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RESEARCH ARTICLE

Constructing a Causal Model for Logistics Management in Thailand's Automotive Industry

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Abstract

This study conducts a comprehensive analysis of the significant transformations and challenges faced by the international automotive industry from 2019 to 2023, attributing these changes to advancements in production and management systems, globalization, digitalization, and increasing market competition. The research constructs a causal model of logistics management, tailored explicitly to Thailand's automotive sector, using a sequential explanatory mixed-method approach. Data was initially gathered through stratified sampling from 683 companies, involving surveys administered to executives, managers, and logistics personnel across 360 companies, and was analyzed using descriptive statistics and structural equation modeling (SEM). This quantitative analysis was enriched with qualitative insights from focus group discussions with experts in automotive logistics, revealing a complex interplay of factors such as organizational structuring, knowledge management capabilities, and governmental policies. These factors exhibited direct and indirect effects on logistics management through supply chain practices. The empirical validation of the model demonstrated robust statistical indices ($\chi 2 = 118.52$, df = 98, $\chi 2/df = 1.20$, P-Value = 0.077, CFI = 0.996, GFI = 0.966, AGFI = 0.941, RMR = 0.00267, and RMSEA = 0.024), confirming the reliability of the identified causal relationships. The findings emphasize the practical implications for enhancing logistics management, advocating for restructuring logistics divisions to increase efficiency, and advanced technologies such as IoT, blockchain, and analytics to maintain competitiveness and adapt to market changes. The study highlights the necessity of leveraging data-driven strategies, including structural equation modeling, to refine supply chain practices and align closely with governmental policies, thereby significantly improving logistics operations and contributing to overall business success and customer satisfaction.

Keywords: Causal model, Logistics management, Automotive, Automotive parts industry

Introduction

Over the past decade, the global automotive industry has experienced a profound transformation, marking a significant industrial revolution characterized by the automation of production processes and an enhanced focus on the quality of automotive components (Teplická et al., 2023; Promngam & Aysanond, 2021). The decline in global automotive sales from 2018 to 2020, which has impacted various regions worldwide, has coincided with this evolution (Praipaisarnkit, 2021; Wattanasungsuth & Meethom, 2021). In contrast, Thailand's automotive industry, flourishing in the 1960s, has emerged as a cornerstone of the country's economy and a critical component of the regional and global automotive supply chain. As the second-largest economy in Southeast Asia, with a GDP valuation of approximately US$632 billion, the automotive sector significantly contributes to around 10 percent of Thailand's GDP, stressing its role as a regional powerhouse (International Labour Organization, 2024).

From 2015 to 2020, Thailand emerged as the leading automobile producer in the ASEAN region, a status enhanced by over five decades of consistent governmental support for its automotive sector. Since 2009, these policies have effectively catalyzed the

nation's status as a global hub for automotive manufacturing and auto parts production, highlighted by its export-oriented industry model, which boasts a commendable export-output ratio. By 2022, Thailand had not only retained its position as the largest producer of motor vehicles in ASEAN but also ranked tenth globally and fourth in commercial vehicles, demonstrating its significant global presence. This robust industrial base has created a dynamic ecosystem for automotive entrepreneurs, leading to Thailand securing the 11th position worldwide in automobile production and topping the charts in Asia. This industry prominence, reinforced by impressive global and Asian sales rankings (17th and 6th, respectively), has been pivotal in driving Thailand's economic development (ASEAN Automotive Federation: AAF, 2022). The automotive and auto parts industries have significantly contributed to employment generation, value addition, and ancillary sector development, integrating everything from raw material suppliers to downstream distributors within the supply chain ecosystem. This comprehensive industry structure necessitates strategic and informed decision-making at every stage to maintain economic momentum and impact, as detailed in studies by Yongphisanphob (2017), Jamfa (2019), and the Global Trade Atlas (2021).

In 2019, the automotive industry faced significant challenges, dramatically exacerbated by the onset of the COVID-19 pandemic, which affected every level of the supply chain, including car assemblers, automakers, and parts manufacturers. Data from the Office of Industrial Economics and the Thailand Automotive Institute (2020) highlighted the vulnerabilities in the automotive ecosystem, identifying approximately 1,000 entities as particularly susceptible, encompassing main contractors and replacement part manufacturers who collectively accounted for significant percentages of the industry's vulnerable segments. Historically, issues such as low component quality, high failure rates, and extensive customer complaints have plagued automotive component manufacturing, leading to high costs and customer attrition. Aichouni et al. (2021) advocate for mitigating these issues through innovative solutions and established continuous improvement methodologies, emphasizing the importance of integrating suppliers and customers into the supply chain to enhance operational efficiency. The root cause of these disruptions has primarily been the operational shortcomings of vulnerable entities, compounded by a sudden decline in orders, emphasizing the need for strategic interventions to enhance the resilience of the automotive supply chain.

Entrepreneurs in Thailand's automotive industry have had to adapt to various challenges specific to their positions within the production supply chain, highlighting the sector's dynamic and adaptive nature, as emphasized by the Office of the Science Promotion Commission for Research and Innovation (2020). Key factors influencing logistics development and supply chain management include fierce competition, globalization, uncertainty, a lack of mutual trust, inadequate coordination and cooperation, and insufficient information sharing. The industry's rapid response and facilitation of substantial information and knowledge exchange among internal and external stakeholders mitigate these challenges. Furthermore, logistics management in Thailand's automotive sector is pivotal, ensuring adequate information and knowledge flow within the automotive ecosystem, which is crucial for managing resources effectively in volatile environments characterized by rapid developments. This approach underscores the importance of logistics management as a critical solution for fostering an interconnected and responsive automotive ecosystem (Iorga et al., 2018; Chalapathi et al., 2019; Aljawarneh et al., 2021).

The necessity for tools that enhance organizational workflow efficiency is paramount in the fiercely competitive modern business environment. Among these tools, logistics management systems are particularly critical, as supported by scholarly research (Esper et al., 2007; Sakchutchawan et al., 2011; Benjamin et al., 2012; Gunasekaran et al., 2017; Sumah et al., 2020). Effective logistics management streamlines various production process stages, optimizes overall logistics operations, and strengthens supply chain management practices, enhancing business competitiveness and customer satisfaction. This integration promotes sustained coordination, allowing businesses to resolve challenges adeptly through strategic interventions and process optimizations, which are crucial for driving future growth (Herden, 2020). Moreover, a key goal in the automotive industry is to increase production efficiency while reducing costs. Experts highlight the strategic importance of logistics

management in achieving several objectives, such as minimizing delivery times, maximizing capacity utilization, reducing inventory and overheads, enhancing transparency, fostering adaptability, reducing environmental impact, utilizing eco-friendly technologies, increasing transportation capabilities, and ultimately elevating customer satisfaction and operational effectiveness (Niekurzak et al., 2023; Kanagavalli & Azeez, 2019). These elements collectively underscore the pivotal role of logistics management in shaping efficient and sustainable business practices.

