
Procurement 4.0 and Sustainable Supply Chain Performance: The Mediating Role of Procurement Process Optimization (PPO)

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ABSTRACT: *The problem statement establishes the direction to assess the complex relationships between Procurement 4.0, Sustainable Supply Chain Performance, and the Procurement Process Optimization within the context of modern supply chain management. This study will help organizations in directional understanding about, how to create synergy between the procurement practices and sustainability goals, while emphasizing the role of procurement process optimization and organizational capabilities. We survey food manufacturers in Pakistan and analyze survey results using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach to test the research hypotheses and our theoretical framework. Finally, a sample business process is simulated to evaluate how Procurement 4.0 automation can optimize the procurement process and improve sustainable supply chain performance. This empirical study shows that procurement process optimization serves as a mediator in this conceptual framework and that Procurement 4.0 strategy, planning, and performance review positively influence the performance of a sustainable supply chain. The trends and gaps identified through our analysis allow us to develop a cogent agenda to guide future ¹SSCM and ²SSCP research.*

KEYWORDS: sustainable, supply chain, performance measurement, food manufacturing units, procurement 4.0, optimization, dynamic capability theory,

INTRODUCTION

According to (Alhabatah, Franzoi, Menezes, & Kerbache, 2023), in today's global business landscape, the complex market requires businesses to become more effective and resilient in order for them to survive in an intricate market that is constantly changing dynamics and highly competitive. As a result, it is urgently necessary to streamline business operations to make them more adaptable to the environment's constant change. However, there are numerous methods for increasing business efficiency, with one of the most essential aspects being to improve the procurement procedure

¹ Sustainable Supply Chain Management

² Sustainable Supply Chain Performance

Publication of the European Centre for Research Training and Development-UK (Bienhaus & Haddud, 2018a; Simões, Madureira, & Amorim, 2023). Efficient procurement can fundamentally affect the organization's strategic purpose, like optimizing costs, streamlining the processes, and ensuring the right supplies at the right time to continue the production pace at the optimum level (Corboş, Bunea, & Jiroveanu, 2023).

The developing excursion of the acquisition was Procurement 1.0 to Procurement 4.0 (Althabatah, Franzoi, et al., 2023; Bienhaus & Haddud, 2018a; Mavidis & Folinas, 2022). The essential objectives of procurement 1.0 were cost decrease and keeping an autonomous provider relationship. To oversee supplies, Procurement 2.0 is tied by laying out fair worth and developing cooperative connections. Given e-procurement frameworks (Bag, Dhamija, Gupta, & Sivarajah, 2021), Procurement 3.0 deals with the whole buying cycle and has multi-organization abilities (Mavidis & Folinas, 2022). Procurement 4.0 is the most recent digitization approach of all business cycles and reconciliation of the information across supply chains to acquire the incentive (Althabatah, Franzoi, et al., 2023; Mavidis & Folinas, 2022).

Effective procurement entails various strategies and practices, including supplier management, automation, centralization, and strategic sourcing. By nurturing robust relationships with dependable suppliers and streamlining processes through technology, businesses can optimize costs and ensure the timely availability of essential goods and services (Bienhaus & Haddud, 2018a). Moreover, embracing strategic sourcing allows organizations to consider factors beyond cost, such as supplier reliability and product quality. This holistic approach to procurement contributes to cost control, supply chain optimization, and, ultimately, heightened efficiency. It is also essential for ensuring compliance, managing risks, and fostering sustainability, aligning with modern business values and practices (Thelander & Pettersson, 2021). Through continuous improvement and adopting emerging technologies, companies can stay competitive and resilient in a rapidly evolving marketplace, affirming the significance of procurement as a linchpin for business success (Marković & Mihić, 2022). However, numerous organizations in Pakistan struggle with many-sided work processes and out-of-date manual systems that consume significant capital and time (Rezaei, Pourmohammadzia, Dimitropoulos, Tavasszy, & Duinkerken, 2020)

In supply chain management (SCM), procurement plays a strategic role and contributes significantly to an organization's overall performance (Govindan, Kannan, Jørgensen, & Nielsen, 2022). Integrating various technologies into the procurement process is a crucial step toward reaping the benefits of an efficient procurement process because of the increased supply chain complexity it creates. The typical approach to improving the procurement process has been to address the issues that most buyers face, such as how to size lots, choose suppliers, and simplify the intricate networks they operate. Even though these things are of significance, there is a limit to what organizations can manage without using computerized devices. Digitalization is vital for this turn of events and is on the plan for some associations. The possibilities of an organization's global digital transformation are driven by newly developed technologies, or at least new supply chain technologies (Liu, Song, & Liu, 2023; Pirrone & Meyer, 2021). It fosters robust connections

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between the procurement and supply chain teams and all levels of the supply base, enabling the central company to access vital information such as costs, inventory availability, delivery lead times, and financial and operational risks (Jahani, Sepehri, Vandchali, & Tirkolae, 2021). Notably, P4.0 reduces transaction times by approximately 30-50 percent and significantly curbs value leakage by 50 percent, as evidenced by research (Althabatah, Yaqot, Menezes, & Kerbache, 2023). Furthermore, the growing body of environmental evidence from various regions worldwide has increased awareness of sustainable manufacturing practices (Yip, Zhou, & To, 2023). It underscores the importance of environmentally responsible approaches in modern procurement and supply chain management (Liu et al., 2023). Within this framework, a sustainable supply chain's performance hinges on optimizing procurement processes. The emergence of the Procurement 4.0 strategy, characterized by integrating digital technologies, automation, and data-driven decision-making, offers a promising avenue to enhance procurement efficiency, transparency, and overall performance.

The focused goal of this research is to analyze the complex relationship among Procurement 4.0 (P4.0), Sustainable Supply Chain Performance (SSCP), and the Procurement Process Optimization (PPO) within the context of sustainable supply chain management. Through this research, we seek to provide valuable insights into enhancing supply chain sustainability and efficiency in the era of Industry 4.0. Specifically, this research aims to achieve the following objectives:

1. The primary objective is to decide the degree of procurement 4.0 adoption and its influence on the overall performance of a sustainable supply chain.
2. Evaluating the mediating impact of procurement process optimization (PPO) is between Procurement 4.0, including strategy, planning, and performance of Procurement 4.0 and Sustainable Supply Chain Performance (SSCP)
3. In particular, we expect to research how Procurement 4.0 practices impact sustainable supply chain performance, and emphasizing the mediating role of Procurement Process Optimization (PPO).

To navigate this uncharted territory, our research raises the following essential research questions:

1. What is the extent of the relationship between Procurement 4.0 Strategy and Procurement Process Optimization in the context of sustainable supply chain performance?
2. To what degree does Procurement 4.0 Performance Review impacts Procurement Process Optimization and, subsequently, contribute to improvements in sustainable supply chain performance?
3. How does the strategic implementation of Procurement 4.0 Planning influence Procurement Process Optimization and what is the resultant impact on sustainable supply chain performance?
4. To what extent does Procurement Process Optimization mediate the relationship between the combined effects of Procurement 4.0 Strategy, Procurement 4.0 Performance Review,

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and Procurement 4.0 Planning, and the enhancement of sustainable supply chain performance?

