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The Impact of Digital Technologies on Business Performance Enhancement: Toward Promoting the Adoption of Effective Digital Transformation in Malaysian SMEs

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ABSTRACT

Digital transformation in Malaysian SMEs typically starts with basic platforms like websites and social media for client engagement but often fails to result in significant business performance improvements. Many SMEs are merely computerized and lack integration of advanced technologies. A major barrier to effective transformation is a limited understanding of advanced technologies such as Cloud Computing, Artificial Intelligence, and Machine Learning, critical for aligning with modern business models. This study evaluates the impact of these technologies on business performance within SMEs, utilizing a quantitative approach with simple random sampling and an online survey of 267 participants. Data will be analyzed through descriptive and inferential statistics to determine the relationship between advanced technology adoption and business performance enhancements. The findings aim to offer insights into the challenges and opportunities for Malaysian SMEs in their digital transformation efforts.

1. Introduction

Small and medium-sized enterprises (SMEs) are a cornerstone of the global economy, representing approximately 90% of businesses worldwide (Costa Melo et al., 2023). Their significant market presence underscores the importance of understanding the challenges and opportunities they face, particularly in the context of digital transformation (DT). The 2030 Digital Compass, aligned with the European Green Deal, emphasises the role of DT in transitioning SMEs toward sustainable production models, highlighting the need for transparency and innovation in this process (Chatzistamoulou, 2023). However, SMEs often struggle with limited resources, including financial constraints and a lack of specialised capabilities, which hinder their ability to fully leverage DT. This, in turn, negatively impacts their operational efficiency, innovation potential, and overall business performance. Moreover, sustainability—often treated as a peripheral concern in DT discussions—remains underprioritised, further limiting SMEs' growth and resilience. Addressing these challenges is critical for achieving Sustainable Development Goals (SDGs) 1, 5, 8, 9, 10, and 12, underscoring the critical role of taking sustainability into account in the digital transformation journey of SMEs (Costa Melo et al., 2023). In the European Union (EU), SMEs face additional hurdles, such as a reactive mindset, limited growth opportunities, and a lack of innovation understanding, which collectively impede digitalisation efforts and business performance. While financing is less of an issue in the EU compared to other regions, the digitalisation gap between the EU and the United States (US) remains significant. The US outperforms the EU in digital adoption rates, driven by a proactive approach, diverse growth opportunities, and a stronger innovation culture (Vavura, 2022). The COVID-19 pandemic further exacerbated these challenges, particularly in South-Eastern Europe, where SMEs lag in e-commerce, social media usage, and big data analytics compared to the EU average (Hunady et al., 2022).

The pandemic made it clear that small and medium-sized businesses (SMEs) need to use digital tools right away to stay competitive and avoid performance drops. Despite these challenges, the integration of digital technologies has been shown to simplify processes, boost productivity, and improve customer experiences, ultimately driving business growth (Kádárová et al., 2023).In Asia, technological innovation has proven to be a key driver of economic growth. For instance, a 1% increase in technological innovation correlates with a 0.043% rise in economic growth, emphasizing the importance of advanced technologies in fostering sustainable development within organizations as well (He et al., 2023). However, SMEs in Asia face significant barriers to DT adoption, including high initial costs, inadequate infrastructure, and a lack of digital skills. These challenges are particularly pronounced in Southeast Asian countries like Malaysia, Singapore, and Thailand, where SMEs struggle with data security, customer-centricity, and agility in adopting new technologies (Gunasilan et al., 2020; Khalid et al., 2019).
In China, SMEs encounter similar obstacles, such as insufficient awareness, financial constraints, and a lack of talent, which hinder their ability to compete in the digital economy (Huang & Wang, 2022). Despite these challenges, the Chinese government has prioritised the integration of the digital and real economies, emphasising the need for SMEs to adopt DT

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to achieve high-quality development (Haohan & Beinan, 2023).In Malaysia, SMEs play a pivotal role in the economy, contributing 38.2% to the country's GDP in 2020 (Nor et al., 2021), constituting 97.4% of total businesses and 59% of opportunities for employment (Moin et al., 2023). However, many Malaysian SMEs remain in the early stages of digitalisation. There is a lack of awareness among Malaysian SMEs about how digital technology might improve their business operations. Consequently, establishing the appropriate business strategy is one of the most significant issues facing SMEs, as revealed by 46% of them in a study (Yuen, 2023).

The understanding gap of how these IR4.0 developments might improve their operations is preventing Malaysian SMEs from moving forward with implementing IR4.0 (Abd Shukor et al., 2023). The lack of understanding among Malaysian SMEs about the potential of cloud computing technology has hindered their adoption of the technology and raised concerns about the return on their investment in digitalisation (Abu Bakar et al., 2021). Malaysian SMEs lack the fundamental understanding about the potential benefits and capabilities of artificial intelligence (AI), hindering their ability to integrate AI applications, particularly in Sabah (Lada et al., 2023). One of the biggest obstacles is a lack of knowledge on how to perform market studies and innovate for effectively taking up the e-commerce trend that has progressively grown in Malaysia and breaking free from the alarming state (Rahim et al., 2019; Zain et al., 2020).In conclusion, the articles' findings indicate a major emphasis on fundamental information systems as the predominant form of technology adoption, surpassing advanced digital technologies such as cloud computing and artificial intelligence in emerging nations' SMEs (Díaz-Arancibia et al., 2024).

