ORGANIZATIONAL CHALLENGES AND CAPABILITIES IN ENHANCING PRODUCTION EFFICIENCY: A CASE STUDY OF THAILAND'S CONTRACT MANUFACTURING INDUSTRY

Thamonwan Waengwan[1]
Boontharika Wongvanich[2*]

Received 14 June 2025
Revised 20 December 2025
Accepted 22 December 2025

Abstract

This article examines organizational challenges and capabilities in enhancing production efficiency within Thailand's contract manufacturing industry, using a case study research design focused on contract manufacturers in the electronics and automotive sectors. It also analyzes the role of government policies, particularly the Thailand 4.0 policy framework and the EEC initiative. The findings reveal that Thailand's contract manufacturing industry faces several critical challenges, including risks from heavy dependence on major customers and an imbalanced customer portfolio, the complexity of managing diverse and stringent quality standards, limited production line flexibility, difficulties integrating advanced technologies to meet the heterogeneous requirements of multiple clients, and constraints related to workforce skills and adaptive capabilities. The study further indicates that developing organizational capabilities across multiple dimensions – such as strategic customer portfolio management, flexible manufacturing processes, adaptive quality management systems, transformational leadership, and an organizational culture that promotes continuous learning and innovation – can significantly enhance production efficiency and competitiveness. Evidence from the case study of Delta Electronics (Thailand) Public Company Limited shows that sustained investment in digital infrastructure, continuous workforce upskilling, and collaborative innovation with customers play a crucial role in strengthening organizational resilience and achieving long-term competitive sustainability.

Keywords: Organizational Challenges, Production Efficiency, Contract Manufacturing Industry

[1 2] Faculty of Business Administration, Rajamangala University of Technology Thanyaburi
Email: [1] thamonwan_wa@mail.rmutt.ac.th
[*] Corresponding author email: boontharika_w@rmutt.ac.th

Introduction

Contract manufacturing is a critical pillar of Thailand's economy, especially in the electronics and automotive sectors, which significantly contribute to export revenue and employment (Gereffi, 2019). In the context of Industry 4.0, contract manufacturers face increasing pressures from global competition, supply chain volatility, rapid technological change, and diverse quality and compliance requirements imposed by multiple customers – challenges that differ substantially from those of traditional manufacturing models (Teece, 2018). Although adopting digital technologies and Industry 4.0 principles is widely seen as a key mechanism for improving production efficiency, research indicates that technological investment alone is insufficient for sustainable organizational transformation without the concurrent development of organizational capabilities, a learning-oriented culture, and continuous workforce upskill (Bharadwaj et al., 2013; Hecklau et al., 2016). This limitation is especially evident in the contract manufacturing industry, where firms must manage risks related to dependence on multiple original equipment manufacturer (OEM) clients, comply with multiple quality management systems, and address constraints in production line flexibility (Psomas & Antony, 2017).

At the policy level, the Thai government has advanced the Thailand 4.0 strategy and the Eastern Economic Corridor (EEC) initiative to upgrade the national industrial structure toward innovation-driven, high-technology manufacturing supported by highly skilled human capital (National Economic and Social Development Council, 2024). Nevertheless, despite a clear and supportive policy framework, a notable knowledge gap remains regarding the internal organizational mechanisms that enable firms to build capabilities for coping with structural, technological, and market pressures, particularly concerning the interrelationships among organizational challenges, organizational capabilities, and production efficiency outcomes. Against this backdrop, the present study investigates the organizational challenges and capabilities that enhance production efficiency in Thailand's contract manufacturing industry. Specifically, the study analyzes the key challenges faced by contract manufacturers, examines organizational capabilities that facilitate effective responses to the demands of multiple customers operating under diverse standards, and explains the roles of digital technology integration, human capital development, and leadership in strengthening organizational efficiency and flexibility. Using a single-case study methodology, the research selects Delta Electronics (Thailand) Public Company Limited as the focal case due to its status as a global contract manufacturer with strong linkages to international OEM clients, its operation under multiple stringent quality standards, and its sustained investments in digital infrastructure, workforce skill development, and customer-oriented collaborative innovation within the Thailand 4.0 and EEC policy frameworks. The selection of this case enables an in-depth and systematic understanding of the dynamic interplay between organizational challenges and capabilities in Thailand's contract manufacturing industry, offering meaningful contributions to both academic scholarship and policy development.

