PATHWAY TO NET ZERO 2050: A CONCEPTUAL EVIDENCE FOR SMES TRANSITIONING TO SUSTAINABLE DEVELOPMENT

PETER, M.[1*] – PETER, D.[1] – PETER, P.[2] – PETER, Y.[3]

[1] *Department of Entrepreneurship and Supply Chain Management, Universiti Tunku Abdul Rahman Kampar Campus, Perak, Malaysia.*

[2] *Department of Accontancy, Finance and Business, Universiti of Management & Technology Kampar Campus, Perak, Malaysia.*

[3] *Independent Scholar, Kuala Lumpur, Malaysia.*

**Corresponding author*
e-mail: marsyallpeter[at]gmail.com

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Abstract. This paper offers a conceptual understanding of the context under which SMEs attempt to shift towards achieving Net Zero emissions by the year 2050. The study examines the progression of sustainable development goals and the significant contribution of SMEs in attaining these objectives by including theoretical and conceptual understandings of SMEs. The Brundtland Report and the Rio Earth Summit originated the sustainable development agenda. These events paved the way for establishing the Sustainable Development Goals (SDGs) 2015. Attaining Net Zero 2050, a condition where the amount of greenhouse gas emissions is offset by removing them from the atmosphere, is crucial for worldwide efforts to address climate change by Sustainable Development Goal 13. SMEs have distinct obstacles and prospects throughout this transformation, encompassing limitations in financial resources, technological preparedness, and compliance requirements. However, they also have the potential to gain advantages such as enhanced efficiency, innovation, and market competitiveness. The paper employs the Technology-Organization-Environment (TOE) framework and the Resource-Based View (RBV) paradigm to examine SMEs' successful implementation of sustainable practices. In addition, this analysis explores the frequently disregarded impact of digital transformation on improving the sustainability efforts of SMEs. The investigation asserts that a well-coordinated strategy is essential for SMEs to effectively achieve the goal of Net Zero 2050 and contribute to global sustainability objectives. This strategy should involve government incentives, industry support, and internal commitment within the organizations. By adopting this approach, SMEs can ensure long-term economic and environmental resilience.

Keywords: *Net Zero 2050, small and medium enterprises, sustainable development, digital transformation*

Introduction

The origins of the sustainable development agenda can be traced back to the Brundtland Report in 1987, which first proposed the notion of sustainable development as the fulfillment of current demands while safeguarding the capacity of future generations to fulfill their own needs. This was further strengthened by the Rio Earth Summit in 1992 and the implementation of the Millennium Development Goals (MDGs) in 2000, which paved the way for more comprehensive and integrated strategies towards sustainability (Campagnolo et al., 2018). The Sustainable Development Goals (SDGs) were established in 2015. It is built upon this framework by defining seventeen targets that address a broad spectrum of economic, social, and

environmental difficulties (Sachs, 2012). These goals underscore the interrelated nature of sustainability concerns. The transition of SMEs towards achieving Net Zero emissions by 2050 is an essential element of worldwide endeavors to address climate change and attain sustainable development (Khalifa et al., 2022). Small and medium-sized enterprises (SMEs) constitute a substantial proportion of economic activity on a global scale and have a vital role in advancing the overall sustainability agenda (Prashar, 2020). Net Zero 2050 refers to establishing a state where the emissions of greenhouse gases are equal to the quantity removed from the atmosphere. The objective is to create a global economy that is not affected by climate change by the middle of the century. This shift follows the United Nations Sustainable Development Goals (SDGs), namely Goal 13, which urges immediate action to address climate change and its consequences (Owusu-Sekyere et al., 2024).

Within the framework of achieving Net Zero 2050, SMEs encounter distinct problems and prospects. Although SMEs have fewer resources than prominent firms, they generally exhibit greater flexibility and innovation, which may benefit from implementing sustainable practices and technology (Baeshen et al., 2021). Nevertheless, budgetary limitations, insufficient knowledge, and regulatory difficulties could impede their development. The literature emphasizes the significance of supporting policies, availability of finance, and capacity-building programs to enable the transition for SMEs. Alam et al. (2022) highlight the need to implement specific support measures, such as subsidies and tax incentives, to motivate SMEs to invest in environmentally friendly technology and sustainable practices.

