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Does Sensing Capability Mitigate the Impact of Internal Lean Supply Chain Barriers on Manufacturers' Performance in Vietnam?

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ABSTRACT

This study investigates the impact of internal barriers to lean supply chain practices on the performance of manufacturing firms in Vietnam, specifically the moderation of organizational sensing capability. Grounded in the extended resource-based view and dynamic capability theory, the research employs a two-phase quantitative design. Data from a structured survey of 234 manufacturers are analyzed using exploratory and confirmatory factor analysis to validate the measurement model, followed by structural equation modeling to test the hypothesized direct and moderating effects. The results indicate that internal barriers to lean supply chain practices, particularly those related to—top management, organizational culture, knowledge-related, and operational constraints—significantly impede firm performance. Among these, knowledge-related barriers stand out as the most critical impediment to firm performance. Notably, while sensing capability significantly buffers the adverse effects of cultural barriers, its moderating influence is non-significant for barriers rooted in top management, knowledge gaps, or operational constraints. Overall, this study empirically demonstrates how firms can leverage sensing capability as the most potent against intangible, socially embedded obstacles. Noticeably, sensing allows firms to detect subtle organizational misalignments, while its moderating efficacy is bounded by the structural and decision-making nature of the barrier in question.

Keywords: *lean supply chain barrier, manufacturing firms, dynamic capability, firm performance, Vietnam*

1. INTRODUCTION

The global trade landscape is undergoing a structural shift characterized by systemic fragmentation and non-linear disruptions, rendering environment instability a permanent feature of the global order rather than a transient shock (World Economic Forum, 2026). In response, corporate strategy is pivoting from rigid cost optimization toward agile ecosystem orchestration (World Economic Forum, 2026). Within this turbulent environment, Vietnam stands at a pivotal geoeconomic juncture. As ASEAN is challenged to go beyond its traditional role as a global factory (World Economic Forum, 2026), Vietnam's strategic mandate emphasizes substantive innovation and technical sovereignty to secure high-value participation within the global value chain and avoid the low-cost assembly trap (Wells-Dang, 2026). However, a functional trap—a strategic imbalance between national aspiration and endogenous execution—continues to limit Vietnamese businesses. Current growth remains predominantly driven by FDI-mandated process optimization rather than fundamental technological expertise; even notable advances in lean and smart factories are largely confined to incremental process improvements (Minh, 2024). Redefining competitive advantage now requires value chain autonomy and strategic agility. This shift demands a strong lean supply chain foundation, where early detection and mitigation of systemic disruptions depend on eliminating informational blind spots and enhancing flow transparency. Yet, while lean supply chain management has established itself as an indispensable operational paradigm for eliminating waste, compressing cycle times, and maximizing value, its deployment in emerging markets faces severe organizational friction. Rather than dismantling deep-seated barriers, operational capabilities built solely on incremental learning-by-doing often entrench legacy routines and organizational inertia (Tidd & Bessant, 2020). Compounding this challenge are systemic operational opacity, entrenched "the way we do things around here" mindsets, and steep power distances that stifle frontline engagement (Schein, 1984; Tidd & Bessant, 2020). Consequently, a critical dilemma persists for manufacturing leaders: why do so many enterprises adopt lean supply chain initiatives with high expectations, only to see them stall and fail to deliver on their promised gains?

Up to date, extensive literature on lean supply chain management utilizing structural modeling and multi-criteria decision-making frameworks identifies endogenous organizational architecture as the primary source of operational barriers (e.g., Ali *et al.,* 2020). These impediments operate within a causal hierarchy where strategic and cognitive constraints precipitate cultural fragmentation, eventually surfacing as operational and

technical inefficiencies. Consequently, operational hurdles are viewed as symptomatic of fundamental structural misalignments in strategic orientation rather than isolated resource deficiencies (Leite *et al.,* 2022). Complementary studies further demonstrate that these barriers evolve alongside lean maturity, remaining deeply embedded in organizational culture, employee behavior, leadership dynamics, and cross-functional collaboration (Bhasin, 2012; Cadden *et al.,* 2020; Leite *et al.,* 2022; Merli & Mosconi, 2019; Moyano-Fuentes *et al.,* 2020). This body of those works therefore establishes internal barriers as a multidimensional and consequential challenge to extending lean practices across the supply chain. However, existing perspectives remain largely focused on identifying, structuring, or characterizing these barriers statically. It offers limited insight into why firms facing comparable internal constraints experience divergent lean supply chain outcomes and, more importantly, which specific organizational capabilities enable firms to actively recognize, navigate and neutralize such constraints.

As lean supply chain management extends operational improvement across organizational boundaries through the integration of complementary resources (Moyano-Fuentes *et al.,* 2020), mitigating internal barriers becomes essential to sustaining effective cross-enterprise integration (Scannell & Curkovic, 2024). Grounded in the extended resource-based view and dynamic capability theory, sensing capability—the dynamic capability for scanning, interpreting, and diagnosing shifts across external and internal environments (Leinonen *et al.,* 2023; Teece, 2007)—provides the critical dynamic mechanism to bridge internal capability gaps and dampen barrier severity. While lean systems maximize efficiency by eliminating slack, this tightly coupled architecture inherently amplifies the cost of late detection, allowing localized disruptions to propagate rapidly through the entire supply chain. In resource-constrained environments where managerial misjudgment carries severe penalties, timely prioritization becomes essential to sustaining performance (Sansone *et al.,* 2020). Sensing capability sharpens this prioritization by directing executive attention toward high-impact operational anomalies, preventing internal inertia from taking root, and institutionalizing continuous learning (Norrman & Wieland, 2020). As lean improvement converts identified problems and effective responses into stronger supply chain capabilities (Bäckstrand & Powell, 2021), sensing becomes the upstream mechanism that prevents internal barriers from silently compounding across the lean system while extending risk awareness and coordinated adaptation across functions, partners, and the wider value chain; and converts recurring disruption into sharper attention, more disciplined resource deployment, and continuous capability renewal.

Despite these compelling theoretical foundations, empirical evidence remains scarce regarding whether sensing mechanisms actively moderate and neutralize internal lean impediments within transitional manufacturing contexts. Addressing this critical theoretical gap, this study conceptualizes internal barriers to lean supply chain practices not as a static inventory of obstacles, but as a dynamic process where obstacles co-evolve with organizational capabilities and market conditions—transitioning from a know-what perspective to a procedural know-how orientation. Accordingly, this study utilizes structural equation modeling on a survey dataset of 234 manufacturers in Vietnam to investigate the impact of internal barriers to lean supply chain practices on the performance of manufacturing firms in Vietnam, specifically how sensing capability moderates and mitigates internal barrier impacts. The resulting dynamic roadmap provides actionable, context-sensitive strategies for managerial intervention amid ongoing global volatility.

2. LITERATURE REVIEW

2.1 Current State of Lean Supply Chain Barrier Research

Lean supply chain management extends lean principles beyond firm boundaries to optimize end-to-end value streams amid intensified chain-to-chain competition (Garcia-Buendia *et al.,* 2023; Moyano-Fuentes *et al.,* 2019). Yet, orchestrating such cross-enterprise alignment is frequently crippled by internal, firm-level barriers that thwart external lean execution. Reflecting this systemic challenge, prior research on barriers to lean supply chain implementation has sought to unpack their inherent complexity through four distinct analytical streams as follows.

The first stream adopts a systems-structural approach using quantitative methodologies like interpretive structural modeling (ISM) and total interpretive structural modeling to map causal hierarchies of implementation barriers (e.g., Ali *et al.,* 2020; Chaple *et al.,* 2021; DeSanctis *et al.,* 2018). High-leverage source barriers, notably weak top management commitment, are identified as cascading impacts on dependent variables like insufficient infrastructure and training (e.g., Ali *et al.,* 2020). While these models offer a strong foundation for prioritizing systemic reforms, their deterministic treatment of barrier cascades leaves limited room for firm-level mechanisms that may buffer or weaken the effects of foundational barriers on implementation outcomes.

The second stream conceptualizes lean supply chain deployment as an evolutionary process in which implementation challenges vary in scope and intensity as organizational maturity advances (Bhasin, 2012; Merli and Mosconi, 2019; Moyano-Fuentes *et al.,* 2019). Broad lean supply chain integration remains contingent upon internal readiness. Consequently, this stream advocates adaptive strategic roadmaps based on cumulative capability development (Merli and Mosconi, 2019). However, the normative stage-based models often limit their generalizability, as they may fail to account for the non-linear and heterogeneous trajectories observed in empirical settings. More importantly, they provide limited insight into why firms at similar levels of lean maturity may achieve different lean supply chain management outcomes, particularly when internal barriers persist.

The third stream adopts a micro-level perspective, positioning organizational behavior and culture as the primary determinants of lean supply chain failure. Accordingly, technical or structural barriers are viewed as surface manifestations of deeper human-centric issues, such as psychological resistance, job insecurity, and the lack of a learning-oriented culture (Cadden *et al.,* 2020; Leite *et al.,* 2022). Prioritizing lean tools over the human dimension often leads to symbolic adoption and diminished

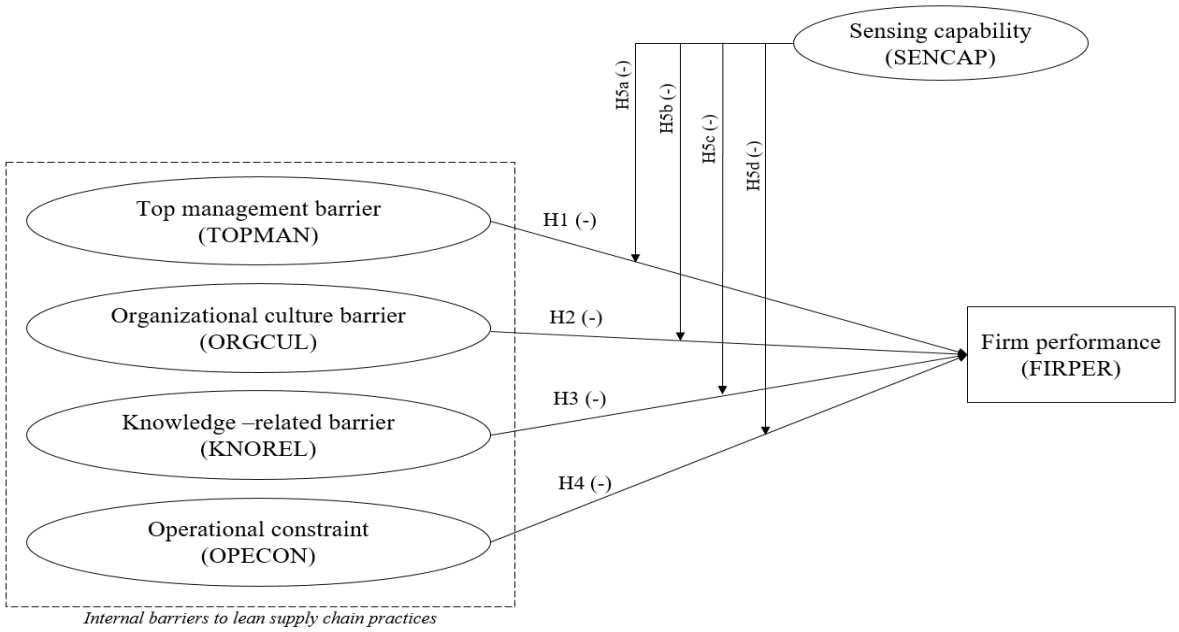

Figure 1 Research Model

organizational commitment (Cadden *et al.,* 2020). Consequently, this stream shifts the analytical focus from tangible enablers to intangible structures—including trust, empowerment, and communication quality—emphasizing that supportive leadership and culture are essential for sustaining continuous improvement (Leite *et al.,* 2022). However, while the importance of these behavioral factors is well-established, the specific mechanisms translating them into concrete managerial practices remain under-theorized.

The fourth stream examines how external contextual conditions shape and intensifies internal barriers to lean supply chain implementation. Variables like firm size, industry characteristics, market uncertainty, and national culture can either amplify or attenuate internal obstacles, creating context-specific configurations of challenges (e.g., Dora *et al.,* 2016; DeSanctis *et al.,* 2018). Besides, financial constraints typically predominate in SMEs, whereas technical challenges are more pronounced in process-based industries (e.g., Bhasin, 2012; Panwar *et al.,* 2015). Despite these insights, the literature remains fragmented, often relying on isolated comparisons rather than a unified theoretical framework to systematically predict how internal barriers emerge and escalate across diverse environments.

