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The Impact of Supplier-Customer Collaboration on Sustainability-Oriented Capability: The Mediating Role of Communication Effectiveness and Technology Adoption in Micro-Enterprises

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Abstract

With many businesses transforming digitally to lead future trends driven by sustainability, supplier-customer collaboration is key in empowering MSMEs. Nevertheless, effective collaborative practices remain challenging for MSMEs due to resource constraints and operational limitations. This study examines the mediating role of communication effectiveness and technology adoption in the relationship between supplier-customer collaboration and sustainability capabilities. Data was collected from 400 MSMEs in Bangkok and metropolitan area, Thailand, and analyzed using partial least squares-structural equation modeling (PLS-SEM). Results indicate that supplier-customer collaboration positively influences sustainability capability directly (β=0.345, $p < 0.001$) and indirectly through communication effectiveness (β=0.370, $p < 0.001$) and technology adoption (β=0.043, $p < 0.001$). Effectiveness of communication appeared to be the superior mediator, providing evidence that the impact of technology adoption is less influential in resource-constrained environments. The study's novelty lies in its focus on micro-enterprises' unique constraints and the creation of a contextualized framework that prioritizes effective communication over technological investments, challenging conventional sustainability models derived from large organizations and offering context-specific policy recommendations for enhancing micro-enterprise sustainability in developing economies.

Keywords: Supplier-Customer Collaboration, Sustainability-Oriented Capability, Communication Effectiveness, Technology Adoption, Micro-Enterprises

1. Introduction

In the context of digital transformation and sustainable business practices, supplier-customer collaboration has received growing attention from the scientific community over the past few years, being identified as an asset for improving the capabilities of Micro, Small, and Medium Enterprises (MSMEs) to create a response to the effects of the ever-increasing pace of change in the market [1]. Communication and technology are catalysts of environmentally friendly practices and operational improvements [2]. Besides, environmentally friendly supply chain management has been reported to be able to facilitate the development of environmental innovations [3] and sustainable growth of enterprises [4]. In the case of Thailand's micro-businesses, these theoretical constructs have yet to be fully exploited, particularly in their use of technology to facilitate high-efficiency communications and enhanced sustainable business capacity [5]. Hence, analyzing the role of communication and technology in the dynamic of supply chain collaboration in relation to sustainable business capabilities will aid in understanding how micro-enterprises can achieve tangible improvements in operational efficiency, environmental sustainability, and market competitiveness even with limited resources and in challenging economic environments. This study aims to address this important research area by examining these relationships specifically in the context of Thai micro-enterprises.

While numerous studies have focused on green supply chain management and its role in sustainable development, there remain gaps in the literature, in particular with respect to the environmental resilience of micro, small, and medium enterprises due to their frequent restrictions in access to resources, technologies, and good management practices [6]. The previous studies' focus has mainly been on medium- to large-sized companies, resulting in a limited insight into

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how micro-entrepreneurs are adopting strategies to boost their sustainability capabilities [7]. Furthermore, several literature reviews have concentrated on the examination of individual elements, for instance, technology adoption or sustainable supply chain management, without an integrative examination of the combined impact of various factors [8]. This knowledge gap can be overcome by studying the role of supplier-customer collaboration in facilitating sustainable business capabilities and the mediating effect of communication efficiency and technology use.

This study focuses on the impact of supplier-customer collaboration on sustainable business performance, using communication efficiency and technology utilization as mediating variables in microenterprises. The study sets the stage for figuring out how microbusinesses can improve their long-term business performance by using good supply chain management techniques and technology in the best way possible. The anticipated benefits from this study can be highlighted (1) to provide insight for microenterprises to conduct communication strategies and technology utilization appropriate to enhance their sustainable business performance; (2) policy recommendations to assist government agencies or the small business support organization to launch appropriate promotional measures; and (3) to fill the knowledge gaps in supply chain collaboration, digitalization, and sustainability-oriented business practices that have not been sufficiently studied in the scope of microenterprises in Thailand which leads to further enhance the global competitiveness of microenterprises through international trade and investment. By addressing these research gaps, this study contributes to both theoretical understanding and practical applications of sustainable business practices in micro-enterprises, with potential implications for similar contexts in other developing economies.

