THE ASIAN BULLETIN OF GREEN MANAGEMENT AND CIRCULAR ECONOMY
Vol 5, Issue 2(2025)

THE ASIAN BULLETIN OF GREEN MANAGEMENT AND CIRCULAR ECONOMY

ISSN (online): 2959-0035

http://abgmce.com/ 10.62019/abgmce.v5i2.154

ISSN (Print): 2959-0027

Strategic Procurement 4.0: A New Era of Sustainable Performance

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Chronicle

Article history

Received: April 13, 2025
Received in the revised format: May 29, 2025
Accepted: June 22, 2025
Available online: Aug 3, 2025

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Abstract

The main objective of the current study is to identify how the strategy for procurement 4.0 (P4.0) effects organizational sustainability performance (OSP) under technological uncertain environments. To achieve the study objective, we surveyed large-scale manufacturing firms. The data were collected through structured questionnaires. A total of 397 supply chain professionals were the study respondents. Structural equation modeling (SEM) strategy through AMOS-24 was used to analyze the collected data. The findings revealed a positive relationship between P4.0 strategy and sustainable organizational performance. Moreover, results also revealed significant moderating role of technological environment uncertainty (TEU). Drawing upon Resource Orchestration Theory (ROT), the paper proposes that P4.0 strategy serves as a strategic enabler of sustainability. However, under conditions of high TEU, the effectiveness of P4.0 strategy in achieving sustainable outcomes may vary. A conceptual model and hypotheses are presented to guide future empirical research.

Keywords: Procurement 4.0; Industry 4.0; Strategic Procurement 4.0; Sustainability Performance.

INTRODUCTION

Sustainability has become a strategic priority for organizations worldwide, particularly in manufacturing sectors where procurement decisions significantly influence environmental and social outcomes. Traditional procurement functions are increasingly being transformed into strategic levers for competitive advantage through the adoption of procurement 4.0; the application of Industry 4.0 technologies such as big data analytics (BDA), artificial intelligence (AI), blockchain, and the Internet of Things (IoT) within procurement processes (Corboș et al., 2023). In the current modernized business environment, procurement has evolved into a strategic function within the production system, shifting from a traditional cost center to a driver of profitability. For manufacturing firms in particular, procurement directly shapes competitiveness by influencing material flow, product quality, and overall production costs. As such, it plays a pivotal role in ensuring consistent access to high-quality raw materials, which ultimately determines the market value of finished products. Beyond operational impact, procurement also serves as a cornerstone of corporate strategy by guiding integration decisions across the supply chain, shaping financial policies, and fostering strong, long-term supplier relationships. Though many past studies, such as De-Sousa Jabbour (2018), Bag et al. (2020; 2021), Akhter (2022), and Iqbal and Ali (2024) highlight the potential of digital procurement to improve efficiency and

resilience, the impact on sustainable performance, covering environmental, social, and economic dimensions, remains underexplored. Furthermore, the uncertain and dynamic technological environment may moderate this relationship by amplifying or constraining the effectiveness of digital strategies. To bridge this research gap, the intention of the current study is to answer the subsequent research questions:

- What is the impact of P4.0 strategy on OSP?
- How does TEU moderate the relationship between P4.0 strategy and OSP?

ROT is a theoretical paradigm that incorporates an expanded dynamic capability theory and resource-based view, therefore addressing the shortcomings of both theories (Sirmon et al., 2011). None of the aforementioned theoretical frameworks explains how organizations can develop their capabilities and resources or what combination of resources allows them to establish a competitive edge (Rojo et al., 2020). ROT fills this gap by highlighting the crucial role that managers can play as orchestra conductors, identifying, combining, and utilizing resources to develop new resources that help organizations to achieve a competitive edge (Sirmon et al., 2011). Combining resources entails their integration to create capabilities, while leveraging them includes using organizational capabilities to get a competitive advantage. When capabilities are challenging to evolve, it is considerably more difficult to attain their coordination and synchronization (Sirmon et al., 2011; Hitt et al., 2016). This study offers substantial theoretical contributions by applying ROT to explain how procurement 4.0 contributes to enhanced organizational sustainability, especially in the presence of technological environmental uncertainty. ROT extends the RBV by emphasizing the significance of managerial actions in efficiently structuring, bundling, and leveraging resources in order to generate value and attain competitive advantage, especially in uncertain and dynamic environments.