Collectively, these research streams offer a multi-layered yet fragmented understanding of internal barriers to lean supply chain practices, necessitating research that systematically integrates disparate obstacles. This study provides empirical evidence for the strategic importance of mitigating internal barriers as a controllable foundation, enabling firms to enhance operational efficacy and navigate supply chain uncertainty.

2.2 Conceptual Model and Hypothesis

Integrating the extended resource-based view and dynamic capability theory, this study examines how internal barriers—specifically top management, organizational culture, knowledge, and operational dimensions—impact firm performance. Crucially, it examines the moderating role of sensing capability, defined as the firm's strategic capacity to navigate inter-organizational challenges (Figure 1).

2.2.1 Relationship Between External Barriers in Lean Supply Chain Practices and Firm Performance

Top management barriers represent leadership-level constraints—characterized by a deficit in executive commitment, strategic vision, and active support—that impede the communication and resource allocation vital for lean supply chain management (Manzouri *et al.,* 2013; Jadhav *et al.,* 2014; Zhang *et al.,* 2017; Pardi *et al.,* 2024). In the absence of a coherent long-term direction, Lean initiatives often devolve into fragmented, reactive firefighting efforts rather than systematic continuous improvement (Bhasin, 2012; Wee and Wu, 2009). This strategic void triggers a negative cascade, resulting in inadequate middle-management support, technical skill gaps, and coordination failures that manifest as resource bottlenecks and protracted decision-making (Scherrer-Rathje *et al.,* 2009; Ali *et al.,* 2020). At the strategic level, the absence of long-term vision and structured planning impedes the institutionalization of lean transformation, resulting in transient and unsustainable outcomes (Belhadi *et al.,* 2017). Ultimately, these leadership deficiencies erode organizational culture and employee trust, culminating in operational inefficiencies that prevent Lean systems from delivering a sustained competitive advantage (Jadhav *et al.,* 2014; Zhang *et al.,* 2017; Pardi *et al.,* 2024).

Hypothesis H1: Top management barrier has a negative effect on firm performance.

Organizational culture barrier— characterized as entrenched norms and behavioral patterns—critically constrain the flexibility, learning orientation, and collaborative mindset essential for effective lean supply chain practices (Jadhav *et al.,* 2014; Cadden *et al.,* 2020; Patil and Kant, 2014). Performance-driven mindsets and rigid routines often stifle the experimentation and process discipline required for sustained transformation, leading to superficial tool adoption rather than internalized problem-solving capabilities (Jadhav *et al.,* 2014; Belhadi *et al.,* 2017; Cadden *et al.,* 2020). These challenges are amplified in supply chain contexts, where divergent communication styles and societal values impede the knowledge exchange

necessary for coordinated decision-making (Manzouri *et al.,* 2013; Patil and Kant, 2014). Furthermore, broader societal and historical contexts, and national cultural dimensions often shape managerial thinking and strategic priorities, creating misalignments between local practices and the collective discipline required by lean systems (Lai *et al.,* 2020). Persistent cultural barriers across supply chain partners significantly impede the collaboration and information sharing required to sustain coordinated lean practices, such as Just-in-Time and pull-based production systems (Manzouri *et al.,* 2013; Pardi *et al.,* 2024). Consequently, these cultural misalignments obstruct the operational efficacy of lean supply chain initiatives, ultimately compromising overall firm performance.

Hypothesis H2: Organizational culture barrier has a negative impact on firm performance.

Knowledge-related barriers encompass deficiencies in conceptual comprehension and technical expertise that impede the effective institutionalization of lean supply chain principles across organizational levels (Manzouri *et al.,* 2013; Takeda-Berger *et al.,* 2021). A fundamental lack of lean supply chain comprehension often results in superficial application and the selection of inappropriate tools, which weakens program effectiveness and creates systemic inefficiencies (Abu *et al.,* 2021; Alam and Daril, 2022). This gap is intensified by unsystematic training, where a lack of rationale-based learning erodes employee ownership and commitment (Nguyen *et al.,* 2017; Pardi *et al.,* 2024). Beyond internal operations, knowledge deficits at the strategic level—such as poor sales forecasting and inadequate information sharing—amplify the bullwhip effect and disrupt pull-based supply chain systems (Taylor, 2006; Anand and Kodali, 2008; Ali *et al.,* 2020). Ultimately, these interlocking deficiencies in technical capability and inter-organizational learning impede continuous improvement, escalating operational waste and deteriorating overall firm performance.

Hypothesis H3: Knowledge-related barrier has a negative impact on firm performance.

Operational constraints represent critical deficiencies in tangible and intangible resources that undermine supply chain efficiency and firm's ability to perform standardized operations, solve production problems, and sustain process improvements (Manzouri *et al.,* 2013; Ramadas and Satish, 2018; Pardi *et al.,* 2024). Internally, a deficit in skilled human capital and specialized cross-functional teams impedes standardized operations and isolates the collaborative learning mechanisms essential for lean supply chain transformation (Jadhav *et al.,* 2014; Dora *et al.,* 2016; Ali *et al.,* 2020). These resource limitations—compounded by inadequate performance measurement systems and suboptimal facility infrastructure—obstruct the feedback loops and material flows necessary for the firm's dynamic improvement and responsiveness to market or supply fluctuations (Anand and Kodali, 2008; Belhadi *et al.,* 2017; Ali *et al.,* 2020; Narkhede *et al.,* 2020). Furthermore, weak supply chain integration inhibits synchronized planning and information sharing, thereby diminishing collective coordination (Manzouri *et al.,* 2013; DeSanctis *et al.,* 2018; Pardi *et al.,* 2024). Collectively, these operational barriers constrain the reconfiguration of organizational competencies, ultimately exerting a negative impact on firm performance.

Hypothesis H4: Knowledge-related barrier has a negative impact on firm performance.

2.2.2 Moderating Effects of Organization's Sensing Capability on the Relationship Between Internal Barriers to Lean Supply Chain Practices and Firm Performance

Sensing capability represents an organization's capacity to identify, analyze, and anticipate external opportunities and risks, a function that is increasingly critical for sustaining competitiveness in contemporary VUCA environments (Teece, 2007; Garrido *et al.,* 2020). Beyond facilitating the rapid detection of supply chain disruptions and technological shifts (Laaksonen and Peltoniemi, 2018; Wamba *et al.,* 2020), this capability serves as a vital radar that mitigates strategic rigidities caused by entrenched managerial assumptions (Teece, 2007). By exposing internal filters to external signals, sensing capability encourages leaders to reassess outdated beliefs and reconfigure assets, thereby counteracting the inertia inherent in top management barriers (Pundziene *et al.,* 2021; Ng'ang'a *et al.,* 2024). While problemistic search is used only to rationalize past failures and rarely catalyze changes (Cyert & March, 1963), proactive sensing deployment leverages operational advantages in cost, quality, and flexibility to enhance performance (Yan *et al.,* 2022). Consequently, by challenging managerial inertia and interpreting environmental signals, sensing capability is likely to weaken the negative impact of top management barriers on firm performance.

Hypothesis H5a: Sensing capability reduce the adverse impact of top management barrier and firm performance.

Under dynamic capability theory, organizational culture acts as a governance system that shapes employee behavior; however, deeply embedded norms often reinforce path dependence and social inertia, constraining environmental adaptation (Teece *et al.,* 1997; Teece, 2007; Chari *et al.,* 2022). Sensing capability mitigates these rigidities by systematically scanning and interpreting external signals, which prompts a reassessment of entrenched cultural assumptions and fosters an entrepreneurial management orientation (Teece, 2007; Schriber and Löwstedt, 2020). By aligning emerging opportunities with strategic vision, sensing capability reduces the restrictive influence of conservative mindsets and promotes no-boundary collaboration, thereby enhancing firm performance (Ng'ang'a *et al.,* 2024; Pundziene *et al.,* 2021; Chari *et al.,* 2022). While narcissistic cultures may still disregard external signals (Wilden *et al.,* 2013), a proactive sensing deployment that stimulates openness and learning effectively weakens the deleterious impact of organizational culture barriers on firm performance.

Hypothesis H5b: Sensing capability reduce the adverse impact of organizational culture barrier and firm performance.

Knowledge serves as a critical intangible asset for sustainable competitive advantage in the dynamic capability framework, yet its efficacy is often hindered by knowledge opacity—where valuable resources remain deeply embedded in tacit routines and context-specific experiences (Teece *et al.,* 1997). By broadening organizational search horizons and facilitating the discovery of insights beyond

existing, potentially dysfunctional practices, sensing capability mitigates the knowledge management-related barriers (Teece, 2007). In addition, sensing activities enable firms to detect outdated practices and codify complex tacit knowledge into repeatable operational practices by interacting with external partners and diverse information sources (Garrido *et al.,* 2020). Furthermore, sensing enhances a firm's ability to integrate and recombine dispersed assets by activating cognitive capital and improving the interpretation of external signals (Ozanne *et al.,* 2022; Saleh and Sadeghi, 2024). While entrenched competencies can narrow managerial focus, proactive sensing deployment expands learning horizons and integrates complementary assets, effectively weakens the negative impact of knowledge-related barriers on firm performance.

Hypothesis H5c: Sensing capability reduce the adverse impact of knowledge-related barrier and firm performance.

Operational constraints—stemming from shortcomings in skills, resources, and process design—frequently manifest as value-chain bottlenecks that undermine organizational performance (Manzouri *et al.,* 2013; Belhadi *et al.,* 2017; Berger *et al.,* 2018; Merli and Mosconi, 2019). According to Wilden *et al.* (2013) and Aslam *et al.* (2018), sensing capability empowers firms to detect technological shifts and supply chain disruptions, facilitating the timely process adjustments necessary to maintain performance under volatile conditions. By interpreting environmental signals, sensing capability can identify inefficiencies in existing activities and alleviate these operational constraints (Teece, 2007). However, the efficacy of sensing is contingent upon managerial attention and resource availability to translate insights into action (Garrido *et al.,* 2020). Therefore, when a firm maintains ordinary capabilities for routine efficiency while proactively deploying sensing for adaptation, sensing capability serves as a moderator to help firms weaken the deleterious impact of operational barriers on firm performance.

Hypothesis H5d: Sensing capability reduce the adverse impact of operational constraints and firm performance.

3. METHODOLOGY

3.1 Construct Measurements

This study integrates the extended resource-based view and dynamic capabilities theory to explain how firms mobilize and reconfigure resources for lean supply chain management. While the traditional resource-based view (Barney, 1991) focuses predominantly on firm-controlled assets, the extended resource-based view broadens this focus to encompass complementary knowledge, capabilities, and relational rents embedded within interorganizational networks (Dyer & Singh, 1998; Lavie, 2006; Moyano-Fuentes *et al.,* 2020). This lens is especially pertinent to lean supply chain management, where successful execution hinges on boundary-spanning collaboration and resource integration with upstream suppliers and downstream customers (Cadden *et al.,* 2020; Marodin *et al.,* 2017). However, internal barriers represent critical intra-firm deficits that impede the absorption of lean practices and leveraging interorganizational advantages (Merli & Mosconi, 2019). To address this limitation, dynamic capabilities theory complements the extended resource-based view through the dual-directional nature of sensing capability. Serving as an operational prerequisite, sensing facilitates the systematic scanning, filtering, and diagnosis of both cross-partner networks and internal operations—allowing organizations to align external supply chain signals with internal capability gaps and vulnerabilities (Teece, 2007; Leinonen *et al.,* 2023). This cognitive awareness establishes the empirical foundation required to mobilize boundary-spanning resources (Aslam *et al.,* 2018; Duchek, 2020), ultimately enabling the strategic alignment of internal capacity with inter-firm resource integration for effective lean supply chain management practices.

Internal barriers to lean supply chain practices are operationalized as a multidimensional construct comprising leadership constraints (Bhasin, 2012; Jadhav *et al.,* 2014; Manzouri *et al.,* 2013; Ali *et al.,* 2020; Zhang *et al.,* 2017), organizational culture impediments (Patil and Kant, 2014; DeSanctis *et al.,* 2018; Abolhassani *et al.,* 2016; Berger *et al.,* 2018), knowledge-related deficiencies (Manzouri *et al.,* 2013; Berger *et al.,* 2018; Kumar and Kumar, 2014; Alam and Daril, 2022; DeSanctis *et al.,* 2018), and operational constraints (Merli and Mosconi, 2019; Belhadi *et al.,* 2017). Sensing capability is measured using items from Garrido *et al.* (2020), while firm performance is assessed via six indicators from Flynn *et al.* (2010), focusing on customization speed, product innovation, demand responsiveness, and service reliability. To ensure contextual relevance within the manufacturing sector in Vietnam, measurement scales are refined through semi-structured interviews with six senior managers (Appendix A) and rigorously validated using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (Appendix B) prior to structural equation modeling.

