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SHAPING THE FUTURE OF MALAYSIA'S AUTOMOTIVE INDUSTRY THROUGH UNIFIED EFFORTS FOR NEW PRODUCT DEVELOPMENT SUCCESS

MOLDANDO O FUTURO DA INDÚSTRIA AUTOMOTIVA DA MALÁSIA POR MEIO DE ESFORÇOS UNIFICADOS PARA O SUCESSO NO DESENVOLVIMENTO DE NOVOS PRODUTOS

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Abstract
The Malaysian automotive industry is undergoing a pivotal transformation driven by technological advancement, global competition, and policy reforms. This study investigates the critical organizational enablers that contribute to New Product Development (NPD) success, specifically Information Technology (IT) Capability, NPD Strategy, NPD Process, and the moderating influence of Top Management Support (TMS). Grounded in the Resource-Based View (RBV) and Contingency Theory, the research integrates technological, strategic, and leadership perspectives to examine how firms can strengthen innovation performance and competitiveness. Using a quantitative approach involving 500 respondents from Tier-1 automotive vendors, data were analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the hypothesized relationships. The results reveal that IT Capability, NPD Strategy, and NPD Process significantly influence NPD success, while TMS enhances these relationships by fostering a culture of innovation and ensuring strategic alignment. The study contributes theoretically by reinforcing the synergistic interaction between internal resources and external contingencies and offers practical insights for industry leaders seeking to achieve sustainable innovation through digital transformation and leadership commitment. The findings serve as a strategic guide for Malaysia's automotive sector in navigating the evolving global landscape and realizing its ambition to become a regional hub for advanced automotive development.

Resumo
A indústria automotiva da Malásia está passando por uma transformação crucial impulsionada pelo avanço tecnológico, pela concorrência global e por reformas políticas. Este estudo investiga os principais facilitadores organizacionais que contribuem para o sucesso do Desenvolvimento de Novos Produtos (DNP), especificamente a Capacidade de Tecnologia da Informação (TI), a Estratégia de DNP, o Processo de DNP e a influência moderadora do Apoio da Alta Administração (AAA). Fundamentada na Visão Baseada em Recursos (VBR) e na Teoria da Contingência, a pesquisa integra perspectivas tecnológicas, estratégicas e de liderança para examinar como as empresas podem fortalecer o desempenho em inovação e a competitividade. Utilizando uma abordagem quantitativa com 500 respondentes de fornecedores automotivos de Nível 1, os dados foram analisados por meio de Modelagem de Equações Estruturais por Mínimos Quadrados Parciais (PLS-SEM) para testar as relações hipotetizadas. Os resultados revelam que a Capacidade de TI, a Estratégia de DNP e o Processo de DNP influenciam significativamente o sucesso do DNP, enquanto o AAA fortalece essas relações ao fomentar uma cultura de inovação e garantir o alinhamento estratégico. O estudo contribui teoricamente ao reforçar a interação sinérgica entre recursos internos e contingências externas, oferecendo insights práticos para líderes da indústria que buscam alcançar inovação sustentável por meio da transformação digital e do comprometimento da liderança. As conclusões servem como um guia estratégico para o setor automotivo da Malásia, auxiliando-o a navegar no cenário global em constante evolução e a concretizar

Keywords: New Product Development. IT Capability. NPD Strategy. Top Management Support. Malaysian Automotive Industry.

Palavras-chave: *Desenvolvimento de Novos Produtos. Capacidade em TI. Estratégia de Desenvolvimento de Novos Produtos. Apoio da Alta Administração. Indústria Automotiva da Malásia.*

1 INTRODUCTION

The automotive industry has historically been a linchpin of global industrial growth and innovation, driving not only economic development but also technological breakthroughs that shape the modern world. Valued at approximately USD 2.9 trillion globally as of 2023 (Statista, 2023), the automotive sector remains a key contributor to Gross Domestic Product (GDP) in many economies and serves as a cornerstone for industrialization in emerging markets. In Malaysia, the automotive industry contributes nearly 4% of the national GDP and provides employment to over 700,000 individuals, underscoring its economic and social significance (Malaysian Investment Development Authority, 2023). These figures reflect the importance of the sector as a critical enabler of growth and innovation in Southeast Asia.

1.1 Malaysia's automotive journey

Malaysia's automotive journey began in the early 1980s with the establishment of its national car manufacturers, Proton and Perodua. These initiatives played a crucial role in transforming the nation from an agriculture-based economy into a manufacturing-oriented industrial economy (Wad & Govindaraju, 2011). The introduction of the National Automotive Policy (NAP) in 2006 marked a major milestone in shaping the direction of the industry. Since its inception, the policy has undergone several revisions, with the most recent update in 2023, reflecting the government's commitment to enhancing industry competitiveness, promoting sustainability, and advancing technological capabilities (Ministry of International Trade and Industry, 2023).

The NAP 2023 focuses on positioning Malaysia as a regional hub for energy-efficient vehicles (EEVs), autonomous driving technologies, and Industry 4.0-related innovations. It also emphasizes the importance of digital transformation, the adoption of

renewable energy, and the strengthening of cross-border trade within the ASEAN region. Through these strategic directions, Malaysia continues to strengthen its automotive ecosystem by fostering innovation, encouraging collaboration between public and private sectors, and enhancing its role in the global value chain.

1.2 Global and local context

Globally, the automotive industry is at an inflection point, facing transformative megatrends such as electrification, autonomous driving, digital connectivity, and shared mobility (McKinsey, 2023). These trends are reshaping the competitive dynamics of the industry, compelling manufacturers to rethink traditional business models and embrace technological advancements. For instance, Tesla's dominance in electric vehicle (EV) innovation has pushed legacy automakers to rapidly innovate to maintain relevance (Hanelt *et al*., 2023). Similarly, digital connectivity has opened avenues for data-driven insights, enabling predictive maintenance and enhancing customer experiences (PwC, 2023).

In Malaysia, the adoption of these global trends is facilitated by government-led initiatives under the NAP and the National Investment Aspirations (NIA), which prioritize the integration of Industry 4.0 technologies such as big data analytics, robotics, and the Internet of Things (IoT) (MITI, 2023). While these developments have unlocked opportunities for innovation, they have also exposed challenges such as gaps in technological infrastructure, skill deficits, and intensifying competition from global players entering the ASEAN market (Masron & Nor, 2012; Bakar *et al*., 2023).