The global automotive industry, a cornerstone of economic development and technological innovation, faces various challenges ranging from supply chain disruptions to shifting consumer demands and environmental regulations. These global pressures necessitate a deeper understanding of logistics management to maintain competitiveness and adaptability. Recognizing the intricacies of a problem and its origins is a crucial precursor to effective problem-solving (Jakhar & Barua, 2013; Sermsai & Vongmahasetha, 2021), accentuating the importance of this study's goal to construct a comprehensive causal model of logistics management within Thailand's automotive and auto parts industries. Such a model aims to give management actionable insights to enhance decision-making processes. In the context of global trends, where logistical strategies must evolve beyond traditional cost considerations to address digital transformation, sustainability, and market volatility, adept logistics becomes paramount. These strategies enhance operational efficacy and profitability while opening new market opportunities, thus emphasizing the potential of logistics management to elevate company performance across various dimensions. This multifaceted approach is particularly critical as the automotive industry navigates through rapid technological changes and intense global competition.

Research objectives

The research seeks to achieve the following objectives: (1) to investigate and analyze the factors influencing logistics management within Thailand's automotive and auto parts industries; (2) to thoroughly examine the causal relationships inherent in the logistics management processes specific to these sectors; and (3) to develop and propose a comprehensive causal model that delineates the complex dynamics of logistics management in Thailand's automotive and auto parts industries. This model aims to provide a detailed understanding of the interplay of various factors, enhancing insights for effective management strategies.

Literature review

Business Process Management: BPM

The integration concept is a cornerstone for enhancing business workflows, enabling seamless connectivity and efficient collaboration. Effective business process management has engendered the notion of shared services, wherein businesses collectively utilize desired services to improve teamwork and efficiency (Permpoon, 2015). This concept, as applied, necessitates restructuring the data warehouse into a functional system database (Shevchenko, 2017). Consequently, business process management (BPM) emerges as a comprehensive methodology and framework, leveraging technology to support strategic planning and governance and ensure the consistent orchestration of organizational processes. The operational paradigm entails continuous compilation and integration of requirements, involving understanding, documenting, designing, analyzing, modeling, implementing, and monitoring business processes (Badakhshan et al., 2020; Dumas et al., 2013; Gunasekaran, 2017; Malinova & Mendling, 2018; McCoy, 2011; Van et al., 2003; Vom & Rosemann, 2015; Weske, 2012).

BPM epitomizes an organizational approach that emphasizes the intricate processes employed in designing, analyzing, and enhancing business workflows to augment organizational efficiency. This strategic orientation emphasizes continuous evolution rather than one-time process alterations, leveraging an array of methodologies and technologies to catalyze transformative changes in business processes. Such an approach fosters h leveraging various eightened employee engagement, which serves to enhance the efficacy and effectiveness of business operations, thereby propelling organizational success through a process-oriented paradigm (Kafetzopoulos et al., 2015; Salam et al., 2017; Pradabwong et al., 2015; Pradabwong et al., 2017; Kim & Sunyoung, 2020). BPM represents an accepted paradigm of organizational design

that drives organizational success (Kohlbacher & Reijers, 2013). Therefore, BPM, involving the execution of processes, has garnered sustained attention from academia and industry practitioners (Dumas et al., 2013). Furthermore, the field of BPM offers many comprehensive methods and tools catering to every stage of the business process management lifecycle (Recker & Mendling, 2016; Aalst, 2013).

This research conducted a comprehensive literature review to synthesize existing knowledge and guide the exploration of how Business Process Management (BPM) influences Supply Chain Management (SCM) and Logistics Management in the Automotive industry (LMA). This synthesis elucidates the interrelationships among the variables studied, facilitating the formulation of research hypotheses. BPM, SCM, and LMA are presented as interrelated and consistent management variables that collectively enhance the efficiency of processes and activities within the automo presented tive industry. These management strategies leverage information technology to efficiently transfer raw materials, goods, or services along the supply chain, minimizing costs and aligning delivery schedules with production needs (Office of the National Economic and Social Development Board, 2016; Sorat, 2007). However, existing research, including studies by Mubeyyen et al. (2015), Pradabwong et al. (2017), Bhattacharya (2014), Hong et al. (2017), and Mangla et al. (2016), indicates that BPM not only impacts logistics management but also serves as a causal factor in SCM within the automotive industry. The study tests the hypotheses H_1 and H_2, which encapsulate this interaction.

Knowledge Management Capability: KMC

In contemporary management theory, recognizing organizational personnel as critical human resources underscores their integral role in shaping the organization's future success. This perspective posits that the organization's most significant assets are its human resources, emphasizing the intrinsic value of the workforce. However, emerging discourse suggests a paradigm shift towards the primacy of organizational and individual knowledge as the cornerstone of organizational excellence. This shift indicates that, since the 1990s, there has been a growing focus on knowledge over individual contributions (Niphonpittaya, 2018; Khomchunsri & Dokthaisong, 2019). The evolution of Knowledge Management Capability (KMC) stresses this transition, highlighting its burgeoning importance in modern management and leadership research. The academic and practitioner consensus suggests that KMC represents a collaborative and integrated methodology enabling organizations to generate, organize, access, and leverage intellectual assets toward achieving long-term sustainability and strategic differentiation. The global integration of Knowledge Management (KM) practices underlines the criticality of KMC in organizational strategy, with core tenets encompassing learning, knowledge creation, and cultural adaptation. These principles facilitate organizational adaptability, the cultivation of specialized competencies, and the strategic application and assessment of knowledge.

According to Martins et al. (2019), the cross-sectoral and intergroup sharing of knowledge within organizations can catalyze profit generation, highlighting the significance of effective information management and learning processes within organizational contexts, as evidenced by research from Kafetzopoulos et al. (2015). The strategic management of human resources and the utilization of information and communication technologies, plays play a pivotal role in enhancing logistics management efficiency (Evangelista, & Durst, 2015). In "Industry 4.0", knowledge sources emerge as paramount for sustaining competitive advantage and fostering success (Karia, 2018). Despite the recognized importance of KMC in logistics management, its application remains underexplored, presenting a critical avenue for leveraging KMC techniques as a contemporary management approach that transforms resources into competencies and influences logistics management outcomes (Schniederjans et al., 2020).

This comprehensive framework systematizes knowledge management within organizations and establishes a foundational strategy for achieving operational excellence and innovation in the highly competitive and dynamic global marketplace. The research examines the consistency of relationship patterns and the causal impact of organizational knowledge management on supply chain and logistics management. Effective management of these relationships enhances strategic management, facilitating the development of commercial and

sustainable logistics activities. This creates a network that links efficient supply chain performance from upstream to downstream, fostering improved logistical outcomes (Phromngam & Aisanon, 2021). The framework of hypotheses H_3 and H_4 explores this conceptualization, highlighting the integral role of knowledge management in optimizing supply chain dynamics.

