and cognitive analytics. International Journal of Physical Distribution & Logistics Management, 49(10), 972–1002.
He, B., Li, F., Cao, X., & Li, T. (2020). Product sustainable design: a review from the environmental, economic, and social aspects. Journal of Computing and Information Science in Engineering, 20(4), 40801.
Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43, 115–135.
Hermann, M., Pentek, T., & Otto, B. (2016). Design principles for industrie 4.0 scenarios. 2016 49th Hawaii International Conference on System Sciences (HICSS), 3928–3937.
Hill, J. A., Chu, S. H., & Blount, I. (2024). EXPRESS: Inclusive Sourcing: Exploring Missing Links in Procurement and Contracting That Adversely Affect the Upward Mobility of Minority Businesses. Production and Operations Management, 10591478241263064.
Huo, B., Wang, B., & Li, Z. (2024). How to deal with technological turbulence for improving innovation performance. Technology Analysis & Strategic Management, 36(3), 549–562.
Jahani, N., Sepehri, A., Vandchali, H. R., & Tirkolaee, E. B. (2021). Application of industry 4.0 in the procurement processes of supply chains: a systematic literature review. Sustainability, 13(14),

7520.
Kagermann, H., Helbig, J., Hellinger, A., & Wahlster, W. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; final report of the Industrie 4.0 Working Group. Forschungsunion.
Kline, R. B. (2023). Principles and practice of structural equation modeling. Guilford publications.
Kohtamäki, M., Kraus, S., Mäkelä, M., & Rönkkö, M. (2012). The role of personnel commitment to strategy implementation and organisational learning within the relationship between strategic planning and company performance. International Journal of Entrepreneurial Behavior & Research, 18(2), 159–178.
Krejcie, R. V, & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607–610.
Kreuger, L., & Neuman, W. L. (2006). Social work research methods: qualitative and quantitative approaches: with Research Navigator. (No Title).
Lauren Cottle. (2023). Second Industrial Revolution | Timeline, Inventions & Effects. Second Industrial Revolution, Including a Timeline of Events, the Inventions It Produced, and How It Differed from the First Industrial Revolution. https://study.com/academy/lesson/the-second-industrial-revolution-timeline-inventions.html
Li, L. (2022). Digital transformation and sustainable performance: The moderating role of market turbulence. Industrial Marketing Management, 104, 28–37.
Munir, I., Mahmood, K., Shafqat, Z., & Ghaffar, M. (2023). Procurement 4.0 and Sustainable Supply Chain Performance: The Mediating Role of Procurement Process Optimization (PPO). Pakistan Journal of Humanities and Social Sciences, 11(4), 4151–4169.
Nicoletti, B. (2013). A Model and Best Practices of e-procurement in cloud computing, in e-Public procurement in Europe: public management, technologies and processes of change. Amazon Books, Dedham, MA.
Nicoletti, B. (2016). Lean and digitize: An integrated approach to process improvement. Routledge.
Nicoletti, B. (2020). Procurement 4.0 and the Fourth Industrial Revolution. In Procurement 4.0 and the Fourth Industrial Revolution. https://doi.org/10.1007/978-3-030-35979-9
Nicoletti, B., & Nicoletti, B. (2018). The future: procurement 4.0. Agile Procurement: Volume II: Designing and Implementing a Digital Transformation, 189–230.
Osmonbekov, T., & Johnston, W. J. (2018). Adoption of the Internet of Things technologies in business procurement: impact on organizational buying behavior. Journal of Business & Industrial Marketing, 33(6), 781–791.
Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879.
Ramirez-Peña, M., Sotano, A. J. S., Pérez-Fernandez, V., Abad, F. J., & Batista, M. (2020). Achieving a sustainable shipbuilding supply chain under I4. 0 perspective. Journal of Cleaner Production, 244, 118789.
Rejeb, A., & Appolloni, A. (2022). The nexus of industry 4.0 and circular procurement: a systematic literature review and research agenda. Sustainability, 14(23), 15633.
Reyes, M. Z. (2004). Social research: A deductive approach. Rex Bookstore, Inc.
Rifkin, J. (2011). The third industrial revolution: how lateral power is transforming energy, the economy, and the world. Macmillan.
Ruparathna, R. J. (2013). Emergy based procurement framework to improve sustainability performance in construction. University of British Columbia.
Saqib, Z. A., & Zhang, Q. (2021). Impact of sustainable practices on sustainable performance: the moderating role of supply chain visibility. Journal of Manufacturing Technology Management, 32(7), 1421–1443.
Schwab, K. (2017). The fourth industrial revolution. Currency.
Sepehri, A., Mishra, U., & Sarkar, B. (2021). A sustainable production-inventory model with imperfect quality under preservation technology and quality improvement investment. Journal of Cleaner Production, 310, 127332.
Silva, M. E., & Ruel, S. (2022). Inclusive purchasing and supply chain resilience capabilities: lessons for social sustainability. Journal of Purchasing and Supply Management, 28(5), 100767.
Singh, A., Kumari, S., Malekpoor, H., & Mishra, N. (2018). Big data cloud computing framework for

low carbon supplier selection in the beef supply chain. Journal of Cleaner Production, 202, 139–149.

Sjödin, D., Kamalaldin, A., Parida, V., & Islam, N. (2021). Procurement 4.0: How industrial customers transform procurement processes to capitalize on digital servitization. IEEE Transactions on Engineering Management, 70(12), 4175–4190.

Skilton, M., & Hovsepian, F. (2018). The 4th industrial revolution. Springer.

Smith, M. E. (2009). V. Gordon Childe and the Urban Revolution: a historical perspective on a revolution in urban studies. The Town Planning Review, 3–29.

Song, H., Yu, K., & Zhang, S. (2017). Green procurement, stakeholder satisfaction and operational performance. The International Journal of Logistics Management, 28(4), 1054–1077.

Stock, T., & Seliger, G. (2016). Opportunities of sustainable manufacturing in industry 4.0. Procedia CIRP, 40, 536–541.

Tabachnick, B. G., & Fidell, L. S. (2007). Experimental designs using ANOVA (Vol. 724). Thomson/Brooks/Cole Belmont, CA.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal, 28(13), 1319–1350.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509–533.

Tomassetti, F., Rizzo, G., Vetro, A., Ardito, L., Torchiano, M., & Morisio, M. (2011). Linked data approach for selection process automation in systematic reviews. 15th Annual Conference on Evaluation & Assessment in Software Engineering (EASE 2011), 31–35.

Uusitalo, J. (2019). Strategic Procurement in the Face of Uncertainty.

Waaly, A. N., Ridwan, A. Y., & Akbar, M. D. (2018). Development of sustainable procurement monitoring system performance based on Supply Chain Reference Operation (SCOR) and Analytical Hierarchy Process (AHP) on leather tanning industry. MATEC Web of Conferences, 204, 1008.

White, R. (2011). Railroaded: The transcontinentals and the making of modern America. WW Norton & Company.