Thailand's contract manufactures Industrial

Thailand's manufacturing base remains strong in two key industries: automotive and electronics. Automobile production in 2024 was reported at approximately 1.47 million units and is projected to increase to 1.50 million units by 2025, reflecting a strong export focus (Thailand Automotive Institute, 2024). Meanwhile, the Manufacturing Production Index (MPI) indicates relatively limited growth, averaging 0–1% year-on-year (YoY), due to cyclical pressures and the need to enhance efficiency and value addition in the contract manufacturing industry (Office of Industrial Economics, 2025; National Economic and Social Development Council, 2024).

National strategies such as Thailand 4.0 and the Eastern Economic Corridor (EEC) emphasize clearly targeted S-Curve industries and position contract manufacturers (CMs) as key mechanisms for technology transfer and workforce development (National Economic and Social Development Council, 2024). In particular, within Thailand's contract manufacturing industry, the electronics (e.g., EMS, semiconductor back-end, PCBA, optics) and automotive (Tier-1, Tier-2, and Tier-3) sectors are expected to play a key role in global value chains (GVCs), contributing approximately 25–30% of the country's total industrial output and providing a major source of employment (Office of Industrial Economics, 2025).

Key differences between contract manufacturing (CM) and conventional manufacturing include:

1. Exposure to demand fluctuations from multiple OEMs
2. Short RFQ-to-SOP timeframes
3. Frequent engineering change orders (ECOs)

These factors impact production efficiency, particularly First Pass Yield (FPY) and Cycle Time (CT). Managing these risks requires agile implementation of APQP and PPAP, as well as flexible capacity planning (Sturgeon, 2008; UNCTAD, 2005).

Additionally, contract manufacturers in Thailand operate under strict audit and certification standards set by their suppliers. For example, contract manufacturers in the automotive industry must comply with IATF 16949, a higher standard than ISO 9001, which emphasizes defect prevention, traceability, and multi-level verification for accuracy. This creates competitive value in the global market, drives customer satisfaction, and delivers measurable operational efficiency (Laskurain-Iturbe et al., 2021). Meanwhile, contract manufacturers in the electronics industry must meet additional requirements, such as RBA/ESG compliance, RoHS/REACH, and PCN controls, all of which add complexity to quality management processes and increase operational costs.

Contract manufacturers continue to face cost reduction pressures driven by open-book costing models linked to BOM volatility and customer-imposed price cuts, which squeeze margins unless offset by productivity improvements such as increased OEE, FPY, and CT, or by Design for Manufacture (DFM) and material sourcing strategies (Sturgeon, 2008). This pressure is prompting many companies to invest in analytics, MES, and SPC to efficiently control their

manufacturing processes. In addition, complex financial and contractual arrangements, such as consignment/VMI agreements, longer repayment cycles, and proprietary tooling requirements, increase liquidity challenges and amplify the “bullwhip effect” throughout the supply chain (Sturgeon, 2008).

Shortages of personnel skilled in automation, data analytics, power electronics, and optics remain obstacles to the full implementation of Industry 4.0, despite policies such as the Eastern Economic Corridor (EEC) that promote labor quality and university-industry collaboration (Intalar et al., 2024; Intarakumnerd & Jutarosaga, 2023). Macroeconomic volatility also continues to impact Thai contract manufacturers, as seen in the decline in orders and factory production in mid-2025 due to a slowdown in automotive production resulting from the rise of electric vehicles and government policies promoting clean energy. This underscores the need for risk diversification, digital transformation, and organizational resilience strategies (Reuters, 2025; National Economic and Social Development Council, 2024).

Organizational Capabilities

In the evolving Industry 4.0 landscape, the competitiveness of Contract Manufacturers (CMs) in 2025 will depend not only on adopting new technologies but also on developing organizational capabilities that enable them to efficiently meet the complex demands of multi-customer environments.

1. Client portfolio management capabilities

One key strategic capability is customer portfolio management, which enables CMs to serve multiple OEMs and ODMs with diverse needs while maintaining strategic alignment and manufacturing efficiency. This capability is crucial for balancing short-term demand response with long-term competitiveness, allowing CMs to allocate resources optimally, manage risk, and maintain customer relationships in highly volatile markets (Day, 2011).