Government Policy: GP

Globally, governments increasingly recognize the pivotal role of logistics and supply chain management as essential components of national and international economic systems. The intersection of government, governance, and regulation plays a crucial role in shaping the efficiency and effectiveness of logistics management (Shakya, 2012). Through formulating and implementing policies, governments endeavor to enhance the operational efficiency of logistics and supply chain management. These policies are expressed through guidelines, activities, and actions designed to optimize the delivery of public services across various sectors (Hanh, 2021). Moreover, the strategic deployment of public policy emerges as a critical instrument in governmental administration, as it encompasses the development of projects and processes designed to achieve specific objectives. These initiatives systematic methodologies aligned with the real-world conditions and the diverse needs of the population in different regions. Chamaram (2016) points out the significance of public policy in steering governmental actions toward attaining desired outcomes, which are feasible within the socio-economic context of society.

Recent studies, such as those by Zhang et al. (2021), have explored the determinants of innovative work behavior, highlighting government support as a pivotal catalyst. This underscores the necessity for inclusive stakeholder engagement in policy-making, especially in sectors crucial to national and global logistics performance. Empirical findings indicate that the enhancement of essential resources, including infrastructure, technology, labor, and education, significantly boosts the efficiency of logistics management within organizations (Wong & Tang, 2018). Additionally, governmental policies profoundly influence the automotive industry, exemplified by vehicle and parts production. For instance, the Automotive Institute under the Ministry of Industry has crafted a strategic plan to drive the Thai automotive industry towards sustainable growth, considering evolving environmental pressures. This scenario illustrates how government policies, strategic resource allocation, and industry-specific initiatives are intricately linked to advancing global logistics and supply chain management. Moreover, the coherence between governmental policy, supply chain management, and logistics management in the automotive and parts industries supports enhancing processes and activities. Legislative and regulatory policies enacted by the government also play a crucial role in shaping supply chain and logistics management practices (Sareekam et al., 2020). This interrelationship is further explored within the framework of hypotheses H_5 and H_6.

Supply Chain Management: SCM

Supply chain management (SCM) is integral to businesses' operational efficacy and agility, enabling them to meet customer demands promptly and efficiently. SCM has emerged as a critical field of study, attracting public and private sectors' attention due to its potential to significantly enhance organizational efficiency and competitiveness in the contemporary business landscape. Applying SCM principles is pivotal for organizations aiming to maximize profitability, as it facilitates Economic Value Added (EVA) through cost reductions across all organizational systems, minimization of both tangible and intangible assets, enhancement of revenue, and optimization of customer satisfaction levels. This is equally applicable to non-profit organizations, where SCM practices can substantially improve in developmental processes and the quality of organizational outputs.

In today's competitive environment, companies strive for cost reduction, service level enhancement, and value creation within their supply chains. Achieving these objectives necessitates the establishment of cooperative relationships with partners (Aharonovitz et al., 2018). SCM encompasses a comprehensive integration of activities to refine the supply chain's procurement, sourcing, transportation, and coordination processes. According to Utami et al. (2019), these practices involve a holistic approach to managing the procurement of raw materials and other resources, underlining the importance of

synchronization and collaboration among supply chain entities. Saragih et al. (2020) propose guidelines for effective SCM, emphasizing the significance of collaboration with key supply chain members and capitalizing on their specialized knowledge and expertise. Such strategic alliances are instrumental in producing a sustainable competitive advantage through SCM practices. Furthermore, empirical research has explored the direct impacts of SCM practices on operational capabilities and, consequently, on the operational outcomes of companies, particularly in logistics management.

Supply chain management (SCM) is the comprehensive coordination and integration of activities ranging from sourcing and procurement to conversion and logistics management. This discipline encompasses a broad perspective that includes strategic sourcing, supplier relationship management, and coordinating activities extending from raw materials to delivering finished products to end customers. SCM entails integrating all business units from upstream to downstream, linking suppliers to consumers. In contrast, logistics management is concerned explicitly with supporting transportation activities, warehouse management, data management, and the efficient distribution of products to customers, particularly ensuring timeliness and accurate placement (Wattanaphuti et al., 2020). Research in the field, including studies by Muntaka et al. (2017), Aharonovitz et al. (2018), and Chandak et. al. (2019), has demonstrated that variables within SCM significantly influence logistics management, including within the automotive industry. The framework of hypothesis H_5 explores these interactions, highlighting the critical interdependencies between SCM and logistics practices.

Logistics Management of Automotive and Automotive Parts: LMA

Logistics management is a subset of supply chain management, specifically focusing on the physical movement and storage of goods. On the other hand, supply chain management is a broader concept encompassing logistics management and other key areas to ensure the entire supply chain operates efficiently and effectively. In a highly competitive business environment, formulating strategic guidelines for logistics management is imperative to ensure efficient production processes and realize sustainable profits. According to Khan and Yu (2021), industrial operators must evolve their organizational structures and processes to augment their business operations' potential for stability and progressiveness. A critical component of this organizational development is the enhancement of logistics efficiency, which serves as a comprehensive measure encompassing various business activities including cost management, time management, and the achievement of customer satisfaction through timely order responses, reductions in operating costs, and improved inventory turnover rates (Thai Federation on Logistics, 2019). Logistics management is the process of planning, implementing, and controlling the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption to meet customer requirements. It involves activities such as transportation, warehousing, inventory management, order processing, and distribution.

In sectors such as the automotive industry, entrepreneurs meticulously assess logistics costs derived from many activities integral to the logistics management process. The objective is to minimize the aggregate costs associated with logistics activities rather than focusing on individual activities in isolation. These costs emanate from both primary and auxiliary logistics activities. The importance of efficient logistics management is highlighted by instances such as the shortage of spare parts in the automotive supply chain, caused by natural disasters like the tsunami in Japan or the floods in Thailand in 2011. These events highlight the necessity for designing, managing, and enhancing logistics systems that are efficient and resilient enough to withstand various contingencies. Moreover, the importance of rapid response mechanisms is acknowledged, albeit with an emphasis on formulating comprehensive logistics management strategies that proactively mitigate the risks of unforeseen critical issues (Chimjiw, 2021).

The evaluation of logistics management efficacy employs diverse methodologies tailored to each organization's specific requirements. As an easily measurable and quantifiable indicator, operational performance includes quantitative metrics, such as percentages and qualitative assessments (Lamanee et al., 2020). Thus, optimal logistics management is instrumental in enhancing the efficiency and

effectiveness of logistics processes and supply chain management practices, culminating in reducing processing times across various stages of the production cycle. Empirical research supports this assertion by examining the direct impacts of operational management practices on logistics management outcomes. The strategic integration of these aspects facilitates a streamlined logistics framework that not only meets the immediate needs of the automotive industry but also ensures its long-term sustainability and competitive edge.