5. To what extent does Procurement 4.0 influence Sustainable Supply Chain Performance (SSCP)?
6. Is Procurement Process Optimization (PPO) a mediating factor in the relationship between Procurement 4.0 and Sustainable Supply Chain Performance (SSCP)?

In the unique context of Pakistan's Food Manufacturing Industry, our research delves into the pressing challenges related to sustainable supply chain performance. These challenges encompass inefficient procurement procedures, opacity in operations, suboptimal supplier management, and a need for more insights into supply chain activities. These issues are not only driving food wastage and escalating costs but are also perpetuating adverse environmental and social repercussions.

The potential remedy to these predicaments lies in implementing Procurement 4.0 within the Pakistani food industry, holding the promise of enhancing sustainable supply chain performance. Nevertheless, scant research has explored the implementation of Procurement 4.0 in this specific context and, more importantly, the unique challenges and opportunities that may surface. This research is a pivotal endeavor, for it establishes a crucial link between Procurement 4.0 processes and sustainable supply chain performance within the Pakistani food industry.

This research comprehensively explains how organizations can leverage Procurement 4.0 practices, potentially mediated by Procurement Process Optimization (PPO), to enhance their Sustainable Supply Chain Performance (SSCP)." The problem statement establishes the direction to assess the complex relationships between Procurement 4.0, and Sustainable Supply Chain Performance, Procurement Process Optimization. This study will help organizations understand how to create synergy between procurement practices and sustainability goals while emphasizing the role of procurement process optimization.

LITERATURE REVIEW

In this section, we present a review of Procurement 4.0 and its processes and the Sustainable Supply Chain Performance (SSCP) to develop a common understanding of how these subjects are related.

Procurement 4.0:

Primarily, the Procurement 1.0 supported elementary relational functions, primarily manual and reactive (Guarnieri & Gomes, 2019). It was about operational Procurement, managing day-to-day activities in Procurement, and meeting the business requirements daily. Procurement 1.0 was also termed the Tactical Procurement Stage and organization called Procurement 1.0 Organization. This stage introduces an early type of Procurement to address the transactional needs of the business in the early stage. Procurement management was a supporting function in this stage, focusing on buying goods or services at the lowest possible cost and maintaining the cost at a minimum level. This traditional approach focused on managing transactional tasks, daily business requests, and

RFXs³. Over the period, the business requirements and competitive market shifted the need of the business to identify the possible strategies for predicting the potential business risk, innovation, and global perspectives. The role of Procurement has evolved to commit to delivering these values through technology, innovation, and collaborative supply network and planning. This advancement is known as Procurement 2.0, where businesses started to apply more noteworthy command over data progression past fundamental instructive apparatuses (Allal-Chérif, Simón-Moya, & Ballester, 2021). Category management, a cross-functional approach, and supplier relationship management are now the primary areas of emphasis in Procurement 2.0 (Malacina et al., 2022). These improvements mark a massive shift from the past cycle of Procurement 1.0. Procurement 2.0 revolved around developing services within an integrated framework of diverse processes. Procurement 2.0 is not exclusively centered around cost decrease. Rather, it takes on a vital, comprehensive methodology that envelops different elements of value creation and risk management in the current complex business landscape and interrelated global supply chain (Mavidis & Folinis, 2022).

The Industrial Revolution directed all businesses to focus on supply chain optimization, considering improving the process and increasing effectiveness while progressing in the overall performance of a supply chain to deliver the correct value to the customer and maintain the competitive edge. It includes different procedures, approaches, and advancements to improve the business's supply side (Delke, Schiele, & Buchholz, 2023). The primary objectives of supply-side optimization are cost reduction, product quality enhancement, customer satisfaction enhancement, and gaining a competitive advantage. Procurement 3.0 is all about supply chain optimization and the advanced technological shape of Procurement 2.0 (Alhabatah, Yaqot, et al., 2023). Procurement 3.0 reflects significant modifications in procurement structure and shifted outlook to cloud-based technology. In this stage, the business strategy has been linked to the business by ensuring that suitable commercial agreements are in place with the right suppliers and that suitable goods and services are delivered (Mavidis & Folinis, 2022). With the development of Procurement 3.0, procurement becomes a business partner and utilizes the robust informational ecosystem, leading the business with data-driven decisions. Researchers (Mavidis & Folinis, 2022) have talked about the e-procurement venture in the public area and its outcomes in further developing admittance to data and straightforwardness in administration. In this review, they look at the difficulties and issues between procurement advances 3.0 and 4.0 and set out a guide for accomplishing new acquisitions for the executives in Industry 4.0. It lays the groundwork for AI-enabled predictive models that will advance decision-making in the future (Simões et al., 2023). A wholly developed utilization of such an innovation should be visible in the following obtainment phase, known as Procurement 4.0. Procurement 4.0 aligns with the Industry 4.0 paradigm, emphasizing augmented information through cognitive analytics and adaptive functions (Obermayer, Csizmadia, & Hargitai, 2022)

³RFXs = Request for information, Request for qualification, request for proposal

Procurement is the pivotal process for managing business relationships with suppliers, encompassing activities such as negotiations and services, as defined by (Harland, Telgen, Callender, Grimm, & Patrucco, 2019). Procurement casts its influence across various facets of business functions, ensuring the acquisition of services and items correctly, thereby facilitating the efficient progression of a company's processes and projects (Heckman, 2020). This stage represents a complex phase in producing products or processes, demanding the expertise of professionals for effective management. In its current organizational structure, the procurement trajectory is evolving to embrace Industry 4.0 capabilities (Ghadge, Kidd, Bhattacharjee, & Tiwari, 2019).

Previous research indicates (Huang & Handfield, 2015) that organizations confronted challenges while carrying out significant business asset arranging (ERP) frameworks, and they further focused on obtaining and overseeing provider connections to execute ERP frameworks effectively. (Huang & Handfield, 2015) proposed two critical considerations. Regardless, ERP systems can engage in ceaseless sharing and compromise business abilities. Second, organizations might profit from utilizing a similar arrangement of pointers while executing acquisition 4.0 frameworks. Procurement 4.0 framework advancement is not generally a simple assignment. A rundown of impediments thwarting the improvement of Procurement 4.0 frameworks was given by (Bienhaus & Haddud, 2018a). They proposed that the bottlenecks could be killed by focusing on techniques, limits, and capacity. Thus, Procurement 4.0 needs to be more considered in the current writing, albeit the acquirement capability is significant to makers

Sustainable Supply Chain Performance (SSCP): In the simplest terms, we will define the Supply Chain as an activity to convert the raw material into a saleable shape and deliver it to consumers for consumption. It covers the entire cycle from the production stage to distribution and is delivered to retailers until consumed by the end user (Elalem, Bicer, & Seifert, 2021). The supply chain process cycle' incorporates the supplier selection exercises, extensive sourcing process of the raw materials, internal and external stakeholders' collaboration, and management decisions. Its fundamental approach is to deliver quality products to consumers at competitive pricing. Further, the supply chain emphasizes reducing manufacturing costs through different productivity initiatives and value chains (Srhir, Jaegler, & Montoya-Torres, 2023). Businesses must find effective ways to address multiple sustainability challenges at various upstream and downstream channel levels to meet each individual business's needs while simultaneously improving the sustainability performance of the entire supply chain, which makes supply chains always complex.