Things that had been learned: A theoretical glance

The vision of Net Zero 2050 is a global pledge to balance the percentage of greenhouse gases released into the atmosphere with the amount extracted to attain a carbon-neutral environment by the midpoint of the 21st century (Welton, 2022). To address the significant consequences of climate change, this aspirational objective must be achieved urgently, which requires substantial decreases in carbon emissions in every sector, including SMEs. The theoretical basis of Net Zero 2050 is founded on sustainable development concepts, which prioritize a balanced approach to economic growth, environmental stewardship, and social responsibility. For SMEs, incorporating sustainable practices and technology is not only about following regulations but also a crucial strategic need that may improve competitiveness, foster innovation, and create new market prospects (Islam and Wahab, 2021). The Technology-Organization-Environment (TOE) paradigm offers a valuable perspective for comprehending how SMEs may effectively navigate this shift. The TOE framework posits that adopting sustainable technologies is influenced by technological readiness, organizational capabilities, and external environmental conditions (Seshadrinathan and Chandra, 2021). From a technological standpoint, SMEs should allocate resources towards acquiring energy-efficient machinery, adopting renewable energy sources, and implementing digital solutions that enhance resource utilization and minimize emissions (Fatima et al., 2021). From an organizational perspective, this transformation necessitates changing the entire organization's culture to prioritize sustainability. This change should be backed by a strong commitment from leadership, active involvement of employees, and the implementation of effective change management strategies (Kallmuenzer et al., 2023). From external environmental conditions and perspective,

SMEs must address the growing legal barriers, meet the rising customer expectations for sustainably produced goods, and navigate the market's competitive landscape.

Despite this, SMEs have several significant obstacles to achieving Net Zero 2050, including financial constraints, a lack of specialized knowledge, and uncertainties on the profitability of sustainable technology. Governments and financial institutions are vital in assisting this shift by offering SMEs incentives, subsidies, and technical assistance. Furthermore, collaborating and exchanging knowledge with peers in the sector can help SMEs use combined intelligence and the most effective methods.

Theories that can be applied in the context of SMEs transitioning to Net Zero 2050

The Technology-Organization-Environment (TOE) framework and the Resource-Based View (RBV) theory provide significant theoretical insights regarding SMEs shifting to Net Zero 2050. The TOE framework, which proposes that technology adoption in SMEs is influenced by technological readiness, organizational capabilities, and environmental factors, offers a complete approach (Ghaleb et al., 2021). The approach considers the complex and diverse obstacles related to sustainability while emphasizing the need to match technology progress and regulatory standards. Nevertheless, the complex structure and resource-demanding implementation of the TOE structure might need help for SMEs, necessitating thorough data gathering and analysis. Moreover, the dynamic and ever-evolving external environment might challenge maintaining an up-to-date and timely framework. On the other hand, the RBV (Resource Based View) theory highlights the need to utilize internal resources and talents to gain a competitive edge. This approach promotes and supports SMEs in developing new and improved ways to use their distinctive advantages, encouraging adopting sustainable practices inside the organizations (El Nemar et al., 2022). Emphasizing internal resources can result in notable competitive advantages and enhanced efficiency. Nevertheless, SMEs frequently have constraints in terms of resources, which might hinder the successful execution of RBV initiatives. Additionally, the introspective character of the RBV theory may lead SMEs to disregard essential external elements such as market trends and regulatory changes. The unchanging perspective of the approach may not adequately address the requirement for ongoing adjustment in the ever-changing sustainable environment.

The TOE framework and RBV theory provide valuable insights for SMEs striving to achieve Net Zero by 2050. The TOE framework's comprehensive approach enables the resolution of external and internal difficulties, while the RBV theory's emphasis on internal strengths fosters creativity and efficiency. Nevertheless, SMEs must skillfully negotiate each theory's balance strategies and constraints, aiming for a well-rounded and flexible approach to attain enduring success.

The relationship between Net Zero 2050 and SME

The association between Net Zero 2050 and SMEs is crucial and complex as SMEs are essential to the global economy, and their combined actions substantially influence the attainment of climate change objectives (Bag, 2024). Net Zero 2050 seeks to achieve an equilibrium between greenhouse gas emissions and their removal from the environment, requiring significant decreases in carbon footprints across all industries (Chen et al., 2022). This process entails embracing sustainable practices and technology for SMEs, which comes with challenges and opportunities. SMEs frequently have

