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Industry 4.0 Integration for Sustainability and Value Creation: Moderating Role of Digital and Environmental Strategy

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ABSTRACT

This study investigates the combined impacts of Industry 4.0 (I4.0) technologies and digital transformation (DT) on sustainable consumption and production (SCP) and on the value creation (VC). It also examines the moderating influence of digital and environmental strategies on these outcomes. Grounded in the triple-bottom-line and resource-based view theories, the study draws on survey data from 137 supply chain professionals in Malaysia's large-scale manufacturing sector. Using Smart-PLS structural equation modelling, the results reveal that I4.0 technologies exert a substantial positive effect, explaining a considerable share of variance in both value creation and SCP outcomes. Environmental strategy further strengthens the link between DT and VC, whereas digital strategy shows no moderating effect between I4.0 technologies and DT. These findings provide actionable insights for industry practitioners and policymakers, highlighting how technological and environmental alignment can simultaneously advance sustainability, economic performance and social value.

1 | Introduction

The world today faces unprecedented challenges, including climate change, global pandemics such as COVID-19, escalating resource scarcity, and rising consumer expectations (Karmaker et al. 2023). These mounting pressures demand a fundamental transformation of the manufacturing sector towards greater resilience, flexibility and environmental sustainability (Rahman et al. 2025). Concurrently, there has been a significant shift away from traditional industrial practices towards more advanced models, as organisations increasingly integrate cutting-edge digital technologies into their operations (Ghobakhloo 2020). This shift, widely recognised as 'digital transformation', lies at the core of organisational evolution and marks the onset of 'Industry 4.0' (I4.0), signalling a paradigm shift in how industries leverage technological innovation to address global challenges (Narula et al. 2021; Ghannouchi 2023). I4.0 integrates cutting-edge technologies such as artificial intelligence, the Internet of Things, blockchain, big data analytics, radio-frequency identification and cloud computing (Mukhuty et al. 2022; Kopeinig et al. 2024). These technologies have revolutionised business operations by enabling precise cost estimation, streamlining production and replacing traditional methods with intelligent digital solutions (Narkhede et al. 2024; Parashar et al. 2023). Moreover, the adoption of I4.0 technologies contributes substantially to environmental sustainability. They enhance resource management, reduce environmental impact and improve energy efficiency (Costa et al. 2024). For example, IoT devices optimise energy use (Nižetić et al. 2020), whereas big data and AI refine logistics to reduce emissions (Singh et al. 2018). Technologies like blockchain and RFID enhance the traceability of goods, promoting ethical sourcing and compliance with environmental regulations (Wang et al. 2023). Sustainability efforts are increasingly framed within the broader context of sustainable consumption and production (SCP) systems, which aim to achieve a balance between economic, environmental and social progress (Wang et al. 2019; Piprani et al. 2025). The rapid adoption of digital technologies signals a global shift towards automation and more efficient resource utilisation, thereby enhancing production processes and operational performance (Zheng et al. 2021). This digital transformation (DT) is reshaping the modern business landscape, with the integration of I4.0 and DT playing a pivotal role in advancing social sustainability outcomes (Mondal et al. 2024).

However, the shift towards advanced digital models presents significant challenges. AlNuaimi et al. (2022) observed that leaders often pursue radical DTs with overly optimistic expectations, resulting in costly failures that trigger management changes, workforce reductions and a retreat to traditional business models, where digital initiatives are reduced to minor projects (Siebel 2019). A key concern is the gap between the ambitious rhetoric surrounding DT and the actual outcomes, often driven by shortcomings in strategy formulation and execution. Furthermore, many organisations struggle with DT due to inadequate planning and a lack of cohesive digital strategies (Haq and Huo 2023). To navigate these challenges successfully, leaders must foster a digital mindset and strategy to adapt to disruptions caused by digital advancements (Vial 2021; Ly 2024). Additionally, incorporating a clear environmental strategy is crucial, as it ensures that the impacts of DT align with sustainable development goals and promote environmental responsibility (Piprani et al. 2024; Guan et al. 2023). This strategic integration not only enhances the effectiveness of DT initiatives but also supports broader sustainability efforts.

Although DT presents significant complexities, its urgency is driven by the disruptive potential of emerging technologies. Organisations increasingly view DT as a fundamental reimagining of business models and processes, not merely a technological upgrade (Ancillai et al. 2023). In the context of I4.0, advanced digital technologies are reshaping industries, offering new pathways for sustainability, efficiency and value creation (VC) (Ghobakhloo 2020). This evolution calls for digital strategies that emphasise long-term environmental, economic, and social benefits. By transforming resource management, optimising energy use and minimising waste, digital technologies can simultaneously deliver economic gains, such as improved productivity and competitiveness (Porter and Kramer 2011) and social value through enhanced work practices, corporate responsibility and societal impact (Elkington 2013). Building on the foundational changes brought by I4.0, it is essential to examine its implications for SCP systems. SCP systems are essential for promoting efficient resource use and minimising environmental impacts, aligning with the goals of enhancing quality of life that modern technologies support. I4.0 technologies can advance these systems by boosting operational efficiencies, developing new business models, improving workplace safety and reducing environmental footprints (Javaid et al. 2022).

Despite the growing body of literature on I4.0 and DT, significant gaps persist in understanding their implications for SCP and multidimensional VC. While digital technologies are recognised for their potential to create value (Teece 2018), empirical evidence remains fragmented regarding the mechanisms through which I4.0 and DT initiatives generate economic, environmental and social outcomes. Furthermore, limited attention has been given to contingent factors that shape these relationships, particularly the role of digital strategy in conditioning the effectiveness of I4.0 deployment and the role of environmental strategy in strengthening or weakening the impact of DT on SCP and sustainable VC.

To address these gaps, this study draws on the resource-based view (RBV) (Barney 1991) and the triple bottom line (TBL) framework (Elkington 2013) to build a comprehensive theoretical approach. From the RBV perspective, I4.0 technologies and digital capabilities are conceptualised as strategic resources that, when valuable, rare, inimitable and non-substitutable, provide sustainable competitive advantage. This perspective highlights how firms can configure unique digital resource bundles that support SCP practices competitors cannot easily replicate. The TBL framework complements this view by assessing how such resources contribute to VC across economic, environmental and social dimensions, thereby addressing the insufficient integration of sustainability perspectives in prior research.

Within this integrated RBV–TBL framework, digital and environmental strategies are positioned as organisational capabilities that determine the extent to which I4.0 resources translate into meaningful outcomes. A coherent digital strategy reflects organisational intent and capability, ensuring that I4.0 investments generate effective DT. Likewise, alignment between environmental strategy and DT fosters synergies that enhance sustainable VC, whereas misalignment constrains potential benefits. This framework therefore clarifies the boundary conditions under which the use of I4.0 technologies leads to VC and bridges the domains of digitalisation and sustainability by explaining the interplay between technology, strategy and organisational outcomes. Based on these theoretical foundations, the study investigates four key questions: (i) How do I4.0 technologies and digital transformation influence SCP and value creation? (ii) Does digital transformation mediate the relationship between I4.0 technologies and SCP and value creation? (iii) How does digital strategy moderate the relationship between I4.0 technologies and digital transformation? (iv) To what extent does environmental strategy moderate the relationship between digital transformation and both SCP and value creation?

