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DETERMINANTS OF SUSTAINABLE OPERATIONS EXCELLENCE: THE MEDIATING EFFECTS OF SUPPLY CHAIN INTEGRATION AND DIGITAL TECHNOLOGY ADOPTION

Mohammed A. Al Doghan[1*] and Ahmad Zainal Abidin Bin Abd Razak[2]

[1]Department of Management, College of Business Administration, King Faisal University, Al-Ahsa 31982, Saudi Arabia.
[2]Universiti Pendidikan Sultan Idris, Malaysia.

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Research Paper

Abstract: *Operational efficiency is essential for optimizing resource utilization and streamlining processes, resulting in cost savings and increased productivity. The aim of this study is to examine the effects of different drivers on the operational excellence of organisations in Saudi Arabia. The study examined the mediating role of supply chain integration and digital technology adoptability. Data were collected from 290 employees across multiple departments in various organisations in Saudi Arabia. The researchers utilised a self-administered questionnaire, a cross-sectional research design, and a quantitative research approach. The study found that supply chain integration and digital technology adaptability had a significant impact on sustainable operational excellence. The study found significant effects of Eco-innovation, control operations process optimisation systems, and operations risk management systems on supply chain integration. This research also found no significant influence of Eco-innovation and process operations management systems on digital adaptability. In addition, the results revealed that supply chain integration and digital technology adaptability act as significant mediators between various factors and operational excellence. The study provides theoretical insight by emphasising the significance of key drivers of operational excellence, such as sustainability, eco-innovation, risk management, and process optimisation. Further, the study illustrates the limited impact of traditional production strategies. The study highlights the practical importance of organisations prioritising certain factors to improve operational performance. The study specifically identifies supply chain integration and digital technology adoption as significant mediators to optimise operations.*

*Corresponding Author: mdoghan@kfu.edu.sa.(M. A. Al-Doghan),
ahmad.zainal@fpe.upsi.edu.my (A. Z. A. B. Abd Razak)

Determinants of Sustainable Operations Excellence: The Mediating Effects of Supply Chain Integration and Digital Technology Adoption

Keywords: *sustainable operational excellence, supply chain integration, digital adoptability, Saudi Arabia*

1. Introduction

Growing environmental concerns have heightened the significance of sustainable operations and performance. Businesses that prioritize sustainable practices to reduce their ecological footprint are increasingly recognized and acknowledged in response to pressing environmental concerns (Elrayah & Keong, 2023). It emphasises the importance of organisations' sustainable actions in both creating performance and ensuring long-term survival. Elrayah and Keong's (2023) discussion on sustainable operational performance has garnered significant interest from both organisations and researchers. The way businesses approach operations management has changed. Instead of relying on traditional methods, there is now a focus on sustainable operations management. The main goal is to improve sustainable operational performance. This involves minimising waste, maximising resource utilisation, and reducing emissions. All these measures are crucial to guaranteeing and asserting sustainable operational excellence (Bocken et al., 2013).

Sustainability is evident not only in developed countries but also in developing ones. In a similar vein, Saudi Arabia is placing a strong emphasis on sustainability. As part of this effort, the Saudi Vision 2030 is implementing comprehensive development standards across various sectors of Saudi society. Saudi Arabia has implemented a range of measurable actions to achieve sustainable goals while also meeting current needs without compromising future requirements (Balabel & Alwetaishi, 2021). While various industries contribute to environmental degradation, this study specifically focuses on the power sector in Saudi Arabia. In 2015, total greenhouse gas (GHS) emissions in Saudi Arabia amounted to 709.79 metric tonnes of CO_2. The power sector accounted for approximately 34.70% of these emissions, followed by transport (19.74%). These figures are important to highlight because they shed light on the environmental impact of these sectors (Crippa et al., 2019). Recently, Agboola et al. (2021) conducted a recent study that underscored Saudi Arabia's significant attention to the power sector. This sector is of great concern due to the high level of emissions caused by the extensive use of fossil fuels. Thus, it is crucial to determine the factors that contribute to the long-term success of operations in the Saudi power sector.

Supply chain integration plays a crucial role in enhancing sustainable operational excellence. As an example, a previous study highlighted that sustainability has become a crucial factor for numerous businesses and supply chains (Han & Huo, 2020). Researchers are also studying the connection between supply chain integration and sustainable operational excellence. According to Han and Huo (2020), the current research on the integration of green supply chains and performance has not received much attention. This is because most studies have primarily focused on supply chain management and environmental performance. According to a recent study by Afum et al. (2020), the supply chain encompasses both suppliers and customers. When looking at the upstream perspective, it refers to the raw materials and other resources that organizations rely on from their suppliers. Customers receive the finished goods in the form of raw materials. However, given the current concerns surrounding sustainability, strategic partnerships between supply chain partners have become increasingly important in achieving organisational objectives. Therefore, it is crucial to acknowledge the significance of supply chain integration in manufacturing firms when it comes to tackling growing environmental concerns (Afum et al., 2020). This study provides a valuable contribution to the existing literature by examining the correlation between supply chain integration and sustainable excellence.

Besides, Digital technology also plays a crucial role in driving sustainability. People view the latest digital technologies, such as the Internet of Things, big data, AI, and blockchain, as crucial for achieving sustainability. The majority of studies have focused on investigating the correlation between digital technologies and sustainable product management (Rusch et al., 2023). As a result, the study has aimed to explore a lesser-explored aspect of sustainable excellence. In recent years, there has been a significant increase in the incorporation of digital technologies in both manufacturing industries and services, according to a recent study. There is an increasing amount of research that highlights the importance of digital technologies in promoting sustainability. Nevertheless, the exploration of the relationship between digital technologies and sustainability remains incomplete (Paiola et al., 2021).