Sustainable Supply Chain Management (SSCM) integrates environmental and social practices into supply chain processes. The objective of the sustainable supply chain is to obtain sustainable sources with competitive pricing to minimize the negative impact on the environment and society (Hazaea et al., 2022). It characterizes how to deal with the progress of capital, materials, and a wide range of data connected with the SC. Organizations are reviewing sustainability in the supply chain from the perspective of the Triple Bottom Line model. They urged to develop an extensive and long-term strategy to deal with sustainability that considers the economic, social, and environmental

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aspects within the operations and the entire supply chain. This approach aims to create value not only for the organization but also for the environment and society as a whole. The TBL framework helps evaluate an organization's productivity in light of three economic, environmental, and social dimensions. It underscores that organizations should quantify achievement not just by monetary benefits but also by their effect on the people and planet.

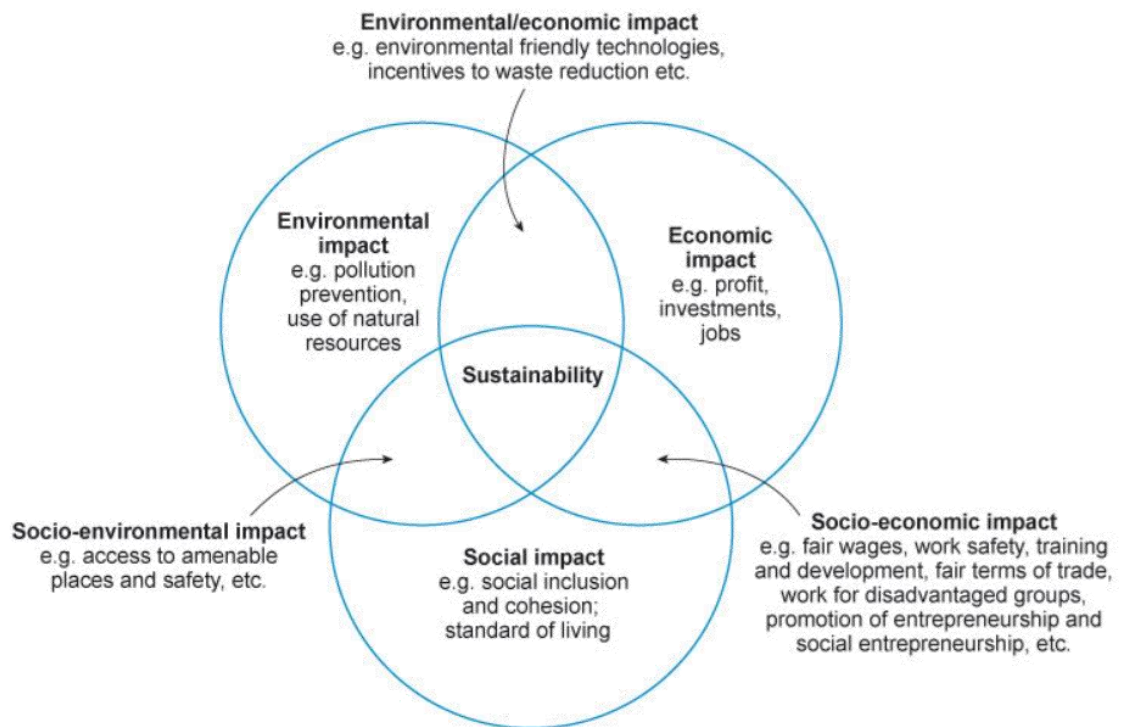


Figure 1. The three impact components of sustainability and their interconnections

Due to the scarcity of natural resources, the sustainability agenda is gradually evolving in the business community. The major contributor to sustainability is Business Operations, and further, these operations are led by the Supply Chain and Procurement department (Ben-Daya, Hassini, & Bahroun, 2019; Ghadimi, Wang, & Lim, 2019). Here, the synergize between the supply chain and procurement is critical, as the supply chain is integrating within the organization and collaborating with the internal stakeholders, whereas the procurement is bridging the goals with the external stakeholders and creating collaboration through the best available resources (Ghadimi et al., 2019; Srari & Lorentz, 2019).

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According to (Chari et al., 2022), participating in sustainability, specifically SSCM, is not optional but instead required. SSCM helps managers answer, "What is it that we need to do, not just to survive, but to thrive, and not just one year, three years, or five years from now, but in ten years, 20 years, and beyond?" SSCM involves the long-term improvement of an organization's economic bottom line. Once more, this is an important idea that can help managers start taking concrete steps.

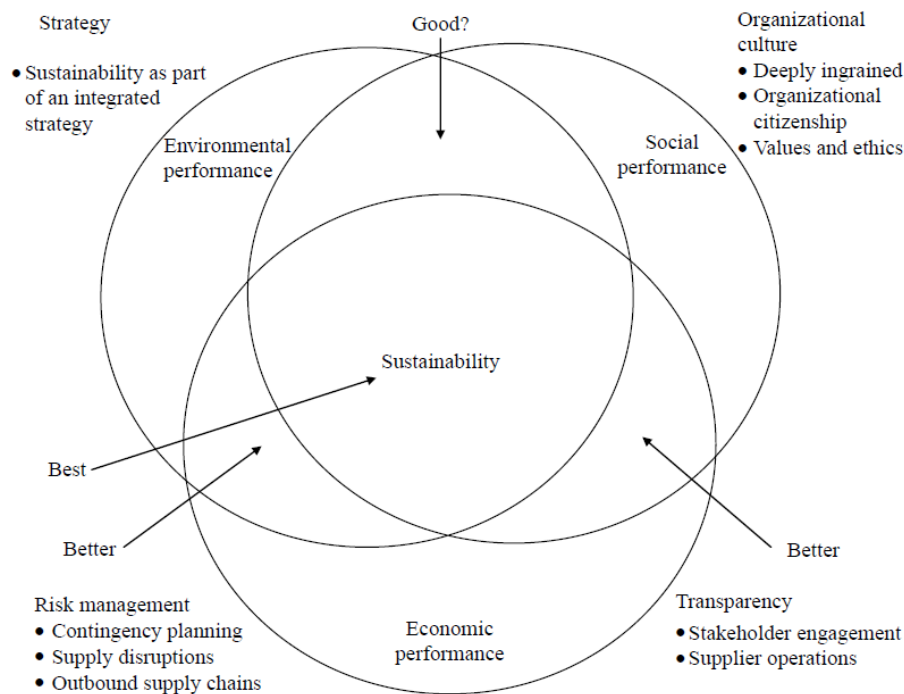


Figure 2. Sustainable Supply Chain Management

(Carter & Jennings, 2002; Yip et al., 2023) identify four supporting facets, or facilitators of SSCM, which are also shown in Figure 2:

- **Strategy** – Comprehensively and deliberately distinguishing individual SSCM drives which line up with and support the association's general manageability methodology
- **Risk management** – Anticipating the possible threats by studying the upstream and downstream supply chain processes.
- **An organizational culture** - which is profoundly imbued and incorporates hierarchical citizenship, and which incorporates high moral principles and

Publication of the European Centre for Research Training and Development-UK assumptions (a structure block for SSCM) alongside a regard for society (both inside and beyond the association) and the regular habitat;

- **Transparency** – means creating strong platform of communication and engagement with all internal and external stakeholders to ensure traceability and reflectivity in the data coming both upstream and downstream of the operations.