A critical issue hindering SMEs' progress is the lack of understanding and awareness about the benefits of advanced digital technologies, such as cloud computing (CC), artificial intelligence (AI), and machine learning (ML), and their transformative impact on business performance. Many Malaysian SMEs find that DT just entails making a front-end digital platform, such as a website or social media page, which doesn't really improve the performance. The majority of SMEs are computerised but not digitalised, as evidenced by the fact that they do distinct tasks on many computers without utilising digital technologies (Yuen, 2023). SMEs' dependence on out-of-date legacy systems and the risk-averse attitude that is widespread among them (Kallmuenzer et al., 2024). Which emphasises that they are computerised but not digitalised; in other words, they adopt ineffective digital transformation. This research aims to assess the impact of digital technologies such as cloud computing, AI, and ML on business performance enhancement and to foster the adoption of effective digital transformation. Specifically, it seeks to answer the following research questions: (1) How does cloud computing technology affect business performance based on SMEs' understanding level? (2) How does AI technology affect business performance based on SMEs' understanding level? (3) How does machine learning technology affect business performance based on SMEs' understanding level? By addressing these questions, this research contributes to the broader discourse on digitalisation and sustainability, offering actionable insights for SMEs' leaders, policymakers, and stakeholders. Ultimately, this study points out the importance of strategic planning, smart investment in infrastructure, and capacity building in enabling SMEs to thrive in the digital era.

2. Literature Review

The rapid advancement of technology, particularly in the domains of artificial intelligence (AI), machine learning (ML), and cloud computing, has profoundly transformed the landscape of business performance. This literature review synthesises existing research on the impact of digital technologies on business operations, drawing on insights from Vidmar et al. (2021), who explored how information technology (IT) enhances sustainable business performance (SBP).In many instances, theoretical foundations provide a structured basis for practical applications, as theories aim to explain underlying phenomena and offer logical frameworks for their real-world implementation (Gaffikin, 2008). In this study, technological theory serves as the guiding foundation, with the research variables derived from a conceptual framework adapted from prior studies (Nor et al., 2021) (Figure 1).The primary objective of this research is to assess the extent to which digital technologies contribute to enhancing business performance in SMEs. The conceptual framework identifies business performance enhancement as the dependent variable, while AI, ML, and cloud computing function as the independent variables. We anticipate that these digital technologies will directly impact dependent variables, influencing how SMEs utilise digital transformation to enhance their performance. The relationship between these variables is illustrated in the following figure:

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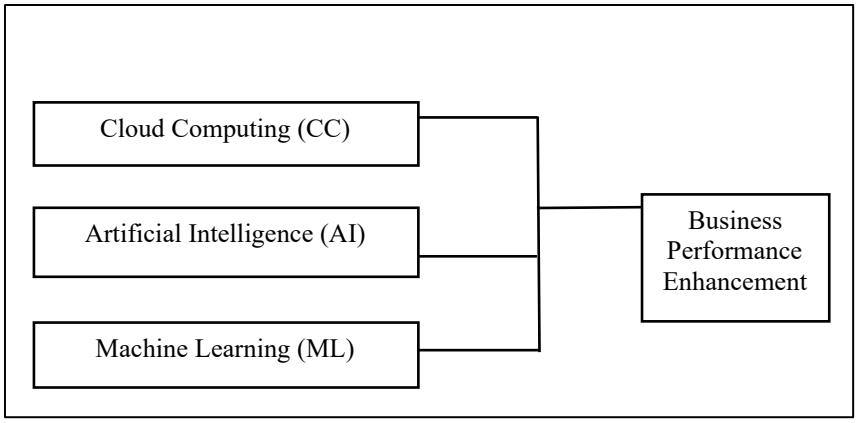

Figure: 1 Conceptual Framework

Hypotheses developed based on the conceptual framework that Figure 1 contains:

H1: There is a positive significant impact of having cloud computing technology on business performance.
H2: There is a positive significant impact of having artificial intelligence technology on business performance.
H3: There is a positive significant impact of having machine learning technology on business performance.

2.1 Business Performance Enhancement

Digital transformation (DT) is a critical process for small and medium-sized enterprises (SMEs), involving the integration of digital technology tools across operational areas to drive innovation and enhance performance. This transformation is essential for improving efficiency, services, and competitiveness, which are key factors in boosting overall business performance in today's dynamic market. By adopting digital tools, SMEs can foster a technological innovation culture, enabling them to adapt to changing market conditions and consumer demands. This includes developing new business models, refining strategies, and optimising existing practices to leverage technology effectively. The integration of digital technologies leads to several performance-enhancing outcomes, such as improved operational efficiency, reduced costs, increased productivity, better customer engagement, and access to global markets. Additionally, data-driven decision-making allows SMEs to analyse data and information effectively, resulting in informed strategies and improved business outcomes. In summary, the adoption of digital technologies not only supports innovation but also enhances performance across multiple dimensions, making it a vital component of SME success (Islam Bhuiyan et al., 2024).The role of information and communication technologies (ICTs) in promoting innovation and enhancing business performance is explored in a study focusing on industrial SMEs in emerging economies.