The overarching aim is to develop and empirically test an integrated RBV–TBL framework that explains the interactions among I4.0 technologies, DT, SCP and VC. The objectives are to evaluate the impact of I4.0 and DT on SCP and VC, examine the mediating role of DT, assess the moderating effect of digital strategy and investigate the moderating role of environmental strategy. The empirical setting is Malaysia, a leading emerging economy actively pursuing DT. Data were collected from 153 manufacturing companies. The findings make three main contributions. First, by integrating I4.0, sustainability and VC within a unified RBV–TBL perspective, the study demonstrates how firms can leverage digital technologies to achieve transformation while creating shared economic and societal value. Second, the results highlight the importance of digital strategy in shaping the effectiveness of I4.0 technologies, showing how strategic alignment enables organisational change, process optimisation and transformation outcomes. Third, the study reveals that digital transformation alone does not guarantee improvements in SCP or broader socioeconomic outcomes; rather, environmental strategy plays a pivotal role in determining whether digital initiatives translate into sustainable results.

This paper is structured as follows: Section 2 discusses the theoretical framework and hypotheses development. While Section 3 outlines the methodology including data collection and measures; Sections 4 and 5 detail results and discussion; and Section 6 concludes the paper.

2 | Literature Review

2.1 | Theoretical Underpinning and Conceptual Background

This study's theoretical framework is underpinned by a convergence of the TBL theory and the RBV. TBL theory espouses balancing the three pillars of economic, environmental and social performance (Elkington 2013), also referred to as the pillars of profits, planet and people. Our study aligns with TBL theory advocating for businesses to prioritise the environmental and social pillars, as much as the economic one; while recognising and harnessing their interconnectedness (Geissdoerfer et al. 2017). We particularly underline the importance of ensuring that business activities ultimately lead to 'social good' that enhances societal well-being (Crane et al. 2015). Notably, the 'social pillar' of the trilogy has been identified as the least researched (Munny et al. 2019; Neri et al. 2021), making our TBL underpinned study on the interconnected impact of I4.0, digitalisation and environmental factors, on societal outcomes, highly pertinent.

The theme of inseparability of the three pillars of the TBL trilogy permeates throughout our theoretical framework. We argue that businesses need to actively engage with I4.0 to ultimately generate societal benefits, which overlap with environmental and economic benefits. To contextualise, we posit that high engagement with I4.0 will help contribute to societal welfare through enhanced SCP aligning with the environmental (planet) pillar and enhanced VC aligning with both economic (profits) and social (people) pillars.

We further juxtapose this with the RBV, which espouses that sustained competitive advantage derivation is determined by the strategies and policies adopted by firms to harness their resources, unique talents and skills in a way that generates value, with a certain level of rarity and inimitability (Barney 1991; Hoopes et al. 2003). Arguably I4.0 offers a significant opportunity to enhance SCP and VC, through DT. However, to successfully achieve this, we argue in line with RBV theory, there is a need for firms to implement appropriate digital and environmental strategies. We reason that to deliver the effectiveness and efficiencies afforded by I4.0, adoption of digital strategies will be crucial to influencing the DT of the firm. Furthermore, separate environmental strategies will also influence the strength of impact of DT activities of firms on their SCP and VC.

Although numerous studies have examined the integration of I4.0 technologies in the context of sustainability, important gaps and contradictions remain. For instance, Andersson et al. (2023) emphasise the role of stakeholder relationships in sustainable supply chains but overlook how I4.0 technologies might mediate these relationships. Similarly, Santos and Sant'Anna (2024), in their systematic review of I4.0 adoption in SMEs, concentrate primarily on technological aspects while leaving the social and environmental dimensions largely unexplored. In another study, Malewska et al. (2024) investigate the role of digital organisational culture in shaping the relationship between DT and business model innovation in energy SMEs, yet they do not consider how these cultural factors align with broader sustainability objectives, particularly within the TBL framework. Building on these gaps, our study contributes by critically analysing the interplay between I4.0 technologies, DT, and sustainability outcomes. Specifically, we examine how digital and environmental strategies condition the impact of I4.0 technologies on SCP as well as on VC. By grounding our investigation in both the RBV and the TBL frameworks, we offer a more comprehensive understanding of the theoretical and practical implications, while clarifying the novel contributions of our research.

2.2 | Hypothesis Development

2.2.1 | I4.0 and DT

I4.0, initially conceptualised as the digital shift that revolutionised manufacturing sector; however, it is now key to the comprehensive DTs of business value chains (Culot et al. 2020). The notion of DT in relation to I4.0 involves the use of certain digital technologies (Ghobakhloo and Ching 2019) such as cloud computing (CCT), big data analytics (BDA), internet of things (IoT), blockchain technology (BCT), artificial intelligence (AI) and radio-frequency identification (RFID) (Kamble et al. 2020; Verma et al. 2024) and creation of valuable fundamental principles (Hermann et al. 2016) as a foundation of DT (Vial 2019; Machado et al. 2020). These are I4.0 design principles crucial components that can enable members of the industrial value-chain to gain the substantial benefits indicated by the transition to I4.0 (Dev et al. 2020; Mondal et al. 2024). According to prior studies, the adoption of I4.0 technologies substantially expedites the DT inside business enterprises (Nagy et al. 2018; Shao and Ünal 2019; Khan et al. 2024) and includes increased production efficiency, amplified manufacturing productivity, and improved customer satisfaction (Machado et al. 2020). Having access to digital technologies, specifically I4.0, technologies is likely to enable DTs in an organisation. Therefore, this examination led to the formation of following hypothesis.

H1. *Industry 4.0 positively influences the digital transformation.*

2.2.2 | I4.0 and SCP

The use of I4.0 technologies provide a greater visibility into industrial processes and improve resource monitoring (Junaid et al. 2024) by emphasising the importance of maximising resource utilisation, minimising waste and harmful elements, advocating the use of renewable energy, generating employment opportunities, enhancing worker health standards and elevating living standards (Veleva and Ellenbecker 2001; Dubey et al. 2016). These improvements resultant in incorporating novel manufacturing techniques, analysing data in real-time and implementing smart supply chain methods (Shao et al. 2021). Such as IoT and AI facilitate precise monitoring and regulation of resource utilisation, which leads to reduction in the use of raw materials and energy, similarly, the use of blockchain and RFID enables more efficient monitoring and control of product life cycles by enabling transparency, making production more accurate and lowering the demand for excess inventory and broader the sustainable development activities (Haghnegahdar et al. 2022; Ali et al. 2023). Additionally, the employment of real-time data processing, and BDA enables organisations to anticipate market trends, optimise operations and make better conclusions based on effective information (Yavuz et al. 2023). These factors work together to create a more socioeconomic, environment-friendly and productive industrial system (Dubey et al. 2016; Kamble et al. 2020; Kumar et al. 2023). Therefore, this leads to the formulation of following hypothesis.

H2. *Industry 4.0 positively influences the sustainable consumption and production.*

2.2.3 | I4.0 and VC

The adoption and incorporation of I4.0 have become increasingly significant in recent times due to its critical role in improving the responsiveness (Nazir et al. 2024), organisational competitiveness (Turel and Akis 2019) and overall value chain (Berman 2012; Nagy et al. 2018). The notion of VC pertains to the process through which a business produces goods and services that are highly valued by all the participants including customers and the market (Chatterjee et al. 2021). VC can manifest in different ways, such as generating financial profits, ensuring customer satisfaction, fostering employee engagement and making a positive impact on society (Ma et al. 2019). According to prior studies, the implementation of I4.0 technologies has been found to have major impact on VC, both in terms of social and economic benefits (Elia et al. 2020; Audretsch and Belitski 2021). These technologies drive innovation, improve productivity and contribute to inclusive growth (Mukhuty et al. 2022). Consequently, this improvement is accomplished by integrating novel technologies such as AI, IoT and automation to optimise processes, reduce operating costs and enhance production efficiency (Kamble et al. 2020; Haghnegahdar et al. 2022). Together, these factors result in increased economic productivity, creation of jobs and enhanced quality of life (Nagy et al. 2018; Mondal et al. 2024). Therefore, this leads to the formulation of following hypothesis.

