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Research Article 02

Developing a Multi-Item Scale for Measuring Operational Excellence

M.P. Kovilage

Department of Tourism Management, Faculty of Management Studies, Sabaragamuwa University of Sri Lanka
https://orcid.org/0000-0001-7628-0027

Abstract

The study sought to develop a comprehensive scale to measure operational excellence (OE) in the manufacturing and service sectors. It employed an exploratory sequential mixed-method design. Items were generated through semi-structured interviews, focus group discussions, and literature surveys and refined through Exploratory Factor Analysis (EFA) using a sample of 500 manufacturing and 500 service companies. The scale's reliability and validity were assessed by utilising Confirmatory Factor Analysis (CFA) with PLS-SEM on data from 1,000 companies. The qualitative phase identified four dimensions for measuring OE: continuous improvement of sustainable operational performance, sustainable competitive advantages, organisational alignment, and continuous improvement culture, supported by 33 items. Both EFA and CFA validated these dimensions, confirming that OE is a multidimensional construct. The current literature lacks a standard scale for assessing OE. Hence, this study contributed to the existing OE literature by developing a validated scale that followed a well-accepted scale development procedure to measure the OE construct across the manufacturing and service sectors worldwide

Keywords: Operational Excellence, Organisational Alignment, Scale Development, Sustainable Competitive Advantages, Sustainable Operational Performance

Corresponding Author: M.P. Kovilage – manori@mgt.sab.ac.lk
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Introduction

Operational excellence (OE) is a strategy to enhance organisational performance and competitiveness. This business management philosophy emphasises the continuous improvement of operations and processes to deliver high-quality products and services at the lowest possible cost. OE is defined as the "*consistent and reliable execution of business strategy through the integrated use of unique resources and capabilities, fostering continuous improvement of sustainable operational performance and competitive advantages while satisfying employees, customers, suppliers, and other stakeholders*" (Kovilage et al., 2022a). The concept is grounded in Resource-based theory, the quality management philosophies of W. Edwards Deming and Joseph M. Juran, and lean philosophy (Basu, 2004).

The popularity of the OE philosophy in industry also sparked increased research interest. However, researchers focus more on developing conceptual frameworks for OE-related antecedents than empirically testing them (Kovilage et al., 2022b). The lack of a comprehensive scale to measure the OE construct has contributed to a scarcity of empirical studies in this area (Saeed et al., 2021). Most existing psychometric scales propose qualitative indicators but lack validation through recognised quantitative methods, such as Exploratory and Confirmatory Factor Analysis. Moreover, these scales have not followed the standard scale development procedures outlined by experts (Churchill, 1979; Hinkin, 1995, 1998; Wilden et al., 2013). Saeed et al. (2021) developed an operational excellence scale grounded in the Shingo Model, emphasising cultural enablers, process improvement, and enterprise alignment. Sustainable competitive advantages are a critical dimension of operational excellence (Kovilage et al., 2022a). Nevertheless, this scale overlooks this aspect. Furthermore, process/operational improvements should address economic, environmental, and social dimensions (Kovilage et al., 2022a). However, Saeed et al. focused exclusively on financial metrics and limited their study to the telecommunications sector. A universally applicable scale for measuring operational excellence across diverse industries is necessary.

The lack of a comprehensive scale for Operational Excellence (OE) hinders quantitative researchers' ability to accurately assess the OE construct and limits the comparability of findings across studies. This disconnect impedes the development of conceptual clarity and precludes meta-analyses that could yield valuable theoretical insights and actionable implications for managers (Shehadeh et al., 2016; Found et al., 2018). Consequently, establishing a standardised psychometric scale for OE is vital for advancing knowledge in this field. While both manufacturing and service sectors implement OE strategies, no comprehensive measure exists to assess OE across these sectors (Kovilage et al., 2022b). This study aims to develop a comprehensive OE scale applicable to both sectors by identifying key dimensions of the OE construct and suitable measurement items under each dimension.

Numerous frameworks and methodologies facilitate organisations in achieving Operational Excellence (OE), including Lean Six Sigma, Total Quality Management (TQM), Kaizen, Business Process Reengineering (BPR), Theory of Constraints (TOC), The Shingo Model, Baldrige Performance Excellence Framework, Business Excellence Models, and ISO Standards. This study primarily followed these frameworks in developing the OE scale. In addition, the existing OE scales were used to identify OE measures. The scale was created for the manufacturing and service sectors in Sri Lanka, encompassing 500 service and 500 manufacturing companies. Following Churchill's (1979) scale development guidelines, a pragmatic worldview was adopted through an exploratory sequential mixed-methods research design, beginning with a qualitative phase and concluding with a quantitative phase.

Accordingly, the operational excellence (OE) scale was developed using qualitative and quantitative research methods. Qualitative methods included literature reviews, expert interviews, and focus group discussions, which were analysed through content and thematic analysis. For the quantitative approach, an exploratory factor analysis (EFA) initially purified the items, followed by confirmatory factor validation using PLS-SEM to assess the scale's generalizability (reliability and construct validity). To evaluate the nomological validity of the OE construct, the researcher posited the hypothesis H1: Management commitment positively affects operational excellence. Management commitment was measured using a five-item scale adapted from Vento et al. (2015), encompassing: (1) resource planning for OE improvement (financial, physical, temporal), (2) establishment of policies and objectives for OE practices, (3) consideration of customer feedback for workplace changes, (4) promotion of an OE culture, and (5) a system for fault identification.

Creating a comprehensive scale to measure operational excellence holds important research implications. It fills a crucial gap in the literature by providing a validated tool to quantify operational excellence, which is key to enhancing organisational performance. This study not only deepens theoretical understanding by providing a concrete measure but also enables empirical testing of the links between operational excellence and various business outcomes. Practically, this scale offers organisations a reliable way to benchmark progress, support decision-making, and foster continuous improvement across industries. It could serve as a cornerstone for both academic and industry research.

Literature Review

Operational Excellence

OE is a management approach focused on the continuous improvement of operations to deliver high-quality products and services while maximising efficiency and minimising costs (Boya & Rao, 2019). More broadly, OE entails the consistent execution of business strategy through unique, non-substitutable resources and dynamic capabilities, driving sustainable performance and competitive edge while ensuring stakeholder satisfaction (Kovilage et al., 2022).

The key attributes of operational excellence (OE) include the continuous improvement of sustainable performance, enterprise alignment, a culture oriented toward continuous improvement, the pursuit of sustainable competitive advantages, and reliable and consistent implementation of operational strategies while ensuring the involvement and satisfaction of employees, customers, suppliers, and stakeholders (Kovilage et al., 2022a). The Shingo Institute of Operational Excellence (n.d.) identifies three dimensions of OE: cultural enablers, continuous improvement, and enterprise alignment, detailing ten core principles: respect for individuals, leadership with humility, striving for perfection, embracing scientific thinking, process focus, quality assurance at the source, value flow and pull, systematic thinking, constancy of purpose, and customer value creation. The primary benefits of OE are optimising internal processes, enhancing customer value, and improving competitive positioning. Fundamental principles associated with OE include a customer-centric approach, standardisation, waste elimination, data-driven decision-making, empowerment, cross-functional collaboration, effective leadership, training and development, flexibility, quality focus, communication of customer feedback, risk management, sustainability, cost management, and innovation (Kovilage et al., 2022a; Fork-Yew, 2014; Saeed et al., 2021).