REVIEW OF LITERATURE AND DEVELOPMENT OF HYPOTHESES

Strategy for procurement 4.0 and sustainable organizational performance

P4.0 performance measures a company's strategic readiness to implement P4.0, aiming to improve overall performance. P4.0 comprises four key elements: strategy, planning, implementation, and performance review (Corboș et al., 2023; Bag et al., 2020). P4.0 strategy includes numerous long-term strategic decisions. Within the context of sustainability, we can analyze a strategy that incorporates both competitive and partnership elements for procurement activities (Kryscynski et al., 2021). It is crucial to remember that the company's corporate strategy, which determines the importance of procurement in the organization's framework, forms the foundation of the P4.0 strategy.

As a result, strategic fit is crucial, as it determines the position and function of procurement within the organization and impacts the attitudes and perception of suppliers and buyers at the strategic level, which in turn helps to enhance the value of P4.0 at the organizational level (Bienhaus & Haddud, 2018; Bag et al., 2020). The nature of the manufacturing activities and the organization's size both play a role in determining the company's P4.0 strategy. P4.0 strategy encompasses both short- and long-term strategic decision-making. However, the increasing amount of demand visibility across the supply chain is a factor that plays a role in such decisions (Corboș et al., 2023). P4.0 strategy entails collaborative and competitive strategies for material recycling and remanufacturing. Remanufacturing operations must be executed with quality, which requires controlling vendor inventory and developing supplier

development initiatives (Bag et al., 2021). Implementing an appropriate P4.0 strategy would decrease supply unpredictability and guarantee timely client supplies to all locations, which would improve overall organizational performance. On the basis of above discussion, we can predict that:

H_1: P4.0 strategy has a significant and positive impact on OSP.

Moderating role of TEU

TEU refers to unpredictability in technology evolution, adoption, and obsolescence. High TEU may challenge organizations' ability to implement digital procurement reliably. P4.0, which includes using cutting-edge digital technologies in purchasing goods, considerably influences how organizations intent to improve their operations, particularly when the technological environments are uncertain (Uusitalo, 2019). P4.0 is characterized by using advanced technologies to improve data-driven decision-making and operational efficiency (Basheer et al., 2024). Organizations leaning towards P4.0 strive to optimize procurement processes to fully utilize these technological advances, aiming to achieve enhanced cost savings, effective management of supplier relationships, and risk reduction (Fröhlich & Steinbiß, 2020). Rapid technological advancement, the inability to forecast the future of technology, and the possibility of obsolescence are some of the challenges that companies confront in a technologically uncertain environment (Darvishmotevali et al., 2020).

P4.0 itself, however, can offer a starting point for reducing these concerns. These technologies help organizations adapt and react to changes in the technological environments by offering real-time data and predictive analytics (Handfield et al., 2019). Many organizations are motivated to optimize their processes through the implementation of P4.0 in order to stay competitive (Nicoletti & Nicoletti, 2018). Organizations understand that by utilizing such technologies and streamlining their procurement procedures, they can anticipate such interruptions and modify their procurement strategies effectively. Increasing the flexibility of contracts, smart sourcing, and working with suppliers on new ideas are ways to optimize (Nicoletti, 2016). Previous research in P4.0 contexts, particularly in Pakistan, shows that TEU moderates the effect of digital procurement on OSP (Huo et al., 2024).

TEU is a critical contextual factor influencing how P4.0 strategies translate into OSP. While moderate levels of TEU stimulate experimentation and digital innovation, excessively high levels may overwhelm firms, diminishing sustainability outcomes. Several studies provide support for the moderating role of TEU. Research on manufacturing firms in Pakistan demonstrated that P4.0 positively influences procurement process optimization, but that environmental and technological uncertainties significantly condition this effect (Iqbal & Ali, 2024). Related studies in supply chain digital transformation also found that uncertainty moderates the impact of digital adoption on performance outcomes such as resilience and competitiveness (Zhou et al., 2023; Abaidullah & Basheer, 2024). These findings align with ROT's assertion that environmental contingencies influence how resources are orchestrated into performance outcomes (Sirmon et al., 2011). Based upon above discussion we can predict that:

H_2: TEU moderates the relationship between P4.0 strategy and OSP.