ICTs are identified as critical facilitators of innovation, enabling SMEs to improve products, processes, and management systems. This, in turn, enhances overall business performance, including financial, organisational, and commercial aspects. The study highlights the importance of integrating ICTs into business strategies to improve operational procedures, profitability, and market orientation. The findings provide empirical evidence that innovation and ICT adoption drive business growth and competitiveness (Cuevas-Vargas et al., 2016). The slow adoption of DT significantly hinders the performance of medical device SMEs in southern Germany. Delays in DT can negatively impact their ability to compete in the market, as they struggle to keep pace with more digitally advanced competitors. However, the study highlights that adopting DT and implementing effective digital technologies can significantly enhance business performance. There is a clear correlation between the level of digital adoption and improved financial outcomes. By integrating advanced technologies, these SMEs can streamline operations, enhance customer engagement, and increase overall efficiency, leading to better financial performance and sustainable growth. Effective data management and decision-making processes further support this transformation.

The research underscores that SMEs that successfully implement digital strategies are better positioned for long-term success in an increasingly digital marketplace. This fosters a culture of innovation, encouraging continuous improvement and further adoption of digital technologies (Elsaman et al., 2023).The adoption of innovative digital technologies is a cornerstone of effective DT. These technologies contribute to dynamic capabilities, which refer to an organization's ability to integrate, build, and reconfigure internal and external competencies to respond to rapidly changing environments. The study indicates that dynamic capabilities positively influence business model innovation, which is crucial for adapting to market changes and customer needs. By leveraging these technologies, SMEs can enhance operational processes, improve customer engagement, and innovate their service offerings. This transformation is essential for maintaining competitiveness in a digital economy. The findings suggest that business model innovation partially mediates the

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relationship between dynamic capabilities and business performance, meaning that while dynamic capabilities directly impact performance, innovation amplifies this effect. Therefore, SMEs that effectively harness their dynamic capabilities through DT are likely to achieve better performance outcomes. The study, which involved 262 managers from Chinese SMEs and used partial least squares structural equation modelling (PLS-SEM), confirms that the relationships between DT, dynamic capabilities, and business performance are statistically significant and positive (Chung et al., 2024).A study focusing on A-share listed enterprises in China from 2012 to 2021 examines how DT influences innovation performance, considering ownership structures and financial flexibility.

The findings reveal a positive relationship between DT and innovation performance in state-owned enterprises, suggesting that digital adoption enhances their ability to innovate and improve business performance. In contrast, non-state-owned enterprises exhibit an inverted U-shaped relationship, where innovative performance initially improves with DT but plateaus after a certain point due to financial constraints. Financial flexibility plays a moderating role, weakening the positive effects of DT in non-state-owned enterprises, particularly those with limited resources. This highlights the challenges SMEs face in leveraging DT for innovation without adequate financial support (Zhang et al., 2022). Another study analyses the impact of DT on 319 SMEs in China's Shanghai and Shenzhen A-share markets from 2007 to 2020, focusing on investment costs and business performance. The findings show a positive correlation between DT and operational performance, indicating that digital investments enhance efficiency and productivity. However, the relationship with innovation follows an inverted U-shaped curve, suggesting diminishing returns beyond a certain level of investment. Financial performance does not show a significant relationship, likely due to time lags, market conditions, and high implementation costs. The study emphasises the need for SMEs to optimise financial efficiency to fully benefit from DT (Teng et al., 2022). Having the right technologies and a digitally skilled workforce is crucial for successful digitalisation (Kallmuenzer et al., 2024).

Additionally, SMEs must focus on improving operation's efficiency internally and organisational resilience to sustain growth and innovation (Teng et al., 2022). The adoption of robust digitalisation strategies is essential for implementing innovation management practices, which positively impact SME performance, particularly in emerging economies. The study reveals a strong relationship between 10 digitalisation strategies and improved business performance, as SMEs that leverage digital tools are better equipped to enhance productivity and market responsiveness. The research, based on data from 300 managers across various sectors, underscores the importance of integrating digital technologies into operations to achieve growth and maintain competitiveness in rapidly changing environments (Khan & Siddiqui, 2023). Policymakers play a crucial role in supporting SME digitalisation by addressing challenges such as high costs and limited resources. Government initiatives, including affordable technology access and high-quality broadband, are essential for enabling SMEs to adopt digital technologies and contribute to economic growth (Yuen, 2023). The transition to 5G networks, for instance, addresses the increasing demand for better data transmission capacity, particularly in densely populated urban areas (Rasiah et al., 2023). Enterprise digital transformation is not just a trend but a critical factor in enhancing innovation performance. The positive correlation between DT and innovation provides valuable insights for policymakers and business leaders to strategise digital initiatives and promote high-quality economic development (Sun, 2022). However, SMEs remain hesitant to adopt technologies like cloud computing due to unclear guidelines and inadequate standards (Abu Bakar et al., 2021). Government-sponsored support organisations play a vital role in helping SMEs overcome barriers to DT. These entities, often funded by the government, provide workshops, training, and project implementation support to educate SMEs about digital innovation (Nor et al., 2021). In Malaysia, government agencies have been instrumental in promoting SME development, with 158 programmes and a budget of RM14.3 billion allocated as of 2018 (Rahim et al., 2019).The e-commerce sector has significantly contributed to Malaysia's economic growth, with its GDP contribution rising from 5.9% in 2015 to 6.1% in 2016, and a target of RM211 billion by 2020 (Rahim et al., 2019). Despite low DT adoption rates, Malaysian SMEs are optimistic about the potential of digital technologies to transform their business models and adapt to unstable environments (Yuen, 2023).