3.2 Survey Design

Observed variables are measured using a five-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree"), chosen to minimize respondent ambiguity (Babakus & Boller, 1992; Bouranta *et al.,* 2009; Dawes, 2008). Adapted from established literature, the questionnaire includes a cover letter, demographic queries, and scales for internal lean supply chain barriers, sensing capability, and firm performance. To ensure linguistic equivalence, the questionnaire undergoes back-translation and expert cross-validation. Content validity is further established through interviews with six senior managers experienced in lean supply chain implementation. Following a pilot test, the final instrument is distributed to manufacturing firms in Vietnam via Google Forms and hard-copy formats.

3.3 Data Collection

This empirical focus is on manufacturing firms within Southern Vietnam's industrial hubs, including Ho Chi Minh City, Dong Nai, and Tay Ninh.

The firm serves as the unit of analysis, with data elicited from senior supply chain or production managers. Using purposive sampling, the sampling frame was derived from official industrial zone registries (e.g., HEPZA, VSIP, High-tech Park). From an initial list of 2,367 firms with complete contact details, data are collected between July and October 2025 via a mixed-mode approach (paper-based and Google Forms) distributed through professional networks and LinkedIn.

Table 1 Respondents' Profile

Characteristics	Category	Frequency (n)	Percentage (%)
Position	Board-level executive	3	1,28%
	General Director/Deputy General Director	13	5,55%
	Supply Chain Director/Deputy Director	5	2,14%
	Department/Division Head (Operations, Manufacturing, Purchasing, Logistics, etc.)	213	91,03%
Years of experience at the company	< 5 years	190	81.20%
	5–10 years	38	16.24%
	11–15 years	3	1.28%
	> 15 years	3	1.28%
Working industry	Mechanical engineering	78	33,33%
	Chemicals	27	11,54%
	Agro-processing	26	11,11%
	Textile & footwear	75	32,05%
	Consumer goods	15	6,41%
	Other	13	5,56%
Number of employees of the responded company	< 100	177	75,64%
	101–250	42	17,95%
	251–500	5	2,14%
	> 500	10	4,27%
Firm age	< 5 years	31	13,25%
	5–10 years	142	60,68%
	11–15 years	46	19,66%
	> 15 years	15	6,41%
Lean supply chain implementation experience	<5 years	217	92,73%
	5–10 years	1	0,43%
	10–15 years	4	1,71%
	> 15 years	12	5,13%

from official industrial zone registries (e.g., HEPZA, VSIP, High-tech Park). From an initial list of 2,367 firms with complete contact details, data are collected between July and October 2025 via a mixed-mode approach (paper-based and Google Forms) distributed through professional networks and LinkedIn.

Of 294 total responses, 234 valid cases were retained following rigorous screening for completeness and sector relevance (Table 1). The sample is primarily composed of mechanical firms (33.33%), textile/garment (32.05%), chemical firms (11.54%), agricultural, forestry, and aquatic product processing firms (11.11%), consumer goods manufacturers (6.41%), and other industries (5.56%). Small and medium-sized enterprises predominate, with 75.64% employing fewer than 100 staff, followed by firms with 101–250 employees (17.95%), 251–500 employees (2.14%), and more than 500 employees (4.27%). The average firm age is 8.8 years.

The final sample of 234 firms exceeds the threshold of 200 observations recommended for stable parameter estimation in Structural Equation Modeling (SEM) (Hair *et al.,* 2019; Kline, 2016), aligning with established conventions in operations management research (Baruch & Holtom, 2008).

3.4 Data Analysis

Utilizing data from 234 manufacturing firms, this study employed SEM to evaluate the hypothesized relationships. Adhering to the two-step approach by Anderson and Gerbing (1988), the analysis first established construct unidimensionality and internal consistency through EFA via Principal Axis Factoring with Promax rotation and Cronbach's alpha (Hair *et al.,* 2018). Subsequently, the measurement model was validated using CFA with maximum likelihood estimation in SPSS 26 and AMOS 24, assessed against fit indices including χ^2/df, CFI, TLI, and RMSEA (Hair *et al.,* 2018). Following measurement model validation, SEM is applied to test the paths between lean supply chain barriers and firm performance. To examine the moderating role of sensing capability, a multi-group SEM analysis is performed by splitting the sample into high and low groups (Figure 2, Figure 3) via a median split (Hair *et al.,* 2018). The presence of moderation was determined through chi-square difference tests comparing constrained and unconstrained models, where a significant difference indicates a moderating effect (Nguyen and Aoyama, 2014; Hair *et al.,* 2018).

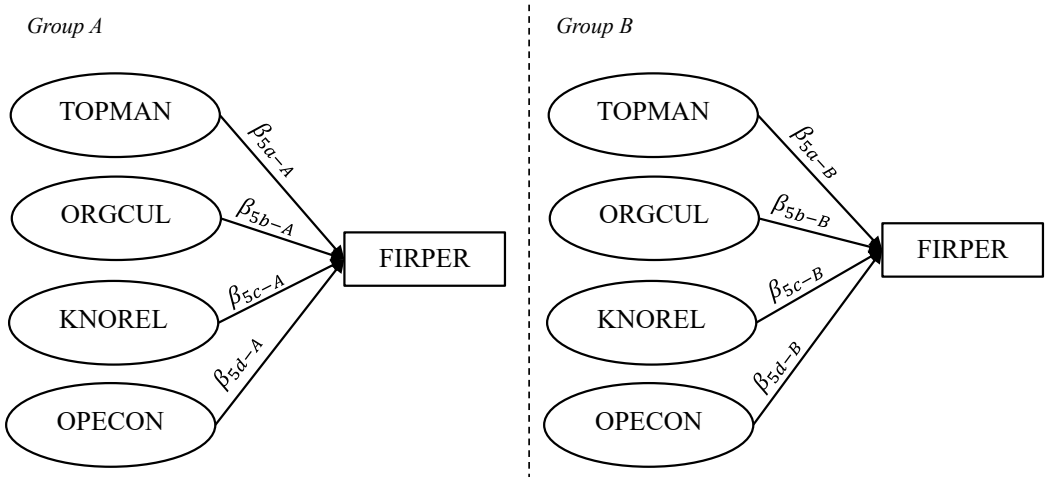

Figure 2 Unconstrained Model

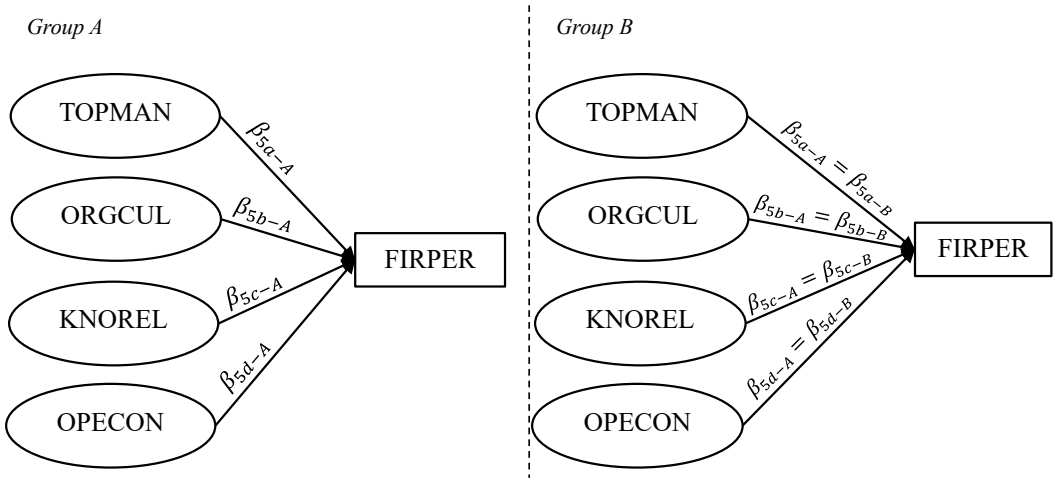

Figure 3 Constrained Model

Table 2 Validity and Reliability Indices of Constructs in the Model (Summarized from Appendix B, Appendix D)

Construct	No. of Item	Mean of Standardised Regression	Cronbach's Alpha	Composite Reliability	Percentage of Variance Extracted
Top management barrier	6	0.837	0.933	0.935	0.709
Culture-related barrier	6	0.827	0.928	0.929	0.688
Knowledge barrier	6	0.865	0.946	0.947	0.748
Operational constraints	5	0.880	0.945	0.945	0.776
Sensing capability	4	0.839	0.905	0.905	0.704
Firm performance	6	0.896	0.965	0.965	0.820

4. FINDINGS AND DISCUSSIONS

4.1 The Reliability and the Validity of Measurement Scale

Initial scale evaluation is conducted via EFA and reliability testing in SPSS 26. Following the criteria of Hair *et al.* (2018), items with inter-item correlations below 0.3 or Cronbach's alpha below 0.7 are excluded. Consequently, three items are removed: SENCAP3 (environmental scanning with strategic foresight) and OPERAT6; OPERAT7 (operational constraints). The remaining 33 variables exhibited robust internal consistency and were retained for subsequent analysis (Appendix B).

The CFA results demonstrated excellent model fit Chi-square/df = 1.512; TLI = 0.962; CFI = 0.966; RMSEA = 0.047) (Figure 4, Appendix C), satisfying established benchmarks (Hair *et al.,* 2018). Validity and reliability metrics (Appendix D, Table 2), are as follows: Average variance extracted (AVE) ranged from 0.688 to 0.820, exceeding the 0.50 threshold (Hair *et al.,* 2018); the square root of the AVE for each construct ranged from 0.830 to 0.906, exceeding all corresponding inter-construct correlations (Fornell and Larcker, 1981); inter-construct correlations ranged from -0.374 to 0.397, remaining significantly below unity (Steenkamp & Van-Trijp, 1991); and composite reliability (CR) values ranged from 0.905 to 0.965, well above the recommended 0.70 (Hair *et al.,* 2018).