To perform the empirical testing, the theoretical framework has been developed and presented in figure 01.

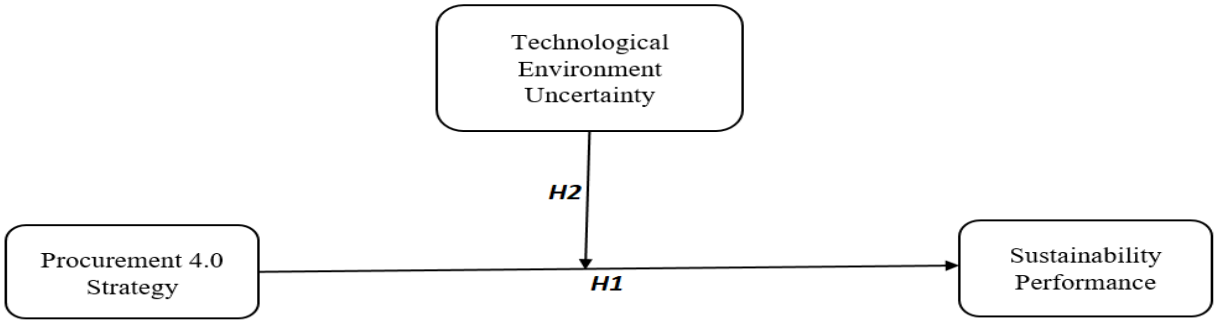

Figure 01.
Research Model

RESEARCH METHODOLOGY

A cross-sectional survey-based quantitative research design is utilized in the current study. Individuals involved in supply chain particularly in procurement activities within large-scale manufacturing firms operating inside Pakistan constituted the "population" of the current study.

Measurement Scales

A measurement scale comprising 9 items, was adopted from the study of Bag et al. (2020) to measure the variable of P4.0 strategy. OSP was measure using a 15-item measurement scale adopted from the study of Arora et al. (2020). TEU was measured using a 4-item measurement scale, which was initially developed by (Li et al.,2024), and also utilized by Huo et al. (2024),. All study variables were measured using a 5-point Likert scale, where "5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, and 1 = Strongly Disagree."

Sampling and Data Collection

With 345 large-scale firms across various manufacturing sectors, it was not possible to collect data from all of them. Moreover, the total population was also indefinite, hence, the study follows "Krejcie and Morgan's formula" for the calculation of unknown population's sample size. According to Krejcie & Morgan, (1970), in case of unknown population minimum sample size should be 384. The study utilized web-based survey for data collection as recommended by Dillman et al., (2014). The questionnaire was shared with the target respondent using multiple channels, such as personal references, social platforms visits, professional bodies, and groups. The total response rate was 57%, as the useful responses were 397 from 700 total shared survey links.

Data Analysis Strategy

To test the hypothesized direct effect, using SEM through AMOS-24, the collected data were analyzed. Through SPSS-26 the moderation effect was tested using the technique of Hayes process macro.

Results

Data Normality Test

Hair et al. (2010) recommended using Skewness and Kurtosis statistics to analyze the normalcy of the data. Multicollinearity should be considered an issue when the variance inflated factor (VIF) value is greater than 5 and the tolerance value is less than 0.20, according to Hair et al. (2010). Multicollinearity across the latent variables becomes apparent when the correlation value is 0.90 or above. Table-1 shows the VIF

statistics, while Table-2 presents the results of correlation analysis. The correlation results show a maximum value of 0.329 considering all research variables, revealing absence of data multicollinearity (see Table-2). Moreover, Hair et al. (2010) also stated that VIF values higher than 10, indicate that the data have the multicollinearity problem, therefore, VIF value must be below 10 for data normality. Data results in Table-1 reveal 1.70 as the highest VIF value, which is considerably lower than the benchmark of 10.

Table 1.
Data Normality

Variables	Mean	SD	Skewness	Kurtosis	Tolerance	VIF
P 4.0 Strategy	3.67	1.04	-0.89	-0.46	0.72	1.40
TEU	3.48	1.12	-0.53	-1.11	0.85	1.17
OSP	3.80	0.84	-1.08	0.09	-	-

N=397

Table 2.
Correlation Matrix

Variables	1	2	3
1- P 4.0 Strategy	1		
2- TEU	.289**	1	
3- OSP	.171**	.329**	1

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

Validity Analysis

Hair et al., (2010) have classified the validity test into convergent validity and discriminant validity, and suggested that it is prerequisite to test the validity prior to hypotheses testing. By following Hair at al. (2010), both validities convergent and discriminant were tested, and results are presented in Table-3.