The principles of quality management established by W. Edwards Deming, Joseph M. Juran, and Lean methodology serve as the foundation for the concept of Operational Excellence (OE) (Basu, 2004). However, a definitive theory explaining the OE construct remains elusive (Fork-Yew, 2014; Saeed et al., 2021; Wahab et al., 2019; Boya & Rao, 2019; Shehadeh et al., 2016). The Resource-Based Theory (RBT) is considered the most suitable framework for this purpose (Fork-Yew, 2014). RBT highlights how organisational operational capabilities can lead to improved performance, competitive advantage, and customer satisfaction (Spanos & Lioukas, 2001). The goals of OE are to achieve superior performance, delight customers, and maintain sustainable competitive advantages, utilising the organisation's existing resources and capabilities (Yeo, 2019; Fork-Yew, 2014; Carvalho et al., 2017; Operational Excellence Society, 2020). The principles of quality management established by W. Edwards Deming, Joseph M. Juran, and Lean methodology serve as the foundation for the concept of Operational Excellence (OE) (Basu, 2004). Given the similarity between the outcome and input objectives of Operational Excellence (OE) and Resource-Based Theory (RBT), RBT emerges as the most relevant framework for understanding the OE construct.

Operational Excellence Frameworks and Models

Organisations can systematically enhance their operational excellence by adopting established frameworks and models. There are various OE methodologies, including Lean, Total Quality Management (TQM), Six Sigma, Kaizen, Business Process Reengineering (BPR), Theory of Constraints (TOC), The Shingo Model, Baldrige Performance Excellence Framework, and ISO Standards, all underpinned by Resource-Based Theory. Lean focuses on minimising waste and inefficiencies to boost overall performance, grounded in the Toyota Production System. Key concepts include pull, value, flow, and striving for perfection. Its ultimate aim is to deliver more value to consumers with fewer resources (Womack & Jones, 2003). Six Sigma is a data-driven approach aimed at reducing process variance and errors. It consists of five main steps: defining, measuring, analysing, improving, and controlling, utilising statistical tools to enhance performance (Pyzdek & Keller, 2014). Total Quality Management is a holistic framework that emphasises a commitment to quality across all organisational activities, engages staff, fosters continuous improvement, and prioritises customer satisfaction (Oakland, 2003). Business Process Reengineering involves radically restructuring procedures to boost productivity and customer happiness, often requiring a complete redesign of current processes (Hammer & Champy, 1993). The Theory of Constraints posits that every system has a bottleneck limiting performance; the goal is to identify and eliminate these constraints (Goldratt, 1990). The Baldrige Excellence Framework evaluates organisational performance across various domains, including leadership and customer outcomes, commonly used for self-assessment (Baldrige Performance Excellence Program, 2021). ISO standards provide structured paths to excellence across areas such as environmental, health and safety, food safety, and quality management (ISO, 2022). Lastly, the Shingo Model promotes an operational excellence culture by addressing both cultural and technical facets of improvement, emphasising value stream mapping, cultural alignment, and continuous improvement (Shingo Institute, n.d.).

Research Gaps

Recent investigations into operational excellence (OE) predominantly focus on antecedents and the formulation of conceptual frameworks, while empirical testing has received comparatively less attention (Kovilage et al., 2022b). A critical shortcoming in the field is the lack of a standardized scale for measuring OE, which significantly hinders the ability to conduct quantitative empirical research (Saeed et al., 2021). There is a notable gap in the literature concerning the development of a psychometric scale that can provide a thorough assessment of OE (Shehadeh et al., 2016; Found et al., 2018). Current OE psychometric instruments typically suggest various qualitative indicators but fail to undergo rigorous validation using established quantitative analysis techniques such as Exploratory Factor Analysis and Confirmatory Factor Analysis (Shehadeh et al., 2016). Moreover, many quantitative studies in the OE domain employ self-developed research tools that do not adhere to recognized scale development protocols, such as those proposed by Churchill (1979), Hinkin (1995, 1998), and Wilden et al. (2013). This lack of a standardized measurement scale restricts the ability to compare findings across different OE studies effectively. Although OE methodologies are applicable across both manufacturing and service sectors, the existing literature lacks a universal measurement scale that caters to both domains. For example, Saeed et al. (2021) formulated an OE scale grounded in the Shingo Model, focusing on cultural enablers, process improvement, and enterprise alignment as its primary dimensions. However, their framework overlooked the importance of sustainable competitive advantages by concentrating exclusively on economic factors and neglecting environmental and social dimensions in process enhancements. Furthermore, this scale was designed with a primary focus on the telecommunications industry (Kovilage et al., 2022b). To conclude, future research should prioritize the creation of a validated and comprehensive OE scale that encompasses all essential dimensions relevant to various sectors.

Research Methodology

This study adhered to Churchill's (1979) guidelines for scale development, outlined in Figure 1. Both qualitative and quantitative data were essential for developing the scale, necessitating an exploratory sequential mixed-methods approach, as outlined in this guide. Qualitative methods facilitated the identification of items, while quantitative methods ensured the scale's validity and reliability. According to this framework specifying the domain of construct (1), generating sample of items (2), collecting data (3), purifying measure (4), recollecting data (5), assessing reliability (6), assessing validity (7) and developing norms (8) are the key stages needs to followed by the researcher when developing a scale. The methodology section of this study presents how these stages were implemented.

According to Churchill (1979), the initial step in scale development is to define the domain of the construct. To delineate operational excellence, OE definition provided by Kovilage et al. (2022a) was utilized. Churchill notes that in the second phase, the researcher must develop items to effectively capture the construct, drawing on existing literature and consulting with experts. Thus, utilising existing literature and semi-structured interviews, I identified relevant measurement items of OE. The literature review encompassed established OE models and frameworks, including Lean, Six Sigma, Total Quality Management (TQM), Kaizen, Business Process Reengineering (BPR), Theory of Constraints (TOC), the Shingo Model, and the Baldrige Performance Excellence Framework, as well as current OE scales. Semi-structured interviews were conducted with 25 experts in OE, who were purposively selected from Sri Lanka. The participants held various roles, including CEO (3), operations manager (6), lean manager (2), factory manager (3), and academics in operations management (6), alongside consultants in OE methodologies (5). An interview protocol featuring three structured questions guided the discussions, supplemented by additional queries tailored to participants' responses. Conventional content analysis was applied to the literature data and thematic analysis to the interview records, to generate initial items for measuring OE. Finally, a focus group interview with 10 Sri Lankan OE experts was organized to achieve consensus on the most appropriate measurement items and to outline tentative dimensions for categorising the finalised items. This session was conducted online through Zoom.

In the third stage, Churchill (1979) advocates for data collection to facilitate item purification (through an Exploratory Factor Analysis (EFA) in the fourth stage. To proceed, I administered a questionnaire featuring the finalised items, focusing on Sri Lankan companies in the manufacturing and service sectors. The sample comprised 500 firms (250 manufacturing and 250 service), as this size is ideal for an EFA according to Churchill (1979) and Comrey and Lee (1992). Sample units were randomly selected from the Sri Lanka Accounting and Auditing Standards Monitoring Board (SLAASMB) database. The questionnaire was distributed online via Google Forms, with participation encouraged by each company's CEO.