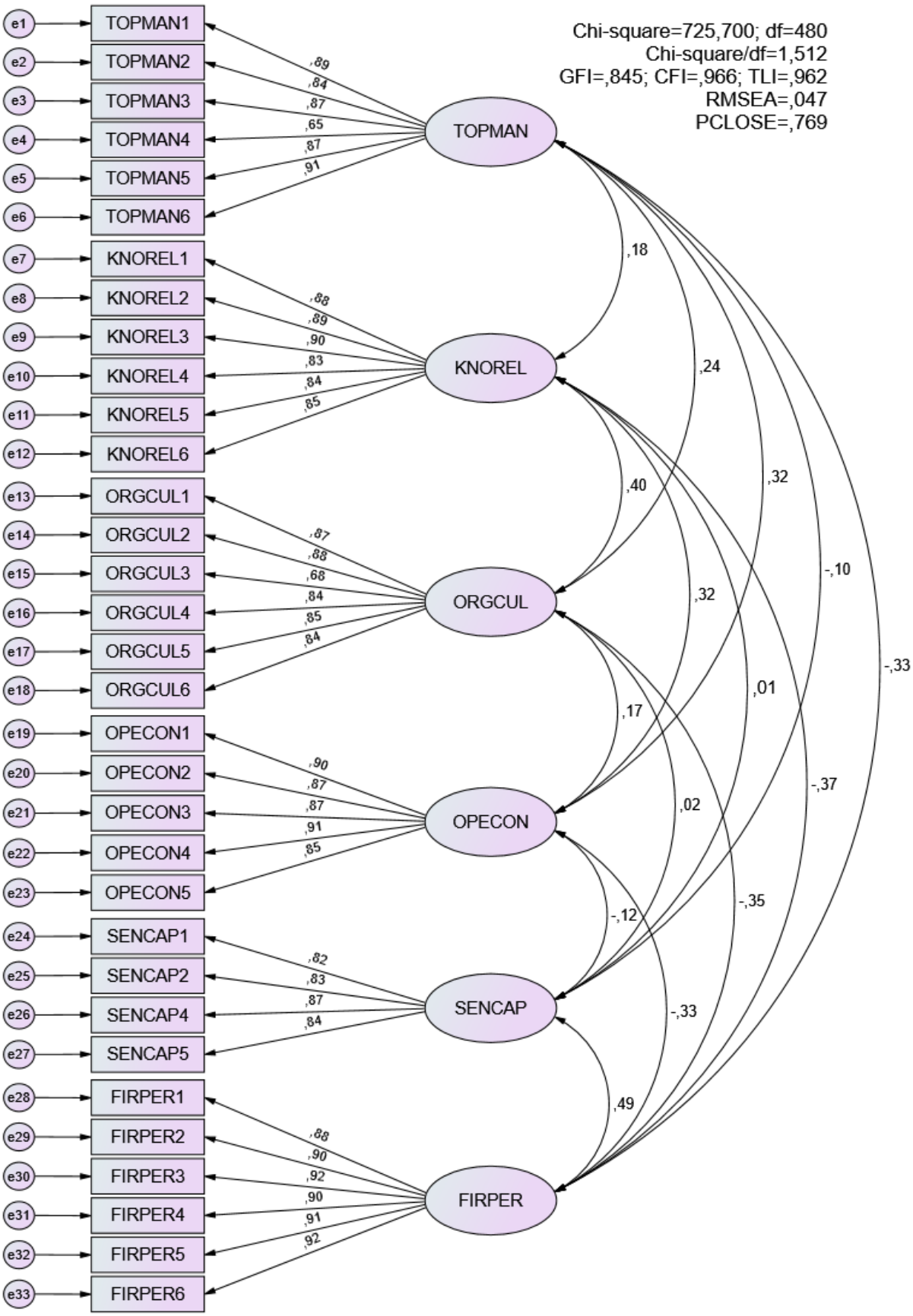

Figure 4 Results of CFA Analysis

4.2 Relationship of Internal Barriers to Lean Supply Chain Practices and Firm Performance

To evaluate the hypothesized relationships, the structural model is estimated via covariance-based SEM using maximum likelihood estimation in AMOS 26. The model demonstrated robust fit according to the criteria established by Hair *et al.* (2018), with indices: chi-squared = 676.179; df = 373; p = 0.000; chi-squared/df = 1.813; TLI = 0.949; CFI = 0.953; and RMSEA = 0.059 (Figure 5). Analysis of the standardized path coefficients confirms that all hypotheses are supported at p-value < 0.05 (Figure 5, Table 3), specifically validating the significant negative impact of internal barriers to lean supply chain practices on firm performance.

The finding that top management barriers significantly and negatively impact firm performance (β = -0.208, p = 0.001) provides empirical support for hypothesis H1, aligning with previous research by Abu *et al.* (2021), Jadhav *et al.* (2014), and Kumar and Kumar (2014). Specific barriers—such as a lack of executive commitment, insufficient involvement, and inadequate leadership support— can weaken the managerial support and signals needed to legitimize lean-related change and mobilize employee participation. When leadership fails to articulate the strategic intent of Lean, champion organizational change, and mitigate employee uncertainty, transformation initiatives often lack the legitimacy and trust necessary to mobilize sustained workforce engagement (Abolhassani *et al.,* 2016; Belhadi *et al.,* 2017; Lai *et al.,* 2020). Insufficient managerial involvement and an ambiguous strategic vision further obscure implementation priorities and dilute accountability, thereby impeding coordinated improvement efforts (Jadhav *et al.,* 2014; Narkhede *et al.,* 2020). Without sustained managerial reinforcement, such weaknesses can persist beyond initial implementation, impeding the institutionalization of new lean routines and heightening the likelihood of regression to established practices (DeSanctis *et al.,* 2018; Leite *et al.,* 2022). Ultimately, top management-level barriers erode the legitimacy, cross-functional coordination, and temporal continuity essential for deeply embedding lean practices, restricts firm performance gains, thereby reinforcing the findings of H1.

Specifically, organizational culture-related barrier significantly impeded firm performance (β = -0.211, p = 0.001), supporting hypothesis H2 empirically. This finding aligns with prior research (e.g., Abu *et al.,* 2021; Cheah *et al.,* 2012; Pardi *et al.,* 2024), suggesting that entrenched traditions, resistance to innovation, and misalignment between organizational values and sustainability goals can create a substantive gap between the formal adoption of lean practices and the operational behaviors required for their efficacy. Weak employee empowerment, formal recognition, and psychological safety further suppress employee voice, transparent problem disclosure, and sustained long-term participation in continuous improvement initiatives (Cadden *et al.,* 2020; Jadhav *et al.,* 2014; Lai *et al.,* 2020). These cultural constraints can become particularly damaging when underlying norms continue to reward siloed or short-term behavior, causing lean practices to remain fragmented or symbolic rather than deeply embedded across the value stream (Bäckstrand & Powell, 2021; Cadden *et al.,* 2020; de Souza & Pidd, 2011). Consequently, cultural barriers can weaken firm performance by preventing formal lean adoption from becoming embedded, system-wide practice.

The knowledge-related barrier significantly hindered firm performance (β = -0.227, p < 0.001), thereby validating hypothesis H3. This result aligns with the findings of Abu *et al.* (2021), Jadhav *et al.* (2014), and Zhang *et al.* (2017), illustrating how deficiencies in employee training, limited awareness of lean methodologies, and fragmented knowledge-sharing practices create systemic intellectual bottlenecks. Beyond reducing employees' problem-solving capacity, these barriers disrupt the continuous learning loop through which operational problems are identified, experience is translated into organizational capabilities for lean implementation (Bäckstrand & Powell, 2021; Tortorella *et al.,* 2015). Limited understanding of supply-chain interdependencies can further weaken coordination across functions and supply-chain members, increasing the risk of locally optimized decisions that undermine end-to-end value flow (de Souza & Pidd, 2011; Moyano-Fuentes *et al.,* 2020). Collectively, these barriers prevent organizations from effectively leveraging internal expertise and supply chain knowledge management, thereby undermining firm performance.

Consistent with hypothesis H4, operational constraints exerted a significant negative impact on firm performance (β = -0.184, p = 0.004). This result supports studies by Abu *et al.* (2021), Cheah *et al.* (2012), and Zhang *et al.* (2017), identifying limited financial resources, inefficient supply chain processes, and inadequate technological infrastructure as primary drivers of performance degradation. More fundamentally, these constraints can erode the human-system complementarity, limiting firms' ability to fully exploit standardized work, measurement systems, and other lean infrastructure under changing conditions (Aslam *et al.,* 2018; Cadden *et al.,* 2020; Teece *et al.,* 1997). As operational deviations persist, scarce time and skilled capacity are diverted into recurrent firefighting, crowding out preventive improvement and locking firms into reactive execution (Abu *et al.,* 2021; Manzouri *et al.,* 2013). Consequently, operational barriers weaken firm performance by undermining the stability and execution capacity required to sustain reliable Lean flow. These constraints impede productivity and slow project execution, stifling a firm's agility in responding to market demands and reinforcing the evidence for H4. Although analytically distinct, these barriers are likely interdependent: managerial support shapes resource deployment, culture conditions, employee engagement, and knowledge enables effective application, while operational capacity determines whether these inputs can be converted into reliable lean execution.

Collectively, the empirical evidence points to the knowledge-related barrier as the most powerful predictor of performance decline. This may be because knowledge underpins how firms interpret lean requirements, convert operational experience into actionable learning, and effectively mobilize existing resources. When this epistemic foundation is deficient, implementation failures diffuse across interconnected components of the lean system rather than remaining localized. This implies that the most critical bottleneck to organizational efficiency in the contemporary market is the inability to efficiently acquire and transfer

Table 3 Hypothesis Testing Results

	Hypothesized Relationship	Standardized Coefficient (β)	SE	CR	p-Value	Result	Comparison with Previous Studies
H1	Top management barrier → Firm performance	-0.208	0.066	-3.259	0.001	Supported	✓ Kumar and Kumar (2014) ✓ Jadhav *et al.* (2014) ✓ Abu *et al.* (2021)
H2	Culture-related barrier → Firm performance	-0.211	0.065	-3.278	0.001	Supported	✓ Abu *et al.* (2021) ✓ Cheah *et al.* (2012) ✓ Pardia *et al.* (2024)
H3	Knowledge-related barrier → Firm performance	-0.227	0.071	-3.551	***	Supported	✓ Abu *et al.* (2021) ✓ Jadhav *et al.* (2014) ✓ Zhang *et al.* (2017)
H4	Operational constraints → Firm performance	-0.184	0.066	-2.893	0.004	Supported	✓ Cheah *et al.* (2012) ✓ Abu *et al.* (2021) ✓ Zhang *et al.* (2017)

Notes: *SE: standard error for estimating regression weight; CR: critical ratio for regression weight; ***: $p < 0.001$. ✓: Result is similar to literature review*

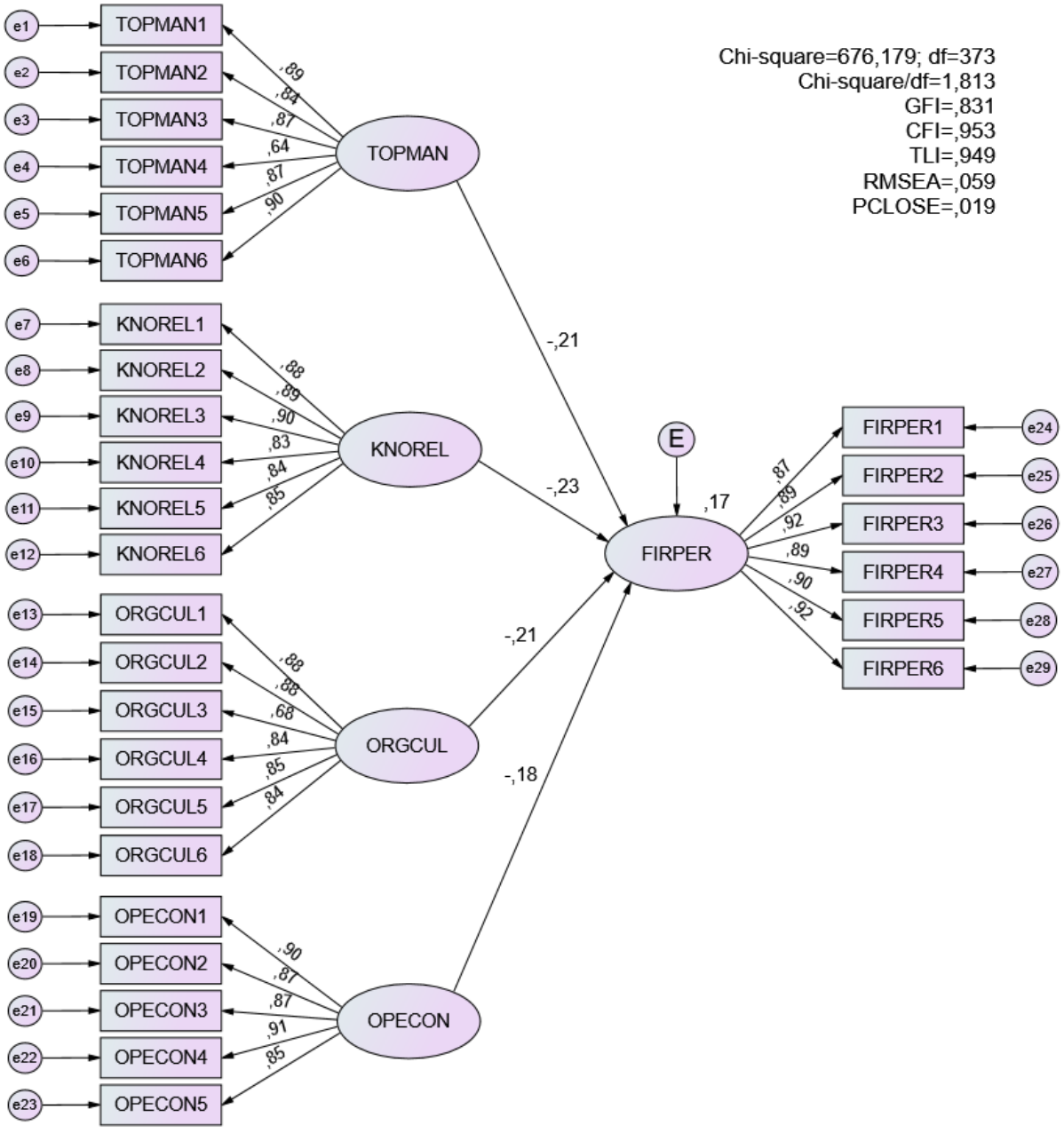

Figure 5 Results of Structural Model Estimation

expertise, even when resource shortages and conventional attitudes are harmful. Moreover, in firms where lean capabilities, managerial systems, and workforce development remain uneven, internal barriers may become more consequential because weaknesses in one organizational domain are less easily absorbed elsewhere. The findings may therefore reflect a contextually amplified form of broader lean implementation challenges rather than a uniquely Vietnam's manufacturing landscape.