H3. *Industry 4.0 positively influence the value creation of an organisation.*

2.2.4 | DT and SCP

The concept of SCP encompasses a holistic strategy that seeks to foster resource efficiency, minimise environmental harm, potentially create job opportunities and improve quality of life by encouraging responsible consumption and production practices (Mondal et al. 2024; Jiang et al. 2024). Consequently, the global shift towards sustainability and DTs are two developments that are gaining momentum at the same time and will likely to have far-reaching effects on many aspects of our society and economy (Dev et al. 2020; Pauliuk et al. 2022). However, their interaction is inevitable because of their comprehensive scope and profundity. Such as, transitioning from physical locations to virtual meetings in online environments decreases the need for materials and energy often required for travelling (van Ewijk and Hoekman 2020). Similarly, the widespread integration of technological advancements in society has the potential to enhance capacity to achieve sustainability goals through improvements in efficiency, such as the promotion of industrial material efficiency facilitated by DT (Neligan 2018) to promote resource utilisation, lowering waste along with hazardous pollutants, enable renewable energy sources, creating jobs, improving worker safety at work and raising living standards (Dubey et al. 2016). Furthermore, according to prior studies (El Hilali et al. 2020; Mukhuty et al. 2022; Robertsone and Lapiņa 2023) DT helps industries to boost their bottom lines by lowering negative environmental impacts, increase their financial metrics and make a positive impact on communities. Therefore, this leads to the formulation of following hypothesis.

H4. *Digital transformation positively influences the SCP.*

2.2.5 | DT and VC

DT leverages various I4.0 technologies and embedded devices to optimise customer experience, streamline processes and innovate valuable business models, ultimately enhancing loyalty and business efficiency (Nambisan et al. 2019). Therefore, according to Berman (2012), organisations must redefine their customer value proposition and overhaul their processes through the implementation of digital technologies to fully capitalise the advantages of DT. This could be achieved by incorporating novel technologies such as CCT, IoT, blockchain and robotics system (Kamble et al. 2020), which collectively result in an enhanced quality of life, job creation, and increased productivity. According to Audretsch and Belitski (2021), the deployment of these technological advancements by firms has the potential to enhance both social value and economic value, leading to improvements in the socioeconomic viability of the region. It is the primary goal of companies to create economic value through maximising profits by utilisation of available resources (Chatterjee et al. 2021; Vrontis et al. 2022) while effectively considering the activities that are intended for the betterment of society (Chatterjee et al. 2022). Therefore, this discussion leads to the formation of following hypothesis.

H5. *Digital transformation positively influences the firms value creation.*

2.2.6 | SCP and VC

The concept of SCP has received mounting attention in the recent years (Tukker et al. 2010; Tseng et al. 2013; Wang et al. 2019). According to Huang et al. (2012), the main reasons behind most serious environmental concerns are unsustainable consumption and manufacturing practices, such as the usage of harmful material in manufacturing process and creating waste and pollutions (Kehinde et al. 2020). Therefore, it is considered a fundamental prerequisite for achieving sustainable goals (Wang et al. 2019), fostering customer loyalty through value provision while ensuring competitiveness (Ma et al. 2019), as customers are becoming more conscious of harmful brand practices and punishing companies that are damaging both society and the ecosystem (Nyilasy et al. 2014). Conversely, customers also reward companies that demonstrate their usefulness to society and the environment by choosing to purchase their products or utilise their services (Eisingerich et al. 2011). According to past studies, it is essential for organisations to adopt sustainable production practices to enhance social economic value (Wang et al. 2019; Iglesias et al. 2020; Jayarathna et al. 2023). This could be achieved through the utilisation of sustainable practices (Tseng et al. 2013), which aims to foster sustainable resource utilisation in manufacturing operations (Bag et al. 2022; Cardoni et al. 2024). This, in turn, leads to improved competitiveness, lowering cost thereby increased economic value (Laukkanen and Tura 2020) while simultaneously fostering local economies through community-focused initiatives and generating new employment opportunities (Gregori and Holzmann 2020). In doing so, this discussion leads to the development of following hypothesis.

H6. *SCP positively influences the firms VC.*

2.2.7 | Moderating Effect of Digital Strategy in Association Between I4.0 and DT

DT refers to a deliberate process of implementing strategic changes that are based on I4.0 technologies (Ghobakhloo and Iranmanesh 2021), such as blockchain, automation, AI, IoT, cloud-computing and BDA (Kamble et al. 2020) for modifying organisational elements, cultures and business processes in accordance with evolving market needs driven by digital technologies (AlNuaimi et al. 2022). In doing so, a digital strategy is an extensive plan to employ novel technology and competencies to assist an organisation in attaining its business objectives, improve its competitiveness and drive innovation and sustainable developments (Porfírio et al. 2021). Nevertheless, the digital environment requires constant data collection, cleaning, storage and execution in order to facilitate analysis and produce meaningful results as well as broaden the scope of organisation (Correani et al. 2020). According to Mikalef et al. (2019), organisations that prioritise the development of robust digital strategies can leverage them to enhance decision-making process of top executives and facilitate the DTs. However, the successful implementation of DT depends upon the development of a digital strategy that aligns with the firms' ambitions (Porfírio et al. 2021). Therefore, companies must develop strategies that clearly outline the crucial role of digital systems within organisation, which help businesses achieve their objectives through the adoption of DT (Teece et al. 2016). Thus, it leads to creation of following hypothesis.

H7. *Digital strategy positively moderates the relationship between* I4.0 *and DT.*

2.2.8 | Moderating Role of Environment Strategy in Association Between DT and SCP

The escalating demand from consumers for companies to adopt socially responsible practices (Iglesias et al. 2020) has been partially propelled by the swift expansion of digital technologies (Elia et al. 2020), which has nurtured a significant more connected and visible environment (Junaid et al. 2024). Conversely, the emerging and rapidly expanding ICT-enabled economies utilising various technologies to link many stakeholders, including individuals, communities, organisations, and governments to generate value through the pooling of resources and promoting sustainable developments (Ma et al. 2019; Jayarathna et al. 2023). In doing so, the alignment of business digital initiatives with sustainability goals has potential to enhance resource efficiency and waste reduction. This, in turn, leads to formation of more sustainable and an effective production and consumption pattern (Robertsone and Lapiņa 2023). Nevertheless, strategic planning at the business level focuses on the various activities that contribute to achieving organisational goals while ensuring environmental stability. Therefore, environmental strategy is a corporate initiative that involves the implementation of measures to mitigate the adverse environmental impact of an organisation while maintaining the quality of service it provides to its customers (Mårtensson and Westerberg 2014; Faraz et al. 2024). Additionally, the implementation of environmental strategy at the business level is a crucial measure to generate profit for the organisation while minimising its environmental impacts (Guan et al. 2023). Consequently, the above investigation led to the formation of the subsequent hypothesis.