2. Multi-client manufacturing flexibility

Another key capability is creating flexibility in multi-client manufacturing processes. This means adapting production lines and processes to accommodate varying product specifications, engineering changes (ECOs), and fluctuating customer demands. Flexibility is supported by advanced production scheduling systems, modular manufacturing structures, and personnel training for multiple tasks. This enables contract manufacturers to quickly adjust operations without sacrificing efficiency or process quality, aligning with the industry 4.0 vision, which emphasizes cyber-physical adaptability (Lee et al., 2015).

3. Quality system adaptability for different client standards

Another crucial aspect of organizational capability is the ability to adapt Quality Management Systems (QMS) to different standards, such as ISO 9001, IATF 16949, AS9100, or specific customer audits or requirements. Empirical research confirms that adapting a QMS to multiple standards can enhance supply chain reliability, process consistency, and customer

satisfaction (Psomas & Antony, 2017). Furthermore, a flexible QMS promotes innovation and continuous improvement, making compliance a competitive advantage rather than a constraint.

4. Leadership and Organizational Culture

Leadership and organizational culture are crucial in achieving these capabilities. Transformational leadership fosters commitment and knowledge sharing, aligning strategic goals with employee behaviors to support adaptability to a diverse customer portfolio (Donate & de Pablo, 2015). Fostering a learning organization culture, which emphasizes continuous improvement, experimentation, and constructive feedback (Garvin et al., 2008), is essential for establishing a foundation for process flexibility and quality system adaptation.

Combined with investments in digital infrastructure and innovation capabilities, organizational capabilities enable contract manufacturers to navigate the pressures of complex customer demands, technological disruption, and global competition with confidence and effectiveness.

Key Challenges in Organizational Transformation

Organizational transformation in the contract manufacturing (CM) industry faces unique challenges distinct from those in traditional manufacturing. These challenges extend beyond structural inefficiencies and cultural barriers, stemming from specific pressures such as customer dependency, varying standards, and the complexity of meeting multiple customer demands. Addressing these pressures requires advanced organizational capabilities, including portfolio management, flexible manufacturing processes, and an adaptable workforce. The integration of diverse and complex technologies must also be managed. Without these solutions, organizations will struggle to remain competitive amid Industry 4.0 dynamics and the volatility of global supply chains.

1. Client Dependency and Portfolio Risks

The risk of over-reliance on a few large OEM customers by FDIs creates high dependency and a power imbalance in negotiations. Relying on customers with increasingly stringent product quality and standards exposes FDIs to volatile and uncertain revenue streams if these customers change suppliers, merge, or enforce aggressive cost reductions. Research on global supply chain networks indicates that customer dependence reduces an organization's strategic autonomy and increases its vulnerability to market fluctuations (Sturgeon, 2008; Gereffi, 2019). Managing this risk requires a customer portfolio diversification strategy, the development of customer relationship management capabilities, and the creation of more balanced contracts to reduce power imbalances and enhance long-term flexibility.

2. Multi-Standard Quality Management

Managing Quality to Different Standards than General Manufacturers Contract manufacturers must comply with multiple quality standards simultaneously, such as ISO 9001, IATF 16949 for the automotive industry, AS9100 for the aerospace industry, and customer-specific audits. This diversity increases compliance workload, leads to duplicate

documentation, and raises the frequency of product audits. Empirical research indicates that the ability to adapt a quality management system (QMS) to various standards can enhance both consistency and innovation, allowing organizations to maintain performance while meeting diverse customer expectations (Psomas & Antony, 2017). Integrating these standards provides a unified approach within a single system, a strategic capability that reduces redundancy and fosters operational excellence to meet requirements.

3. Production Line Flexibility Constraints

Contract manufacturing line flexibility requires frequent production line changes to accommodate engineering changes (ECOs), new product launches (NPIs), and end-of-life (EOL) processes from multiple customers. However, rigid manufacturing systems and high line changeover costs often limit this flexibility, resulting in slow response times and increased operational inefficiencies. Evidence indicates that modular production design, digital twins, and reconfigurable manufacturing systems (RMS) are key to enhancing flexibility in contract manufacturing environments (ElMaraghy et al., 2011). Without these capabilities, contract manufacturers risk delayed delivery, lower first-pass yield (FPY), and customer dissatisfaction.