The Malaysian government's National Industry Revolution 4.0 (IR4.0) Policy, launched in 2021, aims to accelerate digital adoption and build a strong foundation for the digital economy. The policy focuses on enhancing IR4.0 skills, driving DT, and achieving sustainable growth, with the digital economy expected to contribute 22.6% to GDP by 2025 (Rasiah et al., 2023). Initiatives like the National Technology and Innovation Sandbox (NTIS) under the PENJANA plan further support SMEs by providing access to advanced technologies, funding, and market opportunities (Abu Bakar et al., 2021). In conclusion, the future of SMEs in Malaysia hinges on their ability to adopt DT and advance towards IR4.0. By leveraging digital technologies, SMEs can enhance competitiveness, drive economic growth, and ensure long-term sustainability in an increasingly digital world (Abd Shukor et al., 2023).

2.2 Cloud Computing (CC)

Cloud computing (CC) has become a cornerstone of digital transformation strategies due to its unparalleled scalability and flexibility. Consequently, numerous enterprises are shifting from conventional computing technologies to cloud-based solutions to maintain competitiveness in the digital age (Lambropoulos et al., 2021). The pressure to adopt innovative technologies that reduce costs, maintain market position, and enhance profitability has made cloud computing

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an essential component of modern business strategies. Cloud computing, unlike traditional technologies, is not dependent on a specific vendor, protocol, or technology. Instead, it represents a convergence of business essentials and technological innovation, shaped by years of development and advancements across multiple fields. Today, cloud computing is a critical enabler of digital transformation, allowing enterprises to develop new products, services, and business models. By leveraging cloud computing, businesses can access advanced infrastructure and applications without the need to manage or control them directly, enabling new revenue streams and market opportunities. Cloud computing is typically offered through three popular service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS), and four deployment models: Private Cloud, Public Cloud, Hybrid Cloud, and Community Cloud (Hirschheim et al., 2020).Selecting the appropriate cloud model depends on factors such as budget, resources, and business requirements. Public clouds are ideal for businesses seeking scalability without full control over their infrastructure, while private clouds are suited for organisations handling sensitive data that require complete control over their environment. Hybrid clouds, on the other hand, offer a balance of security and scalability, making them suitable for businesses that can manage the complexities of integrating multiple cloud environments (Chirag Sharma et al., 2023).

For SMEs, cloud computing offers significant advantages, including flexibility, cost efficiency, and rapid innovation. Cloud computing reduces financial risks and supports experimental approaches by providing access to a diverse range of state-of-the-art resources through cloud services, including hardware items (storage, databases, servers, and network components), security instruments, development ecosystems, software applications, server administration functionalities, and application development functionalities without requiring upfront investments. This flexibility encourages innovation, particularly for new market entrants. Scalability allows SMEs to adjust IT resources in response to demand fluctuations quickly, enabling rapid growth without substantial capital expenses. Additionally, cloud services ensure high availability, minimising downtime and system failures, which is crucial for SMEs as they expand their operations globally. The pay-as-you-go pricing model further reduces operational expenses, as SMEs only pay for the resources they use. Fully managed services allow SMEs to focus on core competencies while leveraging standardised services, fostering innovation without extensive integration efforts. Collectively, these capabilities drive strategic innovation and empower SMEs to explore new markets, enhancing their competitiveness in a dynamic business landscape (Hirschheim et al., 2020).A study employing a dual-stage analytical approach using Structural Equation Modelling (SEM) and Artificial Neural Networks (ANN) investigated the predictors of cloud computing adoption and their impact on SMEs' performance. The findings revealed that factors such as relative benefit, service quality, considered risks, top management support, enabling conditions, cloud provider influence, server location, computer self-efficacy, and resistance to change significantly influence cloud adoption. Server location emerged as the most critical predictor, followed by enabling conditions and relative benefit. The study confirmed a positive correlation between cloud computing adoption and improved business performance, highlighting the importance of addressing perceived risks, relative benefits, and top management support to enhance operational efficiency and competitive advantage (Khayer et al., 2020).