4.3 The Moderation of Sensing Capability on the Relationship Between Internal Barriers to Lean Supply Chain Practices and Firm Performance

To examine the moderating influence of sensing capability on the relationship between lean supply chain management barriers and firm performance, a multi-group analysis is conducted by comparing unconstrained and constrained structural models. The sample is divided into high and low sensing capability groups, where the unconstrained model allowed for the free estimation of all structural paths across groups: top management barrier ($\beta_{5a\text{-}A}=\beta_{5a\text{-}B}$), organizational culture barrier ($\beta_{5b\text{-}A}=\beta_{5b\text{-}B}$), knowledge-related barrier ($\beta_{5c\text{-}A}=\beta_{5c\text{-}B}$), and operation constraint ($\beta_{5d\text{-}A}=\beta_{5d\text{-}B}$). Conversely, constrained models impose equality restrictions on corresponding paths, resulting in an increase in degrees of freedom from 746 to 747 (Table 4). The chi-square difference test ($\Delta\chi^2$) between the unconstrained and partially constrained models shows a p-value of less than 0.05 (Table 4), indicating that there are significant differences between high and low sensing capability groups in the hypothesized relationships.

Correspondingly, the chi-square difference between the constrained and unconstrained models for the relationship of organizational culture barrier and firm performance is significant ($\Delta\chi^2 = 12.608$, $\Delta df = 1$, $p < 0.001$), supporting H5b. In addition, the negative relationship between organizational culture barrier and firm performance changes substantially in the group of low sensing capability ($m = -.414$, $p < 0.001$), but not in the group of high sensing capability ($m = 0.015$, $p=0.830$) (Appendix E). However, the moderating effects of sensing capability on the relationships between firm performance and top management barrier—H5a ($\Delta\chi^2 = 0.033$, $p = 0.858$), knowledge-related barrier—H5c ($\Delta\chi^2 = 0.426$, $p = 0.514$), and operational constraint— H5d ($\Delta\chi^2 = 0.057$, $p = 0.813$) are not significant, indicating that sensing capability does not significantly alter the impact of these barriers on firm performance.

The asymmetric moderation pattern reveals that the buffering efficacy of sensing capability depends on the underlying mechanism through which a specific barrier undermines firm performance. Organizational culture barriers are embedded in shared assumptions, norms, behavioral routines, and resistance to change (Cadden *et al.,* 2020), which can shape how organizational members interpret problems and respond to lean initiatives. Such culturally embedded mechanisms may allow resistance to persist because established assumptions influence what employees and managers perceive as problematic, relevant, or necessary to change. Sensing capability may challenge this inertia by continuously scanning and interpreting internal and external signals, thereby making misalignment between existing organizational assumptions and emerging performance or environmental requirements more visible to decision makers. This heightened diagnostic visibility can prompt reassessment of prevailing assumptions and strengthen recognition of the need for organizational adaptation. This mechanism may be amplified in Vietnam, where entrenched organizational norms and hierarchical relationships can make cultural assumptions more persistent; however, the single-country design suggests context-specific intensity rather than a uniquely Vietnamese mechanism, which may also apply where deeply embedded norms constrain adaptation.

This divergence suggests that sensing functions primarily as a diagnostic and interpretive mechanism—consistent with Teece's (2007)—rather than an operational remedy that unilaterally dismantles organizational impediments. Consequently, its attenuating power is most potent against socially embedded, intangible constraints like cultural resistance or institutional rigidity (e.g., Lin *et al.,* 2020; Ozanne *et al.,* 2022). Through a behavioral lens, this diagnostic role is particularly relevant because the barrier operates partly through the interpretation and reproduction of established norms. By reshaping how organizational actors recognize, interpret, and question, sensing can weaken the process through which cultural rigidity is translated into persistent performance losses. Thus, sensing does not directly eliminate cultural resistance; rather, it may weaken the negative barrier–performance relationship by reducing the persistence of unrecognized or unquestioned cultural misalignments. The finding may partly reflect Vietnam's manufacturing context, where firms increasingly face changing requirements across integrated supply networks. However, the single-country design does not establish whether this buffering effect is unique to Vietnam. Alternative explanations should also be considered, as stronger sensing may coexist with organizational learning, openness, or complementary seizing and reconfiguring capabilities. Moreover, the cross-sectional design limits inference about the temporal sequence from sensing to subsequent adaptation. Thus, the finding should be interpreted as evidence of a contingent moderating role of sensing capability rather than as evidence that sensing alone resolves cultural barriers.

Conversely, the lack of moderation for top management and knowledge-related barriers may stem from cognitive biases or inherent limitations within the sensing process itself, while operational constraints likely require higher-order dynamic capabilities—specifically seizing and reconfiguring—to enact the resource reallocation and process redesign necessary for performance recovery (Chari *et al.,* 2022; Wilden *et al.,* 2013). In particular, information recognition by itself cannot change decision authority, provide needed expertise, or reallocate operational resources, even though sensing capability allows the company to discover structural bottlenecks and knowledge shortages. While knowledge-related obstacles necessitate significant acquisition, sharing, and integration mechanisms to overcome, top management barriers often involve entrenched strategic commitments and authority structures

Table 4 Moderating Effects of Sensing Capability on the Hypothesised Relationship

	Chi-Square	Df	P-Value	TLI	CFI	RMSEA	Chi-Square/Df	Result
H5a: Top management barrier → Firm performance								
Constrained model	1173.999	747	.000	.925	.931	.050	1.572	
Unconstrained model	1173.966	746	.000	.925	.931	.050	1.574	Not Support
Significant discrepancy	.033	1	.858	0	0	0	-.002	
H5b: Organizational culture barrier → Firm performance								
Constrained model	1186.574	747	.000	.923	.929	.050	1.588	
Unconstrained model	1173.966	746	.000	.925	.931	.050	1.574	Support
Significant discrepancy	12.608	1	.000	-.002	-.002	.000	0.014	
H5c: Knowledge-related barrier → Firm performance								
Constrained model	1174.392	747	.000	.925	.931	.050	1.572	
Unconstrained model	1173.966	746	.000	.925	.931	.050	1.574	Not Support
Significant discrepancy	.426	1	.514	.000	.000	.000	-0.002	
H5d: Operational constraints → Firm performance								
Constrained model	1174.023	747	.000	.925	.931	.050	1.572	
Unconstrained model	1173.966	746	.000	.925	.931	.050	1.574	Not Support
Significant discrepancy	.057	1	.813	0	0	0	-.002	

that resist informational feedback. Similarly, resolving operational constraints depends on tangible routine reconfiguration rather than informational awareness. Therefore, when barrier resolution necessitates significant structural change, resource mobilization, or strategic decision-making beyond early threat detection, sensing capability's moderating influence is limited because it primarily serves as an interpretive diagnostic tool rather than a direct remedial mechanism (Teece, 2007). Consequently, while sensing capability allows for the early detection of subtle organizational misalignments, its effectiveness as a moderator is bounded by the structural or decision-making nature of the barrier in question. In this sense, sensing capability is most likely to buffer the adverse performance consequences of barriers whose persistence depends on how organizational members perceive, interpret, and respond to change, whereas barriers requiring authority, knowledge integration, resource allocation, or process reconfiguration may require additional dynamic capabilities to translate detection into performance improvement.

5. CONCLUSIONS

This study advances the lean supply chain literature by demonstrating that internal barriers—encompassing top management, organizational culture, knowledge, and operational dimensions—significantly undermine firm performance. Crucially, the research reveals that the moderating efficacy of sensing capability is not universal but contingent upon the nature of the barrier. While sensing capability successfully buffers the negative impact of cultural barriers on performance, its moderating effect remains non-significant for top management, knowledge-related barriers, and operational constraints. Consequently, this study refines the boundary conditions of dynamic capability by showing that sensing is most potent against intangible, socially embedded obstacles but limited when facing structural or executive-level constraints.

To address managerial barriers, must transcend viewing lean supply chains as isolated operational tools, instead adopting a long-term strategic orientation prioritizing continuous improvement and cross-functional coordination. This shift requires a leadership mindset capable of sensing environmental disruptions and translating these signals into strategic direction, echoing Tortorella *et al.* (2018)'s call for context-driven leadership adaptation. Crucially, the materialization of this vision depends on middle managers serving as strategic transmission layers who bridge the gap between executive intent and operational execution. By empowering middle management through lean-thinking training and data-driven decision-making, organizations can strengthen these bridging mechanisms, ensuring that visionary leadership is successfully converted into the synchronized internal operations necessary to sustain lean transformations and enhance overall performance.

To sustain lean supply chain initiatives, organizations must transition from isolated improvement efforts toward embedding change management as a routine organizational capability. Fostering this change-ready environment necessitates a culture of continuous improvement and cross-functional collaboration, where leadership commitment provides the visible support required to synchronize operational adjustments across teams. Crucially, a change-ready culture must also remain alert to signals that existing assumptions and routines are losing their fit. Repeated disruptions can serve as powerful learning triggers by exposing blind spots in existing recognition mechanisms and forcing organizations to recalibrate what they monitor, interpret, and escalate. When these experiences are systematically reflected upon and translated into revised routines, sensing shifts from episodic reaction toward proactive vigilance. Over time, this repeated calibration strengthens a sensing-oriented culture in which alertness to weak signals, questioning of established assumptions, and

anticipatory response become shared expectations embedded across organizational levels (Norrman & Wieland, 2020). Achieving this cultural shift requires structural adaptations—such as delegating decision authority and reconfiguring organizational arrangements—to empower cross-functional teams and institutionalize change within daily routines. Furthermore, to move beyond symbolic adoption, businesses should implement behavioral indicators and incentive mechanisms that formally reward employee participation in collective problem-solving and the timely escalation of emerging signals. Ultimately, by integrating change management into the organizational fabric, manufacturers can better sustain lean supply chain practices while reducing organizational culture barrier, maintaining stability and collaboration across the broader supply chain network and developing a distributed capacity to anticipate and coordinate change across organizational boundaries.

To bridge the knowledge-practice gap, organizations must transition from the superficial dissemination of Lean tools toward cultivating internal dynamic capabilities that enable knowledge to be repeatedly tested, challenged, and renewed in practice. This requires a shift beyond lean literacy and single-loop error correction toward a learning-to-learn culture characterized by double-loop learning, where the workforce is empowered to challenge and reshape underlying operational paradigms, exemplified by Saabye and Powell (2024). Such learning can be institutionalized through an experiential cycle of action, reflection, conceptual reframing, and active experimentation (Kolb, 1984), where process deviations and pilot initiatives become opportunities to test assumptions rather than merely correct isolated errors. Importantly, this learning must move beyond ad hoc improvement and become institutionalized through systematic monitoring, recurrent exercises, and formal assessment, so that experience is retained and translated into organizational routines (Norrman & Wieland, 2020). Simultaneously, businesses must enhance their capacity to sense external signals, translating these environmental cues into actionable operational knowledge that strategically guides improvement priorities, consistent with the findings of Gutierrez *et al.* (2022). Ultimately, the recursive interaction between experiential experimentation, external sensing, and the systematic codification of tacit knowledge enables firms to develop the robust implementation capabilities necessary to operationalize and sustain lean supply chain practices.

Besides, businesses must reconceptualize forecasting capability as an orchestrated organizational competence—rather than a siloed technical function—grounded in integrated information systems and outside-in data across the end-to-end supply chain. In pull-driven lean environments, this capability is increasingly augmented by AI-driven demand sensing, which utilizes machine learning to automate routine predictions and detect subtle patterns in real-time data streams (Pham and Bris, 2025). Within this framework, sensing capability serves as a pivotal orchestrator that filters environmental noise and translates distributed signals into actionable, context-aware forecasts, thereby compressing the sensing-to-response cycle. By facilitating cross-functional and inter-organizational alignment, business should emerge forecasting as a dynamic capability that enhances demand visibility and system responsiveness, ultimately transforming traditional statistical exercises into forward-deployed strategic assets that minimize inventory buffers.