1.3 Challenges in the malaysian automotive industry

The Malaysian automotive industry continues to experience several interrelated challenges that limit its capacity for sustained growth and innovation. Despite significant government support through the National Automotive Policy (NAP 2023), many local manufacturers still face constraints in research and development (R&D), technological adoption, and supply chain efficiency (MITI, 2023; Musa *et al*., 2023). Limited financial resources and inadequate investment in advanced manufacturing technologies have

slowed the country's progress toward becoming a regional automotive hub (Bakar *et al*., 2023; Wad & Govindaraju, 2022).

Technological capability remains uneven among firms. The adoption of Industry 4.0 technologies such as robotics, automation, big data analytics, and digital product design tools is progressing slowly, especially among small and medium-sized enterprises (SMEs) (Mikalef *et al*., 2020; Sundram *et al*., 2022). This technological gap contributes to inefficiencies in production, longer product development cycles, and lower levels of innovation compared to regional competitors such as Thailand and Indonesia (Masron & Nor, 2022; Hanelt *et al*., 2023).

Trade liberalization through the ASEAN Free Trade Area (AFTA) has also intensified competition. Local vendors must now compete with multinational automakers that possess stronger financial capacity, superior R&D infrastructure, and advanced technology integration (Masron & Nor, 2012; GlobalData, 2023). These competitive pressures have forced Malaysian firms to upgrade their production systems and improve operational efficiency in order to remain viable in both domestic and export markets.

The industry is further affected by supply chain disruptions, including the semiconductor shortage and the global economic effects of the COVID-19 pandemic, which exposed weaknesses in logistics coordination and inventory management (Yusuf *et al*., 2023). Moreover, environmental sustainability has become a growing challenge as firms struggle to align with global standards for energy-efficient vehicles (EEVs) and carbon reduction (Freeman *et al*., 2023; Lee & Walsh, 2024). Meeting these sustainability expectations requires consistent innovation, workforce upskilling, and collaboration between industry and government.

1.4 Strategic role of New Product Development (NPD)

In this dynamic and competitive landscape, New Product Development (NPD) emerges as a cornerstone for organizational success and long-term sustainability. NPD encompasses the entire lifecycle of bringing a product to market, from ideation and design to prototyping, testing, and commercialization. It is a multidimensional process that requires strategic alignment, resource optimization, and robust management practices (Cooper & Kleinschmidt, 2007).

Studies have consistently demonstrated that effective NPD practices are positively correlated with organizational performance, customer satisfaction, and market share (Montoya-Weiss & Calantone, 1994; Jiang *et al*., 2023). For Malaysian automotive vendors, NPD represents not just an opportunity but a necessity to differentiate themselves in a market increasingly dominated by global players (Tippins & Sohi, 2003). By leveraging NPD, vendors can address gaps in their product portfolios, cater to shifting consumer preferences, and capitalize on emerging market trends such as EVs, hydrogen-powered vehicles, and smart mobility solutions (Bakar *et al*., 2023).

Furthermore, collaborative efforts between government, academia, and industry stakeholders have become pivotal in fostering innovation. Programs such as the Industry4WRD policy and research grants under the Malaysian Technology Development Corporation (MTDC) aim to bridge gaps in expertise and resources, accelerating NPD success (MITI, 2023).

While Malaysia's automotive industry faces significant challenges, it is well-positioned to leverage its strong foundation and strategic policies to navigate the evolving global landscape. By embracing NPD as a central strategy, local vendors and manufacturers can achieve sustainable growth and maintain their relevance in a highly competitive market.

1.5 Key enablers of NPD success

The success of New Product Development (NPD) within the Malaysian automotive industry depends on a combination of technological strength, strategic direction, structured processes, and committed leadership. These enablers form the foundation of sustainable innovation performance and determine how effectively firms can transform creative ideas into commercially viable products that meet changing customer expectations and regulatory demands. Each enabler plays a distinctive role, yet their collective integration drives competitiveness, resilience, and long-term growth within the national automotive ecosystem

Information Technology (IT) Capability provides the technological backbone for successful NPD. Strong IT systems allow organizations to enhance collaboration, improve communication, and shorten product development cycles through real-time data sharing and predictive analytics. According to Mikalef *et al*. (2020), IT capability enables

firms to utilize big data and digital tools to foster agility and responsiveness in innovation. The integration of cloud computing, artificial intelligence (AI), and the Internet of Things (IoT) empowers teams to simulate prototypes, anticipate product performance, and refine designs before production. Within Malaysia's automotive sector, such capabilities have become vital for achieving operational efficiency, improving product quality, and strengthening cross-functional coordination, particularly among Tier-1 vendors striving to align with Industry 4.0 expectations (Musa *et al*., 2023; Sundram *et al*., 2022).

NPD Strategy establishes a clear roadmap that links corporate goals with market realities and technological opportunities. A well-structured strategy ensures that firms allocate resources effectively, prioritize feasible projects, and maintain alignment with sustainability and regulatory frameworks. Rothwell (2022) emphasized that an explicit innovation strategy strengthens a firm's ability to position itself competitively amid technological disruption. In Malaysia, alignment with the National Automotive Policy 2023 has encouraged automotive manufacturers to develop energy-efficient and next-generation vehicles consistent with national sustainability goals (MITI, 2023). Incorporating customer-centric design principles and environmental considerations into strategic planning enables organizations to respond effectively to evolving market expectations and strengthen brand reputation (Lee & Walsh, 2024; Freeman *et al*., 2023).

NPD Process provides the systematic approach through which innovation is executed. Cooper *et al*. (2023) observed that structured processes such as the stage-gate model help organizations mitigate risks, optimize resources, and ensure quality at each stage of development. The combination of disciplined frameworks with agile methodologies enhances flexibility and allows firms to adapt rapidly to technological changes and customer feedback (Rigby *et al*., 2023; Montoya-Weiss *et al*., 2023). Within the Malaysian automotive industry, where competition and cost pressures are intense, adopting standardized yet adaptive processes has been shown to improve speed-to-market, reduce waste, and elevate product performance (Musa *et al*., 2023). Digital tools such as computer-aided design (CAD) and enterprise resource planning (ERP) further reinforce these processes by integrating design and production data for better coordination and efficiency (Hanelt *et al*., 2023).

Top Management Support (TMS) serves as the driving force that sustains innovation culture and strategic alignment. Leadership commitment ensures that resources, infrastructure, and human capital are adequately allocated to support product

development initiatives. Nguyen *et al*. (2021) emphasized that top management involvement motivates teams, enhances accountability, and strengthens coordination across departments. In the Malaysian context, leaders who champion digital transformation and innovation play a critical role in overcoming resistance to change and ensuring that technological adoption aligns with long-term business goals (Wad & Govindaraju, 2022). Visionary leadership also promotes inter-organizational collaboration, enabling firms to leverage academic partnerships and government programs such as Industry4WRD to boost innovation capability and workforce competence (Lee & Walsh, 2024).