Churchill (1979) recommends item purification as the fourth stage. This involves calculating internal consistency (Cronbach's alpha) and inter-item correlations, then removing items with correlations below 0.2. Afterwards, he suggests conducting an exploratory factor analysis (EFA) to group the remaining items. I used SPSS 21 to calculate Cronbach's alpha and inter-item correlations, finding that all items had correlations above 0.2 and that the Cronbach's alpha value was satisfactory. Consequently, I performed an EFA using principal component analysis to assess item grouping under the proposed dimensions.

According to Churchill (1979), the final three stages of this procedure involve collecting new data with purified items, assessing reliability and validity, and developing norms. In this study, data were collected from 1,000 companies in Sri Lanka, split evenly between manufacturing and services, using a second questionnaire with items purified. The sample was randomly selected from the Sri Lanka Accounting and Auditing Standards Monitoring Board's (SLAASMB) company list using simple random sampling, and the questionnaire was administered online via Google Forms, completed by the CEOs. Afterwards, the reliability and validity of the developed scale was assesses using Confirmatory Factor Analysis with PLS-SEM in SMART PLS 3.0, following a disjoint two-stage approach. Reliability was measured using Cronbach's alpha, composite reliability, and reliability coefficients (Hair et al., 2019). Convergent validity was evaluated through indicator loadings and average variance extracted, while discriminant validity was assessed using Cornell and Larker, cross-loadings, and HTMT (Heterotrait-Monotrait) criteria. Finally, a hypothesis (H1: Management commitment positively affects operational excellence) was proposed to ensure the scale's nomological validity. This hypothesis was also tested using PLS-SEM in SMART PLS 3.0 with the same approach.

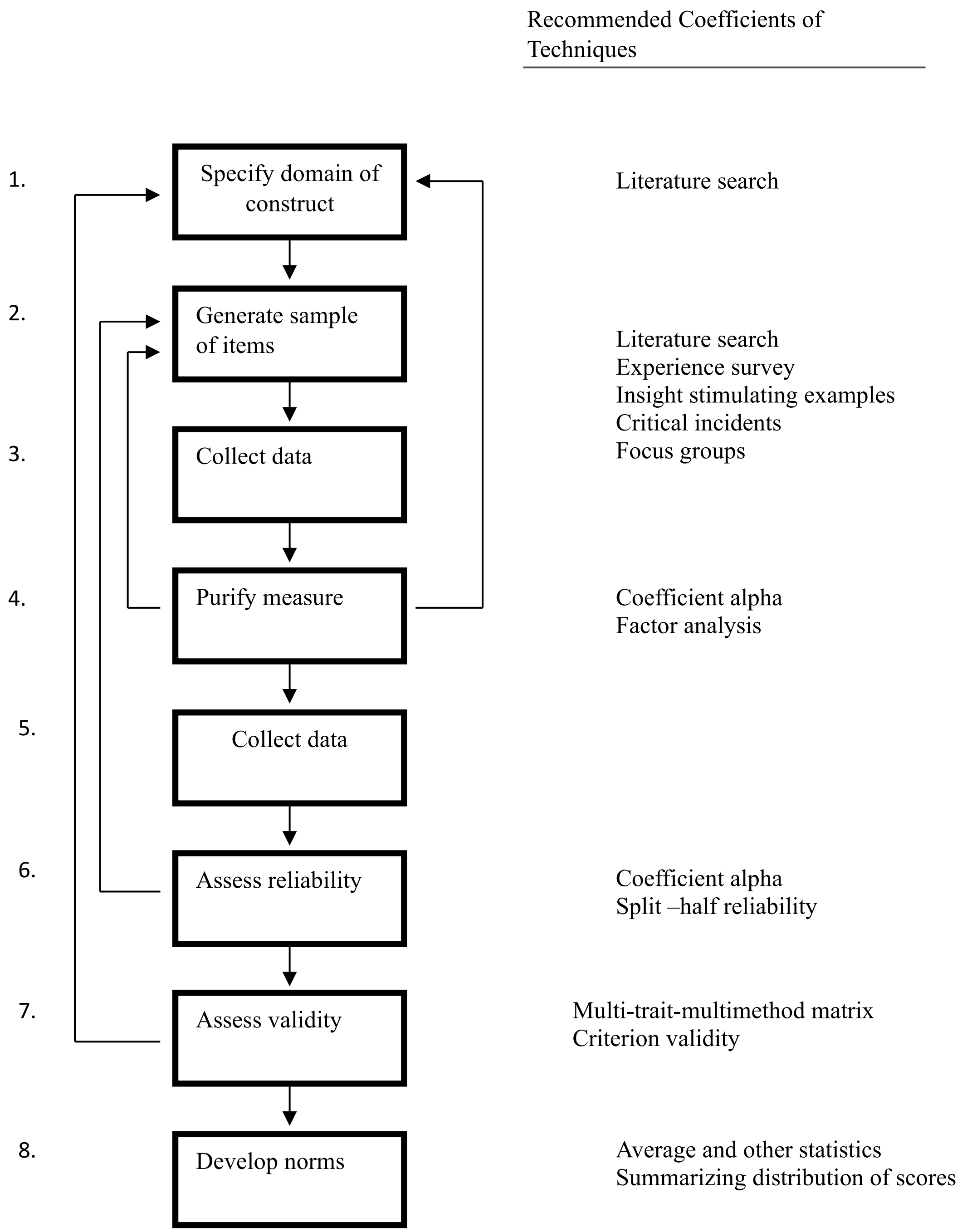

Figure 1: Scale Development Process
Source: Churchill (1979)

Results and Interpretations

Specifying the Domain of the Construct

To specify the operational excellence (OE) construct, I adopted the OE definition by Kovilage et al. (2022a):
"Consistent and reliable execution of business strategy through the integrated use of unique resources and capabilities, aimed at continuous improvement in sustainable performance and competitive advantage while satisfying employees, customers, suppliers, and other stakeholders."

Generate Sample of Items

A literature survey gathered 182 measures of operational excellence. Content analysis yielded 102 in vivo codes/open codes, which were consolidated into 65 axial codes and further organised into 44 themes. Thematic analysis of semi-structured interview records identified 36 operational excellence measures (85 in vivo codes leading to 54 axial codes and 36 themes). The experts, through a focus group discussion, reviewed 80 themes (44+36). Following discussions in the focus group, 33 items were selected as most suitable for measuring the OE construct (see Table 2). Experts proposed four main dimensions of OE: (1) continuous improvement of sustainable operational performance, (2) sustainable competitive advantage, (3) organisational alignment, and (4) continuous improvement culture.

Data Collection and Purifying Measures

The third stage of the scale development process involved collecting data to measure the construct using a questionnaire with finalised items in the second stage. In the fourth stage, Churchill (1979) recommends purifying these items based on the collected data. With the collected data, first, I calculated the internal consistency (Cronbach's alpha) and inter-item correlations using SPSS-21. A score above 0.7 indicates acceptable internal consistency, and the Cronbach's alpha for the OE construct was 0.954. The sub-constructs included continuous improvement of sustainable operational performance (CISOP, $\alpha = 0.978$), sustainable competitive advantages (SCA, $\alpha = 0.972$), organisational alignment (OA, $\alpha = 0.972$), and continuous improvement culture (CIC, $\alpha = 0.976$). Per Piedmont (2014), items with an inter-item correlation below 0.2 must be eliminated; however, all items in this study had correlations above 0.2, so none were removed.