Both production and operations management strategies play a crucial role in improving supply chain management for organizations. A previous study, for example, highlighted the importance of production and operations management (POM) and supply chain management (SCM) in traditional business management approaches. Organizations must prioritize efficient material use, smooth information flow, and effective resource allocation throughout the organization. POM encompasses the various stages of drafting, planning, and controlling production processes to enhance the value of inputs and outputs. While the SCM primarily concentrates on coordinating activities throughout the organisation to deliver products and services to customers, There is a growing need for further research in a developing field that aims to combine POM and SCM in order to improve organisational performance (Salah et al., 2023). In addition, they argued that previous studies have primarily concentrated on the POM and financial performance. Nevertheless, the process by which it occurs still lacks clarity. The present study has examined both operations risk management strategies and production operations management strategies in relation to achieving sustainable operational excellence through supply chain integration. In recent research, it has been argued that there is a growing emphasis on the significance of risk management and integrative processes among both scholars and professionals.

Regarding this matter, there is a strong emphasis on supply chain integration to tackle the challenges and uncertainties. Organisations are working diligently to manage risks, navigate disruptions, and enhance performance in a constantly evolving environment (Munir et al., 2020). This study examines the relationship between sustainable operations control, eco-innovation, operations risk management, continuous operations processes, and production management strategies for achieving sustainable operational excellence. Furthermore, the study investigated the role of digital adoptability and supply chain integration as mediators. The study provides valuable contributions in multiple ways. First and foremost, this is a rare endeavour that focuses on achieving sustainable operational excellence. Historically, the majority of studies have primarily focused on environmental performance. In addition, the study contributes to the existing empirical evidence in the power sector context, which primarily relies on secondary data analysis approaches.

2. Literature Review and Hypothesis Development

The field of sustainable operations control systems is still in its early stages. It has been argued that sustainable operations have gained traction in the past two decades, particularly in the context of sustainable development. Despite being a subject of extensive study, research in this field remains limited and is still in its early stages (Jaehn, 2016). Efficient operations require a seamless integration of the supply chain and a strong focus on digital adaptability. A previous study argued that implementing a sustainable management control system allows for the incorporation and synchronisation of sustainability principles into supply chain practices (Herremans & Nazari, 2016). It allows an organisation to effectively monitor and manage supply chain activities, ensuring that they align with societal and environmental standards. Implementing this system can enhance the sustainability of sourcing and logistics. In addition, it leads to a decrease in waste generation and improves the overall performance of the organisational supply chain (Dharmayanti et al., 2023). When organisations implement a sustainable operations control system, it enables them to transform their supply chains and seamlessly incorporate sustainable practices. Furthermore, it encourages the adoption of technology. This study suggests that the implementation of a sustainable operations control system can enhance organisations' ability to adopt digital technology. As an example, a previous study argued that sustainable operations management leads to increased utilisation of technology and digital solutions for operational issues, processes, and improved communication and integration (Lezoche et al., 2020). The present study suggests that the implementation of a sustainable operations control system can contribute to the increased adoption of digital technology by organisations.

Furthermore, eco-innovation is associated with the latest techniques that enhance environmental transformation. These practices aim to promote environmentally friendly and sustainable solutions for organizations. Manufacturing firms commonly adopt these practices due to their numerous benefits (Janahi et al., 2021). Eco-innovation is believed to contribute to improved integration of supply chain management. Eco-innovation enables organisations to embrace environmentally friendly practices in various aspects, including sourcing, production, and distribution. It fosters a culture of environmental innovation and encourages the adoption of sustainable approaches (Hsu et al., 2016). It is evident that eco-innovation plays a crucial role in enabling organisations to seamlessly integrate their supply chains. The integration of sustainable practices into the supply chain facilitates eco-design, green packaging, and the use of renewable energy sources. By implementing these strategies, organisations can enhance their sustainability (Gawusu et al., 2022). In a recent study by (Li et al., 2023), it was argued that eco-innovation plays a crucial role in driving the adoption of digital technologies like IoT, AI, and augmented reality, among others, to enhance the overall performance of organisations. This study posits that Eco-innovation plays a significant role in driving supply chain integration and digital technology adaptability among firms.

Furthermore, organisations respond to potential opportunities and strive to seize them for their own advantage. On a global scale, there are various challenges to production practices that can complicate supply chains. In such situations, the integration of the supply chain becomes a crucial element that assists organisations in effectively managing the risks they encounter. Therefore, the supply chain integration implemented by organisations in an effort to effectively handle the growing complexity of the supply chain (Wiengarten et al., 2016). This study suggests that operations risk management could be a key factor in driving supply chain integration and the adoption of digital technology. Implementing risk management strategies is beneficial for organisations. However, it is important to be cautious about excessive application of these practices as it may lead to difficulties in managing processes (Chaudhuri et al., 2018). This study argues that implementing effective risk management strategies can enhance supply chain integration. In addition, organisations are increasingly embracing digital technologies to enhance their performance. Furthermore, they implement these technologies to reduce potential risks. It is worth considering that risk may be a potential indicator of digital technology's adoptability. Therefore, some argue that organizations can enhance their supply chain integration and adaptability to digital technology by implementing risk management strategies.