limited resources, making it more challenging to make substantial investments in green technology and sustainable practices compared to larger companies. The upfront expenses of renewable energy systems, energy-efficient equipment, and sustainable raw materials can be financially burdensome. In addition, SMEs may not possess the technical proficiency to adopt and oversee these advances successfully. SMEs that survive on narrow profit margins may face additional operational burdens due to the need to comply with new environmental standards, which can be challenging given the regulatory landscape. On the other hand, the shift towards achieving Net Zero by 2050 also offers significant prospects for SMEs. Adopting sustainability practices can result in substantial financial benefits over time by enhancing energy efficiency and minimizing waste. SMEs that embrace environmentally friendly practices early can get a competitive edge by attracting an expanding group of environmentally diligent consumers and companies. This can create new market prospects and enhance the brand's reputation (Crossley et al., 2021). In addition, governments and financial institutions are progressively providing incentives, subsidies, and assistance programs to help SMEs overcome financial and technical obstacles to achieve sustainability.

The results of this situation depend on several aspects, such as the extent of backing from governments and industry organizations, the accessibility of cost-effective, environmentally friendly technology, and the readiness of SMEs to be innovative and adapt. If SMEs can effectively negotiate the transition, they have the potential to make a substantial contribution to the worldwide effort to reduce the impact of climate change. They may also gain economic advantages by improving their efficiency and market position. On the other hand, if SMEs find it challenging to meet the requirements of achieving Net Zero by 2050, they may fall behind in a more focused sustainability market. This might result in financial and regulatory consequences.

The missing link that much-overlooked patgway in the relationship between Net Zero 2050 and SME

An often-neglected aspect of the connection between achieving Net Zero 2050 and SMEs is the impact of digital transformation on facilitating sustainability. While there is a strong focus on adopting green technologies and following regulations, including digital tools and platforms may significantly improve SMEs' capacity to reach their net-zero 2050 objectives. Digital transformation involves using advanced technologies such as artificial intelligence, the Internet of Things (IoT), big data analytics, and blockchain to enhance operational efficiency, maximize resource utilization, and minimize emissions (Feroz et al., 2021). SMEs may utilize digital technology to access up-to-date data and gain valuable insights into their energy consumption, waste production, and overall environmental footprint. IoT sensors can oversee and regulate energy usage in industrial operations, while big data analytics can detect patterns and pinpoint areas that may be enhanced. The enhanced degree of visibility and control empowers SMEs to make well-informed choices, optimize operations, and decrease their carbon emissions more efficiently. In addition, digital platforms can enable the monitoring and documentation of sustainability indicators, assisting SMEs in fulfilling legal obligations and improving transparency with stakeholders. Moreover, digital transformation can drive innovation in business models and supply chain management. For example, blockchain technology can enhance supply chain transparency and traceability, ensuring that sustainable practices are maintained from raw materials to finished products. This can help SMEs meet the increasing demand from consumers and larger companies for

sustainably sourced products. Digital marketplaces and platforms can connect SMEs with new customers and partners who prioritize sustainability, expanding their market opportunities.

Although the digital transformation pathway has significant promise, it is frequently disregarded due to high expenses, insufficient knowledge, and reluctance to embrace change. SMEs may perceive digital technologies as complicated and costly, discouraging them from adopting them. Nevertheless, incremental investments in digital technologies, supported by government incentives and industry collaborations, have the potential to help mitigate these challenges. In addition, training and support programs may also cultivate essential digital skills within SMEs, promoting a culture of innovation and ongoing enhancement.

Where do we go from here?

The road for SMEs to attain Net Zero 2050 comprises a comprehensive approach encompassing regulatory compliance, technology adoption, digital transformation, and collaborative initiatives. To successfully navigate the shift towards a net-zero economy, policymakers, industry leaders, and SMEs must actively address the obstacles and seize the potential advantages. Governments and regulatory bodies are crucial in establishing a conducive environment for SMEs. They can offer monetary incentives, such as grants, subsidies, and tax exemptions, to compensate for the initial expenses associated with implementing environmentally friendly technology and digital tools. In addition, well-defined and encouraging regulatory frameworks can assist SMEs in effectively managing the complexities of compliance without excessive difficulty. Government-led efforts can also promote information exchange and capacity development, ensuring that SMEs acquire the essential experience and training to adopt sustainable practices effectively. SMEs should adopt an organized and systematic approach to sustainability, incorporating it into their fundamental business activities and long-range planning. This entails allocating resources towards energy-efficient technology, renewable energy sources, and sustainable supply chain processes (Alayón et al., 2022). Incorporating digital transformation into this plan is essential since it allows SMEs to enhance their operations, evaluate their carbon footprint, and revolutionize their business models. Engaging in partnerships with larger corporations, industry groups, and technology suppliers can offer SMEs the opportunity to get access to valuable resources, markets, and proven methods. Industry leaders and larger organizations may assist SMEs by integrating sustainability into their procurement criteria and offering technological and monetary assistance to their smaller partners. Collaborative platforms and networks have the potential to facilitate partnerships and stimulate innovation, enabling SMEs to capitalize on collective knowledge and capacities. By prioritizing sustainability in their supply chains, major corporations have the power to generate a ripple effect that accelerates the adoption of sustainable practices among SMEs.