With satisfactory internal consistency and inter-item correlation, I conducted Exploratory Factor Analysis (EFA) using SPSS-21 to determine if items could be grouped under specific dimensions. I first reviewed the correlation matrix of the OE scale. If this matrix is an identity matrix (indicating item correlations less than 0.3), EFA is unsuitable (Tabachnick & Fidell, 2007). For the OE scale, correlation loadings exceeded 0.3, confirming the matrix was not an identity matrix.

Before conducting factor analysis, it's essential to assess sample adequacy using the Kaiser-Meyer-Olkin (KMO) statistic and Bartlett's test of Sphericity. Kaiser (1974) suggests KMO values: below 0.5 are inadequate, 0.5-0.7 are ordinary, 0.7-0.8 are good, 0.8-0.9 are great, and above 0.9 are excellent (Hutcheson & Sofroniou, 1999). As shown in Table I, the KMO value for the operational excellence scale is 0.940, indicating excellent sample adequacy for EFA.

Bartlett's test checks if the correlation matrix is an identity matrix (Netemeyer et al., 2003). A significant result ($p < .05$) confirms that the data is suitable for EFA (Hair et al., 2019). Here, Bartlett's test is highly significant ($p < .000$), confirming the appropriateness of factor analysis (Table 1).

Table 1: KMO and Bartlett's Test for Operational Excellence Scale

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.940**
Bartlett's Test of Sphericity	Approx. Chi-Square	25278.469
	df	528
	Sig.	.000

Source: Smart-PLS output (2025)

The researcher then conducted factor extraction. According to Netemeyer et al. (2003), if an instrument has multiple items and the researcher aims to reduce them, principal components analysis (PCA) is effective. Thus, I chose PCA for factor extraction. The initial communalities for the OE scale exceeded 0.6, aligning with MacCallum et al. (1999), who consider values above 0.60 as favourable.

After selecting the factor extraction method, the researcher must decide how many constructs to retain for rotation. I applied Kaiser's criterion (eigenvalue > 1), retaining only factors with eigenvalues above one. Four factors were identified for the OE scale, explaining 85% of the variance (factor 1=41%, factor 2=18%, factor 3=13%, factor 4=13%), exceeding the 60% threshold (Hair et al., 2014). Following this, I chose the factor rotation method; Varimax rotation, as noted by Thompson (2004), is the most common for exploratory factor analysis due to its ability to provide a clear structure. Therefore, I utilized the varimax rotation method for this study.

Table 2 presents the rotated component matrix with factor loadings for the OE scale. According to Hair et al. (2014), acceptable loading values are 0.6 for exploratory and 0.7 for confirmatory studies. All OE scale items exceed 0.6 (Table 2), qualifying them to measure the operational excellence construct. Experts identified the four factors as: continuous improvement of sustainable operational performance (CISOP), sustainable competitive advantages (SCA), organizational alignment (OA), and continuous improvement culture (CIC), as each item aligns with its respective dimension.

Table 2: Rotated Component Matrix of Operational Excellence Construct

No	**Items**	**1**	**2**	**3**	**4**
Dimension 1: Continuous improvement of sustainable operational performance.					
1	Our company is achieving continuous improvement in customer satisfaction.	0.900			
2	Our company is continuously improving compliance in executing all its operations including social and environmental aspects.	0.895			
3	Our company continuously executes its operational strategy, complying with the business strategy.	0.830			

4	Our company is achieving a continuous improvement in the operational quality.	0.815		
5	Our company is achieving a continuous improvement in the manufacturing/service speed.	0.891		
6	Our company is achieving continuous improvement in the quality of distribution.	0.909		
7	Our company is achieving a continuous improvement in operational flexibility.	0.898		
8	Our company is achieving a continuous reduction in operational costs.	0.894		
9	Our company is achieving a continuous improvement in profitability.	0.894		
10	Our company is achieving a continuous improvement in employee satisfaction.	0.884		
11	Our company is achieving continuous improvement in the competencies of its employees.	0.863		
Dimension 2: Sustainable competitive advantages				
1	Our company continuously maintains a lower operating cost compared to the key competitors.		0.929	
2	Our company continuously maintains a higher product and process quality than the key competitors.		0.935	
3	Our company continuously receives profits over its key competitors.		0.939	
4	Compared with competitors, our company continuously maintains a satisfactory financial, environmental, and social compliance level.		0.894	
5	Our company's manufacturing/service speed is continuously high over key competitors.		0.920	
6	Our company's operational flexibility is high over the key competitors continuously.		0.858	
Dimension 3: Continuous improvement culture				
1	Our company keeps regular and clear communication with its stakeholders.			0.888

2	Our company maintains high employee involvement in goal setting and execution.			0.902	
3	Our company empowers employees through proper training and development.			0.895	
4	Our company has used to celebrate the success of the organisational efforts.			0.914	
5	Our company encourages teamwork.			0.883	
6	Small incremental changes can be seen frequently in our company.			0.895	
7	Our company honours the value of ‘customers the king’.			0.869	
8	Our company encourages fact-based decision-making.			0.850	
9	Our company regularly measures the outcomes based on correct information and monitoring procedures.			0.890	
	Dimension 4: Organizational alignment				
1	Our company formulates its strategy, aligning with its core purpose.				0.907
2	Our company sets the employee goals, objectives, and actions aligning with the higher-level organisational goals.				0.931
3	In strategy formation, our company gets the involvement of employees based on their experience and expertise.				0.912
4	Our company educates its employees about the standard procedures of executing their processes through clear work descriptions.				0.916
5	Our company constantly reminds and educates everyone about the purpose, vision, and values of the company.				0.906
6	Our company clarifies to its employees how their task achievements contribute to attaining the company's primary purpose.				0.898
7	Our company hires and retains the right people with the skills, experience, and knowledge necessary to achieve its primary purpose.				0.865

Source: Survey questionnaire (2025)

Ensuring Reliability, Validity, and Developing Norms with New Data

According to Churchill (1979), the next steps in scale development involve collecting new data, assessing reliability and validity, and establishing norms. To achieve this, I conducted a questionnaire survey with 33 purified items on operational excellence (OE) and utilized Partial Least Square Structural Equation Modeling (PLS-SEM) using the disjoint two-stage approach. The study's SEM analysis encompasses both measurement and structural models (Hair et al., 2019). Reliability and validity are verified in the measurement model, while the structural model assesses hypothesized relationships.

The study includes two constructs: OE, a reflective-reflective second-order construct, for which a new scale was developed, and management commitment, a first-order reflective construct used to evaluate the OE scale's nomological validity. The measurement model for OE comprises four dimensions: continuous improvement of operational performance (CISOP), sustainable competitive advantages (SCA), organizational alignment (OA), and continuous improvement culture (CIC), along with 33 associated items. The management commitment model consists of 5 items.

Stage One of the Disjoint Two-Stage Approach

In the first stage of the disjoint two-stage approach in PLS-SEM, the quality of first-order constructs in measurement models is evaluated. As illustrated in Figure 1, this stage focuses exclusively on the lower-order components of higher-order constructs. The first-order constructs of the OE construct include CISOP, SCA, OA, and CIC, while management commitment serves as a first-order exogenous construct. Given that management commitment impacts OE (as detailed in Hypothesis 1), it is directly linked to the first-order constructs. All item relationships with these constructs are reflective.