However, organisations are already facing mounting pressure due to growing environmental concerns. Prioritising ongoing enhancements centred on process optimisation is crucial given the current challenges. In addition, it helps to minimise waste and resource consumption. There are various methods available for enhancing the process. Lean six-sigma is a crucial method for enhancing operational efficiency. It is worth noting that it has been implemented in various industries worldwide. Data forms the foundation of this analysis, facilitating the examination of issues and the enhancement of processes (Vinodh et al., 2021). It suggests that organisations need to adopt digital technology in order to optimise their continuous operations process. By utilising data, they can effectively resolve issues and enhance their processes.

Furthermore, it is clear that ongoing operations optimisation requires supply chain integration. This study suggests that optimising continuous operations processes can enhance supply chain integration. It helps improve processes and seamlessly connect suppliers, manufacturers, and distributors, allowing companies to minimise waste, cut costs, and meet customer demands through an integrated approach. Previous studies have also provided support for this idea. For example, (Flynn et al., 2010) argued that implementing continuous improvement strategies, like lean manufacturing, can improve supply chain integration. In addition, a strong focus on optimising resources, minimising lead times, and enhancing collaboration with suppliers and customers can lead to effective supply chain integration (Moyano-Fuentes et al., 2021). Furthermore, a wide range of factors, all interconnected with the production process in an organisation, encompass production and operations management. It encompasses not only the management of production, but also the careful planning of activities to ensure efficient and optimal output. It can be achieved more effectively by efficiently managing resources, labour, materials, and technology (Zhou et al., 2022). This viewpoint emphasises the impact of production and operations management on technology. This study argues that the organisational push to implement production and operations management strategies leads to the adoption of technology and supply chain integration as well.

The connection between supply chain integration and digital technology adaptability lies in their contribution to achieving sustainable operational excellence. Utilising digital technology enables an organisation to achieve long-term sustainability. For instance, applications that focus on data analytics, automation, and real-time data processing can help organisations forecast and optimise resource allocation. It also helps them optimize resource utilization and waste reduction. The digital capabilities of an organisation contribute to enhancing production, competitiveness, and profitability, ultimately leading to sustainable actions (Jabbour et al., 2020). Through the utilisation of digital tools, organisations can uncover potential avenues for implementing sustainable practices, including reducing carbon emissions, promoting ethical sourcing, and fostering supplier diversity (Moshood et al., 2021). All these efforts lead to sustainable operational excellence. Furthermore, the integration of the supply chain enables organizations to achieve sustainable operational excellence. Organisations that prioritise sustainability place equal emphasis on integrating both internal and external components within their supply chains. Organisations often strive to align their internal operations in order to support their sustainability goals, utilising their internal organisational supply chains. In addition, through the integration of external partners, organisations can prioritise supplier selection, practices, and long-term collaboration to achieve sustainable operational excellence.

Simply stated, when organisations strive for sustainable operations, it leads to an increase in supply chain integration. A previous study argued that the desire to establish sustainable management control systems leads to the adoption of integrated and aligned sustainability principles throughout the organisation, especially in supply chains (Herremans & Nazari, 2016). It is beneficial for the organisation to have strong control over supply chain activities, ensuring that they align with societal and environmental standards. Likewise, eco-innovation plays a crucial role in enhancing supply chain integration. It helps the organisation align its actions with the ever-changing environmental demands in a creative and desired manner. It facilitates the implementation of environmentally conscious practices throughout various stages of the supply chain, such as sourcing, production, and distribution (Hsu et al., 2016). This ultimately leads to the integration of the supply chain. Furthermore, there is a close connection between operations risk management and supply chain integration. When organisations consider the implications of operational risks, it can have significant effects on various aspects, such as supply chains. Organizations implement supply chain integration to handle the complexity arising from operations risk management (Wiengarten et al., 2016). Likewise, the seamless coordination of ongoing operations and production activities contributes to the integration of the supply chain. As a result of these factors, supply chain integration leads to sustainable operational excellence (Kang et al., 2018).

This study suggests that the adaptability of digital technology can act as a mediator, in line with existing literature. Incorporating cutting-edge technologies into organizational operations has proven instrumental in enabling them to thrive in today's fiercely competitive business landscape. It is important to note that these technologies are also contributing to organizations' long-term success. For example, with the use of data analytics, automation, and real-time data processing, businesses can make more accurate predictions about their resource needs. This allows for better resource allocation and a decrease in waste generation. By harnessing digital capabilities, organisations not only increase production efficiency and competitiveness but also promote sustainable practices. This synergy between technology and sustainability increases a more responsible and environmentally conscious approach to operations, driving long-term positive impacts on both business performance and the planet. (Jabbour et al., 2020). And technology adaptability is predicted by various factors, for instance, operations risk management strategies. A recent study conducted by (Li et al., 2023) highlighted the importance of eco-innovations in enhancing digital adaptability. The study found that organisations seeking to innovate while adhering to sustainability principles should embrace cutting-edge technologies like AI and IoT. These technologies enhance the operational efficiency of organisations (Ivanov et al., 2019). As a result, they are able to maintain their sustainability. The present study highlights the various factors that contribute to the adaptability of digital technology, ultimately leading to sustainable operational excellence. These factors include sustainable operations, eco-innovation, operations risk, continuous operations, and production operations. Thus, it is hypothesized that;

H1: *Supply chain integration significantly mediates the relationship between sustainable operations control system and sustainable operational excellence.*
H2: *Supply chain integration significantly mediates the relationship between eco-innovation and sustainable operational excellence.*
H3: *Supply chain integration significantly mediates the relationship between operations risk management strategies and sustainable operational excellence.*
H4: *Supply chain integration significantly mediates the relationship between continuous operations process optimization and sustainable operational excellence.*
H5: *Supply chain integration significantly mediates the relationship between production operations management strategies and sustainable operational excellence.*
H6: *Digital adaptability significantly mediates the relationship between sustainable operations control system and sustainable operational excellence.*
H7: *Digital adaptability significantly mediates the relationship between eco-innovation and sustainable operational excellence.*