The sustainable supply chain indicators are currently various and hard to choose for nonexclusive execution assessment. As per the literature, there are three common sustainable supply chain indicators, monitoring and executing within organizations:

The Economic Dimension: A crucial aspect of performance evaluation is the economic aspect. The purpose of these economic indicators is to evaluate an organization's capability. The most widely recognized financial pointers are benefit, costs, adaptability, immortality, efficiency, quality, and business (Gunasekaran, Patel, & McGaughey, 2004). Financial and non-financial indicators are two types of economic indicators. Costs and profitability are financial metrics. Benefit can survey business execution. Productivity can be estimated with markers like profit from venture (return for capital invested), return on resources (ROA), and net benefit. Supply chain performance can also be evaluated using the actual cost. In addition, cost indicators can concentrate on activities at the micro level, such as costs associated with manufacturing, operations, transportation, inventory, labor, and logistics.

The Environmental Dimensions: By making their operations more eco-friendly, businesses must consider their own impact on the environment. Consumption of resources, energy, emissions, and wastes make up the environmental dimension (GRI, G4). Measurements of machine, material, water, air, soil, and land resource use are required. In manufacturing and other supply chain activities, energy and money can be saved by using resources effectively. (Bouchery, Ghaffari, & Jemai, 2010) discussed transportation and warehouse activities' KPIs for energy consumption and greenhouse gas emissions. In the environmental dimension, one criterion is resource consumption. According to (Gupta & Kumar, 2013), energy usage can evaluate environmental performance by evaluating energy consumption and fuel efficiency. For sustainability, renewable energy sources are a crucial issue. Air emissions, CO2 emissions, wastewater generation, solid waste disposal, and the consumption of hazardous, harmful, or toxic materials are examples of emissions and waste. (Vinodh, Arvind, & Somanaathan, 2011) presented non-product output measures of environmental performance metrics. Supply chain activities contribute to environmental problems like air emissions, water pollution, and solid waste. Energy consumption, resource consumption, emission, and waste can all be used to evaluate environmental indicators (EPA, 2007).

The Social Dimensions: The social aspect evaluates production network individuals (for example networks, representatives and clients) inside four principal pointers. Health and safety, employee contentment, noise pollution, and customer satisfaction (Chen, Paulraj, & Lado, 2004; Gunasekaran et al., 2004; Yeung, 2008). A measure of output is how satisfied customers are. A metric for measuring customer satisfaction is customer complaint. The time it takes for an order to be fulfilled and delivered

Publication of the European Centre for Research Training and Development-UK is known as the customer response time or order cycle time. In addition, business activities are influenced by human resource management, which includes employee satisfaction. Human resources are responsible for evaluating human performance based on capabilities and labor productivity (Freeman, 2008). Employee productivity, employee training costs, and employee turnover were some of the people-related indicators proposed by (Dossi & Patelli, 2010). Moreover, (Schmidberger, Bals, Hartmann, & Jahns, 2009) measured performance by presenting employee net availability. Customer satisfaction, employee satisfaction, noise pollution, and health and safety are the identified key performance indicators for the social dimension. The social dimension of each member of the supply chain can be measured using these indicators.

In view of the recent literatures, the key indicators of SSCP⁴ are “Environment, Social, and Economic, whereas these three factors are further spited into 14 distinguished monitoring points or KPIs⁵. The KPIs are

- Economic KPIs
 - a. Net Profit
 - b. Cost of Goods Manufactured
 - c. Adaptability
 - d. Practicality
 - e. Productivity
 - f. Quality
 - g. Employment
- 2. Environment KPIs
 - a. Utilities Consumption
 - b. Resource Utilization
 - c. CO₂, Carbon Emission, Waste
- 3. Social KPIs
 - a. Employee Fulfillment
 - b. Consumer Loyalty
 - c. Health & Safety
 - d. Noise Pollution

Consumers, Employees, 3rd Party Suppliers, regulatory, and community are all stakeholders of any given supply chain and have an essential impact in the formation of environment friendly ecosystem portrays the proposed reasonable markers system for all store network partners.

⁴ Sustainable supply chain performance

⁵ Key performance indicators

Theory Underpinning

The denunciation of research community on RBV⁶ prompted the advancement of dynamic capability theory. The RBV speculation considers firms including in heap of assets, and the firm can use the assets to give a high ground if the assets are one of a kind, significant, and difficult to duplicate. The assets are not spread homogeneously, and the assortment in movement happen after some time (Barney, 1991). Notwithstanding, RBV flops in such conditions because of the continually moving business climate.

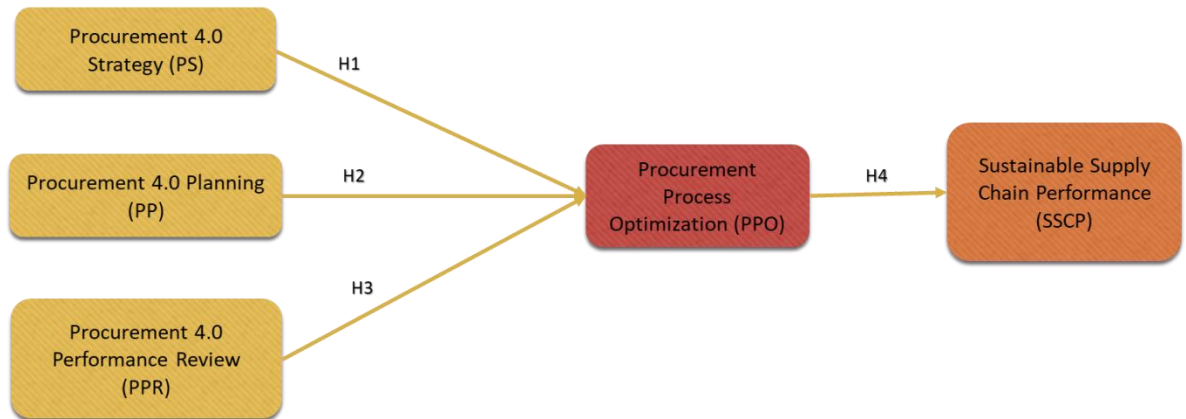
The outlook of dynamic capacities (D. TEECE & PISANO, 1994) (D. TEECE & PISANO, 1994; D. J. Teece, Pisano, & Shuen, 1997) has as of late arisen as the liked hypothetical structure for the researchers to make sense of vital choices in sustainability context (Barreto, 2010). The organizational culture is always changing both internally and externally, so it is vital to respond rapidly to these progressions to try not to offend an organization's performance in overall business domain. According to voice of top management, the approach of dynamic capabilities is to deal with such circumstances and really oversee change in abnormal conditions, creating with progressive bridge of achievements (Barreto, 2010). Opportune reactions are hard to make due (Easterby-Smith, Lyles, & Peteraf, 2009) introduced various difficulties in regards to dynamic abilities and potential future exploration bearings, like their association with IT and other practical regions.