Nevertheless, four key factors influence logistics management within the automotive and automotive parts industries, illuminating the logistics management approach adopted in Thailand's automotive and automotive parts sector. These factors form the foundation for formulating research hypotheses, shaping the conceptual framework depicted in Figure 1.

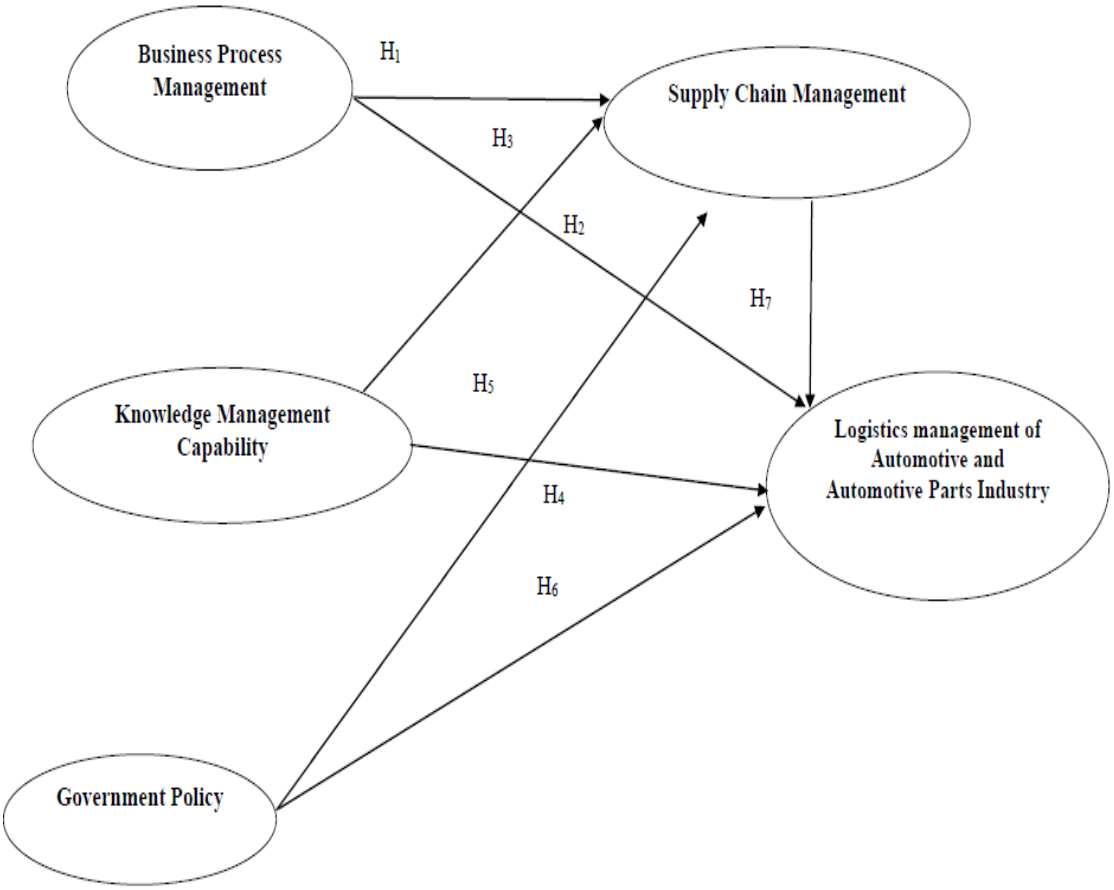

Figure 1 Causal model in logistics management of the automotive and automotive parts industry in Thailand

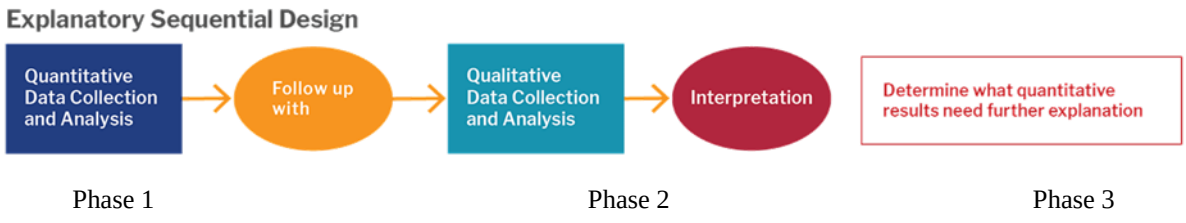

Figure 2 Explanatory sequential design

Research design

To ensure a thorough exploration of logistics management within Thailand's automotive and automotive parts industry, the study will implement various research methods, this study strategically adopted an explanatory sequential mixed-methods research design (Creswell & Clark, 2018; Klangphahon, 2020; Ngamvichaikit, 2015). By integrating quantitative and qualitative methodologies, this approach enabled a robust examination of the complex interplay of factors impacting logistics operations. The quantitative phase, which included structured surveys and statistical analysis, built a strong base of real-world data by figuring out the numbers behind the relationships and starting points for trends in many areas of logistics management. Subsequently, through focused discussions and interviews, the qualitative phase nriched this data by adding contextual depth and insights into the nuances that numbers alone could not fully capture. This methodological collaboration facilitated a more comprehensive understanding of the underlying dynamics and enhanced the study's ability to address the research objectives effectively. By leveraging both numeric evidence and detailed narrative accounts, the mixed methods approach significantly deepened the analysis, allowing for a more informed discussion and nuanced interpretation of how logistic strategies can be optimized in the automotive sector to meet both current challenges and future demands. This multifaceted approach ensures that findings are both statistically valid and pragmatically relevant, providing actionable insights that can benefit educational establishments and (Almalki, 2016). The research design consisted of three phases.

Phase 1 began with a thorough literature review on logistics management to establish a theoretical foundation, as shown in Figure 2. Quantitative research ensued, involving collecting and analyzing data to assess the consistency of various variables. The Confirmatory Factor Analysis (CFA) method validated the measurement model, and the Structural Equation Modeling (SEM) approach was applied to analyze the relationships within the conceptual framework.

Phase 2 transitioned into qualitative research, employing the Focus Group Discussion (FGD) method. This phase leveraged findings from the quantitative analysis to delineate the scope for qualitative data collection. The FGD served as a platform for collaborative brainstorming, facilitating the exchange of opinions and drawing conclusions based on pertinent information. This qualitative inquiry aimed to enhance clarity and accuracy through content analysis (Howard & Bruce, 2017), ultimately contributing to the validation of a logistics management model specific to Thailand's automotive sector.