H8: *Digital adaptability significantly mediates the relationship between operations risk management strategies and sustainable operational excellence.*
H9: *Digital adaptability significantly mediates the relationship between continuous operations process optimization and sustainable operational excellence.*
H10: *Digital adaptability significantly mediates the relationship between production operations management strategies and sustainable operational excellence.*

Based on previous literature study has formulated the research framework in Figure.1 below,

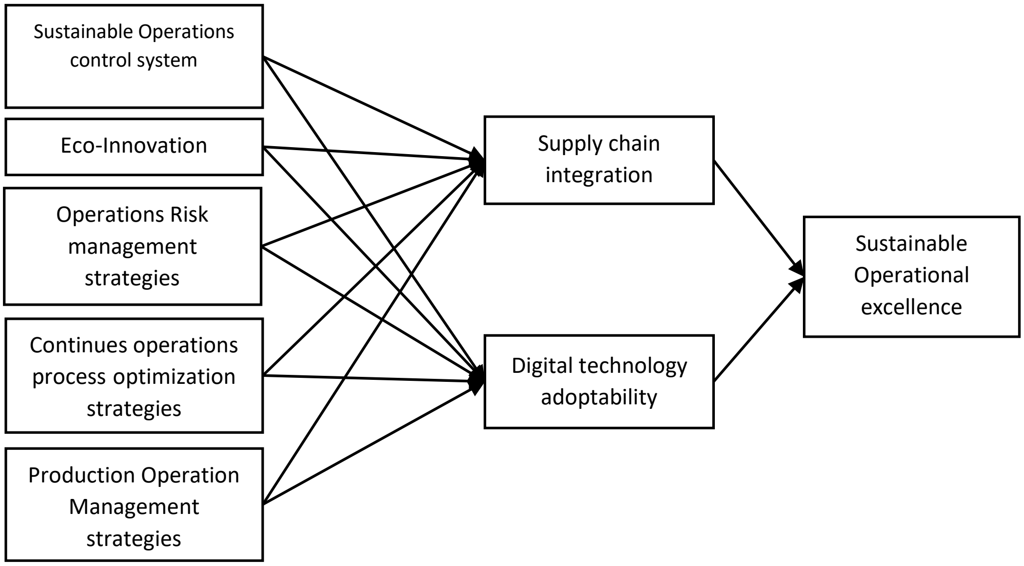

Figure.1: Research Framework

3. Methodology

Thus, the study focuses on examining the effects of different drivers on the operational excellence of organisations in Saudi Arabia. The study also examined the mediating effects of supply chain integration and digital technology adoptability.

3.1 Research Design

The study aims to examine the hypothesised relationship between the variables, adopting a positivist research philosophy and employing a quantitative deductive approach. In addition, the study utilised a cross-sectional time horizon for data collection, as the aim was not to observe any changes over time.

3.2 Questionnaire Design and Pre-testing

The study utilised quantitative methods and employed a questionnaire for data collection. A questionnaire is a commonly used tool for collecting data when the study population is spread across different locations.

The measurement of eco-innovation has been conducted using a seven-item measure developed by (Firman et al., 2023). A control measure for sustainable operations was derived from a previous study that included four items (Adib et al., 2021). The measurement of digital adaptability was conducted using a seven-item measure developed by (Kurniawan et al., 2022). A seven-item measure was utilised to assess sustainable financial performance for achieving sustainable operational excellence (Rodríguez-González et al., 2022). In addition, the measurement of process optimisation in continuous operations was achieved by implementing a metric that focuses on continuous improvement and learning. The study included 5 items (Liu et al., 2006). The measurement of operations risk management strategies was conducted using a six-item measure developed by (Liu et al., 2018). Furthermore, the measurement of supply chain integration was conducted using a set of four items (Seo et al., 2014).

Point 5 Likert scale with the following range “1 --> Strongly disagree to 5 --> Strongly agree” was used. The questionnaire was pre-tested before it was distributed for data collection to ensure accuracy and alignment with the respondents' reading. The content was reviewed by five experts to gain a better understanding of their opinions. Only a few changes were made. Then, a set of 35 questionnaires was also distributed to the respondents as a pilot study. The reliability met the required standards. The questionnaire did not need any revisions.

3.3 Sampling and Data Collection

The study took place in Saudi Arabia. The population consisted of the employees employed in the power-related organisations in Saudi Arabia. The population size was uncertain, so a convenience sampling method was employed to select the participants. Typically, a sample size of 400 valid responses is sufficient for data analysis. In total, 400 questionnaires were distributed to music teachers, and 290 of these were deemed valid for data analysis. The data underwent analysis using SPSS and PLS-SEM.

4. Results

4.1 Measurement Model Assessment

In this study, we evaluated both the measurement and structural models. Firstly, reliability and validity were established, followed by testing the hypotheses (Chin, 1998; Hair et al., 2012; Henseler et al., 2009). The measurement model of the study was evaluated using confirmatory factor analysis (CFA). Further information will be provided in the following section. Table 2 provides a comprehensive breakdown of the findings regarding CFA. Composite reliability values should exceed 0.8. All the values in Table 2 regarding Cr are above 0.8, indicating that there are no concerns regarding reliability (Haider & Yean, 2023). In addition, Table 1 also includes the reported factor loadings. Factor loadings should, ideally, be greater than 0.5. The results presented in the table below indicate that all factor loadings exceed the threshold of 0.5 (Hair Jr et al., 2010). Finally, the AVE values are greater than 0.50. All AVE, factor loadings, and Cr values conform to their respective parameters. Therefore, the present study has successfully established convergent validity.