One of the key aspects of Dynamic Capabilities Theory is that it highlights the importance of organizational learning and knowledge creation. It suggests that firms need to develop learning processes and routines to accumulate knowledge and experience, which can then be applied to sense and seize new opportunities. Additionally, the theory emphasizes the need for strategic flexibility and the ability to make timely decisions and adjust the firm's resource base to align with changing market conditions.

⁶ Resource view theory

Theoretical Framework and Hypothesis Development

Theoretical Framework



1.1.1. Hypothesis Development

H1: There is a significant relationship between Procurement 4.0 Strategy and Procurement Process Optimization.

H2: There is a significant relationship between Procurement 4.0 Planning and Procurement Process Optimization.

H3: There is a significant relationship between Procurement 4.0 Performance Review and Procurement Process Optimization.

H4: The combination of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning collectively influences an improvement in Procurement Process Optimization.

H5: Procurement Process Optimization mediates the relationship between the combined effects of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning, and the enhancement of sustainable supply chain performance.

Procurement 4.0 Strategy and the Procurement Process Optimization:

Procurement 4.0 Strategy (PS) relies upon the idea of assembling activities and size of business. PS includes long and short-term strategic directions. Nonetheless, the rising degree of interest impact such choices over the supply chain network, making a requirement for data handling prerequisites. The fourth modern insurgency has brought forth Procurement 4.0, where every one of the capabilities are coordinated to empower a consistent progression of data. The fundamental accentuation in I4.0 is

Publication of the European Centre for Research Training and Development-UK digitalization utilizing IoT, large information, and man-made consciousness (Zhou, Chong, & Ngai, 2015). PS in the feasible production network includes serious procedure and organization technique for remanufacturing and reusing material. Provider advancement methodologies and overseeing seller inventories for re-appropriating choices are key for the greatness of remanufacturing activities in maintainable store network. Embracing the right PS will lessen supply vulnerability and guarantee opportune client conveyances to every one of the plants. Nonetheless, remanufacturing may experience because of vulnerability about the opposite progression of items as far as the nature of each at the time they will be gotten. Procurement 4.0 empowered innovations can be helpful to take care of convenient data and advance acquisition process. Notwithstanding, PS depends on the business and activities procedure of the firm, which might additionally impact the expectation to upgrade the Procurement interaction. The requirement for close and continuous data for improved supply line perceivability in remanufacturing activities calls for cooperative PS which will additionally set off purchaser and providers' aim to upgrade the Procurement cycle (Srai & Lorentz, 2019). Nonetheless, PS in a supportable climate is molded by savvy production line task qualities in remanufacturing tasks that will decide the shrewd processing plant task-Procurement 4.0 innovation fit. Such an essential fit built up with constant instruction and preparing, expecting to overhaul ranges of abilities will have an impact on the disposition and mentality of purchasers/providers and improve apparent straightforwardness and handiness of Procurement 4.0 for application purposes (Bienhaus & Haddud, 2018a). Accordingly, we contend that the essential administration of the acquisition capability under SSCP increments viability through the structure of cooperative connections and this will assist with spurring workers to additionally apply Procurement 4.0 devices for enhancing the Procurement cycle (Kusiak, 2019; Majeed & Rupasinghe, 2017; Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray, 2018). Therefore, we hypothesize:

H1. There is a significant relationship between Procurement 4.0 Strategy and Procurement Process Optimization.

Procurement 4.0 Planning and the Procurement Process Optimization:

The aggregate supply planning is followed by the, 1)- master production plan, 2)- aggregate production planning, 3)- material requirement planning and all these planning are synergize with some processes, defined by the supply chain department and such planning meeting are executing on different intervals basis. From procurement prospects, the material requirement from material planning is the key output for a buying representative who is doing sourcing decision accordingly (Bag et al., 2021). The capacity planning and inventory management is considered during planning for material requirement based on the production plan.

Advancement of the procurement cycle in SSCP includes the streamlining of resources and expects to improve the life span of the resource through closed-loop monitoring. Improvement of the procurement cycle can be accomplished by replacing the manual cycle with I4.0⁷, which will bring down the cycle

⁷ Industry 4.0

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time of procurement process. Notwithstanding, expectation to improve the procurement cycle time might be subject to the idea of holding inventory, stock levels, carrying cost and other warehousing factors. Nonetheless, the goal to enhance the buying interaction might be subject to the idea of the requirement to source the materials (Johne & Wallenburg, 2021). As expressed before, procurement planning is impacted by numerous elements, and the management support and key objectives are one of the key variables affecting arranging exercises. In short, the procurement planning is the short to medium to long terms strategic planning and decision making to 1)- minimize material supply risk, 2)- controlling cash flow, 3)- avoiding over stock and write-offs, 4)- meeting the consumer demands (Srhir et al., 2023; Virolainen, 1998). Hand-on procurement planning activated through I4.0 can help with quality independent direction. Unstructured information gathered through remote sensors can give significant data. I4.0 innovations can be taken advantage of to empower the presentation of data progressively utilizing a dashboard. Procurement 4.0 arranging will further develop the arranging system altogether as acquisition supervisors have total vigilance of how much the two supplies (upstream) and request (downstream) over the production network. Brilliant obtainment task-I4.0 innovation fit is the essential test in shrewd manufacturing plants (Vickery, Jayaram, Droge, & Calantone, 2003). However, the right fit through proper planning will change the intentions of buyers/suppliers to apply optimization tools (Bienhaus & Haddud, 2018a) and we therefore hypothesize:

H2. There is a significant relationship between Procurement 4.0 Planning and Procurement Process Optimization.

Procurement 4.0 Performance Review and the procurement process optimization:

Now-e-days, the supply network has expanded and converted into global village and the effective time management is the key in making the supply momentum, not only to sustain production pace but also achieving success in remanufacturing and recycling activities. Procurement 4.0 performance review can be directed on a day to day or weekly basis, whereas such scheduling always be decided based on business nature and size. The businesses are setting up review meetings to monitor and discuss the overall procurement performance and supply criticalities can also be examined to make substitute plans in such meetings (Glas & Kleemann, 2016; Schiele, 2007). Such reviews led to drive the SOIP⁸ and take informed decision to sustain production pace, fulfilling sales orders, and minimizing wastages to ensure sustainability targets. The Processes are linked with the business domains and any loopholes may create hindrance within the whole supply chain (Fatorachian & Kazemi, 2020). In this way, procurement reviews significantly affects consumer loyalty levels in remanufacturing and reusing business. Procurement 4.0 Performance Review can be utilized as an instrument to establish a momentum both backward and forward approach and emphasize suppliers and buyers to optimize their business processes and reduce cycle time and lift the sustainability goals along with the organization (Glas & Kleemann, 2016). Therefore, we argue that Procurement 4.0 performance review directs the

⁸ Sales and Operation Integrated Planning

buyer's intention to optimize the procurement process under the SSCP business environment, and we hypothesize that:

H3. There is a significant relationship between Procurement 4.0 Performance Review and Procurement Process Optimization.