H8. *Environment strategy positively moderates the connection between DT and SCP.*

2.2.9 | Moderating Role of Environment Strategy in Association Between DT and VC

DT aims to modernise organisations VC and acquisition through digital technologies (Zhang, Ma, et al. 2023) and has the capability to transform the processes by which organisations generate value (Kotarba 2017). For example, the adoption of DT facilitates the organisation to investigate new avenues for value acquisition across several industries, change their relationship from competing to cooperation and innovate value acquisition methods (Zott et al. 2011). According to Mikalef and Pateli (2017) research findings, it demonstrates that businesses that have a solid digital infrastructure are more likely to reinvent their business models by concentrating on making their value offer better and more resilient to external uncertainties. Nevertheless, DT facilitates direct engagement between organisations, collaborators and customers and fosters VC (Zhang, Ma, et al. 2023; Zhang, Shah, et al. 2023) by improving operational efficiencies and decreasing expenses (Kotarba 2017). However, it also generates pressure for the organisation while simultaneously promoting a more interconnected and transparent environment. For example, the implementation of DTs can be ineffective if not accompanied by a suitable strategic framework and objectives. Empirical research indicates that having an environmental strategy is a crucial requirement for achieving DTs to guide and steer their effect towards sustainable growth (Guan et al. 2023). Consequently, the above investigation led to the formation of the following hypothesis.

H9. *Environment strategy positively moderates the connection between DT and firms VC.*

3 | Research Methodology

3.1 | Instrument Development

This study adopted a quantitative methodology to assess the model shown in Figure 1, using structural equation modelling (SEM) and creating a survey instrument to explore the hypothesised relationships. The choice to use a survey was based on its effectiveness in collecting data from a substantial sample, enhancing the applicability of the results across broader contexts. Following Creswell and Creswell's (2017) guidelines, the first step in developing valid scientific measures involved a thorough literature review to define the domain of the constructs. This foundational work led to the formation of the constructs and the model shown in Figure 1, which directed to the creation of survey instrument. Most measures for the I4.0, DT, SCP, ES, DS and VC constructs were derived from existing research but adapted to meet the specific goals of this study. The questionnaire underwent a detailed refinement process in three stages; initially, five experienced academics from leading Malaysian business schools reviewed the survey for clarity and language; subsequently, 10 experts from the industrial manufacturing sector assessed the accuracy of the results; and finally, pilot surveys with 25 managers from various manufacturing companies were carried out to further refine and validate the content of the indicators. Responses from participants were captured using a seven-point Likert scale, ranging from *strongly disagree* to *strongly agree*. Appendix A enumerates the items sourced from literature to outline the study's constructs.

3.2 | Sampling and Data Collection

This study concentrated on supply chain professionals within Malaysia's large-scale manufacturing industry, which is witnessing substantial growth driven by the nation's digital economy initiatives. The chosen target group was reflective of Malaysia's evolving digital economy trends, which have led to export increases of up to 9 billion USD, with forecasts predicting a surge to 28.5 billion USD by 2030, dependent on successful integration of I4.0 technologies. A stratified random sampling method was used to ensure diverse representation across different manufacturing subsectors. To meet the research objectives, the study targeted manufacturing companies registered with the Federation-of-Malaysian Manufacturers (FMM). To qualify for the study, companies needed to be classified as large-scale manufacturing enterprises under Malaysian criteria, generally employing more than 200 full-time staff. This study followed Kline's (2015) recommendation to estimate the minimum sample size using the G*Power 3.1 programme (Faul et al. 2009). The GPower tool determines the optimal sample size by considering statistical analyses and the number of predictors within the research framework to ensure adequate statistical power. Based on the guidelines by Faul et al. (2009), the required minimum sample size for this study was calculated as 92 respondents, with statistical power set at 80%, a significance level (α) of 0.05 and a medium effect size of 0.15. Data collection was conducted over 4 months, from September to December 2023, through an online survey distributed to 350 supply chain professionals from

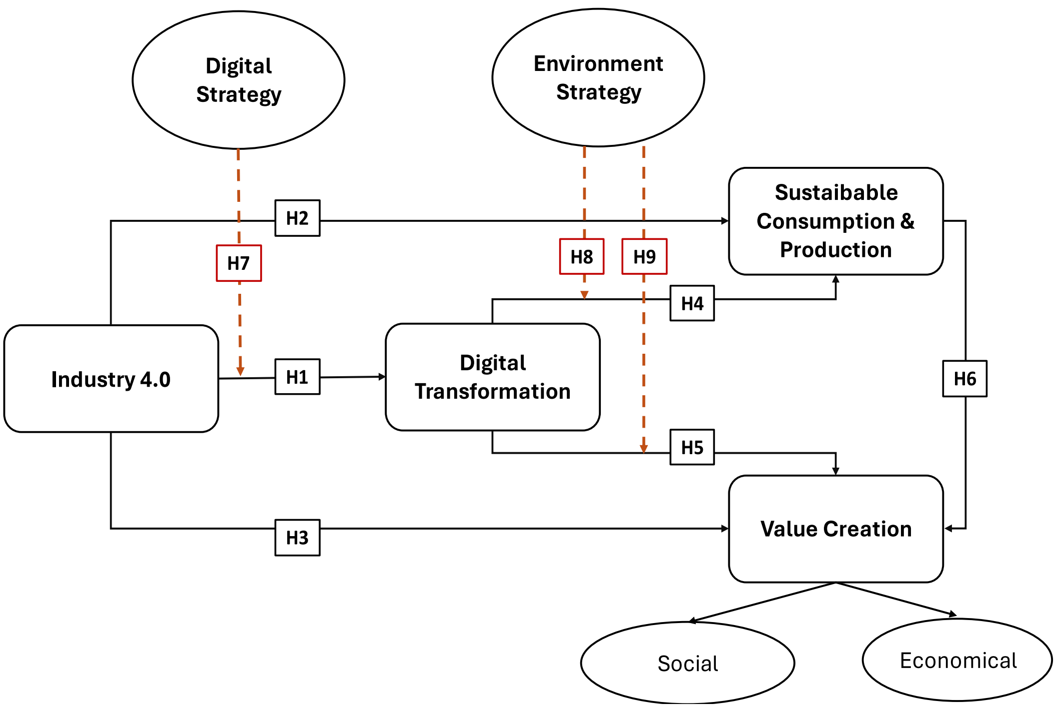

FIGURE 1 | Research framework.

large-scale manufacturing firms. Each questionnaire was accompanied by a cover letter outlining the purpose and significance of the research. The initial round of data collection yielded 59 completed questionnaires. To improve the response rate, the research team issued monthly reminders, followed by a final reminder 1 week before the survey closed. These efforts resulted in an additional 94 responses, bringing the total to 153 completed questionnaires and a response rate of 43.7%. After a thorough screening process, 16 questionnaires were excluded due to issues such as patterned responses and irrelevance to the study's scope. Consequently, 137 valid responses were retained for analysis. This figure exceeded the minimum sample size determined by G*Power, thereby ensuring sufficient representation of the target demographic. The demographic profile of respondents is summarised in Table 1.

3.3 | Common Method Variance and Non-Response Bias

To ensure the generalisability and validity of our findings, especially given the relatively low response rate, we conducted thorough tests for non-response bias and common method variance. For non-response bias, we used a wave analysis technique to compare early and late respondents on key variables. The research team employed *t*-tests as suggested by Armstrong and Overton (1977). This analysis pointed no substantial differences between two groups, indicating that non-response bias did not significantly affect our study.

To discuss common method bias, we adopted a multi-pronged strategy. Initially, this study conducted Harman's single-factor

TABLE 1 | Demographic profiling.