Table 1: Factor Loadings

	CI	COPOS	DTA	ORMS	POMS	SCI	SOCS	SOE
CI1	0.678							
CI2	0.647							
CI3	0.78							
CI4	0.712							
CI5	0.812							
CI6	0.725							
CI7	0.688							
COPOS1		0.919						
COPOS2		0.910						
COPOS3		0.612						
DTA1			0.853					
DTA2			0.854					
DTA3			0.825					
DTA5			0.830					
DTA6			0.730					
DTA7			0.667					
ORMS1				0.741				
ORMS2				0.764				
ORMS3				0.759				
ORMS5				0.839				
POMS1					0.862			
POMS2					0.738			
POMS3					0.887			
POMS4					0.905			
SCI1						0.844		
SCI2						0.740		
SCI3						0.845		
SCI4						0.883		
SOCS1							0.694	
SOCS3							0.756	
SOCS4							0.900	
SOE1								0.858
SOE2								0.779
SOE3								0.793
SOE4								0.873
SOE6								0.884
SOE7								0.846
SOE8								0.823

Table 2: Composite Reliability

	Alpha	rho_a	rho_c	AVE
CI	0.847	0.856	0.884	0.522
COPOS	0.748	0.779	0.862	0.683
DTA	0.884	0.897	0.912	0.634
ORMS	0.784	0.8	0.859	0.603
POMS	0.873	0.88	0.912	0.723
SCI	0.847	0.849	0.898	0.689
SOCS	0.704	0.82	0.829	0.621
SOE	0.929	0.931	0.943	0.701

4.2 Discriminant Validity

The study also assessed discriminant validity by utilising HTMT. This technique is the most recent approach to tackle the issue of discriminant validity, which uncovers the distinctiveness of all the constructs within a framework. According to the given criteria, the HTMT values should be below 0.85 or 0.90 in certain situations (Henseler et al., 2015). All reported values of HTMT are below the cutoff of 0.85. Therefore, discriminant validity is confirmed, indicating that all the constructs are distinct from one another figure 2.

Table 3: HTMT

	CI	COPOS	DTA	ORMS	POMS	SCI	SOCS	SOE
CI								
COPOS	0.872							
DTA	0.564	0.632						
ORMS	0.779	0.937	0.832					
POMS	0.995	0.884	0.518	0.707				
SCI	0.705	0.771	0.754	0.782	0.6			
SOCS	0.802	0.685	0.684	0.669	0.766	0.582		
SOE	0.777	0.719	0.66	0.753	0.724	0.62	0.833	