4. Technology Integration Across Diverse Client Requirements

Contract manufacturers face unique challenges in integrating technology systems to meet diverse customer needs, including varying standards, levels of digital maturity, and interoperability requirements. Existing technologies within organizations often do not support advanced customer needs such as traceability, SPC, MES, or IoT tracking. Research confirms that fragmented IT systems hinder real-time decision-making and undermine the potential for digital transformation (Bharadwaj et al., 2013; Ivanov et al., 2019). Therefore, contract manufacturers must invest in interoperable systems, develop scalable digital infrastructures, and integrate platforms across multiple customer ecosystems, while maintaining cybersecurity.

5. Workforce Adaptability to Variable Production Demands

Workforce adaptability presents a significant challenge, as employees must accommodate fluctuating orders, changing product preferences, and diverse requirements across industries. Skill gaps in automation, data analytics, and systems integration in Thai industries remain a limiting factor, delaying the adoption of Industry 4.0 (Intalar et al., 2024; Intarakumnerd & Jutarosaga, 2023). Research confirms that upskilling, reskilling, and cross-functional training can enhance adaptability and organizational flexibility in the contract manufacturing sector (Pinzone et al., 2019). Investment in digital learning platforms, partnerships with vocational institutions, and continuous skills development programs will help create a workforce prepared to compete amid volatility and technological advancements.

Strategic Framework for Organizational Development

Strategic Framework for Organizational Development Achieving organizational transformation in the Contract Manufacturing (CM) industry requires an integrated, forward-looking strategic framework that addresses the complex dynamics of a diverse customer demand environment. Unlike traditional manufacturers, CMs must balance customer

dependency, compliance with diverse and complex standards, and the need for continuous adaptation of production lines.

A strategic framework for CMs should include the following elements:

1. Client-Centric Strategic Planning
2. Leadership and Change Management
3. Collaborative Innovation
4. Digital Integration and Technological Adaptation
5. Talent Development and Workforce Agility
6. Supply Chain Integration and Vendor Management

Together, these elements foster resilience, agility, and long-term competitiveness in the industry 4.0 environment, which is characterized by volatility and rapid technological change (Teece, 2018).

1. Client-Centric Strategic Planning

In the OEM industry, the vision and strategy must be clearly customer-focused, aligning organizational goals with the needs and expectations of multiple OEMs and ODMs. This approach aligns manufacturing planning, investment prioritization, and operational decisions with the customer portfolio, fostering long-term partnerships and reducing the risk of relying on a single customer. Additionally, aligning strategy with customer needs enables organizations to respond quickly to global supply chain changes while maintaining consistency at all organizational levels, from executives to managers to operations (Kaplan & Norton, 2004).

2. Leadership and Change Management

Effective leadership in a CM context requires balancing cost-cutting pressures, industry compliance demands, and technological disruption while maintaining the trust of diverse customers. Leaders must clearly communicate the value of change, demonstrate integrity in their actions, and engage employees in customer-driven change processes. Engaging internal and external stakeholders, such as customers, is crucial to building shared ownership of change goals. Research confirms that leadership combining transparency, honesty, and inclusive participation can strengthen organizational cohesion and accelerate the adoption of customer-driven change (Simons et al., 2015).

3. Collaborative Innovation with Client Partners

In the contract manufacturing industry, innovation does not originate solely within the organization; it also emerges through collaboration with customers. Contract manufacturers must develop manufacturing processes, pursue joint improvements, experiment with customers on new product designs, and incorporate customer R&D insights into their manufacturing capabilities. Collaborative innovation generates shared value, allowing new ideas to be transformed into real products more rapidly. Edmondson (2011) highlights the importance of “psychological safety,” which enables customer-manufacturer teams to share knowledge, experiment, and solve creative problems together. Building such a

collaborative innovation ecosystem elevates contract manufacturers beyond traditional roles, positioning them as innovative partners in a more competitive environment.