Mediating Role of Procurement Process Optimization (PPO):

The aim to streamline the procurement cycle will impact ways of behaving and further encourage purchasers to improve remanufacturing and reusing tasks execution by zeroing in on boundaries, for example, improving yield rate, eliminate the waste element in resource utilization, minimize process wastes. Imaginative perspectives and convictions in the supportable development way will make a better society. Related knowledge and information on streamlining devices can change the discernment toward apparatus application. Seen simplicity and handiness of streamlining apparatuses can change mentalities towards device application, in actuality, situations and further develop SSCP execution (Bienhaus & Haddud, 2018a; Cegielski, Jones-Farmer, Wu, & Hazen, 2012; Del Giudice, 2016).

The strategy that businesses use to align their procurement procedures with the goals of Industry 4.0 is referred to as the Procurement 4.0 Strategy. This may entail adopting new technologies, strengthening relationships with suppliers, and improving procurement decision-making. Resource allocation and procurement procedures can influence by a clearly defined procurement strategy to support sustainability objectives. Data-driven methods are used in the Procurement 4.0 Performance Review to evaluate and enhance procurement process outcomes (Marković & Mihić, 2022). A good performance review can show where sustainability can be improved, like reducing waste, making the most of resources, or choosing suppliers who are better for the environment. Within the Procurement 4.0 framework, Procurement 4.0 Planning focuses on the strategic design and implementation of procurement processes (Bag, Wood, Mangla, & Luthra, 2020). The selection of suppliers, product design, transportation, and other aspects of sustainable supply chain planning may all have an impact on the supply chain's overall sustainability. Additionally, the systematic improvement of procurement procedures in order to increase their effectiveness and efficiency is referred to as "Procurement Process Optimization." Streamlining workflows, reducing delays, and improving procurement performance are all examples of this optimization (Bag et al., 2021). Now, the hypothesis suggests that Procurement Process Optimization serves as an intermediary. In this context, it means that when companies optimize their procurement processes (e.g., through automation, data analytics, and process improvement), they are better equipped to implement Procurement 4.0 Strategy, conduct effective Performance Reviews, and execute Planning activities with a sustainability focus (Althabatah, Franzoi, et al., 2023). Therefore, we argue that the combination of Procurement 4.0 Strategy, Procurement 4.0 Performance, and Procurement 4.0 Planning collectively influences a significant improvement in Procurement Process Optimization:

H4. The combination of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning collectively influences an improvement in Procurement Process Optimization.

H5. Procurement Process Optimization mediates the relationship between the combined effects of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning, and the enhancement of sustainable supply chain performance.

RESEARCH METHOD

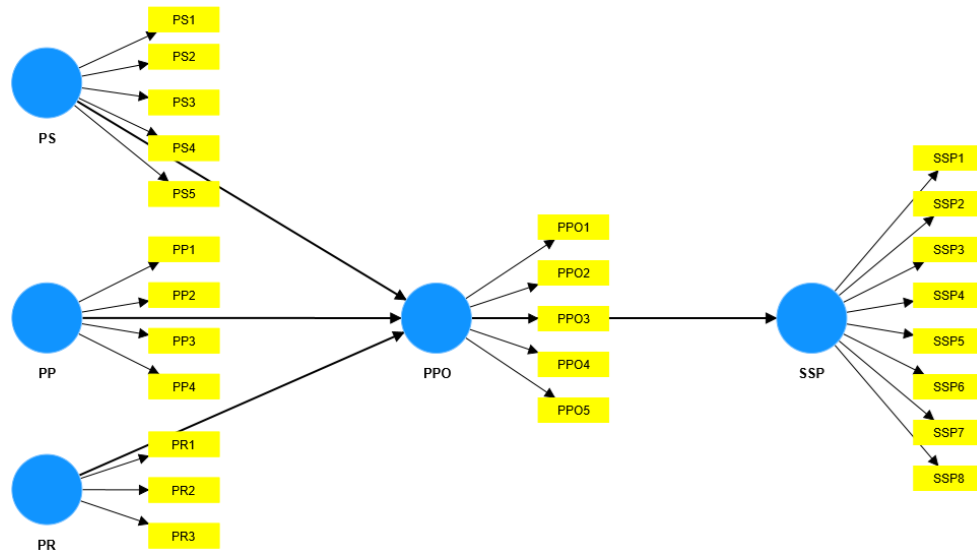
The research design involves sampling from the population of executives like officer, managers, senior managers, and GM/VP/Directors from Pakistani food industry, comprises into the 4 sub areas, 1)- frozen foods, 2)- Food & Beverages, 3)- Bakery and Confectionary, and 4)- Edible Oils and Fats. The profile of food industry is about 2500 + units in Pakistan, further split into zone like 60% in Punjab, 30% in Sindh, 10% in KPK and others (<https://pakistan.um.dk/en/the-trade-council/sectors-in-focus/food-and-agriculture> - Source: Food Demand index is from Global Harvest Initiative (GHI) (2015), Agriculture Output from TFP Growth is from USDA Economic Research Service (2015).

The data was collected through a self-administered survey from the respondents which were taken from the food industry in Pakistan. This cross-sectional study utilized convenience sampling, in which 500 questionnaires were distributed through the internet. In total, 400 questionnaires were returned of which 334 were valid.

To measure the relationship in optimizing the procurement processes with the "procurement strategy, procurement planning, and procurement performance" and the connection between sustainable supply chain performance and optimizing the procurement process, the listed participants were asked to complete the survey. Because they are directly and indirectly involved in or execute the procurement function and are well aware of the challenges, the individuals and industries were selected using purposeful sampling techniques.

The first part of the survey focused on questions about the Procurement 4.0 Strategy consist of five items adapted from (Janda & Seshadri, 2001), the Procurement 4.0 Planning consist of four items adapted from (Bienhaus & Haddud, 2018b; Vickery et al., 2003), the Procurement 4.0 Performance Review consist of three items adapted from and the item in this part was adapted from (Bag et al., 2021; Bienhaus & Haddud, 2018b; Delke et al., 2023), the Procurement Process Optimization consist of five items adopted from (Bienhaus & Haddud, 2018b), and the Sustainable Supply Chain Performance consist of eight items adapted from (Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012). The scales with 25 measurement items were selected to have high levels of reliability and

Publication of the European Centre for Research Training and Development-UK validity, based on previously published research. A multiple-item, 5-point Likert-type scale (1 = 'strongly disagree'; 2='disagree'; 3='neutral'; 4='agree'; 5='strongly agree') is used and such 5-point scales are commonly adopted (Tezel, Koskela, & Aziz, 2018).



RESULTS AND DISCUSSION

This data was collected at organizational level from 400 food-manufacturing units in Pakistan and the Smart PLS 4.0 was used to test the model and outcomes of the study. Table 4.1 displays the respondents' demographics. The majority of respondents were from the food manufacturing sector, where digital practices are more prevalent than in other industries. The responses came from medium and large businesses, as shown in Table 4.1. Because these businesses have the resources and capability to lead the digitalization process and implement sustainable supply chains, this indicates that the sample is suitable for the study. It was essential for the study to obtain responses from individuals holding appropriate organizational positions like Procurement Officers and Managers with more than three years of experience in the field of Procurement and supply chain. The fact that the study aims to comprehend Procurement 4.0 strategies indicates that the respondents are well-positioned to respond to the survey's questions.