Phase 3 integrated the insights gained from study's the quantitative and qualitative strands through a mixed-methods approach. This final phase involved a comprehensive summary and interpretation of the findings from both research streams. We summarized and interpreted the quantitative research results and then proceeded with a similar process for the qualitative findings. The study then discussed how qualitative insights could elucidate and enrich the understanding of quantitative data, facilitating a merged interpretation that leveraged the strengths of both methodological approaches. This integrative analysis aimed to provide a nuanced understanding of logistics management practices within Thailand's automotive and parts industry, thereby contributing to the field's body of knowledge by bridging quantitative analysis with qualitative insights.

Research population and sample

The study divided the population into two groups, with 19 companies involved in automobile production and assembly within the country (Thailand Automotive Institute, 2023). Furthermore, the study included a population of automotive parts manufacturers in Thailand, spanning Tier 1 to Tier 3, totaling 664 companies, according to data from the Parts Manufacturers Association of Thailand (Thai Automotive Parts Manufacturers Association, 2023). The association's selection of parts manufacturing companies was deliberate, given their direct involvement in logistics management processes within the automotive and automotive parts industries (Jaroenchai, 2017). This approach aligned with the methodology outlined by Hair et al. (2014) and adhered to statistical guidelines recommending a sample size 20 times the number of observable variables. Given 18 observable variables in this research, the sample consisted of 360 companies.

Identifying population and sample

The sampling strategy in the quantitative phase of the research was meticulously designed to ensure representative data collection across Thailand's automotive and automotive parts industries. Drawing on Etikan's (2017) guidelines, the study adopted a stratified random sampling approach, which is particularly effective for heterogeneous populations. This technique involves dividing the population into more homogeneous subgroups known as strata based on shared attributes or characteristics pertinent to the research question. In this case, the researchers defined the participants' roles within the industry, categorizing them into Original Equipment Manufacturers (OEM)/Assemblers and different tiers of auto parts manufacturers. This stratification was crucial to ensure that the researchers proportionately represented each segment of the industry, facilitating a more precise analysis of logistics management practices across different levels of the supply chain.

The sample size and composition were determined using probability proportionate to size sampling. This method enhances the accuracy of the sample by adjusting the size of each stratum based on its representation in the population. The researchers allocated specific numbers to different categories within the industry: nine OEMs/assemblers and 153, 232, and 279 companies from Tiers 1 to 3, respectively. This allocation was executed via computer command, which ensured a random and unbiased selection of participants and facilitated a proportional representation of each stratum. Three hundred sixty companies participated, with one representative from each—from business owners to logistics managers—providing a comprehensive cross-section of insights into logistics management practices. This approach not only adhered to rigorous statistical standards but also provided a solid foundation for analyzing the complex dynamics of logistics management within the sector, ensuring that the findings are robust and industry-wide trends.

Moreover, we obtained a qualitative sample group from executives or individuals in logistics management roles within Thailand's automotive and automotive parts manufacturing companies. This group included 10 experts with experience in logistics management, selected through purposive sampling. erience as consultants for government projects related to logistics management or problem-solving experience in establishments. This subgroup comprised three individuals skilled in addressing logistics management-related issues. The researchers divided the experts into two representatives from automobile manufacturers and assemblers, five representatives from automotive parts production groups (Tier 1-3), and academics, government officials, and individuals with at least three years of exp

Research instrument

The study employed questionnaires in the quantitative phase to measure various variables on a 5-point Likert scale (Likert, 1972; Vanichbuncha, 2011). The content of the questions was verified for accuracy through the calculation of the Item Objective Congruence (IOC) by five experts—including a senior manager from an automobile assembly and parts manufacturing company and assistant professors specializing in logistics management—resulting in a consistency index ranging from 0.60 to 1.00 (Tellez et al., 2015). Additionally, a pilot test involving 30 companies from the Thai automotive and parts industry, similar in composition to the main research sample, evaluated the reliability of the questionnaire. The reliability assessment involved calculating Cronbach's Alpha Coefficient (Cronbach, 1990), which yielded an exceptionally high-reliability value of 0.993. Furthermore, the Corrected Item-Total Correlation was analyzed, with each item showing a correlation coefficient exceeding 0.3, indicating robust item consistency (Sekaran, 2003; Vanichbuncha, 2013).

For the qualitative component, we used a focus group data recording form and an open-ended group discussion method to explore Thailand's logistics management model of the automotive and automotive parts industry. This form encompassed questions about the appropriateness of the causal model, along with provisions for ongoing queries and space for noting important messages. The discussion fostered an environment conducive to free exchange among focus group participants, guided by the principle of information provider willingness, allowing for unfettered explanation and question exchange among participants. The triangulation method ensured accuracy validation.

Data analysis

The data analysis encompassed descriptive statistics, including percentage, mean, and standard deviation, and structural equation modeling (SEM). Confirmatory Factor Analysis (CFA) was employed to test hypotheses regarding the structure of the components. Structural Equation Modeling (SEM) was conducted using the LISREL program, with model consistency evaluated based on several criteria, including $\chi 2$, $\chi 2/DF$, *GFI, AGFI, NFI, IFI, CFI, CN, RMR, and RMSEA*. These criteria were drawn from established literature and methodological guidelines (Hair et al., 2019; Kline, 2010; Vanichbuncha, 2013; Wiratchai, 2005; Byrne, 2010; Schumacker & Lomax, 2010).

Results and discussion

Quantitative findings

The researchers utilized Confirmatory Factor Analysis (CFA) to evaluate the coherence between the theoretical causal relationship model and the observed empirical data within the context of logistics management in Thailand's automotive and automotive parts industries. This analysis employed structural equation modeling to rigorously examine and refine the linear relationship model, ensuring it accurately represented the theoretical concepts under investigation, as advocated by Hair et al. (2019). The outcomes of this analysis, which detail the causal influences of logistics management factors as per the hypothesized model, are summarized in Table 1.

Analyzing causal influences through structural equation modeling provides insights into the factors impacting operations within Thailand's automotive and automotive parts industries. This approach assesses the alignment between theoretical frameworks and empirical data, employing methodologies suggested by Suksawang (2013), Diamantopoulos & Siguaw (2000), and Schumacker & Lomax (2010). Table 2 systematically presents the detailed findings, illustrating the direct, indirect, and cumulative influences among each latent variable, explicitly addressing the research objectives outlined in the study. This methodological rigor ensures a comprehensive understanding of the dynamics influencing industry operations.

The data analysis presented in Table 2 elucidates the influence of both external and internal latent variables on logistics management in Thailand's automotive and automotive parts industries. The researchers identified five critical variables as significant influencers: Business Process Management (BPM), Knowledge Management Capability (KMC), Government Policy (GP), Supply Chain Management Guidelines (SCM), and Logistics Management in the Automotive and Automotive Parts Industries (LMA). These variables are ranked based on the aggregate of their impacts, from most to least significant. The analysis highlights that Business Process Management and Government Policy factors exert direct and indirect effects, while Knowledge Management Capability also impacts through direct and indirect routes. Conversely, Supply Chain Management Guidelines primarily influence direct effects without significant indirect contributions. This assessment provides a comprehensive understanding of how various elements contribute to logistics management efficacy in the sector.