Businesses must treat the development of genuine sensing capability as a substantive strategic investment rather than a peripheral technical deployment. To achieve this, businesses should cultivate a transparent sensing ecosystem that integrates internal operations with external market intelligence through rigorous, data-driven performance indicators. Furthermore, businesses must continuously adapt this system to maintain alignment with an evolving market environment while prioritizing the enhancement of employees' analytical competencies to ensure data is translated into actionable insights. Because different Lean dimensions rely on different digital enablers, Lean–technology fit is inherently configuration-specific (Haartman *et al.,* 2025). Sensing reveals when that fit begins to erode and where reconfiguration is required. By institutionalizing a robust sensing framework, businesses activate the essential triggers for subsequent dynamic capabilities: seizing, which facilitates strategic resource mobilization, and transforming, which empowers businesses to reconfigure processes and technologies in response to environmental shifts.

Despite its contributions, this study presents several limitations that establish a foundation for future inquiry. First, while the current analysis prioritizes internal barriers, subsequent research should develop an integrated framework encompassing both internal and external constraints to capture a more holistic view of implementation challenges. Second, although the broad manufacturing focus identifies cross-sectoral patterns, future studies could investigate strategic emerging industries—such as biotechnology, advanced materials, or AI-integrated manufacturing—to determine how high knowledge intensity and rapid technological cycles shape unique operational dynamics. Third, although dichotomizing continuous variables has traditionally been criticized for sacrificing information and reducing statistical power (MacCallum *et al.,* 2002), methodological evidence indicates that median splits remain viable and analytically robust when multicollinearity among predictors is negligible (Iacobucci *et al.,* 2015). In this study, categorizing sensing capability into high and low groups supported clear group-based interpretation, but the potential loss of variance and sensitivity to subtler moderation patterns should be acknowledged. Nonetheless, to capture subtle gradations and avoid any potential loss of variance, future research should retain sensing capability as a continuous or latent construct and employ continuous interaction modeling. Finally, future research should explore the "stage-contingent" nature of dynamic capability moderation; specifically, while sensing capability effectively mitigates interpretive cultural barriers, other capabilities like organizational learning or reconfiguration may be better suited to addressing barriers emerging during the seizing or transforming phases. Investigating this alignment between specific capabilities and barrier types will provide deeper insights into how firms strategically configure their dynamic processes to sustain lean practices in complex environments.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper, and all eligible contributors have been included in the author list.

DATA AVAILABILITY STATEMENTS

In accordance with confidentiality agreements involving the surveyed firms and experts, raw data are not publicly disclosed. All primary empirically statistical results are reported in the main text, while supplementary outputs and anonymized summaries are provided in the Appendix.

REFERENCES

Abolhassani, A., Layfield, K., & Gopalakrishnan, B. (2016). Lean and US manufacturing industry: popularity of practices and implementation barriers. *International Journal of Productivity and Performance Management, 65*(7), 875–897. https://doi.org/10.1108/ijppm-10-2014-0157

Abu, F., Gholami, H., Saman, M. Z. M., Zakuan, N., Streimikiene, D., & Kyriakopoulos, G. L. (2021). An SEM approach for the barrier analysis in lean implementation in manufacturing industries. *Sustainability*, *13*(4), 1978. https://doi.org/10.3390/su13041978

Alam, S. Q. Z., & Daril, M. A. M. (2022). Determining barriers in lean manufacturing implementation among Malaysian SMEs. *Malaysian Journal of Industrial Technology*, *6*(2), 1–16.

Ali, S. M., Hossen, M. A., Mahtab, Z., Kabir, G., Paul, S. K., & Adnan, Z. U. H. (2020). Barriers to Lean Six Sigma implementation in the supply chain: An ISM model. *Computers & Industrial Engineering*, *149*, 106843. https://doi.org/10.1016/j.cie.2020.106843

Anand, G., & Kodali, R. (2008). A conceptual framework for lean supply chain and its implementation. *International Journal of Value Chain Management*, *2*(3), 313-357. https://doi.org/10.1504/ijvcm.2008.019517

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Aslam, H., Blome, C., Roscoe, S., & Azhar, T. M. (2018). Dynamic supply chain capabilities: how market sensing, supply chain agility and adaptability affect supply chain ambidexterity. *International Journal of Operations & Production Management*, *38*(12), 2266–2285. https://doi.org/10.1108/ijopm-09-2017-0555

Babakus, E., & Boller, G. W. (1992). An empirical assessment of the SERVQUAL scale. *Journal of Business Research*, *24*(3), 253–268. https://doi.org/10.1016/0148-2963(92)90022-4

Bäckstrand, J., & Powell, D. (2021). Enhancing supply chain capabilities in an ETO context through "Lean and Learn". *Operations and Supply Chain Management: An International Journal., 14*(3), 360–367. https://doi.org/10.31387/oscm0460308

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. *Human Relations*, *61*(8), 1139–1160. https://doi.org/10.1177/0018726708094863

Belhadi, A., Touriki, F. E., & Fezazi, S. E. (2017). Prioritizing the solutions of lean implementation in SMEs to overcome its barriers: An integrated fuzzy AHP-TOPSIS approach. *Journal of Manufacturing Technology Management*, *28*(8), 1115–1139. https://doi.org/10.1108/jmtm-04-2017-0066

Berger, S. L. T., Tortorella, G. L., & Rodriguez, C. M. T. (2018). Lean supply chain management: A systematic literature review of practices, barriers and contextual factors inherent to its implementation. In J. P. Davim (Ed.), *Progress in lean manufacturing* (pp. 39–68). Springer. https://doi.org/10.1007/978-3-319-73648-8_2

Bhasin, S. (2012). Prominent obstacles to lean. *International Journal of Productivity and Performance Management*, *61*(4), 403–425. https://doi.org/10.1108/17410401211212661

Bouranta, N., Chitiris, L., & Paravantis, J. (2009). The relationship between internal and external service quality. *International Journal of Contemporary Hospitality Management*, *21*(3), 275–293. https://doi.org/10.1108/09596110910948297

Cadden, T., Millar, K., Treacy, R., & Humphreys, P. (2020). The mediating influence of organisational cultural practices in successful lean management implementation. *International Journal of Production Economics*, *229*, 107744. https://doi.org/10.1016/j.ijpe.2020.107744

Chaple, A. P., Narkhede, B. E., Akarte, M. M., & Raut, R. (2021). Modeling the lean barriers for successful lean implementation: TISM approach. *International Journal of Lean Six Sigma, 12*(1), 98–119. https://doi.org/10.1108/ijlss-10-2016-0063

Chari, A., Niedenzu, D., Despeisse, M., Machado, C. G., Azevedo, J. D., Boavida-Dias, R., & Johansson, B. (2022). Dynamic capabilities for circular manufacturing supply chains—Exploring the role of Industry 4.0 and resilience. *Business Strategy and the Environment*, *31*(5), 2500–2517. https://doi.org/10.1002/bse.3040

Cheah, A. C. H., Wong, W. P., & Deng, Q. (2012). Challenges of lean manufacturing implementation: A hierarchical model. *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management*, 1–6.

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm*. Prentice-Hall.

Dawes, J. (2008). Do data characteristics change according to the number of scale points used? An experiment using 5-Point, 7-Point and 10-Point scales. *International Journal of Market Research*, *50*(1), 61–104. https://doi.org/10.1177/147078530805000106

De Souza, L. B., & Pidd, M. (2011). Exploring the barriers to lean health care implementation. *Public Money & Management, 31*(1), 59–66. https://doi.org/10.1080/09540962.2011.545548

DeSanctis, I., Ordieres-Meré, J. B.., Bevilacqua, M., & Ciarapica, F. E. (2018). The moderating effects of corporate and national factors on lean projects barriers: a cross-national study. *Production Planning & Control*, *29*(12), 972–991. https://doi.org/10.1080/09537287.2018.1494345

Dora, M., Kumar, M., & Gellynck, X. (2016). Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis. *Production Planning & Control*, *27*(1), 1-23. https://doi.org/10.1080/09537287.2015.1050477

Duchek, S. (2020). Organizational resilience: a capability-based conceptualization. *Business Research, 13*(1), 215–246. https://doi.org/10.1007/s40685-019-0085-7

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance: A contingency and

configuration approach. Journal of Operations Management, 28(1), 58–71. https://doi.org/10.1016/j.jom.2009.06.001

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of marketing research, 18(1), 39-50. https://doi.org/10.1177/002224378101800104

Garcia-Buendia, N., Moyano-Fuentes, J., Maqueira-Marín, J. M., Romano, P., & Molinaro, M. (2023). Strategic supplier performance in a competitive landscape: Enhancing organizational performance through lean supply chain management. *BRQ Business Research Quarterly, 28*(2), 474–490. https://doi.org/10.1177/23409444231210566

Garrido, I., Kretschmer, C., Vasconcellos, S., & Gonçalo, C. (2020). Dynamic Capabilities: A Measurement Proposal and its Relationship with Performance. *Brazilian Business Review, 17*(1), 46–65. https://doi.org/10.15728/bbr.2020.17.1.3

Gutierrez, L., Lameijer, B. A., Anand, G., Antony, J., & M, V. S. (2022). Beyond efficiency: the role of lean practices and cultures in developing dynamic capabilities microfoundations. *International Journal of Operations & Production Management*, *42*(13), 506–536. https://doi.org/10.1108/ijopm-02-2022-0086

Haartman, R., Prester, J., Bengtsson, L., & Niss, C. (2025). Matching digital technologies with lean practices in production. *Operations and Supply Chain Management: An International Journal, 18*(1), 19–33. https://doi.org/10.31387/oscm0600452

Hair, J. F., Babin, B. J., Anderson, R. E. & Black, W. C., (2018). Multivariate Data Analysis (8th ed.). Hampshire, UK: Cengage Learning.

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Castillo Apraiz, J., Cepeda Carrión, G. A., & Roldán, J. L. (2019). *Manual de partial least squares structural equation modeling (PLS-SEM) (Segunda edición).* OmniaScience. https://doi.org/10.3926/oss.37

Iacobucci, D., Posavac, S. S., Kardes, F. R., Schneider, M. J., & Popovich, D. L. (2015). Toward a more nuanced understanding of the statistical properties of a median split. *Journal of Consumer Psychology, 25*(4), 652–665. https://doi.org/10.1016/j.jcps.2014.12.002

Jadhav, J. R., Mantha, S. S., & Rane, S. B. (2014). Exploring barriers in lean implementation. *International Journal of Lean Six Sigma*, *5*(2), 122–148. https://doi.org/10.1108/ijlss-12-2012-0014

Kline, R. B. (2016). *Principles and Practice of Structural Equation Modeling* (4th ed.). Guilford Press.

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Englewood Cliffs, NJ: Prentice Hall.

Kumar, R., & Kumar, V. (2014). Barriers in Implementation of Lean Manufacturing System in Indian industry: A survey. *International Journal of Latest Trends in Engineering and Technology, 4*(2), 243-251.