4. Digital Integration and Technological Adaptation

The contract manufacturing industry faces the challenge of integrating technologies to meet diverse customer needs, including process traceability, SPC, and AI-enabled predictive maintenance. Adopting Industry 4.0 technologies such as IoT, big data analytics, and AI can enhance operational efficiency and responsiveness to customer requirements (Frank et al., 2019). However, successful digital integration requires connecting and scaling multiple customer systems while maintaining cybersecurity. Aligning digital projects with customer portfolios can transform digital investments from a cost into a sustainable competitive advantage.

5. Talent Development and Workforce Agility

The workforce in the contract manufacturing industry needs both technical skills and the ability to adapt to fluctuating orders, rapid product changes, and diverse certification requirements. Workforce agility can be developed through specialized skills training, cross-functional training, and digital upskilling programs. Research confirms that continued investment in human capital is essential for building competitiveness and adapting to the disruptions of Industry 4.0 (Hecklau et al., 2016). Integrating workforce agility into human resource management (HRM) strategies positions the workforce as a strategic driver of change.

6. Supply Chain Integration and Vendor Management

Supply chain integration is a critical capability for contract manufacturers, enabling upstream suppliers to meet strict quality standards and respond to flexible production capacities, mitigating risks such as delivery delays or part shortages. Research has confirmed that collaborative supply chain integration enhances flexibility, supports efficient inventory management models, and increases responsiveness to fluctuating demand (Christopher & Peck, 2004). For contract manufacturers, effective supplier management helps maintain operational continuity and builds customer trust through consistent delivery of quality, standardized products.

Case Analysis

To gain a thorough understanding of the challenges and capabilities of the contract manufacturers (CMs) industry in Thailand, this research will use a case study methodology, focusing on prominent global players within the Thai industrial ecosystem. This case study also aligns with national policy initiatives such as Thailand 4.0 and the Eastern Economic Corridor (EEC), which aim to advance the country toward an innovation-driven economy.

1. Delta Electronics (Thailand) Public Company Limited

Delta Electronics (Thailand) Public Company Limited is one of the largest and most influential contract manufacturers in the region, specializing in power electronics, energy solutions, and automotive components. Delta not only serves global OEMs but also develops

its own research and development (R&D) and sustainable manufacturing capabilities. Delta's case study illustrates the five challenges identified in the previous chapter, including managing relationships with multiple customers with varying needs and adapting to diverse standards.

Delta has also invested in digital infrastructure, such as MES systems, data analytics, and automation, to improve manufacturing efficiency and supply chain transparency. The company exemplifies human capital development through continuous training, collaboration with higher education institutions, and upskilling its workforce to support new technologies such as automation, robotics, and AI. This case demonstrates that organizational capability development must be integrated with workforce upskilling to achieve sustainable competitiveness.

2. National Policy Implementation and Industrial

The case study highlights the role of public policy, particularly Thailand 4.0 and the Eastern Economic Corridor (EEC), which focus on fostering public-private partnerships to drive digital investment, research and development, and technology transfer. Companies with access to BOI support and EEC infrastructure can enhance their manufacturing capabilities and strengthen their links to global value chains. Integrating corporate approaches with national policies can help OEMs adapt to global market pressures and gain strategic advantages. For example, investments in electric vehicle (EV) manufacturing and renewable energy solutions meet customer needs and align with the country's sustainability goals.

3. Lessons Learned

Analysis of the case studies suggests that organizations that successfully address the challenges of CM are those that:

1. Invest in scalable digital infrastructure
2. Build workforce resilience through training and reskilling
3. Integrate diverse quality systems into a unified system
4. Develop innovative partnerships with customers (co-innovation)
5. Align organizational strategies with government policies and global market changes

These results reinforce the research findings that technology adoption alone is not sufficient; it must be coupled with human capital development, organizational culture enhancement, and the creation of a collaborative strategic ecosystem.

Conclusion and Discussion

The findings of this study indicate that production efficiency among contract manufacturers in the Industry 4.0 era is not achieved solely through investments in digital technologies; rather, it is fundamentally driven by the effective management of organizational capabilities that address the complexity of a multi-customer (multi-OEM/multi-ODM) environment characterized by volatile order patterns, shortened RFQ-to-SOP lead times, and

frequent engineering change orders (ECOs). In this context, firms must develop three interrelated capabilities: strategic customer portfolio management, manufacturing process flexibility to serve multiple clients concurrently, and the ability to adapt quality management systems to comply with diverse and overlapping standards. These capabilities serve as integrative mechanisms that translate external volatility into internal operational outcomes. This finding aligns with contemporary research suggesting that digital technologies enhance supply chain resilience only when supported by effective data flows, visibility, and responsiveness, emphasizing systemic readiness and decision-making agility rather than mere technology deployment (Ning et al., 2023; Tian & Cui, 2025).