The decision coefficient (R^2) for the factors related to the supply chain management approach was 90%, indicating a high level of explained variance within the model. In comparison, the factors related to logistics management in the automotive and auto parts industry group had an even higher level of explained variance at 98%. These findings contribute to developing new models and insights into causal modeling in logistics management that are specific to Thailand's automotive and automotive parts industries. Hypothesis testing further supported the model's validity.

The researchers formulated seven hypotheses to investigate the influences affecting logistics management in this sector. The presentation of the hypothesis testing results, grounded in the structural equation conceptual framework, addressed the first research objective: to study the impact of various factors on logistics management in Thailand's automotive and automotive parts industries. The empirical data corroborated the causal model derived from structural equations, indicating a consistent fit. Hypothesis testing revealed that the outcomes supported the proposed hypotheses, with t-values exceeding the threshold of 1.96, aligning with the criteria set by Hair et al. (2019). This fulfillment of the specified criteria demonstrates the robustness of the causal relationships analyzed within the second research objective, which focused on

delineating causal relationships in logistics management in Thailand's automotive and automotive parts industries. These discussions and analyses indicate the intricate interplay of various factors influencing logistics management and offer a nuanced understanding of the dynamics within this critical sector.

Table 1 The goodness-of-fit statistics of the relationship model

Goodness of Fit Statistics	Criterion	Hypothesized model	Modified model
χ^2		192.31	118.52
Df		125	98
p value of χ^2	> 0.05	0.00010	0.07761
GFI (Goodness of Fite Index)	> 0.90	0.944	0.966
AGFI (Adjusted Goodness of Fite Index)	> 0.90	0.923	0.941
NFI (Normed Fit Index)	> 0.90	0.963	0.977
NNFI (Non Normed Fit Index)	> 0.90	0.983	0.994
CFI (Comparative Fit Index)	> 0.90	0.986	0.996
IFI (Increasmental Fit Index)	> 0.90	0.987	0.996
RFI (Ralative Fit Index)	> 0.90	0.954	0.964
RMSEA (Root Mean Square Error Approximation)	≤ 0.05	0.0387	0.0242
RMR (Root Mean Square Residual)	< 0.05	0.00365	0.00267
Standardized RMR		0.00917	0.00662
CN	≥ 200	308.450	405.307

Table 2 The direct effects, indirect effects, and total effects

Factor		SCM			LMA		
		DE	**IE**	**TE**	**DE**	**IE**	**TE**
Business Process Management: BPM	Factor Loading	0.50	-	0.50	0.26	0.16	0.42
	SE.	0.169	-	0.169	0.131	0.092	0.137
	t-Value	2.964**	-	2.964**	1.972*	1.829	3.116**
Knowledge Management Capability: KMC	Factor Loading	0.25	-	0.25	0.21	0.08	0.29
	SE.	0.124	-	0.124	0.088	0.057	0.104
	t-Value	2.021*	-	2.021**	2.412**	1.473*	2.870**
Government Policy: GP	Factor Loading	0.26	-	0.26	0.21	0.08	0.30
	SE.	0.121	-	0.121	0.093	0.052	0.101
	t-Value	2.170*	-	2.170*	2.336*	1.679	3.037**
Supply chain Management: SCM	Factor Loading	-	-		0.33	-	0.33
	SE.	-	-		0.145	-	0.145
	t-Value	-	-		2.321**	-	2.321**
R^2			0.90			0.98	

Note: DE = Direct Effect, IE = Indirect Effect and TE = Total Effect

Hypothesis H_7 posits a significant relationship between Supply Chain Management (SCM) and Logistics Management within the automotive and automotive parts industries, indicating that these two variables are integrally linked and synergistically contribute to enhancing process and activity efficiency. This hypothesis underscores SCM as an evolutionary extension of logistics management, offering a more encompassing interpretation emphasizing the integration of activities and processes across the entire supply chain-from upstream to downstream. Central to this integration is logistics activities, including the movement, collection, management, and distribution of

goods, which serve as pivotal drivers for efficient management (Lamanee et al., 2020).

This conceptualization agrees with empirical findings that advocate for a comprehensive examination of the causal relationship model between SCM and logistics management within the automotive sector. The empirical data support the notion that the supply chain is meticulously orchestrated from the procurement of raw materials to the delivery of finished products, encompassing all stages from upstream to downstream (Aharonovitz et al., 2018; Barber et al., 2018; Chandak & Dalpati, 2019; Dubey et al., 2015; Hadrawi, 2019; Jindal et al., 2015; Lii, 2016; Muntaka et al., 2017; Puška et al., 2019; Prajogo & Olhager, 2016; Rajaguru & Margaret, 2019; Salam & Seny, 2017; Saragih et al., 2020; Utami et al., 2019).

Leveraging this comprehensive analysis, the researcher utilizes the gathered insights as foundational support for constructing of a causal model in logistics management tailored to companies within Thailand's automotive and automotive parts sectors. This model employs operational outcomes as key indicators, intricately weaving together findings from qualitative research methodologies. The proposed causal model aims to encapsulate the intricate dynamics between SCM and logistics management, elucidating how their effective coordination can significantly elevate firms' operational efficiency and competitive edge within this pivotal industry. This approach contributes to the theoretical landscape and offers practical insights for enhancing the strategic implementation of SCM and logistics in the automotive sector.

Qualitative findings

The qualitative analysis revealed a consensus among focus group participants regarding a causal relationship between five key factors influencing logistics management in Thailand's automotive and automotive parts industries. These factors include business process management (BPM), knowledge management capability (KMC), government policy (GP), supply chain management (SCM), and logistics management, which are specific to the automotive and automotive parts sectors. This unanimity among group discussion participants corroborates the findings from quantitative research, which also identified these five components as critical to understanding the logistics management landscape within the industry.

Experts and professionals within the field concur that the variables identified in the study accurately reflect real-world dynamics and are pivotal in assessing the logistics management capabilities of businesses operating within this sector. This alignment between the qualitative insights and the quantitative data underscores the relevance and applicability of the selected variables to the industry's operational context. Furthermore, the agreement among industry experts validates the research methodology and the theoretical framework underpinning the study, suggesting that these components are integral to a comprehensive evaluation of logistics management efficiency.

The high level of agreement on the measurement outcomes of these components, deemed normal in social science research, indicates a robust theoretical and empirical foundation for the study. This congruence between theory and practice enhances the validity of the research findings, offering valuable insights into the multifaceted nature of logistics management in the automotive and automotive parts industries. Effective logistics management within this sector is contingent upon a synergistic interaction among BPM, KMC, GP, SCM, and logistics management, providing a comprehensive framework for businesses aiming to optimize their logistics and supply chain operations.