Demographic - Table 4.1

Demographic Variables	Categories	Frequency	Percentage
Gender	Male	245	73%
	Female	89	27%
Age	31-40	98	29%
	41-50	122	37%
	51-60	114	34%
Designation	Executive/Officer	94	28%
	Manager	113	34%
	Sr. Manager	93	28%
	GM/VP/Director	34	10%
Experience	1-5 Years	94	28%
	6-10 Years	113	34%
	11-20 Years	93	28%
	More than 20 Years	34	10%
Food Manufacturing Industry	Food & Beverages	117	35%
	Frozen Foods	71	21%
	Bakery and Confectionary	68	20%
	Edible oils and Fats	78	23%

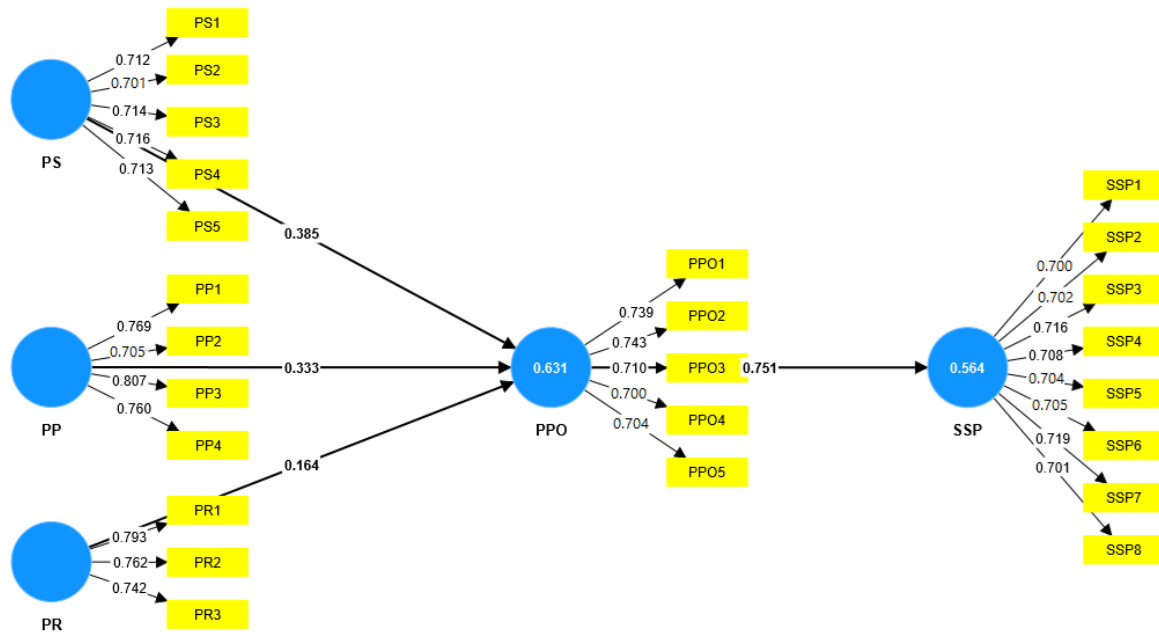
The demographics of respondents are presented in this section, as shown in Table 4.1. Table 4.1 shows that 245 (73%) were male and 89 (27%) were females. In terms of age, the 98 professionals were between 31-49, 122 professionals between the age of 41-50, and 114 professionals between the age of 51-60. In terms of professional experience, the officers, managers, senior managers, and GM/VP/Directors were 94 (28%), 113 (34%), 93 (28%), and 34 (10%) respectively. Similarly, the respondents were taken from the food manufacturing industry, further segmented 35% food & beverages, 21% frozen foods, 20% bakery and confectionary, and 23% edible oils and fats.

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Confirmatory Factor Analysis (CFA) - Table 4.2

Description	Construct	Items	Loadings	Cronbach's alpha	CR	AVE
Procurement Planning	PP	PP1	0.769	0.755	0.846	0.579
Procurement Planning		PP2	0.705			
Procurement Planning		PP3	0.807			
Procurement Planning		PP4	0.760			
Procurement Process Optimization	PPO	PPO1	0.739	0.751	0.843	0.518
Procurement Process Optimization		PPO2	0.743			
Procurement Process Optimization		PPO3	0.710			
Procurement Process Optimization		PPO4	0.700			
Procurement Process Optimization		PPO5	0.704			
Procurement Performance Review	PPR	PR1	0.793	0.703	0.810	0.587
Procurement Performance Review		PR2	0.762			
Procurement Performance Review		PR3	0.742			
Procurement Strategy	PS	PS1	0.712	0.756	0.837	0.506
Procurement Strategy		PS2	0.701			
Procurement Strategy		PS3	0.714			
Procurement Strategy		PS4	0.716			
Procurement Strategy		PS5	0.713			
Sustainable Supply Chain Performance	SSP	SSP1	0.700	0.837	0.889	0.500
Sustainable Supply Chain Performance		SSP2	0.702			
Sustainable Supply Chain Performance		SSP3	0.716			
Sustainable Supply Chain Performance		SSP4	0.708			
Sustainable Supply Chain Performance		SSP5	0.704			
Sustainable Supply Chain Performance		SSP6	0.705			
Sustainable Supply Chain Performance		SSP7	0.719			
Sustainable Supply Chain Performance		SSP8	0.701			

Table 4.2 shows that the AVE value of every variable is above 0.50, the values of CR and Cronbach's alpha are above 0.70 and the value of factor loadings is above 0.60, all of which are within the accepted range. So, the conceptual model is the best fit for the hypotheses. In order to determine whether or not any indicator had been incorrectly assigned to any construct, we carried out a discriminant validity test (Kock, 2014). Using the diagonally displayed square root of average variance extracted (AVE), we examined the correlations between the latent variables. Our model meets the requirement that the AVEs be higher than the construct correlation value in order to pass this test.



The square roots of the AVE (average variance extracted) and the values of the correlations between the LV (latent variables) and the main diagonal of the SEM are depicted in Table 4.3. The Fornell–Larcker model's criteria 1981 were used to determine discriminant validity. In addition, all variables have the largest square root of the AVE (in bold), which falls somewhere in the range of 0.620 –0.758. As a result, the variables' discriminatory validity is maintained and validated for this approximate research model.

Discriminant Validity - Fornell Larcker Criterion - Table 4.3

	PP	PPO	PR	PS	SSP
PP	0.759				
PPO	0.717	0.708			
PR	0.620	0.644	0.766		
PS	0.735	0.706	0.710	0.711	
SSP	0.758	0.701	0.694	0.709	0.684

Procurement 4.0 Strategy (PP), Procurement 4.0 Planning (PP), Procurement 4.0 Performance Review (PR), Procurement 4.0 Process Optimization (PPO), and Sustainable Supply Chain Performance (SSP) Hypothesis Testing in Table 4.4, shows the results of testing the direct and indirect effect hypotheses by running Smart PLS. In the first hypothesis, we assumed a positive and significant association

Publication of the European Centre for Research Training and Development-UK between, Procurement 4.0 Strategy and Procurement 4.0 Process Optimization, and this is supported in Table 4.4 (B=0.067, p = 0.0000), so we assume a positive effect of Procurement 4.0 Strategy in optimizing the procurement process. Similarly the 2nd Hypothesis is showing significant association between Procurement 4.0 Planning and Procurement Process Optimization whereas B=0.026 and p = 0.0000 ensuring that the Procurement 4.0 planning has positive effect in optimizing the procurement process. Likewise, the 3rd Hypothesis is also showing significant association between Procurement 4.0 Performance Review and Procurement Process Optimization whereas B=0.059, p= 0.0003 ensuring that the Procurement 4.0 Performance review has positive effect in optimizing the procurement process. Based on the test and rationale, we've concluded that the procurement process optimization has mediate positive effect in performance of sustainable supply chain (B=0.067, p=0.000).