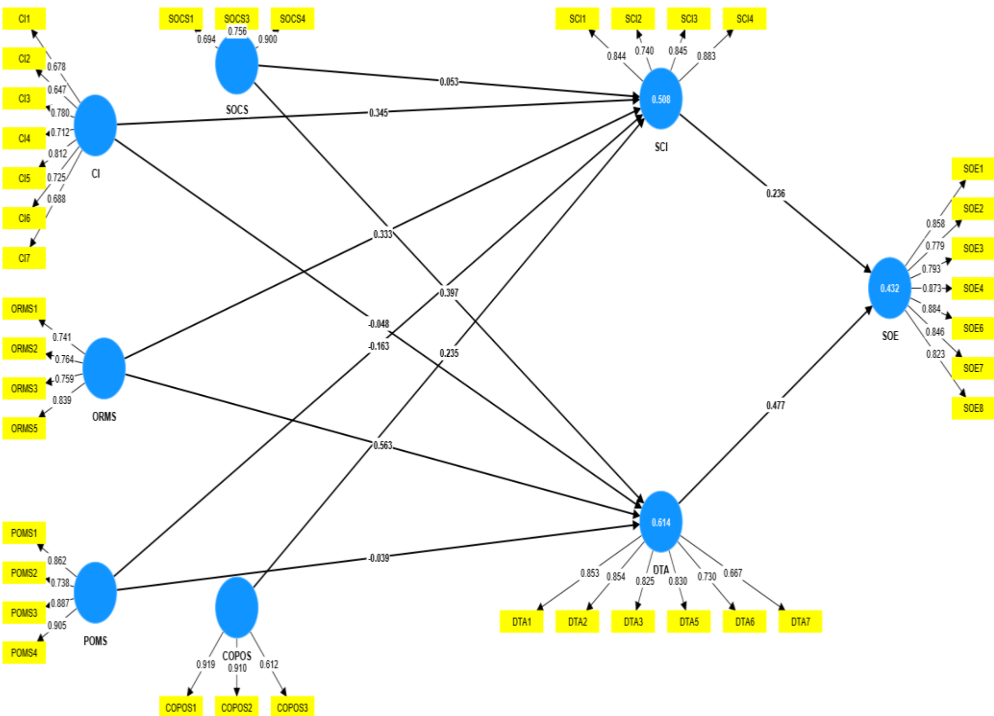

Figure.2: Measurement Model

4.3 Path Analysis

PLS-SEM has been used to test the hypothesized relationships between the variables. Bootstrapping with 5000 sub-samples has been used. The below table 4 shows the results for the hypotheses testing. The results revealed that EI does not influence the digital technology adaptability (β = -0.048, t = 0.663; p>0.05), however, it significantly influences SCI (β = 0.345, t = 4.443; p<0.05). Additionally, results also shows that COPOS (β = 0.235, t = 3.49; p<0.05), ORMS (β = 0.333, t = 5.507; p<0.05), and POMS (β = -0.163, t = 2.114; p<0.05) significantly influences the SCI. However, SOCS did not significantly influence the SCI (β = 0.053, t = 0.980; p>0.05). Moreover, table 4 shows that the ORMS (β = 0.563, t = 11.498; p<0.05), and SOCS (β = 0.397, t = 8.486; p<0.05) significantly influence the DTA. Besides, table 4 also shows the mediation relationships. According to the findings presented in Table 4, SCI plays a crucial role in mediating the impact of ORMS, EI, COPOS, and POMS on SOE. However, we did not find it to be a significant mediator in the relationship between SOCS and SOE. In addition, Table 4 demonstrates the significant role of DTA as a mediator in the relationship between the influence of SOCS and ORMS on SOE. However, it was not found to have a significant impact on the relationship between EI and POMS on SOE.

Table 4 Path Analysis

Relationships	Beta	Std. Dev.	T value	P values	Decision
EI -> DTA	-0.048	0.072	0.663	0.508	Unsupported
EI -> SCI	0.345	0.078	4.443	0.000	Supported
COPOS -> SCI	0.235	0.067	3.499	0.000	Supported
DTA -> SOE	0.477	0.056	8.482	0.000	Supported
ORMS -> DTA	0.563	0.049	11.498	0.000	Supported
ORMS -> SCI	0.333	0.06	5.507	0.000	Supported
POMS -> DTA	-0.039	0.063	0.626	0.531	Unsupported
POMS -> SCI	-0.163	0.077	2.114	0.035	Supported
SCI -> SOE	0.236	0.062	3.784	0.000	Supported
SOCS -> DTA	0.397	0.047	8.486	0.000	Supported
SOCS -> SCI	0.053	0.054	0.98	0.327	Unsupported
		Indirect Effects			
ORMS -> SCI -> SOE	0.079	0.026	3.03	0.002	Supported
EI -> SCI -> SOE	0.082	0.029	2.851	0.004	Supported
SOCS -> SCI -> SOE	0.013	0.014	0.886	0.376	Unsupported
COPOS -> SCI -> SOE	0.056	0.021	2.669	0.008	Supported
POMS -> SCI -> SOE	-0.039	0.02	1.887	0.059	Supported
EI -> DTA -> SOE	-0.023	0.034	0.663	0.507	Unsupported
SOCS -> DTA -> SOE	0.189	0.03	6.332	0.000	Supported
ORMS -> DTA -> SOE	0.269	0.039	6.823	0.000	Supported
POMS -> DTA -> SOE	-0.019	0.03	0.627	0.531	Unsupported

Note: SOCS-sustainable operations control system, ORMS-operations risk management strategies, SCI-supply chain integration, SOE-sustainable operations excellence, EI-eco-innovation, POMS-production operations strategies, COPOS-continues operations process optimization strategies, DTA-digital technology adoption.

5. Discussion

This study aims to investigate the impact of sustainable operations control systems (SOCS), eco-innovation (EI), operations risk management strategies (ORMS), continuous operations process optimisation strategies (COMPS), and production operations management strategies (POMS) on sustainable operations excellence (SOE) in the power sector of Saudi Arabia. This will be achieved through supply chain integration (SIC) and adaptability to digital technology (DTA). Data were collected from employees in the power sector organisations of Saudi Arabia. The study's PLS-SEM results indicate that SOCS has a significant influence on both SCI and DTA. The findings align with prior research. (Rathi et al., 2022) and (Tornjanski et al., 2017) investigated the impact of sustainable practices on waste reduction, resource optimisation, risk reduction, and overall performance improvement. Companies can enhance their supply chains and adopt digital technologies more effectively by aligning with environmental and social objectives. As a result, it can enhance the influence of sustainable operations and control systems on sustainable operational excellence through mediation. Additional findings indicate that EI has a positive and significant impact on SCI and DTA. The findings align with prior research. (Manavalan & Jayakrishna, 2019) contend that organisations can enhance the resilience and efficiency of their supply chains by leveraging digital technologies, implementing eco-friendly initiatives, optimising operations, and pursuing sustainable growth in environmentally conscious markets (Manavalan & Jayakrishna, 2019).

(Jum'a et al., 2022) study from 2022 supports this conclusion. The integration of lean manufacturing techniques and sustainability-oriented innovation has a significant and positive effect on the Triple Bottom Line, encompassing environmental, economic, and social sustainability aspects. The study's findings indicate that organisations that prioritise sustainable operations and eco-innovation achieve improved supply chain integration and adaptability to digital technology, leading to sustainable operational excellence. The impact of POMS on DTA is found to be statistically insignificant. The findings indicate that POMS is not a significant predictor of the DTA. One possible explanation for this phenomenon is that the relationship in question can be further examined by considering other moderating effects. This is because there may be overlapping variables that influence their relationship. Additionally, the study revealed that ORMS has a significant and positive impact on both SCI and DTA. These (Tornjanski et al., 2017)conducted previous research that aligns with this finding. Thus, it can be argued that Saudi Arabia effectively manages risk management strategies in its power sectors to enhance the culture of the supply chain and technologies.