Another study explored how cloud computing can enhance circular economy practices within SMEs, contributing to sustainable business performance. Through a systematic review of 186 scholarly articles, the research identified cloud computing as a key enabler of sustainable business processes, supporting the implementation of the Circular Approach to Business Practices (CABP). The study proposed an integrated framework based on the Technology, Organisation, and Environment (TOE) framework and institutional isomorphism to assess cloud adoption and circular economy execution. The findings suggest that cloud-based applications have the potential to contribute to SDGs and improve overall business performance by fostering industrial and economic progress while minimising environmental effect (Natrajan et al., 2024).A separate study examined the factors influencing cloud computing adoption among SMEs and its impact on sustainable performance. Analysing data from 415 SMEs using a hybrid PLS-SEM approach, the study identified six key determinants: relative benefit, complexity, compatibility, top management support, cost reduction, and government support. The study found that the most influential factors were complexity, cost reduction, and government support, followed by compatibility, top management support, and relative benefit. The study concluded that cloud computing integration enhances business performance by improving operational efficiency, reducing costs, promoting sustainability through lower energy consumption, and fostering agility and innovation.

These findings emphasise the value of addressing these determinants to enable SMEs to leverage cloud computing for sustainable growth and competitive advantage (AlSharafi et al., 2023). Despite its benefits, SMEs in Malaysia face significant challenges in adopting cloud computing, including a lack of digitisation culture, a limited understanding of its advantages, and high adoption costs. A study found that 49% of SMEs cite high costs as a barrier, with 34% viewing cloud computing as costly. Additionally, doubts about the return on investment (ROI) from digitalisation further hinder adoption. To address these challenges, it is essential to educate SMEs about available funding options and highlightthe affordability of cloud-based solutions for business enhancement, data storage, and analytics. Also, proper training for employees is very important to make sure that cloud computing models are used safely and effectively. Data security, an aspect that has been considered as a technological factor within the TOE framework, must also be addressed by selecting cloud service providers that comply with regulations such as the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA). Businesses bear the responsibility of safeguarding their data and applications,

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while cloud providers secure the infrastructure. Cloud-based virtual private networks (VPNs) have become particularly important for ensuring secure remote access, especially during the COVID-19 pandemic (Abu Bakar et al., 2021; Chirag Sharma et al., 2023).Enterprises often rely on public cloud services from providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) for scalable infrastructure without full control over the environment. Public clouds are ideal for tasks like software development and testing, where resources can be provisioned and decommissioned as needed. However, businesses handling sensitive data may prefer private clouds, which offer greater control and security. Private clouds can be hosted on-premises or by third-party providers, making them suitable for industries like finance and government institutions. However, the high costs associated with private clouds can be a barrier for businesses. Hybrid clouds, which combine the benefits of public and private clouds, allow enterprises to transfer workloads between them as needed, offering a balance of control, security, and scalability (Abu Bakar et al., 2021).Cloud computing also plays a critical role in business process optimisation by automating repetitive tasks such as order processing, invoicing, and data entry. This automation reduces manual labour, improves operational efficiency, and allows employees to focus on strategic activities. Cloud-based collaboration tools enable real-time communication and information sharing, enhancing workflows and organisational outcomes.

Additionally, cloud computing facilitates the collection and analysis of large datasets, providing insights into operational efficiency and customer behaviour. These insights support informed decision-making and streamline business processes, enabling SMEs to enhance customer service, reduce operational costs by up to 35%, and increase profitability through better data utilisation (Chirag Sharma et al., 2023; Alaqidi, 2022). Cloud technology also fosters business management by integrating diverse sources of information, reducing expenses, and leveraging innovative technologies such as virtualisation and big data processing. Through advanced services by cloud technology, SMEs can avoid extensive hardware investments and enhance data integration and transfer across departments, leading to a 40% increase in data handling efficiency and a 25% improvement in work flexibility and productivity through remote data access (Zhu, 2020).The pay-as-you-go pricing model of cloud computing allows SMEs to access on-demand computing resources, reducing operational costs and enabling efficient resource allocation. This flexibility supports rapid responses to market changes and the integration of innovative technologies with minimal financial risk. As a key enabler of Industry 4.0 (IR4.0), cloud computing helps SMEs integrate with global markets, enhance innovation capacity, and improve organisational efficiency and service delivery. By reducing the need for physical infrastructure, cloud solutions lower overhead costs, allowing SMEs to reinvest in core business activities and scale operations to enter new markets. This scalability supports faster decision-making, quicker product development cycles, and a stronger competitive edge, positioning SMEs for sustainable growth in the digital economy (GUPTA, 2023; Shetty & Panda, 2021).Cloud computing is integral to digital transformation, providing the tools and infrastructure needed to fundamentally change how businesses operate and deliver value. By offering flexible access to computing resources, cloud technologies reduce the time and cost associated with launching new services and applications.