Table 4.4 - Results of HypothesisTesting

	.Hypothesis	Standard deviation (STDEV)	P values	Supported/Non Supported
H1.	There is a significant positive relationship between Procurement 4.0 Strategy and Procurement Process Optimization.	0.067	0.000	Supported
H2.	There is a significant positive relationship between Procurement 4.0 Strategy and Procurement Process Optimization.	0.026	0.000	Supported
H3.	There is a significant positive relationship between Procurement 4.0 Planning and Procurement Process Optimization.	0.059	0.003	Supported
H4	The combination of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning collectively influences a significant improvement in Procurement Process Optimization.	0.061	0.002	Supported
H5.	Procurement Process Optimization significantly mediates the relationship between the combined effects of Procurement 4.0 Strategy, Procurement 4.0 Performance Review, and Procurement 4.0 Planning, and the enhancement of sustainable supply chain performance.	0.067	0.000	Supported

The results show that the Procurement 4.0 strategy, Procurement 4.0 planning, and Procurement 4.0 performance review all improve the procurement process in a positive way. The strict Procurement 4.0 strategy and the use of predictive analytics and algorithms to digitalize and speed up transactions shift buyers' mindsets and encourage them to focus on process optimization.

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According to (Tortorella & Fettermann, 2018), the findings of this study are therefore comparable to those of previous studies that focused on the positive correlation that exists between the application of I4.0 and lean efforts. Audits of acquirement 4.0 can be useful; provided that managers always have access to relevant data. When businesses make sufficient investments in hardware, software, server maintenance, cyber security, and other aspects of the development of information processing capability, supply chain dashboards that reflect information in near- and real-time can assist in quality decision-making. Various issues that can be immediately settled by advancing the obtainment cycles will be raised during the audits of Acquisition 4.0. to utilize efficient enhancement based on innovation (Wood, Reiners, & Srivastava, 2017), this kind of decision assistance is necessary. As a consequence of this, a look at how Procurement 4.0 performed can help buyers refocus on improving procurement procedures for operational excellence. The end result suggests that sustainable supply chain performance may benefit from buyers' intentions to improve the procurement process. Utilizing both basic and advanced I4.0 tools can help reduce energy consumption, natural resource scarcity, and task completion times. One perspective that this study doesn't consider is the necessity for data handling prerequisites connected with organizations' utilization of I4.0 approaches and advances (Cegielski et al., 2012). (Schroeder, Anggraeni, & Weber, 2019) stressed specific manageable procedures that help with accomplishing manageability objectives.

Process optimization and performance reviews based on the Sustainable-focused procurement strategy could help businesses support the elimination of activities that don't add value, according to this study. Finally, as recently recommended (Moeuf et al., 2018), the discoveries recommend that Acquisition 4.0 can drive huge advantages with the proper improvement of mature obtainment audit and procedure processes. The discoveries are critical on the grounds that they show that old, manual acquirement process steps can be supplanted with robotized ones, fundamentally diminishing process duration. Remanufacturing companies must reduce total cycle time to gain an advantage over competitors. Be that as it may, the effect of Acquisition 4.0 on lessening energy interest during the acquirement cycle can be considered in ensuing tests.

Future Research Direction and Limitations

The study does acknowledge several limitations that are worth considering. One significant constraint is the limited awareness and training of industry participants, which posed a substantial challenge in establishing sustainable supply chain management practices and monitoring its performance. Businesses, including buyers and suppliers, might need help implementing sustainable sourcing initiatives due to various factors. These challenges encompass regulatory and legal complexities, issues related to reliable power supply, and deficiencies in digital infrastructure.

Additionally, there is a notable need for more skilled professionals with the expertise to manage these advanced technologies effectively. These experts are required to implement the framework comprehensively, covering both backward and forward integration, and to ensure the successful execution of sustainable supply chain management practices while monitoring its performance.

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These limitations underscore the multifaceted nature of sustainability initiatives in supply chains. Effective implementation demands a shift in mindset and training and necessitates enabling infrastructure and a workforce with the required skill set to navigate the challenges in a sustainable supply chain. These challenges highlight the need for comprehensive strategies to address these facets to promote sustainable supply chain management effectively.

CONCLUSION

To sum up, the increasing significance of sustainability on both local and global scales has initiated dialogues regarding the effective incorporation of sustainable practices into business operations and strategies. In response to this imperative, Sustainable Supply Chain Management (SSCM) emerges as a valuable methodology that enables organizations to shift from reactive approaches, such as reducing pollution and managing waste, to adopting proactive responsibility across their product lifecycle. This proactive stance encompasses activities ranging from sourcing raw materials to managing product disposal, all underpinned by a steadfast commitment to sustainability principles.

The primary impact of this research paper is its in-depth exploration of the significant effect that Procurement 4.0 and its associated processes impact that Procurement 4.0 and its associated processes have on enhancing sustainable supply chain performance (SSCP). This finding not only underscores the theoretical significance but also the practical relevance of integrating advanced procurement practices into the broader context of sustainability.

What becomes evident from this study is that Sustainable Supply Chain Performance (SSCP) has the potential to generate substantial value for both organizations and the external environment. This value creation manifests in various ways, chiefly by optimizing procurement processes at both internal and external levels. Internally, it facilitates more streamlined and efficient resource allocation and utilization. Externally, it fosters positive supplier relationships and encourages sustainable practices throughout the supply chain.

One of the standout outcomes of SSCP is its role in resource reduction, particularly in materials and waste generation. Through the optimization of procurement processes and the adoption of sustainable sourcing practices, organizations can significantly reduce their environmental footprint. Reducing resource consumption and waste generation aligns with sustainability principles and contributes to more efficient resource utilization. It reduces costs and positions the organization as a responsible steward of environmental resources.

Equally noteworthy is the broader impact of SSCP on achieving the 'triple bottom line,' which encompasses social, environmental, and economic performance. By integrating sustainability into procurement practices, organizations can simultaneously drive positive outcomes in these three crucial dimensions. Socially, they can support local communities, promote fair labor practices, and engage in socially responsible initiatives. Environmentally, they can contribute to the reduction of carbon emissions, the preservation of ecosystems, and the mitigation of resource depletion. Economically, they

Publication of the European Centre for Research Training and Development-UK can enhance operational efficiency, reduce risks associated with supply chain disruptions, and open up new market opportunities.

Ultimately, the study underscores the synergistic potential of sustainability and procurement advancements. These two elements offer a pathway towards a more responsible and efficient business landscape. By embracing Procurement 4.0 and its sustainable principles, organizations can navigate the evolving demands of the market while actively contributing to the broader goals of sustainable development. It signifies a paradigm shift in how businesses perceive and execute procurement, acknowledging its pivotal role in shaping more sustainable patterns.

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