The quality of 'reflective first-order constructs' is assessed through measurement specifications, including 'outer loadings,' 'indicator multicollinearity' (VIF), and 'internal consistency reliability' (Cronbach Alpha, Composite Reliability). Construct validity covers both convergent (Average Variance Extracted-AVE, indicator reliability) and discriminant validity (Fornell and Larcker criteria, cross-loadings, HTMT criteria) (Hair et al., 2019). The next sections detail the results of these assessments.

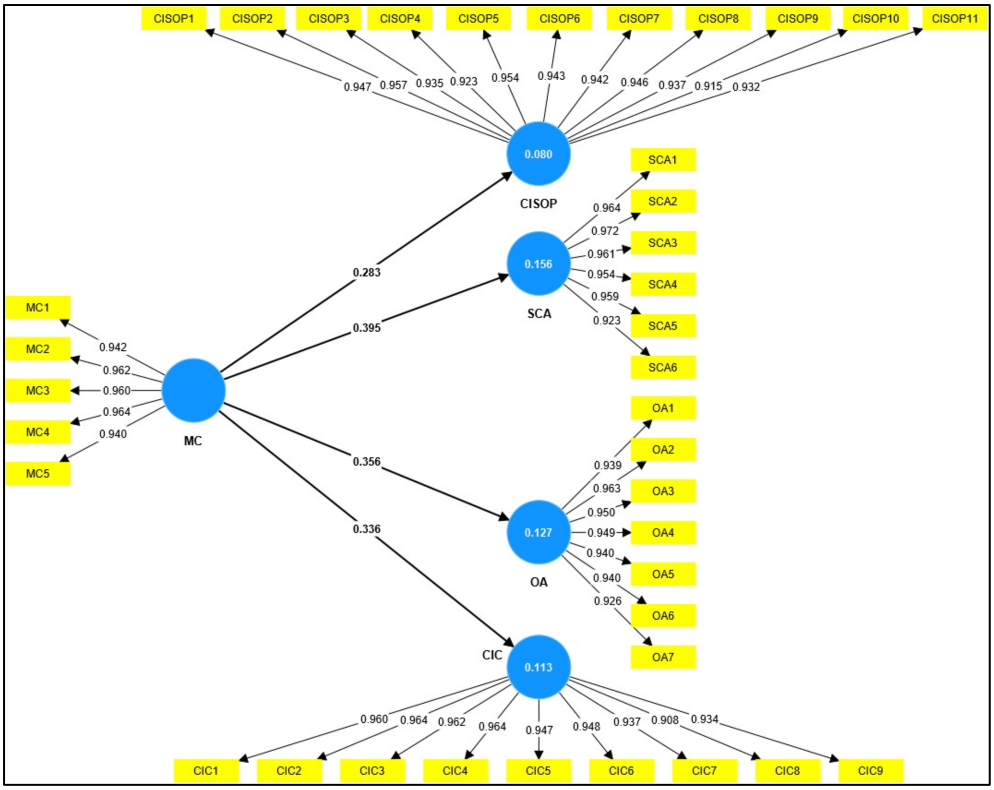

Figure 2: Measurement Model with First-Order Constructs
Source: Structural equation model (2025)

Outer Loadings

Outer loadings assess each observable variable's contribution to the construct or latent variable (Hair et al., 2019). Values above 0.6 are generally expected. In the stage one model, all items met this threshold, as shown in Table 3, indicating that no items need removal from the newly developed scale.

Table 3: Outer Loadings

	CISOP	SCA	OA	CIC	MC
CISOP 1	0.947				
CISOP 2	0.957				
CISOP 3	0.935				
CISOP 4	0.923				
CISOP 5	0.954				
CISOP 6	0.943				
CISOP 7	0.942				
CISOP 8	0.946				
CISOP 9	0.937				

CISOP 10	0.915				
CISOP 11	0.932				
SCA 1		0.964			
SCA 2		0.972			
SCA 3		0.961			
SCA 4		0.954			
SCA 5		0.959			
SCA 6		0.923			
OA 1			0.939		
OA 2			0.963		
OA 3			0.950		
OA 4			0.949		
OA 5			0.940		
OA 6			0.940		
OA 7			0.926		
CIC 1				0.960	
CIC 2				0.964	
CIC 3				0.962	
CIC 4				0.964	
CIC 5				0.947	
CIC 6				0.948	
CIC 7				0.937	
CIC 8				0.908	
CIC 9				0.934	
MC 1					0.942
MC 2					0.962
MC 3					0.960
MC 4					0.964
MC 5					0.940

Source: Survey questionnaire (2025)

Indicator Multicollinearity

The variance inflation factor (VIF) assesses multicollinearity among regression variables (Fornell & Larcker, 1981). Hair et al. (2017) suggest that VIF values over three indicate high multicollinearity, while values over five are particularly concerning in social science research. In the Stage 1 model for the OE scale, no indicators had VIF values exceeding 5.

Reliability Analysis

Internal consistency reliability is a crucial metric for evaluating the reliability of measurement models within PLS-SEM. Cronbach's Alpha and Composite Reliability are the most commonly used statistics, with an acceptable threshold of 0.7 (Hair et al., 2019). The values for the first-order constructs in the measurement model exceed this threshold (Table 4). Therefore, all items and constructs in the newly developed scale meet the criteria for internal consistency reliability.

Table 4: Construct Reliability Analysis (Cronbach's Alpha and Composite Reliability Values)

	Cronbach's Alpha	Composite Reliability
CISOP	0.987	0.987
SCA	0.975	0.988
OA	0.980	0.980
CIC	0.981	0.983
MC	0.986	0.984

Source: Survey questionnaire (2025)

Construct Validity

Construct validity comprises two aspects: convergent and discriminant validity. Convergent validity assesses the correlation between measures that should theoretically be related, while discriminant validity examines whether unrelated concepts or measurements truly lack correlation (Campbell, 1959).

Convergent Validity

Convergent validity in the measurement model was assessed using the average variance extracted (AVE) statistic (Hair et al., 2017). An AVE of 0.5 or higher indicates that items effectively measure the underlying construct (Fornell & Larcker, 1981). Table 5 shows that all first-order constructs have AVE values exceeding 0.5, confirming the quality of the measurement model and satisfying the criteria for convergent validity.

Table 5: Construct Convergent Validity

	Average Variance Extracted (AVE)
CISOP	0.898
SCA	0.882
OA	0.909
CIC	0.891
MC	0.913

Source: Survey questionnaire (2025)

Discriminant Validity

The Fornell-Larcker criterion, cross-loadings, and HTMT (Heterotrait-Monotrait) are commonly used in PLS-SEM to assess constructs' discriminant validity.

HTMT Criteria

The HTMT criterion threshold is set at 0.85 (Henseler et al., 2015). Table 6 shows that all HTMT values fall below this threshold, confirming that the constructs in the measurement model are conceptually distinct and exhibit discriminant validity.