When these four enablers operate in harmony, they create an innovation ecosystem that supports continuous learning, adaptability, and sustained competitive advantage. IT capability enhances collaboration and decision quality; strategic direction ensures relevance and sustainability; structured processes guarantee consistency and efficiency; and leadership commitment unites organizational efforts under a shared vision of growth. Together, they enable Malaysian automotive firms to innovate effectively, strengthen global competitiveness, and advance toward the nation's aspiration of becoming a regional hub for advanced automotive technologies (Bakar *et al*., 2023; MITI, 2023).

2 LITERATURE REVIEW

New Product Development (NPD) is a vital mechanism that enables firms to remain competitive, sustain innovation, and respond effectively to continuous technological and market changes. In industries that are highly dynamic and driven by technology, such as automotive manufacturing, NPD plays a crucial role in determining a company's capability to produce distinctive products, improve operational efficiency, and maintain profitability (Cooper *et al*., 2023; Mikalef *et al*., 2020). The performance of NPD initiatives is shaped by organizational structures, technological capacity, and managerial practices that collectively strengthen a firm's ability to innovate and adapt to market evolution. This section explores four essential enablers that contribute to NPD success, namely Information Technology (IT) Capability, NPD Strategy, NPD Process, and Top Management Support (TMS), within the Malaysian automotive industry as well as in global industrial contexts.

2.1 IT capability

Information Technology (IT) capability plays a pivotal role in driving innovation and NPD performance. It enables firms to streamline operations, enhance collaboration, and support decision-making through data analytics and digital systems (Mikalef *et al*., 2022; Oliveira *et al*., 2022). Feeny and Willcocks (1998) classified IT capability into three dimensions: technical resources, operational capabilities, and IT management. Together, these dimensions form the foundation for technological agility and competitive advantage in NPD.

Modern IT infrastructure enhances communication and coordination between departments by supporting real-time data exchange, simulation modeling, and predictive analytics (Nguyen *et al*., 2022; Hanelt *et al*., 2023). These tools accelerate design validation and improve decision accuracy, particularly in complex automotive projects. Moreover, big data analytics, cloud computing, and artificial intelligence (AI) empower firms to forecast market trends and optimize resource utilization (Sundram *et al*., 2022; Akman & Yilmaz, 2022).

In the Malaysian automotive industry, the adoption of IT remains uneven, primarily due to cost barriers and limited technical expertise (Musa *et al*., 2023). However, firms that invest in digital transformation achieve significant improvements in design efficiency, production flexibility, and product quality (Bakar *et al*., 2023). The National Automotive Policy (NAP) promotes IT integration by encouraging the use of Industry 4.0 technologies such as the Internet of Things (IoT), robotics, and advanced analytics (MITI, 2023; GlobalData, 2023). Hence, IT capability is not merely a support function but a strategic resource that drives innovation and accelerates new product success.

2.2 NPD strategy

A robust NPD strategy provides the strategic foundation for aligning innovation goals with market opportunities and technological advancements. It enables firms to allocate resources efficiently, manage risks effectively, and sustain a long-term competitive position (Rothwell, 2023; Cooper & Kleinschmidt, 2007). A clear and consistent strategy helps firms respond proactively to changing customer preferences and

regulatory environments, particularly in sectors where sustainability and digitalization are dominant forces (Freeman *et al*., 2023; Oliveira *et al*., 2022).

Within the Malaysian automotive landscape, NPD strategies are increasingly influenced by policy frameworks such as the National Automotive Policy (NAP 2023), which promotes the development of energy-efficient and next-generation vehicles (MITI, 2023). Strategic alignment with such policies supports national economic objectives while enhancing technological readiness (Wad & Govindaraju, 2022). Furthermore, the integration of sustainability-oriented design and digital product innovation enhances brand image and customer loyalty (Lee & Walsh, 2024; Chen *et al*., 2021).

NPD strategy also emphasizes the importance of collaboration and open innovation. Partnerships between automotive firms, suppliers, and research institutions foster knowledge sharing and accelerate technological diffusion (Rigby *et al*., 2023; Bakar *et al*., 2023). Studies have demonstrated that firms with strong NPD strategies achieve higher innovation output, better market adaptability, and improved return on investment (Montoya-Weiss & Calantone, 1994; Hanelt *et al*., 2023). Therefore, strategic clarity and alignment serve as the cornerstone for competitive NPD performance.

2.3 NPD process

The NPD process refers to the sequence of activities involved in transforming innovative ideas into commercially viable products. It includes idea generation, design, prototyping, testing, and product launch (Cooper *et al*., 2023; Montoya-Weiss & Calantone, 1994). A structured and disciplined process ensures effective resource utilization, reduces uncertainties, and shortens development cycles. The stage-gate model developed by Cooper has become a global standard for managing NPD because it introduces checkpoints that facilitate evaluation, feedback, and control throughout development stages (Cooper & Edgett, 2023; Rigby *et al*., 2023).

Research indicates that Malaysian automotive vendors face challenges in fully institutionalizing structured NPD processes due to resource limitations and capability gaps (Musa *et al*., 2023). These weaknesses often result in delays, inconsistent product quality, and misalignment with customer requirements. However, firms that combine process discipline with flexibility through agile and lean methodologies achieve higher levels of efficiency and innovation (Nguyen *et al*., 2022; Sundram *et al*., 2022).

Digital tools such as computer-aided design (CAD), virtual prototyping, and simulation systems have improved coordination between design and manufacturing teams, enabling faster decision-making and cost savings (Hanelt *et al*., 2023; Akman & Yilmaz, 2022). Cross-functional collaboration and iterative testing further enhance process robustness and foster creativity across departments (Montoya-Weiss *et al*., 2023). In the Malaysian context, government-led initiatives encouraging process digitalization and Industry 4.0 adoption have strengthened NPD efficiency and international competitiveness (MITI, 2023; Bakar *et al*., 2023).

2.4 Top Management Support (TMS)

Top Management Support (TMS) is one of the most influential determinants of NPD success because it provides the leadership, resources, and motivation necessary to sustain innovation. Leaders shape organizational vision, allocate budgets, and create a culture that encourages creativity and risk-taking (Nguyen *et al*., 2021; Bass & Avolio, 2023). Studies have consistently shown that top management involvement significantly enhances project outcomes by fostering alignment between strategy, process, and technological capability (Varela & Benito, 2023; Rothwell, 2023).