There are several methods that can be sued to test convergent validity. The current study utilizes two different techniques to assess the both validities. Firstly, to test the convergent validity, CR values and AVE values were examined. For convergent validity the values of composite reliability (CR) should be 0.70 or greater, and the values of average variance extracted (AVE) should be greater than 0.50. Results shown in Table-3 confirms the convergent validity as all the study constructs have AVE values are well beyond 0.50 threshold, which endorses the convergent validity. The CFA results reveal that all the CR values are above 0.840, which also confirm the convergent validity. Furthermore, for confirmation of discriminant validity, the current study follows Fornell and Larcker's, (1981) recommendations that the value for the square root of AVE should higher than the construct correlation value. Table-3 shows the results of the Fornell-Larcker Criterion, indicating excellent "discriminant validity" since all square root of AVE values exceed the constructs' correlation values. Consequently, the study's measurement model establishes an adequate validity.

Table 3.
Validity Analysis

Variables	CR	AVE	1	2	3
1- P4.0 Strategy	0.93	0.61	**0.782**		
2- TEU	0.88	0.65	0.308***	**0.804**	
3- OSP	0.95	0.55	0.185***	0.372***	**0.743**

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

HYPOTHESES TESTING

To test the study hypothesis having a direct effect, SEM technique was used, and the direct effect's results are shown in Table-4, whereas the moderation effect is shown in Table-5. Results of the direct effect reveal that there is a positive and significant impact

of P4.0 strategy on OSP (β=0.140, T-statistics=3.35, P<.001), which leads to the acceptance of H1.

Table 4.
Test of Hypothesis (Direct Effect)

Hypotheses	Structural Paths	Estimate	T-value	P
H1	P4.0 Strategy → OSP	0.14	3.35	***

*****p<.001**

The moderation hypothesis was tested using the slop test introduced by Yin et al., (2025). The current study predicted in hypothesis 2 that the relationship between P4.0 strategy and OSP is significantly moderated by TEU, as the results reveal that this relationship becomes stronger in the presence of high TEU (see Table-5). The significant values for R^2 change and F-statistics (R^2-change = 0.086, F=38.82, P<.001) also validates the moderation. Moreover, the relationship slope shown in in figure-2 shows that the relationship between P4.0 strategy and OSP is stronger in the presence of high TEU as compared to low TEU. This leads to the acceptance hypothesis-2 as well.

Table 5.
OSP predicted from P4.0 strategy and TEU

Moderator (TEU)	β	p	95% CI	
Low TEU	-0.151	0.061	-0.301	0.005
Moderate TEU	0.164	0.002	0.263	0.526
High TEU	0.339	<.001	0.319	0.558
"Test(s) of highest order unconditional interaction: (X*W)"				
R^2 -chng = .086***				
F Statistics = 38.82				

*****p<.001**

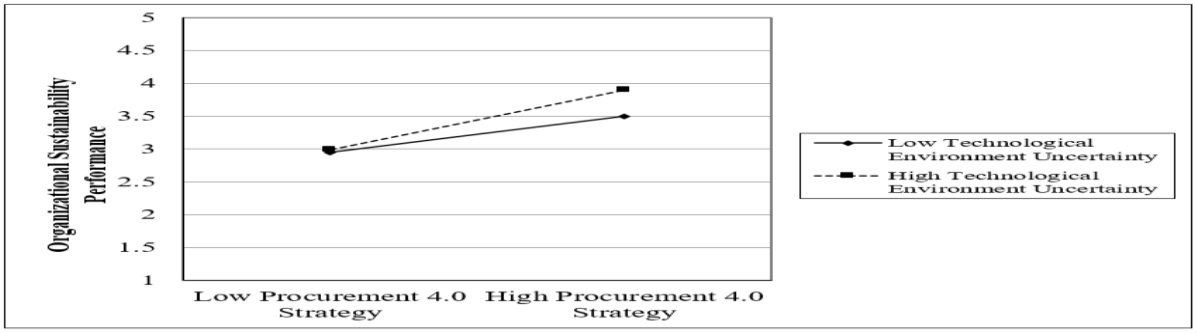

Figure 2.
Moderation Graph (P4.0 Strategy*TEU →OSP)