Table 6: Heterotrait-Monotrait Ratio (HTMT) - Matrix

	CIC	CISOP	MC	OA	SCA
CIC					
CISOP	0.324				
MC	0.342	0.286			
OA	0.274	0.266	0.364		
SCA	0.274	0.374	0.404	0.159	

Source: Survey questionnaire (2025)

The Fronell-Larcker Criterion

Fornell and Larcker (1981) stated that the "Square Root of AVE should exceed the correlation of the construct with others" (Hair et al., 2019). If this condition is unmet, the construct lacks discriminative power. As shown in Table 7, the square root of the AVE for each construct exceeds its correlation with others, demonstrating strong discriminant validity across the measurement model.

Table 7: The Fronell-Larcker Criterion

	CIC	CISOP	MC	OA	SCA
CIC	0.947				
CISOP	0.321	0.939			
MC	0.336	0.283	0.954		
OA	0.270	0.262	0.356	0.944	
SCA	0.272	0.370	0.395	0.157	0.956

Source: Survey questionnaire (2025)

Cross Loadings

Gefen and Straub (2005) describe discriminant validity as being achieved when measurement items show weak correlations with unrelated constructs, except for those they are theoretically linked to. This is assessed through cross-loadings. As shown in Table 8, each item correlates weakly with other constructs, confirming the discriminant validity of the measurement model.

Table 8: Cross Loadings

	CIC	CISOP	MC	OA	SCA
CIC1	0.960	0.315	0.345	0.262	0.293
CIC2	0.964	0.311	0.340	0.273	0.287
CIC3	0.962	0.313	0.343	0.259	0.290
CIC4	0.964	0.299	0.320	0.255	0.280
CIC5	0.947	0.304	0.323	0.256	0.267
CIC6	0.948	0.306	0.316	0.264	0.244
CIC7	0.937	0.308	0.300	0.243	0.237
CIC8	0.908	0.289	0.275	0.242	0.179
CIC9	0.934	0.287	0.295	0.242	0.219
CISOP1	0.299	0.947	0.231	0.260	0.322
CISOP10	0.264	0.915	0.227	0.237	0.300
CISOP11	0.302	0.932	0.248	0.235	0.341
CISOP2	0.301	0.957	0.261	0.263	0.355
CISOP3	0.307	0.935	0.297	0.260	0.394
CISOP4	0.317	0.923	0.315	0.250	0.407
CISOP5	0.318	0.954	0.281	0.254	0.373
CISOP6	0.302	0.943	0.241	0.246	0.315
CISOP7	0.298	0.942	0.262	0.234	0.318
CISOP8	0.303	0.946	0.272	0.235	0.337
CISOP9	0.292	0.937	0.265	0.231	0.333
MC1	0.323	0.290	0.942	0.341	0.379
MC2	0.323	0.272	0.962	0.351	0.376
MC3	0.315	0.254	0.960	0.329	0.358
MC4	0.322	0.262	0.964	0.343	0.370
MC5	0.320	0.271	0.940	0.332	0.400
OA1	0.246	0.220	0.310	0.939	0.112
OA2	0.262	0.243	0.338	0.963	0.158
OA3	0.257	0.249	0.338	0.950	0.163
OA4	0.251	0.242	0.333	0.949	0.141
OA5	0.237	0.249	0.337	0.940	0.140
OA6	0.258	0.253	0.334	0.940	0.134
OA7	0.270	0.272	0.358	0.926	0.184
SCA1	0.253	0.358	0.373	0.144	0.964
SCA2	0.259	0.360	0.377	0.156	0.972
SCA3	0.248	0.338	0.392	0.136	0.961
SCA4	0.263	0.343	0.377	0.160	0.954

SCA5	0.276	0.365	0.387	0.159	0.959
SCA6	0.259	0.360	0.360	0.144	0.923

Source: Survey questionnaire (2025)

Having confirmed that the first-order measurement model met all reliability and validity criteria for the items and first-order constructs of the operational excellence scale, I proceeded to evaluate the reliability and validity of its second-order constructs.

Stage Two of the Disjoint Two-Stage Approach (Validating the Higher-Order Constructs)

In the second stage of the disjoint two-stage approach, lower-order constructs serve as indicators for the higher-order constructs. This phase focuses on measuring and validating the higher-order constructs. Utilizing the latent variable scores of the first-order constructs—CISOP, SCA, OA, and CIC, derived in stage one, I developed and estimated the stage two model, as illustrated in Figure 3.

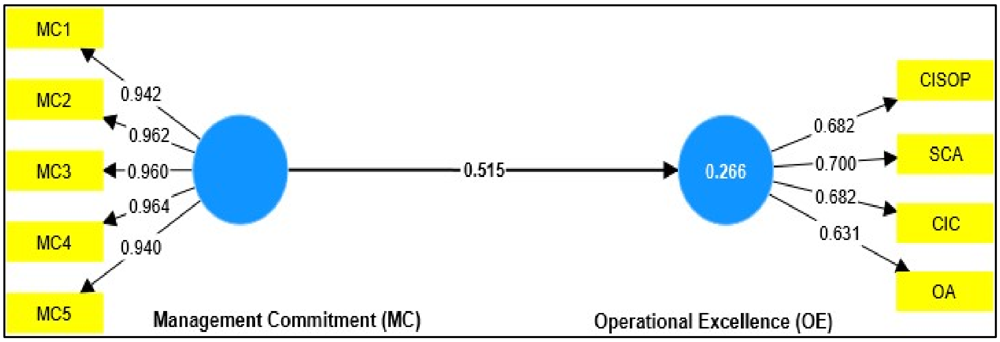

Figure 3: Stage Two Measurement Model with Second-Order Constructs
Source: Structural equation model (2025)

This model conceptualizes Operational Excellence (OE) as a reflective second-order construct comprising four lower-order constructs: CISOP, SCA, OA, and CIC. In assessing reflective-reflective higher-order constructs, the relationships between higher- and lower-order components are interpreted as loadings, with quality evaluated through internal consistency reliability (Composite reliability > 0.7), convergent validity (AVE > 0.5), and discriminant validity (Fornell and Larcker criterion, cross-loadings, and HTMT) (Hair et al., 2017). As shown in Table 9, the outer loadings 0.682 for CISOP, 0.700 for SCA, 0.631 for OA, and 0.682 for CIC demonstrate strong indicator reliability for the OE construct. The composite reliability of 0.769 surpasses the 0.7 threshold, confirming internal consistency. The AVE value for the OE construct stands at 0.455, which is slightly below the typical cutoff of 0.50; however, it still indicates adequate convergent validity. According to Fornell and Larcker (1981), when composite reliability (CR) is high, AVE values slightly below 0.50 can be tolerated, as high CR implies a significant shared variance among the items. In this study, the OE construct and its subdimensions all exhibited composite reliability scores well above the recommended 0.70, indicating solid internal consistency and justifying the construct's inclusion, despite the AVE being marginally below 0.50. Furthermore, Tables 10, 11, and 12 reinforce the discriminant validity of the OE construct, meeting the Fornell and Larcker criterion, exhibiting low cross-loadings, and maintaining an HTMT value below 0.85. Collectively, these findings confirm that the OE construct possesses both convergent and discriminant validity.