		Numbers	Percentage
Firm's age (years)	Less than 10	13	9.49%
	11 to 20	25	18.25%
	21 to 30	27	19.71%
	31 to 40	31	22.63%
	Over 40	41	29.93%
Job function	Supply chain professionals	34	24.82%
	Production/operations	26	18.98%
	Procurement	38	27.74%
	Logistics/transportation	18	13.14%
	Warehouse/inventory	15	10.95%
	Others	6	4.38%
Experience in			
Organisation (years)	Less than and equal to 5	31	22.63%
	6–10	42	30.66%.
	11–15	36	26.28%
	16–20	22	16.06%
	More than 20	6	4.38%
Management position			
	First tier	45	32.85%
	Middle tier	73	53.28%
	Top tier	19	13.87%
Size (number of employees)	201–500	31	22.63%
	501–1000	51	37.23%
	1001–1500	38	27.74%
	1501–2000	12	8.76%
	More than 2000	5	3.65%

(Continues)

TABLE 1 | (Continued)

		Numbers	Percentage
Industry sector	Aerospace	3	2.19%
	Agro based & food processing	5	3.65%
	Automotive	17	12.41%
	Chemicals & chemical products	12	8.76%
	Construction materials	4	2.92%
	Electrical & electronics	11	8.03%
	Energy	7	5.11%
	Furniture & furnishings	7	5.11%
	Industrial machinery & equipment	8	5.84%
	Information & communication technology	4	2.92%
	Metal and metal products	3	2.19%
	Oil and gas	6	4.38%
	Packaging and printing	11	8.03%
	Paper and paper products	6	4.38%
	Plastics and plastic products	6	4.38%
	Rubber and rubber products	5	3.65%
	Textile and apparel	19	13.87%
	Other	3	2.19%

test via exploratory factor analysis, where the first factor accounted for 35.7% of the variance below the 50% threshold that typically suggests common method bias (Podsakoff, MacKenzie, Lee, et al. 2003). Recognising the limitations of this test, including its potential for Type II errors, we further examined this bias using the marker variable technique (Simmering et al. 2015; Podsakoff et al. 2012). We introduced a theoretically unrelated construct, social desirability, as a marker variable. The analysis of correlations among substantive variables, before and after controlling for the marker variable's effects, showed only minimal changes ($\Delta R^2 = 0.043$), suggesting minimal impact from common method variance. We also implemented procedural safeguards during the survey design and administration, such as ensuring respondent anonymity, varying response formats and counterbalancing the order of questions (Podsakoff et al. 2012). These measures, together with our statistical tests, bolster our confidence that common method bias has not substantially influenced our findings.

3.4 | Data Analysis Tool

Due to the complexity of the proposed model and recent phenomenon, data is analysed using partial least squares SEM (PLS-SEM) (Chin and Newsted 1999). The selection of PLS-SEM was predicated on a prior evaluation of the data's multivariate normality, as indicated by Hair et al. (2022). The data were evaluated for multivariate skewness and kurtosis (utilising https://webpower.psychstat.org/models/kurtosis/). The multivariate skewness and kurtosis metrics indicated a statistically significant deviation from multivariate normalcy, as evidenced by Mardia's multivariate skewness ($\beta = 17.151$, $p < 0.01$) and kurtosis ($\beta = 107.195$, $p < 0.01$) (Hair et al. 2022). Consequently, this study employs the PLS-SEM methodology to examine the proposed model. In addition, PLS-SEM is well-suited for prediction-oriented research, making it particularly appropriate for analysing emerging DT phenomena. Furthermore, its robustness in handling complex models with non-normal data and smaller sample sizes strengthens its suitability for this study.

4 | Results and Analysis

4.1 | Measurement Model Analysis

To evaluate the measurement model, we analysed both convergent validity and discriminant validity. As recommended by Hair et al. (2014), we determined convergent validity using factor loadings, average variance extracted (AVE) and composite reliability (CR). The results confirmed that all criteria were met: factor loadings were above 0.7, AVE values exceeded 0.5, and CR values were higher than 0.7. Therefore, the results affirm that the convergent validity of our scale measurements is adequately established, as shown in Table 2.

Henseler et al. (2015) recommended the heterotrait–monotrait (HTMT) ratio of correlations as a measure to evaluate discriminant validity. If the HTMT value exceeds either the 0.85 or 0.90 benchmarks (Kline 2023), it may indicate a compromise

TABLE 2 | Construct reliability and validity.

		Loadings	Cronbach's alpha	CR	AVE
Digital strategy	DS-01	0.805	0.834	0.889	0.668
	DS-02	0.856			
	DS-03	0.766			
	DS-04	0.841			
Digital transformation	DT-01	0.758	0.885	0.913	0.635
	DT-02	0.810			
	DT-03	0.750			
	DT-04	0.785			
	DT-05	0.866			
	DT-06	0.808			
Environmental strategy	ES1	0.892	0.892	0.925	0.756
	ES2	0.792			
	ES3	0.886			
	ES4	0.904			
Economic value	EV1	0.884			
	EV2	0.925	0.937	0.952	0.798
	EV3	0.912			
	EV4	0.847			
	EV5	0.898			
Industry 4.0	Industry1	0.854	0.901	0.923	0.668
	Industry2	0.837			
	Industry3	0.817			
	Industry4	0.752			
	Industry5	0.838			
	Industry6	0.803			
Sustainable consumption production	SCP1	0.852	0.901	0.931	0.771
	SCP2	0.892			
	SCP3	0.886			
	SCP4	0.882			
Social value	SV1	0.859	0.895	0.923	0.704
	SV2	0.818			
	SV3	0.861			
	SV4	0.845			
	SV5	0.812			

Note: ES5, ES6 and SCP5 were dropped due to low loadings.
Abbreviations: AVE, average variance extracted; CR, composite reliability.

in discriminant validity. Table 2 shows that all HTMT values remain below the critical threshold of 0.90 as specified by Gold et al. (2001), thereby affirming the discriminant validity of our study (Table 3).

4.2 | Structural Model Analysis

To assess the structural model, we employed the coefficient of determination ($R2$), standardised beta coefficients and t values,

TABLE 3 | Discriminant validity—HTMT.

	1	2	3	4	5	6	7
1. Digital strategy							
2. Digital transformation	0.586						
3. Environmental value	0.257	0.582					
4. Environmental strategy	0.636	0.673	0.689				
5. Industry 4.0	0.766	0.594	0.420	0.645			
6. Social value	0.667	0.659	0.588	0.822	0.782		
7. Sustainable consumption production	0.498	0.818	0.787	0.754	0.643	0.650	

utilising a bootstrapping approach with 10,000 resamples as outlined by Hair et al. (2022). This method helped us calculate path coefficients and evaluate the precision of the structural model. We computed R^2 values to quantify the explained variance in DT, SCP and VC, which were 0.316, 0.640 and 0.703, respectively, indicating robust explanatory strength. Following the procedures recommended by Hair et al. (2017), we further analysed the changes in R^2 values to estimate effect sizes (f^2), using Cohen's (1988) guidelines, where effect sizes of 0.02, 0.15 and 0.35 denote small, medium and large effects, respectively. The f^2 findings confirmed satisfactory effect sizes for the hypotheses that were supported, with t values exceeding the established cutoff of >1.645.

We also evaluated multicollinearity using the variance inflation factor (VIF), with item-level VIFs ranging from 1.588 to 4.449 and variable-level VIFs from 1.094 to 2.864. Because all VIF values fell below the critical threshold of 5, the study does not exhibit significant concerns regarding multicollinearity. The structural model is presented in Figure 2, and the detailed results are outlined in Table 4. The results demonstrate that I4.0 significantly and positively affects DT ($\beta = 0.369$; $p < 0.01$), SCP ($\beta = 0.167$; $p < 0.1$) and VC ($\beta = 0.151$; $p < 0.05$). Furthermore, DT significantly influences SCP ($\beta = 0.460$; $p < 0.01$), though no significant impact was noted on VC ($\beta = 0.066$; $p > 0.1$). Additionally, SCP markedly enhances VC ($\beta = 0.317$; $p < 0.01$).