2. Literature Review

2.1. Supplier-Customer Collaboration

Supplier-customer collaboration can be explained by two main theoretical frameworks: the Resource-Based View (RBV) and the social exchange theory. According to RBV theory by Barney [9], organizations can develop a sustainable competitive advantage with the resources and capabilities if they are valuable in nature, rare, imitable, and substitutable. Particularly for resource-constrained small businesses, supply chain collaboration is a must to gain access to these resources and capacities [10]. Another theory that expands the RBV idea is the relational view theory, which is based on the observation that relationships between different organizations are a source of competitive advantage and result from investing in assets specific to a relationship, knowledge exchange, integration of complementary resources, and transaction cost reduction [11]. Sociologically, inter-organizational collaboration is reflected in the social exchange theory established by Blau [12], wherein it takes place when both parties perceive mutual rewards and trust each other, which develops through continuous mutually rewarding social interactions. Cropanzano and Mitchell [13] state that social exchange is dependent on reciprocity, trust, and equality norms. Across the supply chain, the exchange of resources, knowledge, and best practices between organizations and partners builds joint capabilities, including sustainability capabilities [14], [15]. Furthermore, Cao and Zhang [16] explored key aspects of supply chain cooperation, such as information sharing, decision-making, indicator adaptation, and resource sharing, which were found to enhance overall industrial progress and innovation capability.

Supplier-customer collaboration, as a research field, is critical for organizations in the era of the digital economy and accelerates this approach for organizations to be more competitive and sustainable in the market. Collaboration enables both parties to enhance product and service quality [17], address sustainable innovation, and mitigate environmental effects [18]. While collaboration can help in driving efficiency and value addition for the businesses, the integration of collaboration is a challenge. In particular, for very complex industries like manufacturing and logistics, technologies need to link data and adjust to the circular economy [19]. The research of Li et al. [3] proves that green supply chain management fosters ecological innovation through information sharing and cooperation between suppliers. However, achieving effective collaboration necessitates well-defined communication channels and the use of digital technologies for enhanced operational efficiency [20]. Mehrabi et al. [7] also stressed the importance of collaboration in the agricultural industry supply chain, discovering that farmer and supplier suggestion exchange improved adaptation to sustainability trends. The research of Sun et al. [5] also suggested that suppliers who collaborate with organizations that keep high ESG standards have an incentive to enhance their production processes toward being more environmentally friendly. The key challenges surrounding supply chain collaboration, including trust among suppliers, technology integration, and communication styles, still need to be examined to lay the foundation for strategies that

can help develop sustainable business capabilities via supply chain collaboration. This is surprising, as despite numerous studies on supplier-customer collaboration, the extant literature still has substantial gaps, particularly in the small business context. The research by Li et al. [3] and Sun et al. [5] discusses green concerns and ESG standards but applies them to large organizations with high resources and investment capabilities, whereas small businesses have profoundly different constraints in resources, bargaining power, and access to global supply chain networks. Furthermore, Mehrabi et al. [7], although performed in the field of smallholder farmers, is industry-specific to agriculture and lacks a cross-industry applicative framework. A complementary gap is that little is known about the exact mechanisms by which small businesses can form effective collaborations, given their limited bargaining power and resources. Therefore, this research seeks to learn how to formulate mechanisms, suited to the small business context, that build collaborations to develop sustainability capabilities.