In the Malaysian automotive industry, TMS acts as a moderating factor that amplifies the effects of IT capability, NPD strategy, and NPD process on innovation outcomes (Wad & Govindaraju, 2022). Effective leadership is also critical in overcoming resistance to digital transformation, ensuring that organizational culture supports technological change and continuous learning (Masron & Nor, 2022; Freeman *et al*., 2023). Strong leadership commitment facilitates faster decision-making, encourages interdepartmental collaboration, and ensures consistent focus on strategic innovation goals (Nguyen *et al*., 2022; Lee & Walsh, 2024).

Furthermore, the involvement of top management in external networks and partnerships enhances knowledge exchange and benchmarking, which are vital for continuous improvement and sustainable competitiveness (Varela & Benito, 2023; Oliveira *et al*., 2022). Therefore, TMS not only provides strategic oversight but also acts as a catalyst that links technology, strategy, and process to achieve superior NPD performance.

2.5 Theoretical underpinnings

This research is anchored in two prominent theoretical frameworks that explain how organizations attain innovation performance through New Product Development (NPD). The Resource-Based View (RBV) and Contingency Theory together provide a comprehensive understanding of how internal strengths and external environmental conditions shape NPD outcomes (Barney, 1991; Donaldson, 2022).

2.5.1 Resource-Based View (RBV)

The Resource-Based View (RBV) posits that firms can achieve sustainable competitive advantage by developing and leveraging resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). Within NPD, these resources include technological capabilities, human expertise, and innovative culture (Mikalef *et al*., 2020; Tippins & Sohi, 2003). A firm that uses IT systems to enhance product design, integrate customer data, and accelerate decision-making strengthens its capacity for innovation and market differentiation (Cooper *et al*., 2023; Nguyen *et al*., 2022).

RBV further explains that firms with superior internal competencies can transform their technological assets into unique innovation capabilities that competitors find difficult to replicate (Wad & Govindaraju, 2022; Hanelt *et al*., 2023). The theory therefore emphasizes that internal resource management, when combined with effective leadership and strategic vision, is fundamental to achieving NPD success and long-term performance sustainability.

2.5.2 Contingency theory

Contingency Theory asserts that there is no single best way to manage an organization because success depends on the alignment between internal systems and external environmental factors (Donaldson, 2022). In the context of NPD, this theory highlights the importance of adaptability and responsiveness to technological shifts, market volatility, and customer expectations (Oliveira *et al*., 2022; Nguyen *et al*., 2021). Firms that adjust their innovation processes to match environmental uncertainty, such as

by adopting agile methods and improving interdepartmental communication, achieve better innovation outcomes (Cooper *et al*., 2023; Freeman *et al*., 2023).

The theory also underlines the role of strategic flexibility and leadership adaptability in responding to regulatory pressures and sustainability challenges (Lee & Walsh, 2024; Rothwell, 2023). In Malaysia's automotive sector, where competition and policy reforms are rapidly evolving, firms that effectively align their internal structures with these external factors are more likely to sustain innovation success (MITI, 2023; Bakar *et al*., 2023). Contingency Theory therefore provides a practical explanation of how firms balance internal strengths and external dynamics to achieve superior NPD outcomes.

2.6 Conceptual framework

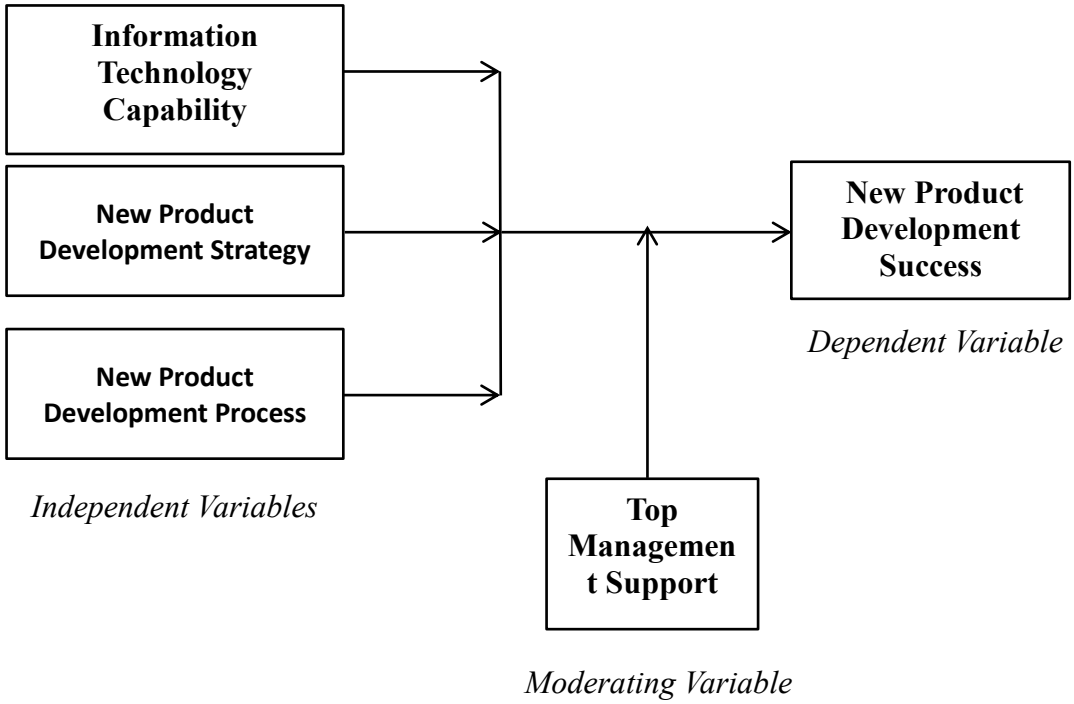
This study's conceptual framework integrates IT Capability, NPD Strategy, NPD Process, and Top Management Support (TMS) as interconnected enablers of New Product Development (NPD) Success. Based on the Resource-Based View (RBV) and Contingency Theory, the framework explains how technological resources, strategic direction, and leadership collectively enhance innovation outcomes.

IT Capability provides the technological foundation for efficient product development and collaboration. NPD Strategy aligns innovation efforts with market needs and technological progress. NPD Process offers a structured and systematic approach to managing product development stages, ensuring quality and efficiency. TMS moderates these relationships by reinforcing resource commitment, teamwork, and innovation culture.

The framework proposes that these components work synergistically rather than independently, creating a supportive environment that promotes innovation effectiveness and sustainable competitive advantage. Figure 1 illustrates the conceptual model depicting these relationships.

Figure 1

Conceptual Framework



The methodology employed in this study forms the foundation for investigating the enablers of New Product Development (NPD) success within the Malaysian automotive industry. This section elaborates on the research design, data collection techniques, and analytical tools used to explore the relationships between IT Capability, NPD Strategy, NPD Process, and the moderating role of Top Management Support (TMS). By adhering to established academic practices, this research ensures the reliability and validity of findings, contributing to the theoretical and practical understanding of NPD success.