This enables businesses to test new products, services, and business models without significant IT infrastructure investments, making cloud computing a critical driver of digital innovation (Chirag Sharma et al., 2023). For SMEs, cloud computing provides access to advanced IT infrastructure, software, and services without large upfront costs, enabling them to improve operational efficiency, streamline processes, and adopt emerging technologies like artificial intelligence and big data analytics. The ability to scale IT resources according to business demands is critical to maintaining competitiveness in the rapidly evolving IR4.0 landscape. Cloud services also enhance real-time collaboration, improve decision-making through better data accessibility, and reduce reliance on physical IT infrastructure, leading to significant cost savings (GUPTA, 2023). As a transformative technology, cloud computing breaks free from traditional IT boundaries by offering on-demand access to computing-service resources, enabling SMEs to innovate and respond efficiently to market changes, thereby enhancing overall business performance (Shetty & Panda, 2021).

Future trends in cloud computing include edge computing, multi-cloud strategies, serverless computing, and cloud-native applications. Edge computing enables real-time data processing and analysis, reducing latency and improving response times for applications such as AI and machine learning. Multi-cloud strategies allow businesses to select the best cloud platform for each workload, enhancing performance and reducing costs while avoiding vendor lock-in. Serverless computing eliminates the need for infrastructure management, allowing businesses to focus on core operations and scale efficiently. Cloud-native facilitates rapid development and deployment of applications efficiently, reducing time-to-market and improving agility. These trends highlight the evolving role of cloud computing in driving innovation and efficiency across industries (Chirag Sharma et al., 2023).

2.3 Artificial Intelligence (AI) and Machine Learning (ML)

Artificial Intelligence (AI) and Machine Learning (ML) are integral components of the Fourth Industrial Revolution (IR4.0), representing transformative technologies that enable machines to perform tasks traditionally requiring human intelligence. AI refers to the field of computer science focused on creating intelligent systems capable of tasks such as data analysis, decision-making, learning from experiences, and problem-solving. These systems rely on algorithms, large datasets, and ML models to adapt and improve over time (Lada et al., 2023; OECD, 2021). AI

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applications are increasingly being utilised across various sectors, including smart agriculture, healthcare diagnostics, autonomous vehicles, environmental monitoring, energy management, and personalised education. Additionally, AI is driving new avenues for creative expression, such as interactive art installations, augmented and virtual reality, personalised content creation, and cross-disciplinary collaborations (Putri & Athoillah, 2024). Despite the significant role SMEs play in Malaysia's economy, there is a lack of comprehensive research on AI adoption within this sector, particularly in regions like Sabah. The distinctive business landscape of Sabah's SMEs complicates the application of general findings from extensive studies to their particular context. While SMEs contribute substantially to the GDP, there is limited understanding of their AI adoption trends, models, and challenges. This gap highlights the need for targeted research to explore how AI can optimise internal operations and enhance business performance in Malaysia's SME sector, particularly in Sabah (Lada et al., 2023).

The integration of AI and ML technologies into business operations offers numerous benefits, particularly in improving operational efficiency, decision-making, and customer engagement. For instance, in the financial sector, AI and ML streamline processes, enhance accuracy, and reduce costs, leading to better decision-making and personalised services. These technologies also enable predictive analytics, allowing businesses to identify market trends, manage risks, and allocate resources more effectively. However, the adoption of AI in finance introduces new risks, such as biases in output due to bad quality of input data; concentration risks come through the reliance on some huge efficient companies due to a costly investment requirement; and challenges related to explainability, which may decrease a system's resilience. Policymakers must address these concerns to ensure that AI adoption aligns with regulatory standards and promotes market stability (OECD, 2021).AI and ML technologies are also transforming cost management practices by enabling businesses to analyse large datasets, identify cost-saving opportunities, and optimise resource allocation. Machine learning algorithms, such as linear regression, decision trees, and neural networks, are particularly effective in predicting financial outcomes and improving efficiency. For example, neural networks excel at detecting precise patterns in cost data, enabling businesses to develop more effective cost management strategies. Cloud-based AI and ML solutions further enhance these capabilities by providing scalable and cost-effective infrastructure for data analysis and innovation (Chirag Sharma et al., 2023; Ismanov et al., 2024).The order business process design focuses on monitoring, managing, and addressing customer demands in real time, facilitating swift market reactions while optimizing both production efficiency and supply chain cycles. Similarly, the inventory process design plays a pivotal role in balancing product availability with demand by strategically stockpiling goods based on market forecasts or specific orders.

This approach enhances delivery speed, improves responsiveness to market fluctuations, and maximises manufacturing efficiency. The design of distribution processes emphasises the efficient and timely movement of goods, with logistics routes dynamically adjusted based on vehicle capacity and client-specific requirements. Meanwhile, the transportation business process design integrates digital tracking systems for real-time monitoring of both goods and vehicles, improving delivery accuracy and logistical coordination. A key optimization challenge within SCM is the Vehicle Routing Problem (VRP), which seeks to minimize transportation costs while maximizing delivery efficiency. Addressing VRP effectively contributes to reduced logistical expenses and enhanced overall SCM performance. The adoption of AI-driven technologies, such as Natural Language Processing (NLP) and Robotic Process Automation (RPA), has revolutionised customer service, communication, and administrative tasks. NLP automates complex interactions, reducing reliance on human support staff and lowering operational expenses while improving response times and accuracy. On the other hand, RPA automates routine tasks, minimising errors and freeing up human resources for more strategic roles. These technologies not only reduce costs but also enhance productivity and operational efficiency, enabling businesses to achieve sustainable growth and competitive advantage (Ismanov et al., 2024; Lin et al., 2022).