The triangulation of the findings

The triangulation of findings achieved through integrating quantitative and qualitative research methodologies provides a comprehensive analysis of factors affecting logistics management within Thailand's automotive and automotive parts industries. This approach validates theoretical constructs and hypotheses by identifying patterns and consistencies across diverse data sets.

Quantitative analysis delineated the significant influence of Business Process Management (BPM), Knowledge Management Capability (KMC), Supply Chain Management (SCM), and Government Policy (GP) on logistics management. The effects of these factors, both direct and, where applicable, indirect, were confirmed through a structured causal model. Statistical indices substantiated the model's fit: $\chi 2 = 118.52$, df = 98, $\chi 2/df = 1.20$, P-Value = 0.077, CFI = 0.996, GFI =

0.966, AGFI = 0.941, RMR = 0.000267, RMSEA = 0.024, indicating a high level of consistency with empirical data. Qualitative findings complemented this analysis, highlighting the interconnectedness and mutual reinforcement among the identified factors. Participants concurred that BPM, KMC, GP, and SCM collectively underpin the efficiency and effectiveness of logistics management in the sector. This qualitative consensus underscores the practical applicability of the causal model developed from quantitative data, suggesting that the model not only aligns with theoretical expectations but also reflects the operational realities of the industry.

The convergence of quantitative and qualitative findings affirms the robustness of the research outcomes. Experts and specialists in the field validate that both strands of research—quantitative variables and qualitative insights align, reinforcing each other and providing a multidimensional understanding of logistics management dynamics. This collaboration between different research modalities enhances the credibility and applicability of the study, offering a nuanced perspective that can inform both theoretical exploration and practical application in logistics management within Thailand's automotive and automotive parts industries.

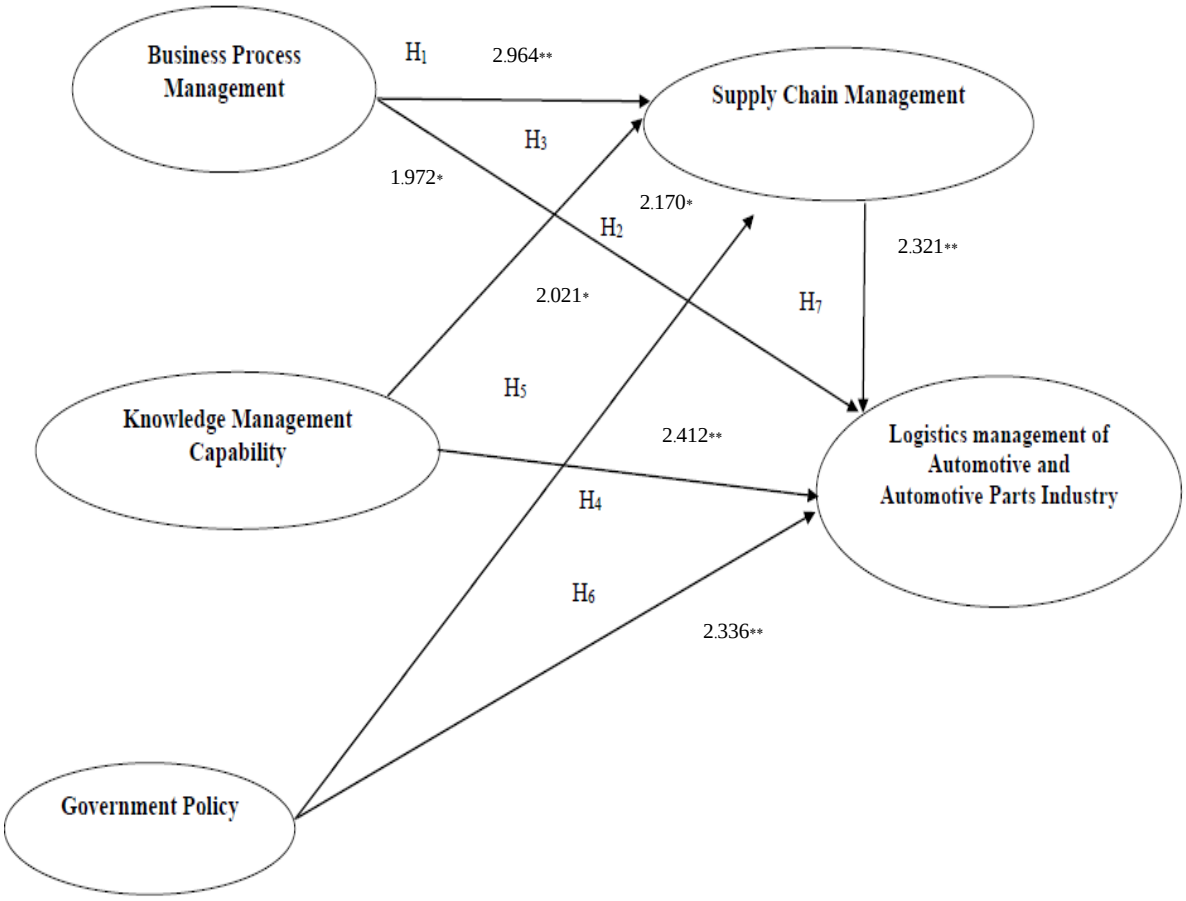

Figure 3 Results of the causal models

Note: * means statistically significant at the 0.01 level ($p < 0.01$)

** means statistically significant at the 0.01 level ($p < 0.05$)

Conclusions

The third research objective aimed to construct a comprehensive causal model for logistics management within Thailand's automotive and automotive parts industries, drawing on the conceptual frameworks and empirical findings from a wide array of studies, including Pradabwong et al. (2017), Chen (2018), Hong et al. (2017), Jimenez et al. (2019), Schniederjans et al.

(2020), Mangla et al. (2016), Zhang and Yang (2021), Onsel et al. (2019), Kohn et al. (2011), Salam et al. (2017), Munim and Schramm (2018), Utami et al. (2019), Aharonovitz et al. (2018), Hadrawi (2019), and Saragih et al. (2020). Integrating insights from these diverse sources allows for a comprehensive understanding of the research topic, the study develops a new conceptual framework that identifies Business Process Management (BPM), Knowledge Management Capability (KMC), Government Policy (GP), and Supply Chain Management (SCM) as pivotal factors influencing logistics management. This framework encapsulates the essence of the identified factors and undergoes rigorous hypothesis testing to validate its applicability and effectiveness in enhancing logistics management practices within the specified industry context. The results, affirming the interplay among these factors, contribute novel insights into optimizing logistics operations, thereby offering a valuable reference for industry practitioners and policymakers to elevate the sector's competitiveness and efficiency in Thailand, as seen in Figure 3.