Table 9: Reliability and Convergent Validity Measures of Operational Excellence Construct

HOC	LOC	Outer loadings	Composite Reliability	AVE
OE			0.769	0.455
	CISOP	0.682		
	SCA	0.700		
	OA	0.631		
	CIC	0.682		

Source: Survey questionnaire (2025)

Table 10: Fornell and Larcker Criterion of Operational Excellence Construct

	Management Commitment (MC)	Operational Excellence (OE)
Management Commitment (MC)	0.954	
Operational Excellence (OE)	0.515	0.675

Source: Survey questionnaire (2025)

Table 11: Cross Loadings of First Order Constructs

	Operational Excellence	Management Commitment
CISOP	0.682	0.283
SCA	0.700	0.395
OA	0.631	0.356
CIC	0.682	0.336
MC1	0.500	0.942
MC2	0.497	0.962
MC3	0.472	0.960
MC4	0.488	0.964
MC5	0.499	0.940

Source: Survey questionnaire (2025)

Table 12: HTMT Criterion of Operational Excellence Construct

	Management Commitment (MC)	Operational Excellence (OE)
Management Commitment (MC)		
Operational Excellence (OE)	0.661	

Source: Survey questionnaire (2025)

Structural Model of the Study

After verifying the reliability and validity of construct measures, the subsequent step is to assess the structural model of the study. This model encapsulates the hypothesized relationships between constructs or latent variables outlined in the research framework (Duarte et al., 2010; Hair et al., 2017).

Evaluating the structural model involves a series of critical stages, each contributing to the robustness of the analysis. The initial stage focuses on assessing the multi-collinearity among the exogenous constructs. Notably, this analysis pertains specifically to a singular exogenous construct: management commitment (This construct was employed to fulfil the final criterion of Churchill's scale development process, specifically the developing norms). Therefore, the collinearity test is not applicable to this structural model. The second stage involves evaluating the significance of path coefficients (Hair et al., 2017). To analyze the relationship between operational excellence and management commitment, I performed bootstrapping with 5,000 samples using the Bias-Corrected and Accelerated (BCa) Bootstrap method, applying a two-tailed test at a 0.05 significance level. A path coefficient close to +1 indicates a significant positive relationship between the constructs (Hair et al., 2017). The path coefficient for management commitment and operational excellence is +0.515 (Figure 3), suggesting a positive relationship. The significance of the path coefficient is assessed using T-values and p-values (Hair et al., 2017). The T-value threshold for a two-tailed test at the 0.05 significance level is 2.447 (Hair et al., 2017). In the current model, the T-value is 21.172 and the p-value is 0.000, indicating a significant positive relationship between management commitment and operational excellence.

The coefficient of determination, R^2, is the third step in assessing a structural model, measuring its predictive power as the squared correlation between actual and predicted values of specific endogenous constructs (Hair et al., 2017). R^2 values of 0.75, 0.50, and 0.25 indicate substantial, moderate, and weak levels, respectively (Henseler et al., 2015). With an R^2 value of 0.266, this structural model is above the weak threshold. Falk and Miller (1992) consider an R^2 of 0.10 to be both substantial and acceptable, implying that the model's R^2 is indeed satisfactory.

The effect size (f^2) is crucial for assessing a structural model, as it indicates the impact on the R^2 of an endogenous variable when one exogenous variable is removed (Hair et al., 2019). Recommended f^2 values are 0.02 (weak), 0.15 (medium), and 0.35 (large) (Henseler et al., 2015). The measured effect size of 0.362 between management commitment and operational excellence indicates a large effect.

The predictive accuracy of the path model can be assessed using the Q^2 value (Geisser, 1974), which indicates a model's predictive relevance. A Q^2 value greater than zero demonstrates predictive relevance for a specific endogenous construct, while values of zero or lower indicate a lack of relevance (Hair et al., 2019). In this study, the Smart PLS blindfolding procedure yielded a Q^2 value of 0.262, confirming the predictive relevance of the operational excellence construct.

Discussion

This study aims to develop a comprehensive, multi-item OE scale applicable across both manufacturing and service industries. The researcher followed Churchill's (1979) methodological framework of scale development in developing this scale. To define the construct's domain in stage one, I adopted Kovilage et al.'s (2022a) definition of operational excellence, rooted in Resource-Based Theory. This definition describes operational excellence as the consistent execution of business strategy through the integrated use of unique resources and capabilities, aimed at continuous improvement of sustainable performance and competitive advantage while maintaining stakeholder satisfaction.

Items for the construct of operational excellence were developed by reviewing existing literature and conducting semi-structured and focus group interviews with experts in the field. Qualitative analysis identified 33 suitable items for measuring operational excellence. Experts also proposed four main dimensions: (1) Continuous Improvement of Sustainable Operational Performance (CISOP), (2) Sustainable Competitive Advantages (SCA), (3) Organisational Alignment (OA), and (4) Continuous Improvement Culture (CIC). Here, the items: 'achieving continuous improvement in the competencies of its employees' and 'continuously improving compliance in executing all its operations, including social and environmental aspects' under the dimension, continuous improvement of sustainable operational performance, were identified through the expert views. Further items: 'frequent small incremental changes in the company' and 'celebrating the success of the organisational efforts', which were under the dimension, continuous improvement culture, were identified through the expert views.

The EFA, which was conducted to refine the items, identified four factors, with all items having factor loadings above 0.7, confirming their relevance to operational excellence: continuous improvement of sustainable operational performance (CISOP), sustainable competitive advantages (SCA), organizational alignment (OA), and continuous improvement culture (CIC). Since all the items were qualified, the same questionnaire was utilised for the second-round data collection (stage four) to assess the reliability and validity of the scale (stage five). A disjoint two-stage PLS-SEM approach was used to verify the scale's reliability and validity. To evaluate nomological validity, I proposed the hypothesis, H1: operational excellence positively correlates with management commitment. In the first stage of the disjoint two-stage approach, the reliability and validity of the first-order constructs CISOP, SCA, OA, and CIC were evaluated. These reflective constructs were accepted due to satisfactory outer loadings, internal consistency (Cronbach's alpha and composite reliability), and construct validity (convergent and discriminant validity). In the second stage, operational excellence was assessed as a reflective second-order construct comprising the four lower-order constructs. For higher-order reflective constructs, the relationships between higher-order and lower-order components are interpreted as loadings, with quality evaluated through internal consistency (composite reliability > 0.7), convergent validity (AVE > 0.5), and discriminant validity (Fornell-Larcker criterion, cross-loadings, HTMT). The outer loadings were 0.682 for CISOP, 0.700 for SCA, 0.631 for OA, and 0.682 for CIC, indicating strong indicator reliability. The construct demonstrated internal consistency, with a Cronbach's alpha of 0.731 and a composite reliability of 0.769. The AVE was 0.455, approaching the 0.5 threshold for convergent validity. Discriminant validity was confirmed through the Fornell-Larcker criterion, low cross-loadings, and an HTMT value below 0.85.

Overall, this scale effectively measures operational excellence and supports the positive relationship between management commitment (exogenous variable) and operational excellence (endogenous variable) with $\beta = 0.515$, $t = 21.172$, $p < 0.05$ ($P = 0.000$). Finally, this scale could be recommended as a norm or a standard scale since it could successfully measure the operational excellence construct to confirm the well-proven relationship between operational excellence and management commitment. That is, management commitment (exogenous variable) positively affects operational excellence (endogenous variable) ((β= 0.515, t=21.172, p<0.05(P=0.000)).