Evidence from the case of Delta Electronics (Thailand) further demonstrates that investments in digital infrastructure, such as Manufacturing Execution Systems (MES), analytics platforms, and automation technologies, achieve their full potential only when embedded in organizational routines that facilitate sensing customer-driven changes, rapid resource reallocation, and cross-functional coordination to minimize losses associated with product model or specification changes. These practices can be seen as manifestations of dynamic capabilities that enable digital transformation to be directly linked to tangible performance outcomes. Prior studies in both Thai and international contexts support this interpretation by highlighting that strategic capabilities, governance mechanisms, and collaborative ecosystem arrangements play a more decisive role in successful transformation than isolated or fragmented technology adoption (Abdurrahman et al., 2024; Thanakijcharoenpat et al., 2022).

Regarding the dimension of multi-standard quality management, the study finds that the ability to adapt quality management systems to diverse requirements should not be viewed merely as an administrative or documentation burden; rather, it is a competitive capability that reduces redundancy, shortens the time required for requirement interpretation, and enhances the consistency of organizational practices. This finding aligns with empirical evidence from Thai studies showing that integrated management system approaches encompassing quality, environmental, and occupational health and safety standards can significantly reduce the volume of documentation and forms, thereby improving implementation flexibility and facilitating practitioners' understanding of the system (Chanyoothayotin & Lertwisuttipaiboon, 2022). At the same time, the sustainability of quality systems remains highly dependent on employees' participatory behaviors and attitudes toward standards, which are critical for maintaining process discipline in production environments subject to frequent change (Warnhorm & Akakulanan, 2022).

Within the Thai context shaped by the Thailand 4.0 policy and the Eastern Economic Corridor initiative, the findings support the view that the primary bottleneck in transforming the contract manufacturing industry has increasingly shifted from machinery to human skills and organizational capabilities. Thai research highlights both the necessity of designing and evaluating workforce development programs aligned with the actual needs of industrial zones

and the importance of information and communication technology competency frameworks to support targeted industrial labor forces (Jangruxsakul & Athikulrat, 2023; Suwanwak et al., 2022). Integrated with international literature, these insights underscore that the most robust approach is to position upskilling as a continuous strategic endeavor embedded within career pathways and lifelong learning systems, enabling the workforce to effectively perform data-intensive tasks, engage in cross-functional collaboration, and rapidly adapt to evolving processes (Li, 2024).

Recommendations

Based on the findings of this study, strategic recommendations for enhancing production efficiency and competitiveness in Thailand's contract manufacturing industry can be summarized at both the organizational and policy levels as follows.

1. At the contract manufacturing organization level, firms should shift their managerial focus from short-term operational responsiveness to the long-term development of organizational capabilities as a central priority. They should implement systematic customer portfolio management strategies to reduce risks associated with dependence on a few major customers and to strengthen bargaining power within the supply chain, while also developing strategic relationships with customers through long-term partnerships. Additionally, organizations should integrate multiple quality management systems into a single, flexible, and coherent system to reduce redundant compliance burdens while maintaining effective alignment with each customer's specific requirements.

2. In the production domain, firms should prioritize investing in highly flexible manufacturing technologies, such as Reconfigurable Manufacturing Systems (RMS), and digital platforms that can interoperate with multiple customer systems to enhance adaptability to demand volatility and ongoing engineering changes. These technological investments should be accompanied by human capital development through training, reskilling and upskilling initiatives, and the cultivation of an organizational culture that supports learning, experimentation, and innovation to ensure the full and effective use of technology.