2.2. Communication Effectiveness

The theory of organizational communication offers a conceptual framework for how organizations communicate to accomplish their aims and objectives [21]. Intra- and inter-organizational communication is a structured and symbolic process by which members of an organization and members of other organizations produce, share, and understand information and knowledge [22]. In the Einwiller and Boenigk [23] model of communication, sender, communication channel, message, receiver, and response are included, with noise being a barrier to effective communication. The model that gives a complete overview of how and why communication will be effective is SMCR (source-message-channel-receiver), developed by Berlo [24]. According to this model, the effectiveness of communication is through a number of factors such as communication skills, attitudes, knowledge, social systems, and cultures of the sender and receiver, followed by the message content, structure, code, and channels of communication. Mohr and Nevin [25], in the context of the supply chain, develop the concept of overall communication that considers its frequency, direction, format, and content. This hinders collaboration, satisfaction, and efficiency in relationships in marketing channels. Furthermore, the two-way symmetrical theory of Grunig and Hunt [26] emphasizes that organizations reciprocate in information and opinion exchange with stakeholders, which establishes trust and a maintainable relationship between stakeholders and the organization. Taking this particular insight into the supply chain context, effective communication allows organizations to share complex and sensitive information, including environmental implications, regulatory compliance, and sustainability innovation, that serve as key elements in the generation of joint sustainability capabilities [27].

Communication effectiveness is one of the essentials that allows organizations to successfully work together with minimal errors and be more competitive in a continuously changing atmosphere [28]. In such a complex supply chain, effective and timely communication enables suppliers and operators to exchange critical information that is important for operations, minimize delays, and enhance the efficiency of order management [29], [30]. Nonetheless, communication issues remain one of the greatest challenges for all companies, particularly small and medium-sized enterprises (SMEs) without the means to build technological infrastructure [31]. It is said that integrated effective communication makes it possible for businesses to work together and organizes and prioritizes the information that is shared between organizations, which improves the efficiency of communication between them [32]. Meanwhile, Martey et al. [33] noted that the communication skills of an organization are directly related to its ability to retain customers and increase consumer confidence, while Tian et al. [34] revealed that good internal communication improves employment engagement and lowers turnover, thus affecting long-term operational performance. In fact, the application of digital platforms can accelerate communication, but a lack of appropriate data management strategies and an internal communication culture will be a limiting factor in achieving business success [35], [36]. Thus, future studies should guide overcoming effective technological development and digital economy adaptation challenges, providing insight on developing capable communication management frameworks that liaise with evolving technology. The current literature on communication effectiveness in the supply chain context still has significant gaps, especially in terms of small businesses. The research of Shaikh et al. [31] suggests that SMEs struggle with establishing the technological structure for communication without introducing practical measures that would work considering their resource and personnel constraints. On the other hand, Martey et al. [33] and Tian et al. [34] do not address the key role of communication in adamant relationships in the supply chain perspective. A notable gap is the limited research on low-cost yet effective communication models for resource-poor SMEs, particularly in the context of the

digital era with an array of high- and low-level communication use cases. Moreover, the literature is limited in its deep understanding of how SMEs can use effective communication to gain bargaining power in a supply chain environment where large organizations often dominate the decision-making process. The current research aims to find out this gap by investigating the effective communication mechanisms that are suitable for the SME context.