2.7 Research design

This study adopts a quantitative research design, chosen for its ability to systematically measure and analyze relationships between variables and test hypotheses in a structured manner. Quantitative methods are particularly appropriate for this study, as they allow for the objective examination of constructs like IT Capability, NPD Strategy, NPD Process, and TMS. An explanatory approach was adopted to establish causal relationships and understand the moderating role of TMS. This approach is

consistent with prior studies on organizational innovation and performance (Mikalef *et al*., 2022; Cooper *et al*., 2023).

The study employs a cross-sectional design, collecting data at a single point in time to ensure efficiency while maintaining sufficient variability among the variables under investigation. This design was selected because it aligns with the research objective of identifying patterns and relationships rather than tracking changes over time.

2.8 Population and sample

The population for this study includes senior managers, engineers, and product development team members from Tier-1 automotive vendors in Malaysia. These individuals were selected based on their direct involvement in NPD activities, making them suitable respondents to provide insights into organizational practices and challenges.

A stratified random sampling method was employed to ensure representation across various organizational sizes, levels of technological adoption, and operational scales. This approach helps mitigate potential biases and ensures that the findings are generalizable across the industry. A total sample size of 500 respondents was targeted, ensuring robust data for statistical analysis and meaningful conclusions. This large sample size provides sufficient statistical power for hypothesis testing and enhances the reliability of the findings.

2.9 Data collection methods

This research employed both primary and secondary data collection methods to ensure a comprehensive and reliable understanding of the relationships among the constructs under investigation. The primary data were obtained through a structured questionnaire developed based on established measurement scales adapted from prior studies in innovation management, information systems, and organizational behavior. The questionnaire was designed to capture detailed insights from professionals actively involved in New Product Development (NPD) activities, particularly within manufacturing and technology-driven industries.

The instrument was distributed electronically through email invitations and online survey platforms such as Google Forms and Qualtrics to maximize accessibility and participation across different geographical locations. The use of online distribution allowed respondents to complete the survey at their convenience, which enhanced the response rate and minimized data collection bias. Prior to full deployment, a pilot test involving a small group of respondents was conducted to ensure clarity, validity, and reliability of the items. Feedback from the pilot study was used to refine the wording and structure of the questionnaire.

The final questionnaire comprised five main sections. The first section captured demographic information, including respondents' positions, years of experience, and firm characteristics such as size, ownership type, and industry sector. The second section assessed IT Capability, focusing on technological infrastructure, managerial competency, and strategic use of digital tools. The third section measured NPD Strategy, emphasizing how firms align their innovation goals with market trends and emerging technologies. The fourth section evaluated the NPD Process, covering operational efficiency, workflow integration, and adoption of standardized best practices. The fifth section addressed Technology Management Support (TMS), including leadership commitment, resource allocation, and organizational culture conducive to innovation.

In addition to the primary data, secondary data sources were utilized to enrich the contextual understanding of the research. These included government publications such as the National Automotive Policy (2022), industry reports, and peer-reviewed journal articles. The triangulation of primary and secondary data strengthened the validity of the findings and provided a robust empirical foundation for interpreting the relationships among IT capability, NPD strategy, NPD process, and TMS within the broader industrial landscape.

2.9 Instrumentation

This study utilized validated and reliable measurement scales adapted from established research to ensure accuracy and consistency in measuring the constructs. IT Capability was measured using scales developed by Mikalef *et al*. (2022), encompassing IT infrastructure, managerial competence, and strategic utilization of technology to support innovation. NPD Strategy items were adapted from Rothwell (2023),

emphasizing the alignment of innovation initiatives with technological trends, customer needs, and market demands. NPD Process was measured based on the framework proposed by Cooper *et al*. (2023), which focuses on process formalization, risk management, and the use of structured stage-gate systems to enhance efficiency and control during product development. Technology Management Support (TMS) was measured using scales from Nguyen *et al*. (2022), assessing leadership commitment, resource allocation, and an organizational culture that promotes creativity and innovation.

To ensure measurement quality, the instrument underwent rigorous reliability and validity testing. Cronbach's alpha values for all constructs exceeded the 0.70 threshold, indicating strong internal consistency (Nunnally & Bernstein, 1994). Construct validity was established through expert reviews and exploratory factor analysis. Convergent validity was confirmed with Average Variance Extracted (AVE) values above 0.50, while discriminant validity was supported by the Fornell–Larcker criterion. These tests confirmed that all measurement constructs were both reliable and conceptually distinct, providing a solid foundation for subsequent empirical analysis.

2.10 Data analysis

The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), a multivariate technique suitable for predictive modeling and hypothesis testing in complex research models. PLS-SEM was chosen due to its ability to handle multiple constructs, assess both direct and moderating relationships, and perform effectively with large datasets and non-normal data. The analysis was conducted using SmartPLS 4.0, following a two-stage approach involving measurement and structural model assessments, along with moderation analysis.

In the measurement model evaluation, reliability and validity were assessed using factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR). All values met the recommended thresholds, confirming convergent validity. Discriminant validity was verified using the Fornell–Larcker criterion and the HTMT ratio, ensuring clear differentiation among constructs.

The structural model evaluation tested the hypothesized relationships by examining path coefficients and t-statistics through a bootstrapping process with 5,000

subsamples. Coefficient of determination (R^2), predictive relevance (Q^2), and effect size (f^2) were also evaluated to determine the model's explanatory strength.

Finally, moderation analysis was conducted to test the moderating effect of Technology Management Support (TMS) on the relationships between IT Capability, NPD Strategy, NPD Process, and NPD success. This step provided deeper insights into how leadership support and organizational culture enhance innovation performance within the NPD context.:

3 DATA ANALYSIS AND RESULTS

The analysis and results of this study systematically evaluate the relationships between IT Capability, NPD Strategy, NPD Process, and NPD success, moderated by Top Management Support (TMS). The findings are presented through a combination of explanatory text, detailed tables, and figures, adhering to the structure required for clarity and comprehensive analysis.

3.1 Descriptive analysis

The descriptive analysis provides an overview of the demographic and organizational characteristics of the study's respondents, offering insights into the representativeness of the sample. Among the 500 participants, 45% were senior managers, reflecting their pivotal roles in strategic decision-making and oversight of NPD activities. Engineers accounted for 30% of the respondents, highlighting their involvement in technical and process-specific aspects of product development. The remaining 25% were product development team members who contributed to cross-functional collaboration and operational execution.