Following the approach of Preacher and Hayes (2008), we performed a mediation analysis focusing on DT. The bootstrapping mediation outcomes are detailed in Table 5. Notably, our analysis demonstrates that DT mediates the link between I4.0 and SCP ($\beta = 0.170$; $p < 0.01$). This is confirmed by the confidence interval (CI) for the estimate of indirect effects, which excludes zero, indicating a significant mediation effect. However, DT does not mediate relationship between I4.0 and value creation ($\beta = 0.024$; $p > 0.1$).

Furthermore, Shmueli et al. (2019) introduced PLSpredict, a technique that uses a 10-fold PLS-Predict method for generating case-level predictions at either the item or construct level to assess predictive relevance. They posited that if all item differences (PLS-LM) are lower, it indicates strong predictive power. Conversely, if all differences are higher, predictive relevance is not confirmed. If the majority of differences are lower, there is moderate predictive power, whereas a minority being lower indicates low predictive power. According to Table 6, the majority of the errors in our PLS model were higher than those in the LM model. Consequently, we can conclude that our model possesses strong predictive power for DT and SCP but exhibits weak predictive power for value creation.

The analysis of the moderation hypothesis, as detailed in Table 4, produced mixed results. The table illustrates influence of environmental strategy on the connections between DT and SCP, as well as between DT and value creation. It also examines how digital strategy impacts the connection between I4.0 and DT. The findings reveal a significant positive moderating effect of environmental strategy on the DT-SCP relationship ($\beta = 0.371$; $p < 0.05$), thus supporting H8. However, no significant moderating impact of environmental strategy was observed on the relationship between DT and VC ($p > 0.1$). Additionally, the moderating effect of digital strategy on the link between I4.0 and DT was also found to be insignificant. Thus, rejecting H7 and H9. For a visual comparison of how these moderators affect the relationships under study, we employed Dawson's (2014) recommended framework. Figure 3 graphically represents these relationships, with higher and lower levels of environmental strategy marked by a green dotted line and a dark blue solid line, respectively. The graph demonstrates a more robust relationship between DT and SCP at higher environmental strategy levels, indicating that the benefits of DT on SCP are more pronounced under conditions of elevated environmental strategy. Thus, enhancing SCP through DT is dependent on the organisation's strong emphasis on environmental strategy. Consequently, the statistical data suggest that an enhanced environmental strategy intensifies the positive relationship between DT and SCP.

5 | Discussion

This study investigates the potential effect of I4.0 on achieving the inter-related environmental, economic and social TBL outcomes (Geissdoerfer et al. 2017) of SCP, and economic and social value creation. Successfully achieving these outcomes are arguably vital to various firm's sustainable competitive advantage. Simultaneously we consider the importance of robust strategy implementation to achieve competitive advantage, espoused by the RBV theory including enhancing and harnessing internal resources and capabilities (Barney 1991). Herein, our model considers the potential pathway of DTs within firms in helping I4.0 led to higher SCP and value creation. Furthermore, we also consider the potential influence of developing and adopting clear environmental and digital strategies in enhancing SCP, and

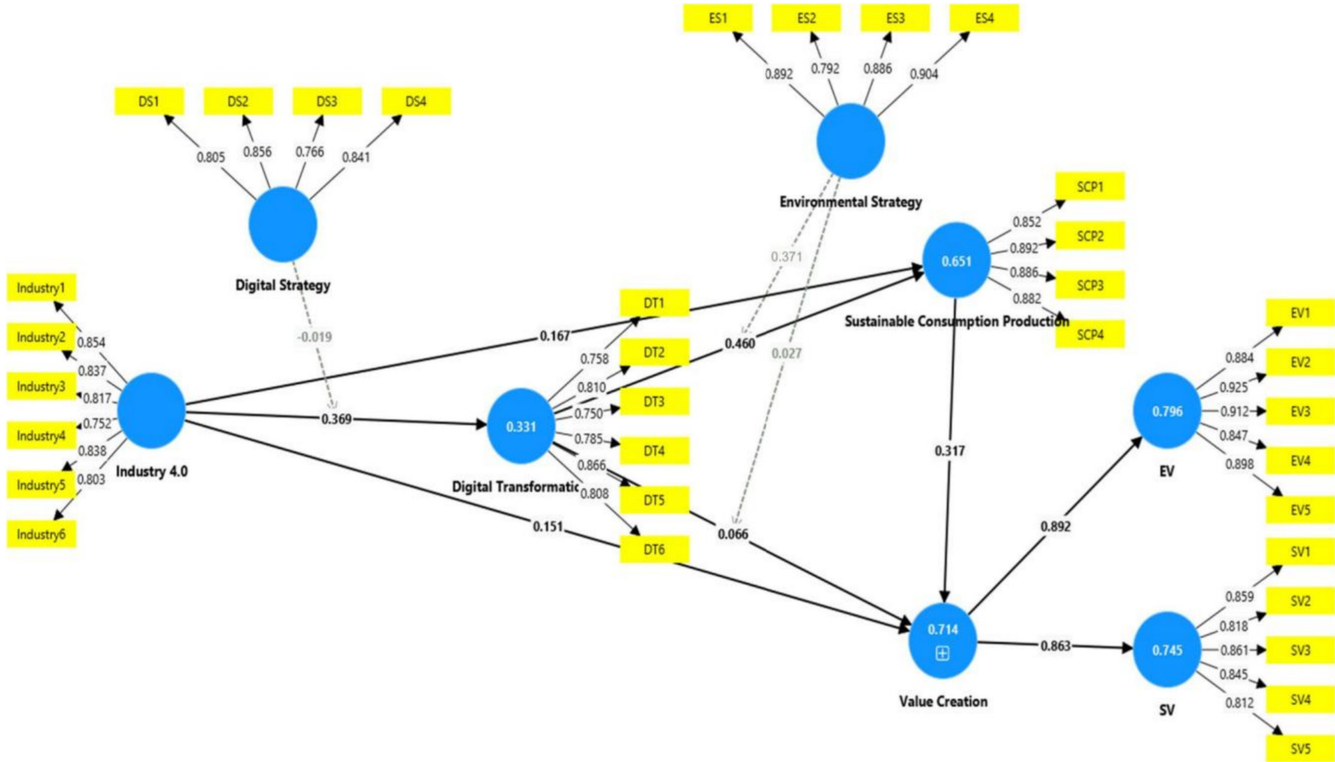

FIGURE 2 | Study model—path model.

TABLE 4 | Bootstrap results.

Path model	Beta	Std dev	t value	*p*	BCI LL	BCI UL	Decision
Digital transformation → sustainable consumption production	0.460	0.076	6.029	0.000	−0.116	0.101	Yes
Digital transformation → value creation	0.066	0.076	0.860	0.390	0.302	0.6	No
Industry 4.0 → digital transformation	0.369	0.091	4.076	0.000	0.315	0.575	Yes
Industry 4.0 → sustainable consumption production	0.167	0.096	1.733	0.083	−0.012	0.137	Yes
Industry 4.0 → value creation	0.151	0.059	2.548	0.011	−0.042	0.108	Yes
Sustainable consumption production → value creation	0.317	0.085	3.712	0.000	0.184	0.54	Yes
Digital strategy × Industry 4.0 → digital transformation	0.019	0.054	0.349	0.727	0.783	0.912	No
Environmental strategy × digital transformation → sustainable consumption production	0.371	0.039	2.825	0.028	0.14	0.476	Yes
Environmental strategy × digital transformation → value creation	0.027	0.039	0.703	0.482	0.829	0.925	No

TABLE 5 | Mediation effect.