The expected result of these coordinated endeavors is a more robust and competitive SME sector that substantially contributes to global sustainability objectives. SMEs that effectively shift to operating with zero net emissions will benefit from advantages such as reduced expenses, more significant market positioning, and strengthened relationships with stakeholders. Additionally, they will possess enhanced capabilities to address the changing requirements of customers, investors, and regulatory authorities. More significantly, if SMEs widely implement sustainable practices, greenhouse gas

emissions will substantially decrease (Afolabi et al., 2023). This will help reduce the effects of climate change and achieve Net Zero by 2050.

The transition of SMEs towards achieving Net Zero emissions by 2050 is both challenging and transformative. This study integrates key theoretical frameworks with an uni-dimensional construct, namely the Technology-Organization-Environment (TOE) framework and the Resource-Based View (RBV), to better understand the drivers and barriers SMEs face in this transition (*Figure 1*). Integrating digital transformation further enriches the conceptual framework by providing an innovative pathway for SMEs to overcome these challenges. Each of the four propositions outlined in the framework sheds light on the multifaceted nature of this transition. The following propositions are, therefore, accentuated with detailed elaboration.

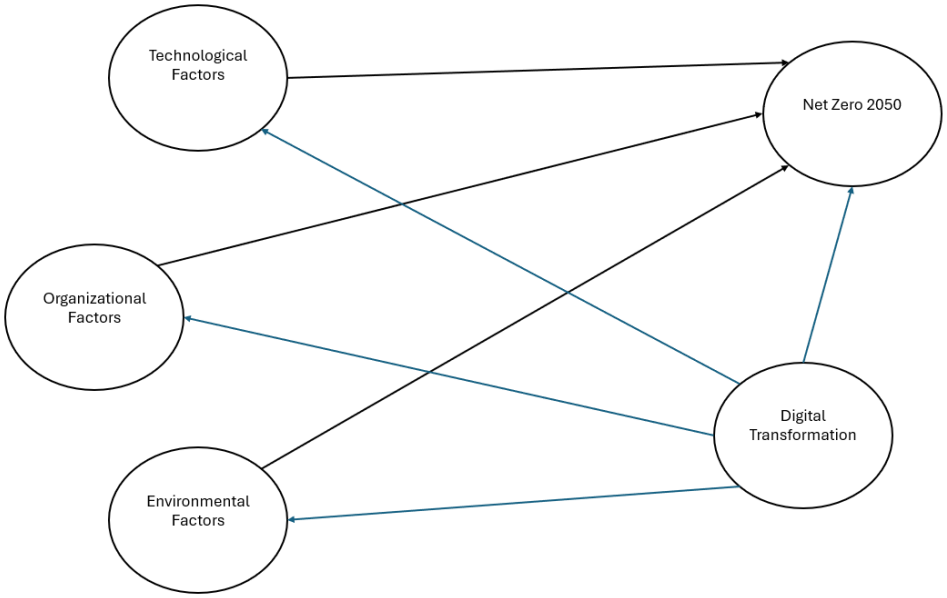

Figure 1. *Integrated framework.*

Proposition 1: Technological readiness and sustainable practices

The first proposition argues that SMEs with higher technological readiness are more likely to adopt sustainable practices effectively. Technological readiness is integral to successfully implementing sustainable technologies such as energy-efficient machinery and renewable energy solutions. Alam et al. (2024) found that SMEs that invest in green technologies comply with regulations and benefit from reduced operational costs and improved energy efficiency. However, the financial constraints SMEs face present a significant barrier to adopting such technologies, as Bag (2024) noted. The upfront costs of renewable energy systems and other sustainable technologies often exceed the financial capacity of smaller firms. This limitation is counterbalanced by the growing recognition of governmental support programs, such as subsidies and tax incentives, aimed at helping SMEs adopt green technologies. For instance, governments in many countries have introduced financial incentives to facilitate the shift towards sustainability (Feroz et al., 2021). Furthermore, digital transformation plays a crucial role in enhancing technological readiness. Using Internet of Things (IoT) sensors, artificial intelligence (AI), and big data analytics can optimize energy usage, reduce waste, and enhance operational efficiency, thus making sustainability practices more

accessible and cost-effective for SMEs. The integration of these technologies, however, requires overcoming significant barriers, including limited technical expertise and the initial cost of investment (Neumeyer et al., 2020).