Laaksonen, O., & Peltoniemi, M. (2018). The Essence of Dynamic Capabilities and their Measurement. *International Journal of Management Reviews*, *20*(2), 184–205. https://doi.org/10.1111/ijmr.12122

Lai, E. T. H., Yun, F. N. J., Arokiam, I. C., & Joo, J. H. A. (2020). Barriers affecting successful lean implementation in Singapore's shipbuilding industry: a case study. *Operations and Supply Chain Management: An International Journal, 13*(2), 166–175. https://doi.org/10.31387/oscm0410260

Lavie, D. (2006). The Competitive Advantage of Interconnected Firms: An Extension of the Resource-Based View. *Academy of Management Review, 31*(3), 638–658. https://doi.org/10.5465/amr.2006.21318922

Leinonen, S., Reiman, A., & Kauppila, O. (2023). Dynamic capabilities in supply chain resilience management in the Finnish energy industry. *International Journal for Quality Research, 17*(4), 1061–1084. https://doi.org/10.24874/ijqr17.04-06

Leite, H., Radnor, Z., & Bateman, N. (2022). Meaningful inhibitors of the lean journey: A systematic review and categorisation of over 20 years of literature. *Production Planning & Control*, *33*(5), 403–426. https://doi.org/10.1080/09537287.2020.1823511

Lin, C., Sanders, K., Sun, J., Shipton, H., & Mooi, E. A. (2020). HRM and innovation: the mediating role of market-sensing capability and the moderating role of national power distance. *The International Journal of Human Resource Management*, *31*(22), 2840–2865. https://doi.org/10.1080/09585192.2018.1474938

MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological Methods*, 7(1), 19–40. https://doi.org/10.1037/1082-989x.7.1.19

Manzouri, M., Rahman, M. N. A., Saibani, N., & Zain, C. R. C. M. (2013). Lean supply chain practices in the Halal food. *International* Journal of Lean Six Sigma, 4(4), 389–408. https://doi.org/10.1108/ijlss-10-2012-0011

Marodin, G. A., Tortorella, G. L., Frank, A. G., & Godinho Filho, M. (2017). The moderating effect of Lean supply chain management on the impact of Lean shop floor practices on quality and inventory. *Supply Chain Management: An International Journal, 22*(6), 473–485. https://doi.org/10.1108/SCM-10-2016-0350

Merli, F., & Mosconi, L. (2019). *Investigation on barriers hampering lean supply chain development: An interpretive study* [Master's thesis, Politecnico di Milano]. POLITesi. https://www.politesi.polimi.it/retrieve/a81cb05d-73b9-616b-e053-1605fe0a889a/2019_12_Merli_Mosconi.pdf

Minh, N. D. (2024). A Samsung production system-based approach to improve manufacturing process management in Vietnamese firms. *Management*, 28(*1*), 49–72. https://doi.org/10.58691/man/185638

Moyano-Fuentes, J., Bruque-Cámara, S., & Maqueira-Marín, J. M. (2019). Development and validation of a lean supply chain management measurement instrument. *Production Planning & Control, 30*(1), 20–32. https://doi.org/10.1080/09537287.2018.1519731

Moyano-Fuentes, J., Maqueira-Marín, J. M., Martínez-Jurado, P. J., & Sacristán-Díaz, M. (2020). Extending lean management along the supply chain: impact on efficiency. *Journal of Manufacturing Technology Management, 32*(1), 63–84. https://doi.org/10.1108/jmtm-10-2019-0388

Narkhede, B. E., Raut, R. D., Roy, M., Yadav, V. S., & Gardas, B. (2020). Implementation barriers to lean-agile manufacturing systems for original equipment manufacturers: an integrated decision-making approach. *The International Journal of Advanced Manufacturing Technology*, *108*(9–10), 3193–3206. https://doi.org/10.1007/s00170-020-05486-5

Ng'ang'a, A. W., Ndegwa, J., & Kangu, M. (2024). Sensing capabilities and performance of supermarkets in Kenya. *African Journal of* Business and Development Studies, 1(1), 1–12. https://doi.org/10.70641/ajbds.v1i1.52

Nguyen, N. T. D., & Aoyama, A. (2014). Achieving efficient technology transfer through a specific corporate culture facilitated by management practices. *The Journal of High Technology Management Research*, *25*(2), 108–122. https://doi.org/10.1016/j.hitech.2014.07.001

Nguyen, N. T. D., Dang, D. T., & Lan, H. T. P. (2017). Achieving the successful lean implementation at manufacturing companies in Vietnam: Awareness of critical barriers. *Ho Chi Minh City Open University Journal of Science*, *7*(1), 89-106. https://doi.org/10.46223/hcmcoujs.econ.en.7.1.199.2017

Norrman, A., & Wieland, A. (2020). The development of supply chain risk management over time: revisiting Ericsson. International *Journal of Physical Distribution & Logistics Management, 50*(6), 641–666. https://doi.org/10.1108/ijpdlm-07-2019-0219

Ozanne, L. K., Chowdhury, M., Prayag, G., & Mollenkopf, D. A. (2022). SMEs navigating COVID-19: The influence of social capital and dynamic capabilities on organizational resilience. *Industrial Marketing Management*, *104*, 116–135. https://doi.org/10.1016/j.indmarman.2022.04.009

Panwar, A., Nepal, B. P., Jain, R., & Rathore, A. P. S. (2015). On the adoption of lean manufacturing principles in process industries. *Production Planning & Control*, *26*(7), 564–587. https://doi.org/10.1080/09537287.2014.936532

Pardi, H., Rahman, M. N. A., Saibani, N., & Muhamed, A. A. (2024). A systematic literature review of critical success factors and barriers in lean supply chain management. *Jurnal Kejuruteraan*, *36*(2), 533–558. https://doi.org/10.17576/jkukm-2024-36(2)-15

Patil, S. K., & Kant, R. (2014). A fuzzy AHP-TOPSIS framework for ranking the solutions of knowledge management adoption in supply chain to overcome its barriers. *Expert Systems with Applications*, *41*(2), 679–693. https://doi.org/10.1016/j.eswa.2013.07.093

Pham, H. B., & Bris, P. (2025). AI in Supply Chain: Techniques, Applications, Real-World Cases and Benefits under SCOR Framework. *Operations and Supply Chain Management: An International Journal, 18*(2), 300–316. https://doi.org/10.31387/oscm0610474

Pundziene, A., Nikou, S., & Bouwman, H. (2021). The nexus between dynamic capabilities and competitive firm performance: The mediating role of open innovation. *European Journal of Innovation Management, 25*(6), 152–177. https://doi.org/10.1108/EJIM-09-2020-0356

Ramadas, T., & Satish, K. (2018). Identification and modeling of employee barriers while implementing lean manufacturing in small- and medium-scale enterprises. *International Journal of Productivity and Performance Management*, *67*(3), 467–486. https://doi.org/10.1108/ijppm-10-2016-0218

Saabye, H., & Powell, D. J. (2024). Fostering insights and improvements from IIoT systems at the shop floor: a case of industry 4.0 and lean complementarity enabled by action learning. *International Journal of Lean Six Sigma*, *15*(5), 968–996. https://doi.org/10.1108/ijlss-01-2022-0017

Saleh, I. M., & Sadeghi, M. T. (2024). Bridging information technology capability and firm performance: Unveiling the mediating role of supply chain collaboration. *Membrane Technology*, 2024(6), 385-395 (ISSN: 1873-4049).

Sansone, C., Hilletofth, P., & Eriksson, D. (2020). Critical Operations Capabilities for Competitive Manufacturing in a High-Cost Environment: A multiple case study. *Operations and Supply Chain Management: An International Journal, 13*(1), 94–107. https://doi.org/10.31387/oscm0400255

Scannell, T., & Curkovic, S. (2024). Overcoming barriers to supply chain involvement in supplier integration into new product development. *Operations and Supply Chain Management: An International Journal, 17*(4), 358–366. https://doi.org/10.31387/oscm0590447

Schein, E. H. (1984). Coming to a new awareness of organizational culture. *Sloan Management Review*, 25(2), 3–16.

Scherrer-Rathje, M., Boyle, T. A., & Deflorin, P. (2009). Lean, take two! Reflections from the second attempt at lean implementation. *Business Horizons*, *52*(1), 79–88. https://doi.org/10.1016/j.bushor.2008.08.004

Schriber, S., & Löwstedt, J. (2020). Reconsidering ordinary and dynamic capabilities in strategic change. *European Management Journal*, *38*(3), 377–387. https://doi.org/10.1016/j.emj.2019.12.006

Steenkamp, J. B. E. M., & Van-Trijp, H. C. M. (1991). The use of LISREL in validating marketing constructs. International Journal of Research in Marketing, 8(4), 283–299. https://doi.org/10.1016/0167-8116(91)90027-5

Takeda-Berger, S. L., Tortorella, G. L., Rodriguez, C. M. T., Frazzon, E. M., Yokoyama, T. T., & De Oliveira, M. A. (2021). Analysis of the relationship between barriers and practices in the lean supply chain management. *International Journal of Lean Six Sigma*, *12*(3), 607–626. https://doi.org/10.1108/ijlss-01-2019-0003

Taylor, D. H. (2006). Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. Supply Chain Management: An International Journal, 11(3), 271–280. https://doi.org/10.1108/13598540610662185

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350. https://doi.org/10.1002/smj.640

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal,* 18(7), 509-533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Tidd, J., & Bessant, J. R. (2020). *Managing innovation: Integrating technological, market and organizational change* (7th ed.). Wiley

Tortorella, G. L., De Castro Fettermann, D., Frank, A., & Marodin, G. (2018). Lean manufacturing implementation: leadership styles and contextual variables. *International Journal of Operations & Production Management*, *38*(5), 1205–1227. https://doi.org/10.1108/ijopm-08-2016-0453

Wamba, S. F., Dubey, R., Gunasekaran, A., & Akter, S. (2020). The performance effects of big data analytics and supply chain ambidexterity: The moderating effect of environmental dynamism. *International Journal of Production Economics*, *222*, 107498. https://doi.org/10.1016/j.ijpe.2019.09.019

Wee, H., & Wu, S. (2009). Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company. *Supply Chain Management: An International Journal*, *14*(5), 335–341. https://doi.org/10.1108/13598540910980242

Wells-Dang, A. (2026, February 9). *Vietnam's Party Congress endorses ambitious growth agenda*. Stimson Center. Available online at: https://www.stimson.org/2026/vietnams-party-congress-endorses-ambitious-growth-agenda/ [Accessed on 20-Mar-2026]

Wilden, R., Gudergan, S. P., Nielsen, B. B., & Lings, I. (2013). Dynamic capabilities and performance: Strategy, structure and environment. *Long Range Planning*, *46*(1-2), 72–96. https://doi.org/10.1016/j.lrp.2012.12.001

World Economic Forum. (2026, January 19). *Global value chains outlook 2026: Orchestrating corporate and national agility*. https://www.weforum.org/publications/global-value-chains-outlook-2026-orchestrating-corporate-and-national-agility/

Yan, B., Yao, B., Li, Q., & Dong, Q. (2022). Study on the Impact of Supply Chain Dynamic Capabilities on Long-Term Performance of Enterprises. *Sustainability*, *14*(19), 12441. https://doi.org/10.3390/su141912441

Zhang, L., Narkhede, B. E., & Chaple, A. P. (2017). Evaluating lean manufacturing barriers: an interpretive process. *Journal of Manufacturing Technology Management*, *28*(8), 1086–1114. https://doi.org/10.1108/jmtm-04-2017-0071

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Appendix A Scale Items

Original Measuring Items	Measuring Items After Depth Interview	Coded Item
Top Management Barrier (TOPMAN)		
Lack of commitment of senior manager (Bhasin, 2012).	*Our company* lack*s* commitment of *top* management *in lean supply chain practices.*	TOPMAN1
Lack of top/senior management involvement, commitment and support (Jadhav *et al.,* 2014).	*Our company* lacks *top* management involvement in *lean supply chain practices*.	TOPMAN2
Lack of management support (Manzouri *et al.,* 2013).	*Our company* lacks *top* management support *in providing sufficient resources for implementation in lean supply chain practices.*	TOPMAN3
Lack of supervision from line management (Ali *et al.,* 2020).	*Our company* lacks line management supervision *in lean supply chain practices.*	TOPMAN4
Insufficient senior management skills to implement lean (Zhang *et al.,* 2017).	*Our company's top management has* insufficient skills to implement lean *supply chain practices.*	TOPMAN5
Lack of long-term vision from top management (Zhang *et al.,* 2017).	*Our company*'s top management lacks a long-term vision *in lean supply chain practices.*	TOPMAN6
Organizational Culture Barrier (ORGCUL)		
Lack of proper organizational structure to create and share knowledge (Patil & Kant, 2014).	*Our company* lack*s a* proper organizational structure to create and share knowledge *in lean supply chain practices.*	ORGCUL1
Lack of empowerment of employees (Jadhav *et al.,* 2014).	*Our company* lack*s* empowerment of employees *(within permitted limits) in lean supply chain practices.*	ORGCUL2
Lack of motivation and reward (Patil & Kant, 2014).	*Our company* lack*s recognition,* motivation and reward *for valuable contributions in lean supply chain practices.*	ORGCUL3
Functional and professional silos (de Souza & Pidd, 2011).	*Our company lacks collaboration and experience sharing with partners when implementing lean supply chain practices.*	ORGCUL4
Employee resistance to change in lean implementation (Albohassani *et al.,* 2016).	*Our company encounters* employee resistance to change *when* implement*ing lean supply chain practices.*	ORGCUL5
Difficulties for cultural changes (Berger *et al.,* 2018).	*Our company encounters* difficulties in changing *organizational values and beliefs when implementing lean supply chain practices.*	ORGCUL6
Knowledge-Related Barrier (KNOREL)		
Lack of understanding of lean supply chain management concepts (Manzouri *et al.,* 2013).	*Our company lacks a full* understanding of *lean supply chain* concepts *and its core principles.*	KNOREL1
No adequate knowledge of functioning of other supply chain members (Patil & Kant, 2014).	*Our company does not have* adequate knowledge of *the* functioning of other supply chain members *in lean supply chain practices.*	KNOREL2
Improper selection of lean tools & practices (Alam & Daril, 2022).	*Our company lacks the knowledge and experience to appropriately* select lean tools & practices *for lean supply chain management.*	KNOREL3
Lack of implementation know-how (Kumar & Kumar, 2014).	*Our company* lack*s* implementation know-how *for effectively implementing lean supply chain practices.*	KNOREL4
Absence of sound strategic action/ logistical planning system (Jadhav *et al.,* 2014).	*Our company lacks* a sound strategic action/logistical planning system *for lean supply chain practices.*	KNOREL5
Poor sales forecasting (DeSanctis *et al.,* 2018)	*Our company has limited capability for* sales forecasting *in order to prepare adequate resources for lean supply chain practices.*	KNOREL6
Operational Constraints (OPECON)		
Lack of skilled workers (Manzouri *et al.,* 2013).	*Our company* lack*s a workforce with the necessary* skill*s in lean supply chain practices.*	OPECON1
Lack of specialized team development (Berger *et al.,* 2018).	*Our company* lacks *a* specialized team *responsible for lean supply chain practices.*	OPECON2
Lack of availability of resources (Berger *et al.,* 2018).	*Our company does not appropriately utilize* available resources *in lean supply chain practices.*	OPECON3
Lack of monitoring standardized work for managers (Merli & Mosconi, 2019)	*Our company* lack*s* standardized *operating procedures in lean supply chain practices.*	OPECON4
Lack of an adapted measurement system (Belhadi *et al.,* 2017).	*Our company* lacks an adapted measurement system *for lean supply chain practices.*	OPECON5
Poor facilities and layout configuration (Belhadi *et al.,* 2017).	*Our company faces limitations in the* layout *of production* facilities*, warehouses, and logistics systems when implementing lean supply chain practices.*	OPECON6
Lack of supply chain integration, especially with trade marketing and distribution teams (Manzouri *et al.,* 2013).	*Our company has poor* supply chain *coordination with partners, especially with* marketing and distribution teams, *when implementing lean supply chain practices.*	OPECON7