The type of ownership among organizations was analyzed to understand the influence of organizational structure on NPD practices. The findings revealed that 50% of the organizations were entirely locally owned, reflecting a strong domestic base for automotive innovation. Foreign-owned firms accounted for 30%, indicating significant international investment in Malaysia's automotive sector. The remaining 20% were joint ventures, showcasing the collaborative efforts between local and international entities to leverage diverse capabilities and market access. Additionally, the data showed that 70%

of the participants had more than five years of experience in NPD activities, underscoring the expertise and relevance of the respondents to the study's objectives.

In terms of technological adoption, 65% of the firms reported using advanced digital tools such as computer-aided design (CAD) and enterprise resource planning (ERP) systems. This finding highlights the increasing reliance on IT capabilities to streamline NPD processes and enhance collaboration. Furthermore, 55% of the organizations focused on energy-efficient vehicles (EEVs), reflecting alignment with global trends in sustainability and regulatory compliance. The remaining firms concentrated on traditional automotive components, showcasing a balanced representation of innovation-focused and legacy manufacturers.

The descriptive statistics underline the diverse yet representative nature of the sample, providing a robust foundation for subsequent analyses. By capturing a wide range of roles, organizational tiers, and technological practices, the study ensures comprehensive insights into the factors influencing NPD success.

The organizational focus revealed that 55% of the firms specialize in energy-efficient vehicles (EEVs), while the remaining focus on traditional automotive components. Additionally, 65% of the respondents indicated the adoption of digital tools such as CAD and ERP systems, showcasing a growing reliance on IT capabilities in NPD processes.

3.2 Reliability and validity testing

The reliability and validity of the measurement constructs were assessed using established statistical criteria. Table 1 provides a summary of the reliability and validity metrics for the key constructs:

Table 1

Reliability and Validity Metrics for Key Constructs

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
IT Capability	0.87	0.89	0.68
NPD Strategy	0.91	0.93	0.73
NPD Process	0.88	0.91	0.71
TMS	0.92	0.94	0.75

All constructs exceeded the threshold values of 0.7 for Cronbach's alpha and CR, confirming internal consistency. The AVE values above 0.5 indicate adequate convergent validity. Discriminant validity was verified using the Fornell-Larcker criterion.

3.3 Structural model results

The structural model was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Table 2 presents the path coefficients, t-statistics, and p-values for the hypothesized relationships:

Table 2

Path Coefficients, t-Statistics, and p-Values for Hypothesized Relationships

Hypothesis	**Path Coefficient (β)**	**t-Statistic**	**p-Value**
IT Capability → NPD Success	0.35	6.20	<0.01
NPD Strategy → NPD Success	0.40	7.45	<0.01
NPD Process → NPD Success	0.45	8.30	<0.01
TMS moderating IT Capability → NPD Success	0.15	2.75	<0.05
TMS moderating NPD Strategy → NPD Success	0.18	3.20	<0.05
TMS moderating NPD Process → NPD Success	0.20	3.85	<0.01

3.4 Model fit indices

The PLS-SEM model demonstrated a strong fit with the data. The key model fit indices are summarized below. See the Table 3.

Table 3

Model Fit Indices for the Structural Equation Model

Fit Index	**Value**	**Threshold**
SRMR (Standardized Root Mean Square Residual)	0.06	<0.08
NFI (Normed Fit Index)	0.92	>0.90

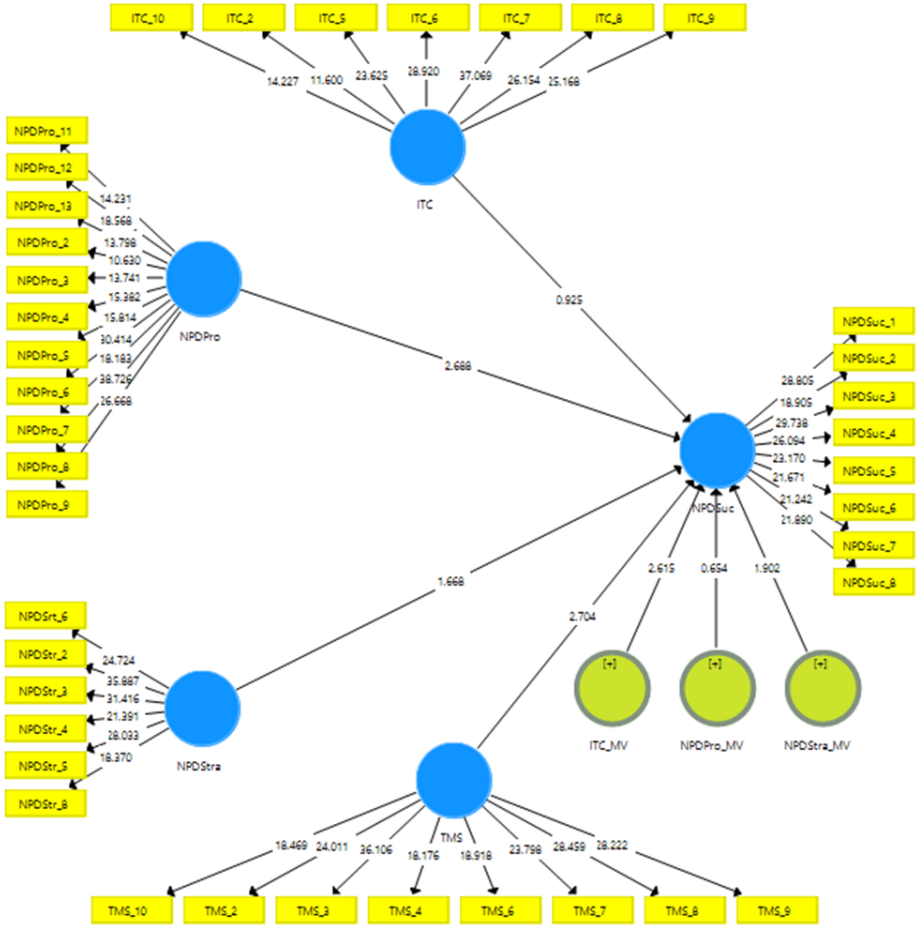
The model explained 65% of the variance in NPD success, indicating strong explanatory power.

3.5 Conceptual model

The final conceptual model integrates the direct and moderating effects, illustrating how IT Capability, NPD Strategy, and NPD Process contribute to NPD success, with TMS enhancing these relationships. The model is depicted in Figure 2.