Additional findings reveal that ORMS play a notable role in influencing SOE through SCI. This discovery is in line with studies that suggest that successful operational risk management systems have a positive impact on supply chain integration, leading to improved overall efficiency. For example, a study conducted by (Tornjanski et al., 2017) discovered that ORMS has a positive impact on SCI in the manufacturing industry. This leads to better operational performance and sustainability results. Thus, the impact of SCI between ORMS and SOE underscores the significance of integrating ORMS initiatives with SCI in the Saudi Arabian power sector. Furthermore, additional findings indicate that EI has an indirect impact on SOE through SCI. This finding aligns with academic research that emphasises the correlation between EI and

SCI in enhancing SOE (Alzoubi et al., 2023; Dharmayanti et al., 2023). Thus, within the realm of the Saudi Arabian power sector, the presence of SCI as a mediator between EI and SOE indicates that strategic investment in eco-innovations and their seamless integration into supply chain processes can greatly enhance the overall performance of the sector. In a different context, SOCS can have an indirect impact on SOE through SCI. Nevertheless, the absence of support for this mediating effect implies the existence of additional variables or a more intricate relationship between SOCS, SCI, and SOE in the Saudi Arabian power sector. Although there may be a lack of academic research specifically examining this correlation in the power sector, studies conducted in other industries indicate that implementing sustainable control systems can have a positive impact on SCI and SOE. However, COPOS has also demonstrated a notable influence on SOE through SCI's mediating effect. The findings indicate that COPOS plays a crucial role in Saudi Arabia's power sector, leading to an increase in the SCI and subsequently boosting the SOE. The findings align with previous studies (Alzoubi et al., 2023; Dharmayanti et al., 2023), which demonstrated that process improvement initiatives have a positive impact on SCI, resulting in improved SOE. Based on the findings, it is evident that the relationship between COPOS and SOE is significant. This highlights the importance of streamlining operations and effectively integrating them within the supply chain to achieve sustainable excellence in the Saudi Arabian power sector.

The other findings indicate that POMS has an impact on SOE through SCI's mediating effect. (Alzoubi et al., 2023) and (Rocamora et al., 2020) demonstrate a positive correlation between POMS and SOE, supporting the findings. Thus, the impact of SCI between production operations management systems (POMS) and supply SOE highlights the significance of aligning strategies in the Saudi Arabian power sector to achieve long-lasting success. Additional findings indicate that emotional intelligence does not have a significant impact on the state of emotional well-being through the process of emotional regulation. The results indicate that while efforts in EI may contribute to DTA, they may not necessarily result in direct improvements in sustainable operations excellence. One potential explanation for this relationship is the presence of overlapping variables that could have an impact on their correlation. The results align with the research findings from (Alzoubi et al., 2023) and (Choi et al., 2022). Additional findings show that DTA mediates the positive impact of SOCS on the level of SOE. These findings indicate that power companies in Saudi Arabia that have efficient SOCS are more likely to improve their SOE through DTA. The findings presented here are consistent with the results of previous studies (Alzoubi et al., 2023; Choi et al., 2022). Furthermore, ORMS has a positive impact on SOE via DTA. The results suggest that power companies in Saudi Arabia can improve their state-owned enterprises by implementing effective strategies for managing operational risks, such as DTA. Put simply, POMS have little impact on SOE via DTA. This suggests that although POM may be significant, its direct impact on enhancing sustainable operations excellence through the adoption of digital technology is uncertain. One potential explanation for this correlation is that the production strategies in Saudi Arabia may not be effectively fostering a conducive digital technology environment, which is crucial for enhancing the operational performance of organisations. Another potential factor to consider is the presence of overlapping variables that could have an impact on the relationship between them.

The presented findings underscore the importance of implementing various strategies, integrating them into supply chain processes, and adopting digital technology to achieve sustainable operations excellence. It also emphasises the need for additional research or improvements in implementation strategies to effectively enhance sustainable performance. Previous research supports the significant contribution of the mediating effect of SCI and DTA, as highlighted in the study's findings (Alzoubi et al., 2023; Erboz et al., 2022; Heredia et al., 2022).

6. Implications

This study presents several implications. Organisations that embrace eco-innovation are able to achieve long-term sustainability. In order to achieve their goals, individuals and organisations can adopt certain practices that focus on saving costs through energy reduction, maximising resource utilisation, and minimising waste. This approach can contribute to the long-term viability of organisations. This also carries certain positive implications for the business. An organisation that embraces eco-innovation can enhance its brand reputation, appeal to a larger base of environmentally conscious consumers, meet their needs, and achieve significant financial gains. Managers should prioritise eco-innovation in their organisations to enhance resilience in their supply chains and leverage the latest digital technologies for improved operational management, ultimately achieving organisational sustainability. The study also has practical implications from the perspective of supply chain integration. Organisations can enhance internal supply chain collaboration by involving various departments. This will improve their understanding of the supply chain flow and allow for the identification and elimination of any bottlenecks.

In addition, enhancing such a system will allow organisations to maintain a seamless and consistent flow of information, ensuring smooth delivery of products and services to customers. Managers can promote integration within the organisation by establishing cross-functional teams and facilitating real-time information sharing. This will enhance the efficiency of the production process and supply chain. In order to achieve this objective, organisations can also focus on enhancing the integration of their external supply chain. It will empower them to meet customer demands and attain sustainable operational excellence. The collective vision among the departments regarding the integration of supply chains for sustainability will greatly enhance the overall efficiency of the organisations. According to the study's findings, it is recommended to integrate digital technologies into organisational operations in order to enhance sustainability compared to traditional production methods. These cutting-edge technologies will allow the organisation to utilise effective information technology tools within the company and facilitate seamless information flow. The firm can benefit from improved operations management when all operational activities integrate seamlessly and information flows smoothly. To achieve sustainable operational excellence, department managers should investigate ways to seamlessly incorporate cutting-edge technology into organizational operations and efficiently manage them.