Proposition 2: Organizational capabilities and sustainability

The second proposition emphasizes the role of internal organizational capabilities in facilitating the Net Zero transition. The Resource-Based View (RBV) suggests that an SME's internal resources and capabilities, such as leadership commitment and employee engagement, are critical to implementing sustainable practices effectively. El Nemar et al. (2022) argue that SMEs with strong leadership and a culture of sustainability are more likely to achieve long-term success in their sustainability efforts. Strong leadership can foster a commitment to sustainability across the organization, while employee involvement ensures that sustainability becomes a part of the organizational culture. However, Jafari-Sadeghi et al. (2023) argue that a sole focus on internal capabilities may cause SMEs to overlook critical external factors, such as regulatory pressures and market forces. For instance, while internal resources are vital for strategy execution, SMEs must adapt to shifting market demands and regulatory frameworks to succeed in their sustainability efforts. A balanced approach that aligns internal capabilities with external environmental conditions is necessary to navigate sustainability's complexities successfully. Recent examples, such as SMEs in the European Union that have aligned their sustainability efforts with the EU's Green Deal, highlight the importance of internal and external factors in achieving sustainability goals (Salfi, 2022).

Proposition 3: Environmental context and regulatory support

The third proposition stresses the significance of favorable external environmental conditions, such as supportive policies and market incentives, in driving SMEs' sustainability efforts. A key external factor is the regulatory environment, which has been found to influence the adoption of sustainable practices heavily. Khalifa et al. (2022) highlight that government incentives, such as subsidies and tax exemptions for renewable energy adoption, can significantly encourage SMEs to invest in green technologies. Regulatory frameworks incentivizing sustainability, such as the EU's carbon pricing policies and emission reduction targets, have effectively pushed SMEs toward Net Zero goals. However, excessive reliance on such external incentives can lead to dependency, as Pfeffer and Salancik (2015) argued. SMEs may become dependent on subsidies without making long-term investments in sustainability. Therefore, there is a need for policies that not only provide financial support but also promote capacity-building initiatives and long-term sustainability education. For example, the Malaysian government's "Green Technology Financing Scheme" provides financial assistance to SMEs for green technology adoption while offering training and consultancy services to enhance SMEs' ability to manage sustainable transformations (Khalifa et al., 2022).

Proposition 4: Digital transformation as a catalyst

The final proposition discusses the role of digital transformation in accelerating SMEs' progress toward achieving Net Zero emissions. Integrating advanced digital technologies such as AI, IoT, blockchain, and big data analytics can significantly improve SMEs' operational efficiency and reduce their environmental impact. Digital

transformation enables SMEs to track energy consumption, optimize resource use, and enhance supply chain transparency, thus supporting sustainable practices. For example, IoT-enabled sensors can monitor energy consumption in real time, helping SMEs identify areas for improvement and reduce waste (Feroz et al., 2021). Blockchain technology further enhances supply chain transparency, ensuring that sustainable practices are maintained from raw material sourcing to finished products (Crossley et al., 2021). Despite the significant benefits, SMEs often perceive digital technologies as complex and costly, which can deter their adoption. Alayón et al. (2022) argue that SMEs may lack the technical expertise and financial resources to implement digital transformation effectively. However, public-private partnerships and government initiatives to reduce the cost of digital tools can help mitigate these challenges. For instance, the availability of digital innovation hubs and government-sponsored digitalization programs has helped SMEs in developing countries to adopt and scale digital technologies more effectively (Marinho and Costa Melo, 2022).

Conclusion

In conclusion, SMEs will be pivotal in achieving Net Zero by 2050. Still, their ability to transition effectively depends on a balanced approach that incorporates technological readiness, organizational capabilities, external support, and digital transformation. As the global focus on sustainability intensifies, aligning internal capabilities with external pressures, supported by digital innovation and government policies, will determine the success of SMEs in contributing to global sustainability objectives. By adopting a comprehensive strategy that includes all these dimensions, SMEs can reduce their carbon footprints and gain significant competitive advantages in the emerging green economy.

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Conflict of interest

The authors confirm no conflict of interest involving any party in this research study.

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