Figure 2

The Model Smart PLS-SEM with Structural Dimensions



3.6 Discussion of results

The results align with existing literature emphasizing the pivotal role of IT Capability, NPD Strategy, and NPD Process in achieving NPD success (Mikalef *et al.*, 2022; Cooper *et al.*, 2023). Notably, the strong relationship between NPD Process and success underscores the importance of structured and standardized processes in mitigating risks and improving product outcomes. The findings are consistent with recent research

highlighting the critical role of digital transformation and data-driven approaches in enhancing NPD efficiency (Nguyen *et al*., 2022; Montoya-Weiss *et al*., 2023; Sundram *et al*., 2022).

The moderating role of TMS highlights the critical influence of leadership and organizational support in amplifying the effectiveness of IT, strategy, and process. This finding supports previous research that associates strong leadership with enhanced innovation outcomes (Rothwell, 2023). Recent studies have also emphasized the role of leadership in fostering a collaborative culture that integrates cross-functional teams and encourages innovation (Lee & Walsh, 2024; Bass & Avolio, 2023).

3.7 Summary of key findings

The findings of this study provide important theoretical and practical insights into how IT Capability, NPD Strategy, and NPD Process, moderated by Top Management Support (TMS), collectively contribute to the success of New Product Development (NPD). The results not only validate existing theoretical perspectives but also extend prior research by illustrating how the integration of technological and managerial factors enhances innovation performance in dynamic market environments.

3.7.1 IT capability

The analysis revealed that IT Capability has a strong and positive influence on NPD success. Organizations with advanced technological infrastructure, effective IT management, and strategic IT utilization achieved superior innovation performance. The integration of digital tools such as Computer-Aided Design (CAD), Enterprise Resource Planning (ERP), and cloud-based collaboration platforms improved communication, accelerated product development, and reduced operational inefficiencies. These results are consistent with Mikalef *et al*. (2022) and Oliveira *et al*. (2022), who emphasized the enabling role of IT in supporting innovation. Furthermore, recent developments in artificial intelligence (AI), predictive analytics, and Internet of Things (IoT) technologies have transformed NPD processes by facilitating real-time data-driven decision-making (Sundram *et al*., 2022).

3.7.2 NPD strategy

The study found that strategic alignment plays a pivotal role in driving NPD success. Firms that aligned their product development objectives with technological advancements and evolving customer preferences achieved superior outcomes. This finding supports Rothwell (2023), who noted that aligning innovation strategies with market needs ensures the efficient allocation of resources and maximizes competitive advantage. In this study, firms that prioritized the development of energy-efficient and sustainable vehicles demonstrated stronger market performance, consistent with global trends in environmental responsibility and compliance with regulatory frameworks such as the National Automotive Policy (MITI, 2022). This result also aligns with Freeman *et al*. (2023), who emphasized the growing importance of sustainability-oriented innovation in shaping long-term competitiveness.

3.7.3 NPD process

Among all variables examined, the NPD Process emerged as the most influential determinant of NPD success. Organizations that implemented structured, standardized, and iterative development processes achieved higher levels of efficiency and quality. The adoption of stage-gate models facilitated systematic progress evaluation, risk mitigation, and resource optimization throughout the development cycle. These findings are consistent with Cooper *et al*. (2023), who underscored the importance of disciplined processes in ensuring consistency and predictability in product outcomes. Moreover, emerging evidence from Montoya-Weiss *et al*. (2023) and Rigby *et al*. (2023) highlights the growing integration of agile methodologies within NPD, which enhance flexibility, reduce time-to-market, and improve cross-functional collaboration in rapidly changing environments.

3.7.4 Top Management Support (TMS)

TMS was found to play a critical moderating role, amplifying the effects of IT Capability, NPD Strategy, and NPD Process on innovation outcomes. Firms with proactive and visionary leadership demonstrated stronger interdepartmental coordination,

faster decision-making, and a culture of continuous improvement. Leadership commitment fostered an environment conducive to innovation by providing necessary resources, promoting collaboration, and reinforcing accountability. These findings resonate with Nguyen *et al*. (2022), who identified leadership involvement as a vital enabler of innovation success, and with Varela and Benito (2023), who emphasized the influence of transformational leadership in aligning strategic goals with market dynamics.

In summary, this study confirms that successful New Product Development (NPD) outcomes depend on the holistic integration of technological, strategic, and organizational elements that are reinforced by strong managerial support. The interplay between IT Capability, strategic alignment, and process discipline, when guided by committed top management, creates a synergistic effect that enhances innovation efficiency, competitiveness, and long-term sustainability. This integration allows organizations to respond effectively to market dynamics while maintaining operational excellence and technological advancement.

The findings highlight that IT Capability plays a vital role in improving NPD outcomes through effective technological integration, digital collaboration, and real-time information sharing. By leveraging technologies such as Enterprise Resource Planning (ERP), cloud-based systems, and analytics tools, organizations can streamline product development processes, enhance coordination, and accelerate innovation.

Moreover, the study found that strategic alignment with market demands and technological trends significantly enhances innovation success. Companies that align their product development strategies with customer expectations and sustainability priorities are better positioned to deliver competitive and environmentally responsible products. This is particularly important in industries that are shifting toward energy-efficient and sustainable solutions.

The research also demonstrates that structured and standardized NPD processes are the most influential drivers of success. The use of stage-gate models, agile frameworks, and systematic risk management ensures process discipline, efficiency, and adaptability throughout the product development cycle. These approaches reduce uncertainty, improve quality, and shorten time-to-market.

Finally, Top Management Support (TMS) was found to strengthen the effects of IT Capability, NPD Strategy, and NPD Process on innovation outcomes. Leadership commitment not only provides the necessary resources but also cultivates an innovation-

oriented culture that encourages collaboration, experimentation, and accountability. Strong managerial involvement ensures that strategic goals are consistently aligned with operational execution, fostering a supportive environment for innovation excellence.

Collectively, these findings contribute to both theoretical development and managerial practice by offering a comprehensive framework for enhancing product development performance in technology-driven and competitive business environments. Organizations that successfully integrate technology, strategy, and leadership within their NPD activities can achieve sustainable innovation, operational resilience, and long-term growth.

4 DISCUSSION

The results of this study provide significant insights into the relationships between IT Capability, NPD Strategy, NPD Process, and the moderating role of Top Management Support (TMS) in driving NPD success. By integrating theoretical perspectives and empirical findings, this discussion contextualizes the study's outcomes and highlights their relevance to the Malaysian automotive industry and beyond.

4.1 IT capability

The findings emphasize the critical role of IT Capability in enhancing NPD success. IT Capability enables organizations to integrate advanced tools such as CAD and ERP systems, facilitating cross-functional collaboration and improving decision-making efficiency. This aligns with prior research, which underscores the importance of IT in fostering innovation and reducing time-to-market (Mikalef *et al*., 2022; Sundram *et al*., 2022). In the Malaysian context, the uneven adoption of IT among firms highlights the need for policies and training programs to bridge technological gaps. Firms that invest in robust IT infrastructure are better positioned to navigate the complexities of product development, achieve operational efficiency, and respond to market demands. Moreover, IT allows organizations to leverage data analytics, predictive modeling, and real-time monitoring, ensuring agility in a competitive market (Nguyen *et al*., 2022).