The analysis of causal relationship models within the logistics management domain of the automotive and automotive parts industries reveals a nuanced interplay of factors exerting both direct and indirect effects on logistics management outcomes. This investigation identifies four pivotal factors Business Process Management (BPM), Knowledge Management Capability (KMC), Government Policy (GP), and Supply Chain Management (SCM) each contributing positively to the logistics management process in varying magnitudes:

1. **Business Process Management (BPM)** emerges as a significant determinant, exhibiting a total influence of 0.42 on logistics management outcomes. This encompasses a direct positive influence of 0.26 and an indirect influence mediated by SCM of 0.16, underscoring BPM's integral role in enhancing logistics efficiency through both intrinsic processes and external SCM interactions.

2. **Knowledge Management Capability (KMC)**, with a total impact of 0.29, reflects a direct positive contribution of 0.21 alongside an indirect influence of 0.08 via SCM practices. This highlights the essential function of KMC in bolstering logistics management through strategically harnessing knowledge and information within the supply chain.

3. **Government Policy (GP)** is identified as having a secondary yet impactful influence, totaling 0.30, with direct and indirect contributions of 0.21 and 0.08, respectively. This underscores the regulatory and facilitative role of government policies in shaping logistics management practices through direct interventions and the modulation of SCM practices.

4. **Supply Chain Management Practices (SCM)** directly influence logistics management outcomes with a magnitude of 0.33, highlighting the foundational role of SCM in orchestrating logistics operations.

The hierarchical order of influence from the greatest to the least-BPM, KMC, SCM, and GP-reflects how these factors impact logistics management within the automotive sector. Notably, BPM, KMC, and GP influence both directly and indirectly through SCM, as evidenced by decision coefficients (R2) of 90% for SCM and 98% for logistics management outcomes. This comprehensive analysis culminates in developing a novel causal model for logistics management in Thailand's automotive and automotive parts industries, advancing the theoretical and practical understanding of the dynamics at play. This model not only delineates the specific contributions of each factor but also illustrates the intricate relationships that collectively define logistics management efficiency in this critical sector.

Suggestions

1) This study has developed logistics management knowledge for companies in Thailand's automotive and auto parts industries. The study results found a new element with Confirmatory Factor Analysis (CFA). The study's findings uncovered a new element that is an appropriate indicator of logistics management in the automotive and automotive parts industries. There are 5 components: 1) Business Process Management (BPM) 2) Knowledge Management Capability (KMC) 3) Government Policy (GP) 4) Supply Chain Management (SCM); and 5) Logistics Management of Automotive and Automotive Parts (LMA). The researchers found knowledge management ability was found to be important. Knowledge Storage is the arrangement of agencies responsible for collecting information on logistics management. The research yielded an average value of 4.26, the highest of all components.-A system that links and and continuously updates information often characterizes effective logistics management. This

can effectively improve logistics processes and decisions. Automated data reporting and analysis Effective use of technology must be flexible to improve and add various capabilities according to business needs.

2) The causal model for logistics management in Thailand's automotive and automotive parts industries was developed based on a comprehensive literature review and subsequent empirical validation. This model effectively captures the intricacies of a crucial midstream sector within the global supply chain, comprising companies that manufacture vehicles and auto parts. The research findings demonstrate alignment with the empirical data collected from these companies. For a more robust analysis, comparisons could be made with the upstream industry, industries involved in the manufacturing and services of machinery, mechanical tools, equipment, molds, instruments, and grippers. The encompassing producers and suppliers of essential raw materials such as steel, plastics, rubber, electronics, and glass, as well as textiles, leather, chemicals, petrochemicals, paints, and plating. Additionally, the downstream industries should be considered, encompassing support service industry, particularly those providing delivery, sales, after-sales services, financial services, insurance, testing, and specialized consulting, also plays a vital role in the broader automotive ecosystem, contributing to a holistic understanding of the sector's logistics management dynamics.

3) Recommendations for Implementation: This research elucidates several key factors influencing logistics management within the automotive and automotive parts industries, providing a nuanced understanding of their respective impacts and interrelationships:

1. Business Process Management (BPM) emerges as a critical determinant, with strategic alignment identified as the most influential pathway. We advise organizations to thoroughly align their vision, policies, and business strategies with their logistics management systems, ensuring coherence with the overarching strategic plan. This alignment should extend to integrating logistics strategies with broader business objectives, guaranteeing that logistics operations bolster the general strategic goals of the organization. A logistics management system designed to align with customer service objectives and subjected to regular audits can significantly enhance operational efficiency and customer satisfaction.

2. Supply Chain Management (SCM) is pivotal, as researchers identify supply chain integration and responsiveness as essential components. Effective supply chain management, underscored by integration and responsiveness, produces precision in managing supply chain operations. Industries are encouraged to foster collaboration across all supply chain sectors, grounded in mutual trust, encompassing procurement, agreements with manufacturers, transportation processes, and collective bargaining with material suppliers. This holistic approach optimizes inventory management and order processing, maximizing efficiency and customer value.

3. Knowledge Management Capability (KMC) is highlighted as influencing logistics management, with the acquisition and application of knowledge deemed crucial. Organizations should prioritize enhancing logistics management knowledge through continuous training and development programs, promoting a culture of learning that encompasses both internal and external knowledge sources. The emphasis on self-directed learning and adopting new technologies and resources can further enhance personnel's logistics management abilities.

4. Government Policy plays a significant role, albeit as a less dominant factor than the others. Nevertheless, government policies to support logistics management within the industry actively. This includes facilitating investment in logistics infrastructure and technology, and fostering the development of relevant skills among entrepreneurs. Government initiatives should create a conducive environment for logistical advancements, reflecting the importance of national, ASEAN, and global competitiveness.

5. Logistics Management of Automotive and Automotive Parts is critical, with purchasing practices particularly influential. Companies should implement robust policies for raw material procurement that emphasize supplier selection standards, foster strong supplier relationships, and utilize information technology, such as Enterprise Resource Planning (ERP) systems, for enhanced efficiency. Implementing tracking and

notification systems can further streamline the logistics process, ensuring timely and accurate delivery of products.

In summary, this research offers a comprehensive analysis of the management factors in the automotive and automotive parts industries, suggesting strategic alignment, supply chain integration, knowledge management, governmental support, and effective purchasing practices as key areas for development. Organizations can significantly improve their logistics operations by addressing these areas, contributing to overall business success and customer satisfaction.

4) Future research should explore several avenues to elucidate further the dynamics of logistics management in Thailand's automotive and automotive parts industry. Firstly, it is crucial to investigate the indirect influences within causal modeling research, positioning this as the primary hypothesis to understand bettert he underlying mechanisms affecting logistics operations. Researchers should conduct a comparative causal analysis between companies in Thailand's automotive and auto parts industries and those in other ASEAN countries. This comparative study would highlight regional differences and similarities and potentially reveal unique strategic insights applicable across broader geographical contexts, thereby enriching the understanding of logistics management practices within the Southeast Asian automotive sector.

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