3. Regarding government policy, priority should be given to designing industrial policies that systematically support the development of organizational capabilities among contract manufacturers. This includes promoting collaboration between the public and private sectors to support digital investment, research and development, and applied technology transfer, along with continuous workforce skill development in cooperation with higher education and vocational training institutions. The government should also support the integration of domestic supply chains, particularly by upgrading upstream suppliers and enhancing data connectivity across the entire value chain, to increase flexibility and reduce vulnerability to external volatility.

Future Research

1. Future research should use quantitative methods, such as large-scale questionnaire surveys of contract manufacturers, to test causal relationships between digital transformation, organizational capabilities, and production performance outcomes.

2. Future studies should broaden the scope to include other manufacturing industries with high technological and innovative intensity, to compare organizational challenges and patterns of capability development across different industrial contexts.

3. Future research should conduct regional comparative studies of contract manufacturers in Thailand, Vietnam, and Malaysia to analyze strategic and institutional factors contributing to differences in competitiveness, as well as the roles of industrial policies and innovation ecosystems in each country.

Reference

Abdurrahman, A., Gustomo, A., & Prasetio, E. A. (2024). Impact of dynamic capabilities on digital transformation and innovation to improve banking performance: A TOE framework study. *Journal of Open Innovation: Technology, Market, and Complexity, 10*(1), 100215. https://doi.org/10.1016/j.joitmc.2024.100215

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. V. (2013). Digital business strategy: toward a next generation of insights. *MIS quarterly, 37*(2), 471-482. https://www.jstor.org/stable/43825919

Chanyoothayotin, O., & Lertwisuttipaiboon, S. (2022). Development of standard system integration process for the automotive industry. *The Journal of Industrial Technology, 18*(1), 175–192.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management, 15*(2), 1–14. https://doi.org/10.1108/09574090410700275

Day, G. S. (2011). Closing the marketing capabilities gap. *Journal of Marketing, 75*(4), 183–193. https://doi.org/10.1509/jmkg.75.4.183

Donate, M. J., & de Pablo, J. D. S. (2015). The role of knowledge-oriented leadership in knowledge management practices and innovation. *Journal of Business Research, 68*(2), 360–370. https://doi.org/10.1016/j.jbusres.2014.06.022

Edmondson, A. C. (2011). Strategies for learning from failure. *Harvard Business Review, 89*(4), 48–55. https://www.hbs.edu/faculty/Pages/item.aspx?num=40142

ElMaraghy, H., Algeddawy, T., Azab, A., & ElMaraghy, W. (2011, October 2). Change in manufacturing–research and industrial challenges. In *Enabling Manufacturing Competitiveness and Economic Sustainability: Proceedings of the 4th International Conference on Changeable, Agile, Reconfigurable and Virtual production,* (pp. 2-9). Berlin, Heidelberg: Springer Berlin Heidelberg.

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics, 210*, 15–26. https://doi.org/10.1016/j.ijpe.2019.01.004

Garvin, D. A., Edmondson, A. C., & Gino, F. (2008). Is yours a learning organization?. *Harvard Business Review, 86*(3), 109–116. https://hbr.org/2008/03/is-yours-a-learning-organization

Gereffi, G. (2019). Global value chains and international development policy: Bringing firms, networks and policy-engaged scholarship back in. *Journal of International Business Policy, 2*(3), 195-210. https://doi.org/10.1057/s42214-019-00028-7

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic approach for human resource management in Industry 4.0. *Procedia CIRP, 54*, 1-6. https://doi.org/10.1016/j.procir.2016.05.102

Intalar, N., Ueki, Y., & Jeenanunta, C. (2024). Enhancing Competitiveness: Driving and Facilitating Factors for Industry 4.0 Adoption in Thai Manufacturing. **Economies, 12**(8), 210. https://doi.org/10.3390/economies12080210

Intarakumnerd, P., & Jutarosaga, T. (2023). The evolution of university–industry linkages in Thailand. *Asian Economic Policy Review, 18*(2), 265-282. https://onlinelibrary.wiley.com/doi/10.1111/aepr.12422

Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research, 57*(3), 829–846. https://doi.org/10.1080/00207543.2018.1488086

Jangruxsakul, S., & Athikulrat, K. (2023). Evaluation of labor skill development projects in the Eastern Economic Corridor (EEC) by using CIPP model. *Maejo Business Review, 5*(1), 1–20.