2.3. Technology Adoption

Importantly, the adoption and use of technology in organizations can be explained by Davis' Technology Acceptance Model (TAM) [37] and Rogers' diffusion of innovation theory [38]. The framework from TAM states that there are two main constructs that influence the acceptance of technology: perceived usefulness and perceived ease of use, both of which influence attitude towards use, intention to use, and system use behavior. Venkatesh et al. [39] expanded upon the TAM and led to the development of the Unified Theory of Acceptance and Use of Technology (UTAUT), which incorporates additional determinants of technology acceptance: efficacy expectancy, effort expectancy, social influence, and facilitating conditions. Rogers's diffusion of innovation theory explains that accepting new ideas happens in a series of steps: noticing the innovation, being convinced of its value, making a choice to use it, putting it into action, and confirming its usefulness. This process also relies on five key features of innovation: how much better it is than what came before, how well it fits with existing values and needs, how complicated it is to use, whether people can try it out first, and how visible its benefits are to others. According to Rogers, innovation adopters could be separated into five classes: innovators, early adopters, early majority, late majority, and laggards, each presenting their own characteristics and behaviors signaling technology adoption [38]. Moreover, Tornatzky and Fleischer [40] established the TOE (technology-organization-environment) framework, stating that organizations adopt technology based on technological factors such as technology readiness and alignments with existing technologies; organizational factors such as organizational size, structure, and resources; and environmental factors such as industry, competition, and government policies. Technology adoption brings unique challenges for small businesses due to constraints in their resources, skill sets, and evolving business processes. Ghobakhloo et al. [41] identified technology adoption metrics based on technology factors, market factors, resource factors, and business owner factors in small and medium-sized businesses.

Particularly, the implementation of technology improves a business's rates of competition in terms of customer service and the development of products that satisfy market demand [42]. Automation, digital platforms, and artificial intelligence enable businesses to instantly answer customer inquiries through online platforms, tailor products to customer behavior, and improve consumer experiences proactively [43]. Although technology adoption enhances the efficiency of business processes, there are still challenges that lie in organizations' capabilities to govern data, integrate with new technologies, and gain customer trust in digital channels [44]. Research by Koval et al. [45] argues that by using technologies congruent to the circular economy approach, businesses can enhance their environmental performance sustainably, whereas Acosta-Prado et al. [46] test this premise, concluding that organizations' ability to manage knowledge plays a central role as a mediation between technology adoption and subsequent innovation performance. But the end use of technology depends on government policy support and internal incentives. According to Faasolo and Sumarliah [47], government incentives build positive attitudes among SMEs to adopt more sustainable technologies. While technology helps to track product status and tailor promotions to meet customer needs, there is an infrastructure and strategic management factor businesses still need to consider making technology adoption as effective as possible [20], [48]. Although many studies on technology adoption exist in the supply chain context, considerable gaps still exist, particularly related to the small firm context. The research by Koval et al. [45] and Acosta-Prado et al. [46] provides a case for technology as a driving force for green innovation and the circular economy but does not factor in the barriers facing small businesses: capital, personnel, and the ability to creatively disrupt their business processes. Although Faasolo and Sumarliah [47] highlighted the importance of the government motivating SMEs to adopt new technology, there are yet to be extensive studies on the factors within the organization that drive effective technology adoption. One more area where there is significant disconnect is the understanding of desirable technology for small businesses, for instance, not the newest and most expensive technology but that which is in line with the needs, resources, and skills of the organization. Additionally, research on incremental technology adoption approaches in resource-constrained small businesses has been sparsely documented in the literature. This research aims

to fill this gap by examining the patterns and processes of technological adoption that are appropriate for the context and constraints of small businesses.

2.4. Sustainability-Oriented Capability

From the view of RBV, sustainability capability is a dynamic capability that an organization can adopt to assist in dealing with environmental change and increasing sustainability demands [49]. Teece et al. [50] presents dynamic capability as an organization's ability to integrate, build, and restructure internal and external competencies in order to address rapidly changing environments. Dynamic capability is comprised of three processes: sensing, seizing, and reconfiguring resources and capabilities. The natural-resource-based view theory was proposed by Hart [51], which is based on the concepts of RBV but highlights the connection of organization to the natural environment. According to this theory, environmental strategies include three categories, pollution prevention, product stewardship, and sustainable development, each providing firms a competitive advantage if they capitalize on them during the commercial cycle, which requires companies to possess distinct resources and capabilities, such as continuous improvement, stakeholder integration, and shared vision. Furthermore, Goodhue and Thompson [52] have claimed that performance and use of the technology will increase when the technology is aligned to the task needs and characteristics. This concept says that organizations must choose technologies that are compatible with the organization's needs and its capabilities, especially concerning sustainability capabilities. Sarkis et al. [53] reveal that the effect of technology and information systems in a green supply chain must be examined appropriately with business processes and organizational sustainability practices. Within the smallest businesses, these theories imply that in order to advance sustainability capabilities, the relationship between available resources, adaptability, selected technologies, and sustainability goals must harmonize, requiring a context-appropriate pathway to compliance and beyond, given the unique limitations of the smallest businesses [54].