	Beta	Std dev	t value	*p*	BCI LL	BCI UL
Industry 4.0 → digital transformation → sustainable consumption production	0.170	0.055	3.092	0.002	0.074	0.290
Industry 4.0 → digital transformation → value creation	0.024	0.030	0.799	0.424	−0.031	0.091

value creation. We conducted this study with 137 valid responses from manufacturing firms within Malaysia. Thus, findings from this study can be beneficial particularly for manufacturing organisations in informing their sustainability and value creation strategy development and workflow. Thereby, this study makes a valuable contribution by synergising TBL and RBV theories to examine the interactions among I4.0 technologies, DT, sustainability and value creation, within a major emerging manufacturing economy.

The research findings determine a positive link between firm orientation and use of I4.0 tools and DT within the firm. Moreover, the findings revealed that the adoption or lack of a digital strategy did not influence the depth of relationship between I4.0 and DT. This shows that actively investing in the appropriate I4.0 technology including cloud-computing, IoT, AI and so on; will directly speed up digitalisation within firms, irrespective of strategic intervention. Furthermore, firms with high I4.0 orientation as well as organisations proactively engaged in implementing overall DT within their organisations, also demonstrated higher achievement of their sustainability performance indicators of SCP. In other words, greater engagement with I4.0 opportunities and organisation-wide DT's, improved sustainable and socially responsible consumption and production processes, efficient usage of natural resources, reduction in toxic waste and improvement in employee life quality (Dubey et al. 2016). Post hoc investigations also revealed that DTs positively mediated the link between I4.0 and achieving SCP success. This shows that harnessing the opportunities offered by I4.0 tools in a holistic fashion is crucial to successfully embedding beneficial DT within manufacturing firms, which in turns have significant effect on not only protecting the physical natural environment but also achieving overall societal welfare for key stakeholders like the employees of the firms. This is a key contribution of this study emphasising the benefits of holistically implementing I4.0 and DT initiatives to facilitate both SCP in the manufacturing industry.

This study also makes a valuable contribution by confirming the highly favourable impact that I4.0 directly exudes on both economic and social value creation. Interestingly, however, our study showed that DT did not necessarily contribute to improving economic and social value creation. As per post hoc investigations, neither did it mediate the relationship between I4.0 and value creation. Furthermore, nor did environmental strategy moderate the link between DT and VC. Although this is an unexpected empirical contribution, a possible explanation for these findings is that the ethos of economic value creation is not only an embedded core focus of manufacturing firms, but it may also be argued to be the core purpose of organisations. There is also significant awareness of not only the business case for social responsibility (Ngai et al. 2018) but also intertwined benefits of prioritising both economic & social value creation simultaneously. Furthermore, in the post-internet era, the importance and opportunities offered by intricate technological advances encompassed by I4.0 could be more universally accepted than previously. Therefore, the firm's focus on economic and social value creation using I4.0 technology would be less reliant on the

TABLE 6 | PLS predict.

	Q^2predict	PLS-SEM_RMSE	LM_RMSE	PLS—LM
DT-01	0.211	0.98	1.001	−0.021
DT-02	0.117	1.191	1.196	−0.005
DT-03	0.241	1.041	1.021	0.020
DT-04	0.180	1.098	1.093	0.005
DT-05	0.188	1.251	1.239	0.012
DT-06	0.128	1.154	1.159	−0.005
EV1	0.302	1.209	1.184	0.025
EV2	0.331	1.256	1.231	0.025
EV3	0.280	1.324	1.267	0.057
EV4	0.264	1.402	1.344	0.058
EV5	0.200	1.462	1.483	−0.021
SV1	0.513	0.876	0.819	0.057
SV2	0.423	1.019	1.057	−0.038
SV3	0.437	0.845	0.827	0.018
SV4	0.386	0.964	0.881	0.083
SV5	0.423	0.838	0.779	0.059
SCP1	0.351	1.035	1.022	0.013
SCP2	0.372	1.076	1.099	−0.023
SCP3	0.359	1.188	1.230	−0.042
SCP4	0.355	1.203	1.283	−0.080

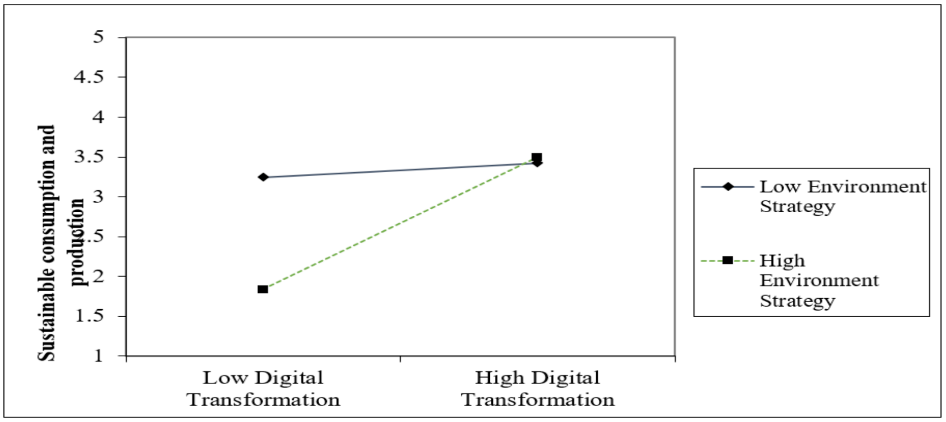

FIGURE 3 | Visual analysis—moderation effect.

DT initiatives being implemented within the firms, and having access to I4.0 technology will directly lead to the firms' internal stakeholders actively employing these technologies to enhance economic and social value creation. Similarly, creating economic and social values may be considered part of the core business by most organisations; therefore, irrespective of the implementation of an explicit environmental strategy, business operations are expected and likely to conduct business in a manner that yields higher economic and social values.

Moreover, a further contribution of this study is the evidence that a robust environmental strategy further strengthened the favourable relationship between DT and SCP. This contributes to theory by supporting our resource-based contention that a strong environmental strategy will accelerate the impact of DT on achieving efficiencies in terms of sustainable consumption of natural resources, reduction in harmful and wasteful emissions and contributions towards improved life quality. Finally, our study also demonstrated the positive association between social consumption and production and economic and social value creation, which makes a crucial research contribution to practice by further strengthening the business case for sustainability and provides evidence for the inseparability of sustainable performance of business and economic and social improvement and development.

6 | Research Contribution and Future Directions

6.1 | Theoretical Contributions and Implications

This research contributes to the landscape of I4.0 in relation to business strategy, the environment and sustainability while extending the breadth of the underpinning TBL and RBV theories. This research sheds light on the nuanced influence of resource-based digital and environmental strategies on outcomes embodied by the three pillars of the TBL theory of economic, environmental and social benefits. This research contributes to the existing scholarly discourse through the development of integrated framework on I4.0 technologies, SCP and value creation. Furthermore, this research advances the field by evaluating the impact of digital and environmental strategies on the interlink between I4.0 technology technologies, DT and SCP. This investigation helps to plug the dearth in the literature exploring the specific impact of I4.0 technologies and DT on SCP systems, alongside their influence in enhancing organisational economic & social value. This study also addresses the need for empirical evidence on the influence of digital strategy on I4.0 technologies and DT, alongside that of the environmental strategy on SCP. The findings demonstrate the significant potential of I4.0 technologies like IoT, blockchain and AI in helping achieve SCP and better value creation, through resource optimisation, waste reduction and relative energy efficiencies. Furthermore, this study empirically supports the moderating influence of environmental strategy on the linkage between DT and SCP, indicating that robust environmental strategies help better achievement of sustainable operations and outputs, consistent with TBL theory emphasising optimisation of economic and environmental outcomes. This study extends support for the RBV theory, by demonstrating that digital and environmental strategies play a crucial role in facilitating organisational exploitation of I4.0 technologies in achieving sustainable consumption, production and value creation, both economically and socially.