The study also provides valuable recommendations for optimizing ongoing operational processes. Organisations should regularly conduct audits of their processes to identify any bottlenecks, inefficient techniques, and areas for improvement. Employees directly involved in the production processes can provide feedback to achieve this. In order to achieve ongoing operational optimisation, it is crucial for managers to align key performance indicators. It is important for the employees to collaborate closely in order to ensure it. In order to assist employees in achieving their goals and comprehending the evaluation process, managers can also arrange training sessions and workshops. This can foster a culture of ongoing process optimisation. Finally, this study provides insights into the implications of production and operation management strategies. In order to achieve this goal, managers must take a series of measures, one of which is creating a comprehensive production plan. With the assistance of a comprehensive production plan, they can effectively organise resources, create production schedules, oversee inventory, and ensure quality control. By adopting this approach, they can enhance their ability to effectively manage and mitigate operational risks. Managers should implement stringent quality control measures to guarantee that the products consistently meet or exceed customer expectations. Given the focus on sustainability, it is crucial for managers to ensure that their operations are in line with customer needs and expectations in this area. Overall, the study provided valuable insights for practical application and highlighted ways to effectively implement and maintain sustainable operations.

7. Limitations and Future Directions

The study has successfully achieved the research objectives and provided answers to the research questions. However, there are still some limitations that can be addressed in future research studies. The research is being carried out in the Power sector of Saudi Arabia. We advise approaching the findings with caution, taking into consideration the influence of religion. Therefore, it would be prudent to carry out a study in a Western setting to ascertain the attainment of similar outcomes. Additionally, it will contribute to the existing body of knowledge. In addition, the study included a sample size of 290 employees. While the sample size is adequate, it may not provide an accurate representation of the overall population. It would be beneficial for future studies to gather data from managers who have direct control and influence over organisational policies, rather than solely relying on employees who typically follow those policies. Another way to broaden the scope of future research is to incorporate additional variables and factors that pertain to sustainable practices and financial performance. Future studies may want to incorporate additional variables such as corporate social responsibility initiatives, employee engagement, and stakeholder perspectives to gain a deeper understanding of sustainable operational excellence.

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Appendix 1: Questionnaire

To what extent do you agree with each of the following statements. Please indicate your answer using the following 5-point scale where:

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

		SD	*D*	*N*	*A*	*SA*
	The following questions related to Eco-Innovation					
1	Number of Eco-Innovative Products/Services is increasing	1	2	3	4	5
2	Reduction in energy consumption and water usage	1	2	3	4	5
3	Adoption of Green Technologies	1	2	3	4	5
4	Collaborations and Partnerships	1	2	3	4	5
5	Employee Engagement and Skills	1	2	3	4	5
6	Conservation of biodiversity and natural resources	1	2	3	4	5
7	Revenue attributed to eco-innovative products or services	1	2	3	4	5
	The following questions related to Digital Technology Adaptability					
1	Digital Skills and Competencies	1	2	3	4	5
2	Technology Adoption and Integration	1	2	3	4	5
3	Data Analytics and Insights	1	2	3	4	5
4	Customer Engagement and Experience	1	2	3	4	5
5	Innovation and Agility	1	2	3	4	5
6	Innovation and Agility	1	2	3	4	5
7	Digital Culture and Leadership	1	2	3	4	5
	The following questions related to Sustainable Operational Excellence					
1	Return on Investment	1	2	3	4	5
2	Revenue and Profitability	1	2	3	4	5
3	Cost Efficiency	1	2	3	4	5
4	Risk Management	1	2	3	4	5
5	Market Value	1	2	3	4	5
6	Stakeholder Perception and Reputation	1	2	3	4	5
7	Reporting and Transparency	1	2	3	4	5
	The following questions related to Sustainable Operations control system					
1	Compliance with Environmental Regulations	1	2	3	4	5
2	Resource Efficiency	1	2	3	4	5
3	Stakeholder Engagement	1	2	3	4	5
4	Governance and Ethics	1	2	3	4	5
	The following questions related to Operations Risk management strategies					
1	The company uses different means to encourage its employees to share their knowledge about risk management.	1	2	3	4	5
2	The company has included the subject of risk management as an important topic in new personnel training.	1	2	3	4	5

3	The company provides training to its employees regarding the necessary measures to take in the event of a risk incident	1	2	3	4	5
4	Ensuring the proper functioning of the supply chain is every employee's top priority	1	2	3	4	5
5	Risk awareness is common in our company.	1	2	3	4	5
6	The company believes that 'risk management' and 'job performance' are equally important.	1	2	3	4	5
	The following questions are related to Supply chain integration					
1	We have a high level of responsiveness within our plant to meet other departments' needs	1	2	3	4	5
2	We have an integrated system across functional areas of plant control	1	2	3	4	5
3	Within our plant, we emphasise information flows amongst purchasing, inventory management, sales, and distribution departments	1	2	3	4	5
4	Within our plant, we emphasise physical flows amongst production, packing, warehousing, and transportation departments	1	2	3	4	5
	The following questions are related to Continues operations process optimization strategies					
1	We strive to continually improve all aspects of products and processes, rather than taking a static approach	1	2	3	4	5
2	If we aren't constantly improving and learning, our performance will suffer in the long term	1	2	3	4	5
3	Continuous improvement makes our performance a moving target, which is difficult for competitors to attack	1	2	3	4	5
4	We believe that improvement of a process is never complete; there is always room for more incremental improvement	1	2	3	4	5
5	Our organization is not a static entity, but engages in dynamically changing itself to better serve its customer	1	2	3	4	5