Sustainability-oriented capability is a significant concept directly linked to the efficient and economical utilization of resources, curtailment of operational waste, adapting to the environmental trends by utilizing sustainable raw materials, and reducing environmental impact [3], [7]. Those having such capability can sustain their competitive advantage more by embracing green culture and green supply chain management [4]. Although government policies, as well as consumer pressures that favor sustainable operations, support sustainability in business, small business owners typically face cost and resource constraints that negatively impact their capacity to implement sustainability strategies effectively [6]. The transition to a circular economy is also a vital factor that enables firms to utilize resources efficiently and decrease waste in the manufacturing process. However, it is dependent on investments in the right technologies and innovations [18], [48]. The adoption of ESG (Environmental, Social, and Governance) factors in the industrial sector for the production process enables companies to uphold the relationship with the supply chain and maximize the possibility of extending the market to customers that care about sustainability [5]. That is, in addition to meeting environmental compliance requirements, a sustainable business requires management that has, among its lines of action, strategies linked to the innovation and technologies that can transform the operational processes with greater efficiency [20]. Micro businesses need to build supply chain partnerships and utilize digital technology as a vital pathway to improving their sustainability capabilities to remain competitive in the long run. There are still significant gaps in the sustainability capability literature in the context of small businesses. Most research, such as Li et al. [3], focuses on developing sustainability capability in large organizations with high resources and investment capacity. The works cited in Triguero et al. [6] identify constraints of small businesses in implementing sustainability strategies but do not propose concrete and appropriate solutions to those constraints. Another significant gap is the lack of understanding of the specific mechanisms that small businesses can use to develop sustainability capability that are consistent with their resource constraints and organizational capabilities. The works cited in Ahmad et al. [18] and Urbancová and Vrabcová [48] introduce the concepts of circular economy and resource efficiency but do not explain how small businesses can effectively apply these concepts under capital and resource constraints. In addition, the literature lacks studies on the appropriate path of sustainability capability development for small businesses' life cycle and growth, especially in the start-up and early growth stages, when businesses are most resource constrained but need to lay the foundation for long-term sustainability development. This research aims to fill this gap by investigating the path of developing sustainability capability that is consistent with the life cycle and constraints of small businesses.

2.5. Development of the Conceptual Framework and Hypothesis

This research develops a conceptual framework that integrates theoretical concepts from two main fields, the RBV and the inter-organizational collaboration theory, to explain the mechanisms by which small businesses can develop sustainability capabilities through supply chain collaboration. According to RBV theory [9], Valuable, Rare, Inimitable, and Non-Substitutable (VRIN) resources and capabilities generate competitive advantage. In this regard, sustainability capabilities are seen as dynamic capabilities that allow organizations to adjust to the changing environment and respond to growing sustainability needs [49], [50]. The inter-organizational collaboration theory suggests that organizations can create mutual value and benefits for the organization by collaborating with external stakeholders [12], [22]. Particularly, the collaboration with suppliers and customers is an important strategy for the resource-constrained small business to access the resources, know-how, and capabilities they do not have [10]. This research conceptual framework integrates both theories that promote how small businesses can build their sustainability capabilities through the relationship with suppliers and customers, where the communication and technology adaptability act as bridging mechanisms.