However, the high initial costs of AI adoption, coupled with the complexity of integrating AI into existing systems and the need for employee upskilling, present substantial obstacles for SMEs. Many organisations mistakenly perceive AI as an immediate solution, resulting in significant investments in software tools and infrastructure, without addressing organisational and cultural barriers. Successful AI implementation requires a strategic approach, including multidisciplinary collaboration, employee training, and alignment with organisational goals. Leaders must invest in AI education and foster a culture of innovation to fully realise the potential of AI technologies (Fountaine et al., 2019; Jöhnk et al., 2021). The application of Conditional Generative Adversarial Networks (CGANs) significantly enhances a business's performance within supply chain management (SCM). The integration of ML techniques, including CGANs, plays a crucial role in optimising dynamic decision-making processes, particularly in the selection of supply chain partners. This aspect is especially valuable in scenarios where decision-making involves a large number of attributes but is constrained by limited data availability. To

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mitigate the risk of reduced classification accuracy, CGANs effectively reduce data dimensionality and complexity, thereby improving the overall efficiency of the classification process (Lin et al., 2022).

The growing global investment in AI reflects its increasing importance in driving DT and maintaining competitiveness. Private sector investment in AI is expected to double from $50.1 billion in 2020 to over $110 billion by 2024, with a projected compound annual growth rate (CAGR) of 20% from 2019 to 2024. This trend highlights the critical role of AI in supporting DT initiatives and enabling businesses to adapt to the rapidly evolving digital landscape (OECD, 2021). The adoption of AI and ML technologies also introduces cybersecurity risks. The global cost of cybercrime is estimated to reach $10.5 trillion by 2025, making data security a top priority for organisations leveraging AI. AI systems are vulnerable to attacks such as data poisoning, algorithm manipulation, and model exploitation, which can compromise their integrity and lead to incorrect decisions. To mitigate these risks, organisations must implement robust security measures, including adversarial training, data integrity checks, secure model deployments, and continuous monitoring. Collaboration with security experts and adherence to regulatory standards are also essential for ensuring the safe and effective use of AI technologies (Rasiah et al., 2023; Putri & Athoillah, 2024).In conclusion, AI and ML technologies offer significant opportunities for SMEs to enhance business performance by optimising operations and driving innovation toward the achievement of sustainable growth and keeping competitiveness. However, successful adoption requires addressing challenges related to employee training, integration, costs, and the security of data. Strategically leveraging AI and ML can be achieved within SMEs.

3. Methodology and Expected Results

3.1 Methodology

This research is going to use quantitative analysis method and data gathering through online surveys (Google Forms). The ability to reach as more as possible of a diverse participant the more of valuable insights with more efficient data that the researcher can obtain; by randomly selecting the participants, a researcher can capture accurate representative sample of the population.

3.2 Data Collection & Sampling Methods

The data collection process involves distributing the survey to SME owners, managers, and decision-makers who are directly involved in the adoption and implementation of digital technologies. The survey includes structured questions that measure the understanding levels of adoption benefits of CC, AI, and ML, as well as their perceived impact on business performance indicators such as operational efficiency, cost savings, and innovation. The use of an online survey ensures efficient data collection, allowing the researcher to reach a geographically dispersed audience while maintaining consistency in data quality.

This research would employ a simple random sampling approach for ensuring reliability in this study by minimizing the risk of selection bias since a research population number which could be too large is unknown. The author will analyze data from 267 enterprises without considering their nationality or the registration status of them, and this sample size is based on Daniel's formula (1988) sample size was taken from (Sileyew, 2019), a widely recognized method for calculating the required sample size of unknown population number in quantitative research and with simple random sampling approach for sampling design that strengthens much more the need for properly used of this formula. The formula is as follows:

$$nn = \frac{z^2 pp(1-pp)}{d^2}$$

Where:

- n = sample size
- Z = confidence level (1.96 for a 95% confidence level) is widely accepted in social science and business research as it provides a high level of reliability while remaining practical. A 95% confidence level is 1.96, which is derived from the standard normal distribution. This value ensures that the study's findings are statistically robust and credible.
- P = expected proportion (0.5, representing maximum variability) is a common practice in sample size calculations when the population proportion is unknown, as it provides a "worst-case scenario" estimate that guarantees adequate sample coverage, this conservative approach ensures that the sample size is sufficient to capture the true population characteristics, even in the absence of prior knowledge about the actual proportion.
- d = margin of error (0.06, or 6%) is considered reasonable for this study, as it provides a good compromise between accuracy and the practical limitations of data collection. This level of precision is sufficient to draw

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meaningful conclusions; a larger margin of error would reduce the sample size but at the cost of reduced precision in the findings.