6.2 | Practical Contribution and Implications

By developing and examining this integrated framework, this study contributes empirically by evidencing the influential mediative pathway of DTs in facilitating I4.0 led SCP, and value creation within firms. The specific focus of this study on the emerging economy of Malaysia is of added value, particularly where most I4.0 studies tend to be based on western developed economies. Through the integrated framework, this study makes a valuable research contribution by emphasising to researchers and practitioners, the crucial need to develop effective digital and environmental strategies to leverage I4.0 technologies and DT in ultimately achieving sustainable outcomes as well as economic and social value creation. This demonstrates to managers that through the implementation of digital technologies, organisations can achieve optimal resource usage, effective waste management and production efficiencies. Furthermore, reduction in costs can be achieved while improving quality and customisation for customers, creating economic and social value. This research contributes to practice by evidencing to managers that prioritising DT is conducive to streamlined processes enhancing production efficiencies, competitive advantage, higher revenue and enhanced social value. Thus, study evidence to managers that through comprehensive digital strategies, I4.0 technological outlays can be aligned to business objectives in a manner that optimises harnessing novel technology for sustainable, economic and social value creation. The positive association between SCP and value creation indicates to practitioners that by emphasising ethical resourcing, waste and resource efficiencies, better value outcomes can be generated for various stakeholders and the environment. Thus, overall, this research contributes by emphasising the criticality for organisations to adopt a holistic model towards DT heeding sustainability needs in various aspects of business strategy and operations. Through responsibly and sustainably harnessing I4.0 affordances, organisations can create value for a wide range of stakeholders while helping to develop sustainable futures.

6.3 | Conclusions, Limitations and Future Research Directions

Notably findings from this study are particularly relevant to manufacturing firms of emerging Southeast Asian economies in informing their sustainability and value creation strategy development and workflow implementation. This study provides valuable managerial insights, highlighting that even in the absence of formalised digital strategies, I4.0 know-how significantly enhances SCP. Therefore, management would reap greater returns by investing budgets and resources directly in deploying I4.0 know-how on the ground, including IoT metering, blockchains and machine learning, rather than strategy maturity modelling. Nonetheless, this research evinces that DT enhances SCP provided it was reinforced by a robust environmental strategy, emphasising the criticality of integrating sustainability goals into digital solutions upfront. Therefore, it can be concluded that managers should align DT investments with clearly articulated environmental performance targets to enhance sustainable productivity, thereby navigating digital investments towards resource efficiency, waste reduction, and social well-being. The positive association found between SCP and value creation further strengthens the business case for sustainability, showing that environmental responsibility ultimately enhances competitive and economic advantage. Therefore, in practice, managers in manufacturing firms would benefit by embracing an integrated approach uniting the operational capabilities of I4.0 with governance mechanisms espousing environmental priorities, ensuring both sustainable outcomes and value creation.

This study focused exclusively on manufacturing firms, a crucial sector, which is extensively exposed to and engaged with I4.0 technology. This may also be construed as a limitation of this study and other types of industries like retail, service and health will also benefit from an investigation of this framework given the universal TBL imperative of all businesses to balance their economic profit related targets with contributing to society through environmental and social considerations. Therefore, this paper calls for more future research on how I4.0 influences SCP and value creation in non-manufacturing firms. Furthermore, this study focuses exclusively on manufacturing firms in the country of Malaysia, which is an important emerging economy. Consequently, while a limitation is that the findings from this study may not necessarily be generalizable to advanced economies, the framework developed, can serve as a useful guide for other emerging economies in the southeast Asian region, as well as in facilitating strategic alliances and partnerships in the region. Therefore, we argue studying the impact and role of I4.0 and digitalisation on sustainability and value creation performance indicators of firms in other countries will be worthwhile, including both emerging and advanced economies. In particular, considering the global context in which businesses have to function and the global influence of I4.0 technology, this paper calls for cross-cultural, multi-nation comparative studies exploring the enablers and pathways facilitating sustainability and value creating outcomes, through I4.0 technology and investments. Moreover, this study adopted a macro-level approach surveying a large number of manufacturing firms in Malaysia. Future studies would benefit from micro-level detailed investigations into individual firms taking into account their functional and cultural nuances which may involve in-depth qualitative and case-study methodologies. Although this study is cross-sectional, longitudinal studies in future would help triangulate causality. A key strength of this study is the use of primary data. These results could be further bolstered through revalidation studies including combining primary data with secondary data, taking into account published reports from think-thanks, consultancy outputs and learned societies.

Author Contributions

All authors contributed equally to the following roles: conceptualisation, methodology, data collection, formal analysis, writing the original draft, writing review and editing and validation. Each author has reviewed and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix A

Industry 4.0 (Kamble et al. 2020; Mondal et al. 2024)	
	Our firm is in the process of implementing or implemented cloud computing
	Our firm is in the process of implementing or implemented big data analytics
	Our firm is in the process of implementing or implemented internet of things
	Our firm is in the process of implementing or implemented RFID
	Our firm is in the process of implementing or implemented AI
	Our firm is in the process of implementing or implemented blockchain technology
Digital transformation (Nasiri et al. 2020; AlNuaimi et al. 2022)	
	In my organisation, we aim to digitalise everything that can be digitalised.
	In my organisation, we collect large amounts of data from different sources.
	In my organisation, we aim to create more robust networking with digital technologies between the different business processes.
	In my organisation, we aim to enhance an efficient customer interface with digitality.
	In my organisation, we aim at achieving information exchange with digitality.
Sustainable consumption and production (Dubey et al. 2016; Mondal et al. 2024)	
	We are able to efficiently use natural resources
	We are able to significantly reduce harmful elements
	We able to create more jobs in our firm
	We able to improve the health standards of the workers in our firm
	We able to improve the living standards for the people in our firm
Value creation (Vrontis et al. 2022; Porter and Kramer 2011)	
Economic	Our firm can achieve economic value through profit maximisation.
	Our firm can achieve economic value by adopting various technologies.
	The economic value changes if the price of the good or the service changes.
	In my organisation, economic value increases with the enhanced utilisation of advanced tools and technologies.
	Our firm has been able to reduce product development costs through the use of appropriate technologies.
Social	Our firm could gain social benefits by performing work that benefits society.
	Our firm believes that social value originates from corporate social responsibility
	Improving the social value is an important aspect of our organisation.
	Customers may favour those firms that spend more to uplift the society.
	Our firm believes in fostering shared values among employees.
Environmental strategy (Guan et al. 2023)	
	Our company has clearly defined environmental targets
	Our company has a comprehensive environmental management system
	Our company has an environmental policy
	Our company has a system of environmental reporting
	Our company has green product development
	Our company is 14,001 certified organisation
Digital strategy (AlNuaimi et al. 2022)	
	In my organisation, we integrate digital technology and business strategy to attain strategic alignment with the government and other partners.
	In my organisation, we create a shared vision of the role of digital technology in business strategy.
	We jointly plan how digital technology will enable the business strategy.
	In my organisation, we confer before making strategic decisions.