In a notable initiative to establish a comprehensive scale for measuring operational excellence, Saeed et al. (2021) introduced a framework comprising three dimensions: cultural enablers, continuous process improvement, and enterprise alignment, specifically designed for the telecommunications industry. The literature base of this scale was limited to the Shingo Model of Organisational Excellence by the Shingo Institute.

The Cultural Enablers (CE) dimension, as discussed in Saeed et al. (2021), primarily emphasizes respect for individuals, employee well-being, safety, social community rights, and the investment in employee training and hands-on experience. These aspects reflect the traditional Shingo-based cultural values that serve as a foundation for employee respect and safety. However, the new scale introduces advancements through the Continuous Improvement Culture construct, which integrates various behaviours and practices that were not included in Saeed et al.'s original scale. This updated dimension encompasses stakeholder communication, employee involvement in both goal setting and execution, empowerment facilitated by targeted training, celebration of organizational successes, teamwork, a focus on small and frequent incremental improvements, customer-centric values, fact-based decision-making, and evidence-based monitoring. These elements indicate a more comprehensive and behaviorally reinforced improvement culture. Consequently, the new scale transitions from a focus on essential cultural enablers to a broader, strategically embedded improvement culture, reflecting how organizations implement continuous learning, transparency, and employee engagement.

The Continuous Process Improvement (CPI) dimension defined by Saeed et al. emphasizes essential aspects like operational responsiveness, flexibility in products/services, monitoring deterioration, adding value, and defect elimination and prevention. Their approach is primarily driven by principles of Lean and Total Quality Management (TQM), which focus on enhancing both processes and quality. In contrast, the new scale introduced the dimension of Continuous Improvement of Sustainable Operational Performance, significantly expanding the scope of the dimension. This broader perspective encompasses various elements, including improving customer satisfaction, enhancing operational quality, increasing service and manufacturing speed, refining distribution quality, boosting operational flexibility, reducing operational costs, and enhancing profitability. It also highlights the importance of strengthening employee competencies and satisfaction while continually improving environmental and social compliance. This broader set of items reflects the evolving understanding of operational excellence as an integrative performance improvement philosophy that spans strategic, sustainability, human capability, and operational domains, rather than focusing solely on process-level improvements.

A major advancement of the new OE scale is the introduction of the Sustainable Competitive Advantages (SCA) dimension, which is absent in Saeed et al. (2021). This new dimension emphasizes an organization's capability to sustain lower operating costs, deliver superior product and process quality, achieve higher profitability, and maintain compliance across financial, environmental, and social domains. Additionally, it highlights the organization's flexibility and speed in relation to key competitors. This theoretical contribution is important as it reframes operational excellence as a crucial source of competitive advantage, rather than just an internal process improvement tool.

The Enterprise Alignment (EA) dimension discussed by Saeed et al. emphasizes the importance of planning inclusiveness, standardized work descriptions, and the definition of relevant metrics. While these aspects are central to achieving alignment, the newly proposed scale presents a more comprehensive and strategically grounded Organizational Alignment dimension. The new items underscore key elements such as alignment between the organization's core purpose and its strategy formulation, ensuring that goals and actions cascade from the organizational level down to individual employees. It also highlights the importance of involving employees in strategy formation by leveraging their expertise and experience. Additionally, there is a focus on educating employees regarding standard procedures through clear work descriptions, which helps to reinforce the organizational vision, purpose, and values. Furthermore, this approach clarifies how individual tasks contribute to the overall organizational purpose and emphasizes the hiring and retention of talent that aligns with the organization's needs and values. This expanded alignment dimension aligns more closely with contemporary strategic alignment practices, including Hoshin Kanri, strategic coherence frameworks, and purpose-driven organizational management. Therefore, it offers a richer and more actionable measurement of alignment.

Overall, the newly developed operational excellence scale provides a more contemporary, strategically integrated, and sustainability-oriented understanding of OE. Compared with Saeed et al. (2021), it expands the scope from cultural and process-level practices to the broader domains of sustainability, competitive advantage, organizational purpose alignment, stakeholder communication, and ongoing capability development. By integrating elements of environmental and social performance, strategic execution, behavioural reinforcement, and employee capability development, the new scale addresses important conceptual gaps in existing OE measurement literature. These contributions demonstrate that the newly developed scale not only complements existing OE frameworks but also advances the theoretical and empirical understanding of operational excellence for modern organizations.

Conclusion and Recommendation

The study aimed to develop a psychometric scale for measuring the operational excellence (OE) construct in manufacturing and service sectors. I integrated qualitative and quantitative research methods following Churchill's (1979) scale development framework. I used Kovilage et al.'s (2022) OE definition based on RBT to define the construct. This process yielded 33 items across four dimensions: (1) Continuous Improvement of Sustainable Operational Performance, (2) Sustainable Competitive Advantages, (3) Organisational Alignment, and (4) Continuous Improvement Culture. An Exploratory Factor Analysis (EFA) purified these items. Utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) in a disjoint two-stage approach confirmed the scale's reliability and validity. This scale effectively measures OE and reinforces the positive influence of management commitment (exogenous variable) on OE (endogenous variable). Thus, this scale serves as a normative measure of the OE construct, and future research may apply this scale to various global contexts to enhance its generalizability.

This OE scale evaluates operational excellence (OE) in industrial organizations across manufacturing and service sectors, comprising four dimensions: continuous improvement of sustainable operational performance (11 items), sustainable competitive advantages (6 items), organizational alignment (7 items), and continuous improvement culture (9 items), for a total of 33 items. Developed through comprehensive data collection (literature review, expert interviews, focus groups) and analyses (thematic analysis, content analysis, EFA, CFA with PLS-SEM), this scale includes all critical attributes of the OE construct while uniquely integrating sustainable competitive advantages (SCA), which previous scales often overlooked. Traditional scales focused primarily on economic factors, neglecting environmental and social dimensions. Therefore, I redefined the dimension "continuous improvement of operations" to "continuous improvement of sustainable operational performance" and included items that assess this aspect. The scale was validated using data from 1,000 organizations in the service and manufacturing sectors. The newly developed OE scale is the most comprehensive tool for measuring OE in the corporate sector. Managers, researchers, policymakers, and society can use it to clearly understand OE attributes and dimensions, identify limitations in existing processes, and adopt essential OE principles and practices.

By focusing on primary dimensions of Operational Excellence (OE), managers can use this scale to accurately assess their organization's OE level and identify areas for improvement. This tool also aids in evaluating employee skills and organizational capacity for achieving OE outcomes. Policymakers can leverage the scale to prioritize sustainable competitive advantages and consider environmental and social factors when formulating OE-related policies. These revised policies can help organizations reduce operational costs, increase profitability, and optimize capital expenditures. OE researchers should adopt this standard scale for empirical studies, enhancing the comparability of findings and conceptual clarity. These findings can support meta-analyses that provide theoretical insights and practical implications. I followed Churchill's (1979) recommended scale development process, regarded as the gold standard. Future researchers can utilize this process to better understand scale development. The OE construct was developed as a second-order construct, and I validated this scale using PLS-SEM with a disjoint two-stage approach, which is uncommon in current literature. This approach can serve as a model for future researchers. Socially, this scale empowers organizations to achieve operational excellence while fostering respect for individuals within and outside the workplace, contributing to a secure and supportive work environment.

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