Appendix A Scale Items (Cont'd)

Original Measuring Items	Measuring Items After Depth Interview	Coded Item
Sensing Capability (SENCAP)		
Our firm monitors the structural evolution of our business/sector (Garrido *et al.,* 2020).	Our *company systematically* monitors *developments in* our business/sector *when implementing lean supply chain practices.*	SENCAP1
Our firm monitors and understands the current and latent (future) demand of the market, suppliers, and competitors (Garrido *et al.,* 2020).	Our *company* monitors and understands the current and *potential* demands of the market, suppliers, and competitors *when implementing lean supply chain practices.*	SENCAP2
Our firm's owners and management know how to interpret the business environment, what technology they should chase and on which markets they should focus (Garrido *et al.,* 2020).	Our *company's management* know how to *analyze* the business environment, *identify the technology to pursue* and *the markets to focus on when implementing lean supply chain practices.*	SENCAP3
Our firm is constantly seeking information from different sources, such as news, relationships, formal and informal contacts with customers, competitors and suppliers, fairs, universities, etc (Garrido *et al.,* 2020).	Our *company* is constantly seeking information from different sources, such as news, relationships, formal and informal contacts with customers, competitors and suppliers, fairs, universities, etc. *when implementing lean supply chain practices.*	SENCAP4
Our firm clearly allocates resources for activities such as searching and analyzing information and discovering new opportunities in technologies and markets (Garrido *et al.,* 2020).	Our *company* clearly allocates resources for activities such as searching and analyzing information and discovering new opportunities in technology and markets *when implementing lean supply chain practices.*	SENCAP5
Firm Performance (FIRPER)		
Our company can quickly modify products to meet our major customer's requirements (Flynn *et al.,* 2010).	*No adjustment*	FIRPER1
Our company can quickly introduce new products into the market (Flynn *et al.,* 2010).		FIRPER2
Our company can quickly respond to changes in market demand (Flynn *et al.,* 2010).		FIRPER3
Our company has an outstanding on-time delivery record to our major customer (Flynn *et al.,* 2010).		FIRPER4
The lead time for fulfilling customers' orders (the time which elapses between the receipt of customer's order and the delivery of the goods) is short (Flynn *et al.,* 2010).		FIRPER5
Our company provides a high level of customer service to our major customers (Flynn *et al.,* 2010).		FIRPER6

Note: *The italicized words have been adjusted as a result of in-depth interviews.*

Appendix B Scale Assessment Results

Sample Size: N = 234			Preliminary Assessment (EFA)		Scale Validity (After CFA)		Standardised Regression Weight
Coded Item	**Mean**	**Std. Dev**	**Factor Loading**	**Item-Total Correlation**	**Factor Loading**	**Item-Total Correlation**	
Top Management Barrier (TOPMAN)							
TOPMAN1	3.295	0.991	0.895	0.859	0.895	0.859	0.891
TOPMAN2	3.321	1.017	0.840	0.806	0.840	0.806	0.840
TOPMAN3	3.265	0.984	0.872	0.837	0.872	0.837	0.867
TOPMAN4	3.205	0.954	0.643	0.624	0.643	0.624	0.647
TOPMAN5	3.308	1.027	0.866	0.831	0.866	0.831	0.872
TOPMAN6	3.252	0.998	0.906	0.869	0.906	0.869	0.906
Eigenvalue			*4.520*		*4.520*		
Percentage of variance			*70.854 per cent*		*70.854 per cent*		
Cronbach's alpha			*0.933*		*0.933*		
Organizational Culture Barrier (ORGCUL)							
ORGCUL1	3.205	1.036	0.875	0.836	0.875	0.836	0.874
ORGCUL2	3.145	1.000	0.880	0.841	0.880	0.841	0.882
ORGCUL3	3.073	0.967	0.678	0.654	0.678	0.654	0.678
ORGCUL4	3.085	0.968	0.839	0.804	0.839	0.804	0.837
ORGCUL5	3.137	1.006	0.848	0.810	0.848	0.810	0.850
ORGCUL6	3.128	1.053	0.841	0.806	0.841	0.806	0.839
Eigenvalue			*4.428*		*4.428*		
Percentage of variance			*68.841 per cent*		*68.841 per cent*		
Cronbach's alpha			*0.928*		*0.928*		

Appendix B Scale Assessment Results (Cont'd)

Sample Size: N = 234			Preliminary Assessment (EFA)		Scale Validity (After CFA)		Standardised Regression Weight
Coded Item	**Mean**	**Std. Dev**	**Factor Loading**	**Item-Total Correlation**	**Factor Loading**	**Item-Total Correlation**	
Knowledge-Related Barrier (KNOREL)							
KNOREL1	3.274	0.932	0.883	0.853	0.883	0.853	0.884
KNOREL2	3.235	0.954	0.887	0.857	0.887	0.857	0.886
KNOREL3	3.252	0.963	0.898	0.867	0.898	0.867	0.898
KNOREL4	3.244	0.974	0.832	0.807	0.832	0.807	0.832
KNOREL5	3.218	1.048	0.836	0.810	0.836	0.810	0.835
KNOREL6	3.265	0.993	0.851	0.823	0.851	0.823	0.853
Eigenvalue			4.738			*4.738*	
Percentage of variance			74.791 per cent			74.791 per cent	
Cronbach's alpha			0.946			*0.946*	
Operational Constraints (OPECON)							
OPECON1	3.269	0.985	0.894	0.862	0.894	0.862	0.898
OPECON2	3.265	1.043	0.877	0.847	0.877	0.847	0.874
OPECON3	3.303	1.039	0.866	0.837	0.866	0.837	0.866
OPECON4	3.231	0.998	0.912	0.878	0.912	0.878	0.914
OPECON5	3.201	1.005	0.855	0.828	0.855	0.828	0.850
OPECON6	*2.923*	*1.105*	—	—	—	—	—
OPECON7	*3.030*	*1.144*	—	—	—	—	—
Eigenvalue			*4.103*			*4.103*	
Percentage of variance			77.595 per cent			77.595 per cent	
Cronbach's alpha			*0.945*			*0.945*	
Sensing Capability (SENCAP)							
SENCAP1	2.983	0.859	0.822	0.771	0.822	0.771	0.816
SENCAP2	3.000	0.839	0.839	0.785	0.839	0.785	0.835
SENCAP3	3.444	0.935	—	—	—	—	—
SENCAP4	2.936	0.874	0.863	0.806	0.863	0.806	0.865
SENCAP5	3.004	0.905	0.832	0.781	0.832	0.781	0.840
Eigenvalue			*3.113*			*3.113*	
Percentage of variance			70.435 per cent			70.435 per cent	
Cronbach's alpha			*0.905*			*0.905*	
Firm Performance (FIRPER)							
FIRPER1	2.846	1.109	0.877	0.860	0.877	0.860	0.866
FIRPER2	2.906	1.164	0.902	0.883	0.902	0.883	0.890
FIRPER3	2.919	1.152	0.926	0.906	0.926	0.906	0.916
FIRPER4	2.944	1.105	0.898	0.880	0.898	0.880	0.889
FIRPER5	2.872	1.135	0.906	0.887	0.906	0.887	0.897
FIRPER6	2.906	1.208	0.923	0.903	0.923	0.903	0.916
Eigenvalue			*5.100*			*5.100*	
Percentage of variance			82.017 per cent			82.017 per cent	
Cronbach's alpha			*0.965*			*0.965*	

Appendix C Discriminant Validity Between Constructs in the Model

Correlations	Estimate (r)	CR(r)	SE	(1-r)	(1-r)/SE	P
KNOREL↔TOPMAN	0.182	2.576	0.051	0.818	16.039	***
KNOREL↔ORGCUL	0.397	5.191	0.057	0.603	10.579	***
ORGCUL↔OPECON	0.175	2.467	0.057	0.825	14.474	***
OPECON↔SENCAP	-0.124	-1.740	0.044	1.124	25.545	***
TOPMAN↔ORGCUL	0.240	3.324	0.057	0.76	13.333	***
TOPMAN↔SENCAP	-0.095	-1.336	0.044	1.095	24.886	***
FIRPER↔TOPMAN	-0.330	-4.498	0.063	1.33	21.111	***
TOPMAN↔OPECON	0.321	4.359	0.057	0.679	11.912	***
KNOREL↔OPECON	0.316	4.300	0.053	0.684	12.906	***
KNOREL↔SENCAP	0.005	0.076	0.041	0.995	24.268	***
FIRPER↔KNOREL	-0.374	-4.998	0.060	1.374	22.900	***
ORGCUL↔SENCAP	0.020	0.278	0.045	0.98	21.778	***
FIRPER↔ORGCUL	-0.352	-4.725	0.066	1.352	20.485	***
FIRPER↔SENCAP	0.492	6.046	0.055	0.508	9.236	***
FIRPER↔OPECON	-0.330	-4.497	0.063	1.33	21.111	***

Appendix D Results of Discriminant Validity

	CR	AVE	MSV	MaxR(H)	FIRPER	KNOREL	TOPMAN	ORGCUL	OPECON	SENCAP
FIRPER	0,965	0,820	0,243	0,966	**0,906**					
KNOREL	0,947	0,748	0,158	0,949	-0,374***	**0,865**				
TOPMAN	0,935	0,709	0,109	0,947	-0,330***	0,182*	**0,842**			
ORGCUL	0,929	0,688	0,158	0,937	-0,352***	0,397***	0,240***	**0,830**		
OPECON	0,945	0,776	0,109	0,948	-0,330***	0,316***	0,321***	0,175*	**0,881**	
SENCAP	0,905	0,704	0,243	0,906	0,492***	0,005	-0,095	0,02	-0,124†	**0,839**

Appendix E Unstandardized Estimation on Moderating Effect of Sensing Capability

		Unconstrained Model								Constrained Model			
		Low Sensing Capability				High Sensing Capability							
		m	SE	CR	p	m	SE	CR	p	m	SE	CR	p
H5a	Top management barrier → Firm performance	Not be considered											
H5b	Organizational culture barrier → Firm performance	-0.414	0.082	-5.072	***	0.015	0.071	0.215	0.830	-0.189	0.056	-3.390	***
H5c	Knowledge-related barrier → Firm performance	Not be considered											
H5d	Operational constraints → Firm performance	Not be considered											