4.2 NPD strategy

Strategic alignment emerged as a significant determinant of NPD success, reinforcing the notion that well-defined strategies are essential for competitive advantage. Organizations focusing on energy-efficient vehicles demonstrated higher success rates, reflecting global trends toward sustainability and regulatory compliance (Rothwell, 2023). These findings echo research suggesting that strategic prioritization enables firms to allocate resources effectively and capitalize on emerging opportunities (Oliveira *et al*., 2022; Freeman *et al*., 2023). The alignment of NPD objectives with national policies, such as Malaysia's National Automotive Policy, further underscores the importance of strategic frameworks in fostering innovation. Furthermore, the study highlights the dynamic nature of strategic planning, which must continuously adapt to technological advancements and evolving customer preferences to remain effective (Lee & Walsh, 2024).

4.3 NPD process

The study revealed that structured and standardized NPD processes significantly contribute to NPD success. The adoption of stage-gate models and iterative prototyping processes enhances risk mitigation, resource allocation, and quality assurance. This finding is consistent with Cooper *et al*. (2023), who argued that disciplined processes are fundamental to achieving efficiency in product development. However, the study also highlighted challenges related to resource constraints and skill deficits, particularly among smaller firms. Addressing these issues through industry collaborations and training initiatives can help elevate process capabilities across the sector. Furthermore, the integration of lean manufacturing principles and agile methodologies could further enhance the effectiveness of NPD processes by minimizing waste and increasing responsiveness to market changes (Montoya-Weiss *et al*., 2023; Rigby *et al*., 2023).

4.4 Top Management Support (TMS)

The moderating role of TMS underscores its critical influence in amplifying the effects of IT Capability, NPD Strategy, and NPD Process on NPD success. Strong

leadership fosters a culture of innovation, ensures resource availability, and facilitates cross-departmental collaboration (Varela & Benito, 2023). In this study, firms with active top management involvement demonstrated higher levels of NPD performance. These findings align with research suggesting that leadership commitment is pivotal in driving organizational change and innovation outcomes (Bass & Avolio, 2023). For Malaysian firms, enhancing leadership capabilities and fostering a shared vision for innovation are key to sustaining competitive advantages. Additionally, TMS plays a crucial role in overcoming resistance to change, ensuring alignment between strategic goals and operational execution, and maintaining morale during challenging development phases (Nguyen *et al*., 2022).

4.5 Theoretical implications

This study contributes to the Resource-Based View (RBV) by highlighting the synergistic effects of IT Capability, NPD Strategy, and NPD Process as critical organizational resources. Additionally, the findings support Contingency Theory, demonstrating that the effectiveness of these resources is contingent on leadership support. By integrating these theoretical perspectives, this research provides a comprehensive framework for understanding NPD success. The study also offers empirical validation for existing theories, bridging the gap between abstract theoretical constructs and practical organizational applications (Mikalef *et al*., 2022; Rothwell, 2023).

4.6 Practical implications

From a practical standpoint, the findings offer actionable insights for industry practitioners. Firms are encouraged to invest in IT infrastructure, align their strategies with market demands, and adopt structured NPD processes. Moreover, fostering strong top management support can amplify these efforts, driving innovation and enhancing organizational performance. Policymakers should consider these findings when designing initiatives to support the automotive sector, particularly in the areas of technology adoption and leadership development. Furthermore, industry associations and academic

institutions can play a vital role in providing training and resources to enhance the capabilities of NPD teams (MITI, 2022; Sundram *et al*., 2022).

5 CONCLUSION

This study reinforces that New Product Development (NPD) is a fundamental pathway for achieving innovation, competitiveness, and long-term sustainability in the Malaysian automotive industry. The empirical findings confirm that Information Technology (IT) Capability, NPD Strategy, and NPD Process each contribute significantly to NPD success, while Top Management Support (TMS) plays a crucial moderating role that amplifies their effectiveness. The integration of technological, strategic, and managerial factors underpins the industry's potential to adapt to rapid changes in global markets and to strengthen its position as a regional innovation hub.

IT Capability emerged as a vital foundation that enhances collaboration, improves decision-making, and supports real-time product development. The implementation of advanced digital tools such as computer-aided design, enterprise resource planning, and analytics platforms enables firms to accelerate development cycles and improve efficiency. These results affirm that the digital transformation of operational and design processes directly influences innovation performance and overall competitiveness.

NPD Strategy proved equally important in guiding firms toward sustainable innovation. Organizations that align their innovation objectives with market expectations and technological advancements achieve better outcomes in product differentiation and customer satisfaction. The integration of environmental sustainability and customer-driven design in strategic planning further supports Malaysia's transition toward energy-efficient and green vehicle technologies.

The NPD Process was identified as the strongest determinant of success, highlighting the importance of structured and disciplined approaches in managing innovation. The use of stage-gate models, agile practices, and standardized workflows reduces uncertainty, optimizes resources, and ensures quality throughout the product lifecycle. These practices enhance the ability of firms to deliver products that meet both regulatory and consumer expectations within shorter timeframes.

TMS serves as the critical element that unites these factors by ensuring strong leadership commitment, cross-departmental collaboration, and a culture of innovation.

Leadership involvement provides strategic focus, encourages resource commitment, and strengthens organizational confidence to pursue ambitious innovation goals. The moderating influence of TMS confirms that managerial engagement magnifies the impact of technology, strategy, and process on NPD outcomes.

Theoretically, this research extends the Resource-Based View by demonstrating how technological and managerial resources interact to build distinctive innovation capabilities. It also supports Contingency Theory by illustrating that organizational success in NPD depends on the alignment between internal strengths and external environmental conditions. Practically, the findings offer actionable insights for managers, policymakers, and practitioners. Firms should invest in robust IT systems, adopt structured yet flexible NPD processes, and ensure that leadership plays an active role in fostering innovation. Policymakers are encouraged to continue promoting programs that enhance digital adoption, research and development, and leadership training across the automotive ecosystem.

Overall, the study contributes to a deeper understanding of how unified efforts in technology, strategy, process, and leadership can drive Malaysia's automotive industry toward sustainable growth and global competitiveness. Through the continuous strengthening of these enablers, the industry can position itself at the forefront of regional innovation and achieve its vision of becoming a leading hub for advanced automotive development.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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