Kaplan, R. S., & Norton, D. P. (2004). *Strategy maps: Converting intangible assets into tangible outcomes.* Harvard Business School Press. https://www.hbs.edu/faculty/Pages/item.aspx?num=15760

Laskurain-Iturbe, I., Arana-Landín, G., Landeta-Manzano, B., & Uriarte-Gallastegi, N. (2021). Exploring the influence of industry 4.0 technologies on the circular economy. *Journal of Cleaner Production, 321*, 128944. https://doi.org/10.1016/j.jclepro.2021.128944

Lee, J., Bagheri, B., & Kao, H.-A. (2015). A cyber-physical systems architecture for Industry 4.0-based manufacturing systems. *Manufacturing Letters, 3*, 18–23. https://doi.org/10.1016/j.mfglet.2014.12.001

Li, L. (2024). Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. *Information Systems Frontiers, 26*(5), 1697-1712. https://doi.org/10.1007/s10796-022-10308-y

National Economic and Social Development Council. (2024). *Thai economic performance in Q2/2024 and outlook for 2024.* https://www.nesdc.go.th/nesdb_en/article_attach/07%20Economic%20Report%202024-Q2.pdf

Ning, Y., Li, L., Xu, S. X., & Yang, S. (2023). How do digital technologies improve supply chain resilience in the COVID-19 pandemic? Evidence from Chinese manufacturing firms. *Frontiers of Engineering Management, 10*(1), 39-50. https://doi.org/10.1007/s42524-022-0230-4

Office of Industrial Economics. (2025). *Manufacturing production index (MPI): January 2025.* https://www.oie.go.th/oie2/uploads/news/4801-p1558j21793.pdf

Pinzone, M., Guerci, M., Lettieri, E., & Huisingh, D. (2019). Effects of 'green'training on pro-environmental behaviors and job satisfaction: Evidence from the Italian healthcare sector. *Journal of cleaner production, 226*, 221-232. https://doi.org/10.1016/j.jclepro.2019.04.048

Psomas, E., & Antony, J. (2017). Total quality management elements and results in higher education institutions: The Greek case. *Quality Assurance in Education, 25*(2), 206-223. https://doi.org/10.1108/QAE-08-2015-0033

Reuters. (2025). *Thailand factory output falls more than expected in June 2025.* https://www.reuters.com

Simons, T., Leroy, H., Collewaert, V., & Masschelein, S. (2015). How leader alignment of words and deeds affects followers: A meta-analysis of behavioral integrity research. *Journal of Business Ethics, 132*(4), 831-844. https://doi.org/10.1007/s10551-014-2332-3

Sturgeon, T. J. (2008). *From commodity chains to value chains: interdisciplinary theory building in an age of globalization.* https://isapapers.pitt.edu/84/1/2008%2D02_Sturgeon.pdf

Suwanwak, L., Suksawang, P., & Makmee, P. (2022). Development of the ICT competency assessment framework for preparing the labor on new S-Curve Industries in eastern special development zone. *Dhonburi Rajabhat University Journal, 16*(2), 11-26.

Teece, D. J. (2018). Business models and dynamic capabilities. *Long range planning, 51*(1), 40-49. https://doi.org/10.1016/j.lrp.2017.06.007

Thailand Automotive Institute. (2024). *Facts & figures 2024.* https://data.thaiauto.or.th/images/PDF/Facts_Figures_2024V1.pdf

Thanakijcharoenpat, S., Jarutirasarn, P., & Boonchunone, S. (2022). The relationship between dynamic capabilities and digital transformation components of performance in the automobile manufacturers industry in Thailand. *Arts of Management Journal, 6*(3), 1392–1405.

Tian, Y., & Cui, L. (2025). Supply chain resilience and digital transformation: perspectives from a supply chain network. *Humanities and Social Sciences Communications, 12*(1), 1738. https://doi.org/10.1057/s41599-025-06011-3

UNCTAD. (2005). *World Investment Report 2005: Transnational corporations and the internationalization of R&D.* United Nations Conference on Trade and Development (UNCTAD). https://unctad.org/webflyer/world-investment-report-2005

Warnhorm, S., & Akakulanan, S. (2022). The participation in maintaining the quality management system standard ISO 9001 of employees in an information and communication technology company. *BU Academic Review, 21*(2), 1–14.