DISCUSSION

The data analysis findings revealed that the P4.0 strategy is positively associated with the organization's overall sustainability performance. Strategic decision-making over the long and short terms is an important part of procurement strategy, and seamless information flow is necessary for making strategic decisions (Bag et al., 2020). P4.0 technologies facilitated this information flow through the integration of all organizational functions. The main emphasis of 4.0 technologies is to digitalize the processes using innovative technologies, like, artificial intelligence, internet of things, big data, cloud computing, blockchain, and smart contracts (Ng et al., 2022). These technologies help organizations in making more sustainable procurement decisions. These technologies can also help the organizations in minimizing the environmental effects, cutting costs, and increasing the overall procurement process efficiency.

Additionally, P4.0 enables businesses to make their supply chains more transparent and manageable, guaranteeing that sustainable practices are followed throughout the procurement process (Ng et al., 2022). The study results are well aligned with the study of Yevu et al., (2021), which established that P4.0 has the potential to significantly enhance an organization's sustainability performance by encouraging more eco-friendly procurement decisions, more supply chain visibility, and efficient use of accessible resources. Furthermore, P4.0 may help the businesses in the reduction of waste and carbon emissions, managing and monitoring their purchasing operations, highlighting the areas of improvement, and putting more environment friendly strategies into action. The study by Bag et al. (2021) validates the current study's results, confirming that an appropriate P4.0 strategy implementation would decrease supply unpredictability and ensure timely client supplies to all locations, thereby improving overall organizational performance.

IMPLICATIONS

This study makes significant theoretical contributions by applying Resource Orchestration Theory (ROT) to explain how P4.0 initiatives contribute to enhanced OSP, particularly in the context of environmental uncertainties. ROT extends the "Resource-Based View (RBV) Theory" through putting more emphasis on the significance of managerial actions in effective resource structuring, resource bundling, and resource leveraging for the generation of maximum value and to attain sustainable competitive advantage, especially in dynamic and uncertain environments. Importantly, the study also introduces environmental uncertainty as a moderating variable, offering a critical boundary condition within which the effectiveness of resource orchestration is assessed. Consistent with ROT, the findings are expected to demonstrate that the outcomes of digital procurement strategies are highly contingent upon external environmental conditions, such as regulatory shifts, market volatility, and supply chain disruptions.

This contextual sensitivity enhances the explanatory power of ROT by applying it in a volatile and emerging economy context. Additionally, this research makes three key theoretical contributions; (i) it extends the application of ROT into the digital procurement and sustainability literature, and (ii) it conceptualizes environmental uncertainty as a contextual moderator, refining ROT's application in dynamic and unpredictable environments. These contributions provide a solid theoretical foundation for understanding how digital transformation in procurement can be strategically managed to achieve sustainability outcomes in real-world, uncertain conditions. This study also offers practical value for procurement managers, operations leaders, and policy-makers in Pakistan's large-scale manufacturing sector by providing clear insights into how strategical P4.0 can be implemented to drive process optimization and improve sustainability performance. It highlights that the success of digital tools, such as automation, analytics, and IoT, depends not just on adoption, but on how effectively they are aligned with organizational processes and capabilities. The research also emphasizes the need to build resilient procurement strategies that can withstand environmental uncertainties, which are common in Pakistan's industrial landscape due to market volatility, energy crises, and regulatory shifts. By applying the principles of ROT, the study provides a practical framework for managing digital transformation more effectively, helping manufacturing firms improve efficiency, reduce waste, and enhance long-term competitiveness in an uncertain environment.

CONCLUSION

The current study highlights P4.0 as a strategic sustainability driver, moderated by the nature of TEU. This study is grounded in ROT and also supported by many current empirical studies (especially within developing countries), it demands comprehensive digital adoption strategies that take consideration of both TEU as well as the sustainability necessities. This study provides a roadmap to the procurement professionals and researchers, while also contributes in extending the discourse of digital transformation in the procurement and supply chain practices.

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the contributor of research and their different affiliations.
Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant for this research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally to the creation of this work.
Conflicts of Interests: The authors declare no conflict of interest.
Consent to Participate: Yes
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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