Therefore, by calculating the sample size using the previous formula and the determined variables:

$$nn = \frac{(1.96)^2 * (0.5)(1 - 0.5)}{0.06^2} = 267$$

Using these parameters, the calculated sample size is 267 respondents. This sample size ensures a high level of reliability and precision in the findings, balancing the need for statistical significance with practical constraints in data collection. The sample includes SMEs of varying sizes and industries, ensuring the results are generalizable to the broader SME population in Malaysia.

3.3 Data Analysis

Data analysis is conducted using Statistical Package for the Social Sciences (SPSS) software, a robust tool for statistical analysis in social science research. The analysis is divided into two main stages:

1. Descriptive Analysis: This stage summarizes and organizes the collected data, providing an overview of the demographic characteristics of the respondents (sample), such as industry sector, company size, and digital technology adoption levels. Descriptive statistics are used to present the data in a clear and interpretable format.
2. Inferential Analysis: This stage examines the relationships between the independent variables (CC, AI, and ML) and the dependent variable (business performance). Correlation and regression analyses are employed to identify significant relationships and quantify the impact of digital technologies on business performance. Regression analysis helps determine the strength and direction of these relationships, providing insights into how CC, AI, and ML contribute to operational efficiency, cost reduction, and innovation in decision-making and strategy, and to reach the conclusion.

The methodology is designed to ensure a logical and coherent flow from data collection to analysis. By employing a simple random sampling approach, the study minimizes bias and enhances the representativeness of the sample. The use of Daniel's formula for sample size calculation ensures the study achieves statistical reliability, while the combination of descriptive and inferential analyses provides a comprehensive understanding of the research problem. This structured approach ensures the findings are robust, credible, and applicable to the broader context of SME digital transformation in Malaysia.

3.4 Expected Results

To begin with, demographic overview of the respondents will be presented where these descriptive statistics will provide insights to reveal the characteristics of the participants, such as age, gender, education, the level of digital skills or digital management proficiency, business' full-time employees, and business' annual income. This information will be presented in tables and graphs to make it easier to understand and interpret the results.

H1: Positive Impact of Cloud Computing (CC) Technology on Business Performance Enhancement.

- Regression analysis is likely to reveal a significant positive relationship between cloud computing adoption and business performance indicators toward an enhancement such as:
  - Operational efficiency, reduce processing time.
  - Cost savings, reduce IT infrastructure expenses.
  - Improved customer satisfaction, higher customer retention rates.

H2: Positive Impact of Artificial Intelligence (AI) Technology on Business Performance Enhancement.

H3: Positive Impact of Machine Learning (ML) Technology on Business Performance Enhancement.

- The analysis is expected to show that AI and ML significantly enhance business growth and operational capabilities, resulting in:
  - Improved and accurate predictive analytics.
  - Automated decision-making processes and routine tasks and procedures which save time and reduce human error and frees up staff to focus on more strategic activities.
  - Increased productivity and innovation in customer-centric services.
- Path analysis using statistics (correlation and regression) is expected to demonstrate that the addressing of understanding gap toward the relationship between the impact of these three digital technologies and business performance enhancement contribute to promote an adoption of effective digital transformation significantly.

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4. Conclusion

This study explores the impact of digital technologies, specifically cloud computing (CC), artificial intelligence (AI), and machine learning (ML), on enhancing the business performance of Malaysian SMEs and fostering effective digital transformation (DT). SMEs are a vital component of the global economy, contributing significantly to employment and GDP. However, many SMEs, particularly in Malaysia, remain in the early stages of digitalisation, often limited to basic online platforms like websites or social media accounts. This "computerisation without digitisation" approach fails to unlock the full potential of DT, leaving SMEs vulnerable to inefficiencies and missed growth opportunities. The slow adoption of advanced digital technologies, such as CC, AI, and ML, is primarily due to challenges such as limited awareness, high costs, and a lack of digital skills.The research employs a quantitative approach, utilising online surveys and statistical analysis via SPSS to examine the relationships between digital technologies and business performance enhancements. The study hypothesises that CC, AI, and ML have a positive and significant impact on business performance, enabling SMEs to improve operational efficiency, reduce costs, enhance customer satisfaction, and drive innovation. The findings are expected to reveal that the adoption of these technologies fosters effective DT, positioning SMEs for long-term growth and competitiveness in the market.

Cloud computing offers SMEs scalability, flexibility, and cost efficiency, enabling them to access advanced IT infrastructure without significant upfront investments. AI and ML technologies streamline operations, improve decision-making, and enable predictive analytics, allowing SMEs to adapt to market changes and customer demands more effectively. However, the adoption of these technologies requires addressing the challenges. Policymakers and business leaders must prioritise strategic investments, capacity building, and the development of supportive frameworks to facilitate the effective digital transformation of SMEs.

In conclusion, this study underscores the transformative potential of digital technologies in enhancing SME performance and driving sustainable growth. By leveraging CC, AI, and ML, SMEs can optimise operations, innovate their business models, and remain competitive in an increasingly digital marketplace. Ultimately, this research contributes to the broader discourse on digitalisation, highlighting the critical role of digital technologies in shaping the future of SMEs in Malaysia and beyond.

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