Improvement of sustainability capabilities through a number of mechanisms relies on supplier-customer collaboration. First, based on the social exchange theory [9], efficient cooperation between organizations and their supply chain partners results in an exchange of resources, knowledge, and sustainability best practices. Li et al. [3] indicate that green supply chain management based on collaboration encourages ecological innovation through both information sharing and collaboration with suppliers. Second, collaboration enhances supply chain efficiency and resource usage [48], which minimizes redundancy in the production process, improves material and information flow, and reduces any waste in the production process. A study by Mehrabi et al. [7], whose address is in the agricultural context, discovered that the exchange of feedback between farmers and suppliers leads to better adaptation to sustainability trends. Also, Sun et al. [5] show that suppliers working with organizations having high ESG standards tend to enhance their own production approaches in an eco-friendly manner. Supplier and customer collaboration is an effective tactic, especially for small businesses, in order to overcome resource constraints and bargaining power [6]. Therefore, the first hypothesis is proposed as:

H1: Customer-supplier collaboration influences sustainability-oriented capability.

Collaboration in the supply chain involves communication that guarantees that important information is addressed in a timely manner [28]. According to organizational communication theory, effective communication is one of the essential mechanisms for inter-organizational coordination and relationship building [21]. Sustainability capability development involves sharing nuanced and sensitive information like environmental, regulatory compliance, and sustainability innovation information [4]. The organizations need to efficiently communicate this information and ensure it flows in a timely manner, which reduces errors, increases product quality, and improves customer service [29]. A study by Shaikh et al. [31] also found that SMEs that are capable of utilizing technology and communications effectively enjoy a strategic advantage over organizations that rely on traditional operating systems. Furthermore, to better manage supply chains, integrated communication management that collects and prioritizes these types of interactions is required between the organization and its counterparts [32]. From this evidence, it can be concluded that:

H2: Customer-supplier collaboration influences sustainability-oriented capability through communication effectiveness.

Supply chain management processes and sustainable business operations are largely dependent on digital technology. Based on the technology acceptance model [37] and diffusion of innovation theory [38], the acceptance of new types of technologies in an organizational context is dependent upon the perceived usefulness, ease of use, and organizational relevance. Within the sustainability realm, digital technology allows companies to gather data on customers, analyze market trends, and be flexible to customers' needs [42] , [43]. Research by Koval et al. [45] shows that the implementation of technologies in accordance with the principles of the circular economy may support enterprises in waste reduction and enhancing environmental performance, while Acosta-Prado et al. [46] emphasize that organizational knowledge management capabilities bridge technology adoption to green innovation performance. Depending on the current state of small enterprises, the subsequent technological approach can drive operational

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efficiency as an optimal strategy to address limited resources. According to Faasolo and Sumarliah [47], findings show that SMEs have positive attitudes toward adopting sustainable technologies due to government incentives. Thus, the implementation of technologies in the supply chain is not only beneficial for business performance but also decreases the environmental consequences, leading to the hypothesis that:

H3: Customer-supplier collaboration influences sustainability-oriented capability through technology adoption.

Effective communication and technology adoption are found to be the direct influencing factors of sustainability capability, but they also have a correlation based on a causality relationship between them. The task-technology fit theory [52] underscores that effective use of technology necessitates a clear communication flow within an organization to ensure that the technology aligns with both employee and organizational performance objectives. Research by Shaikh et al. [31], shows that combine technology and communication strategically take advantage. Effective communication helps organizations to share information with their suppliers and customers, which paves the way for the adoption of new technology and business sustainability [18], [47]. Effective communication is a significant factor that affects the success of technology adoption, especially in the context of small businesses that often face resource constraints and severely lack the availability of technologically skilled personnel. Effective communication allows employees to contextualize technology in terms of purpose and benefits, lowers inertia to change, and helps technology adoption to be an overall success [32]. From this idea, it leads to the hypothesis that:

H4: Customer-supplier collaboration influences sustainability-oriented capability through communication effectiveness and technology adoption, which is shown in the figure 1.

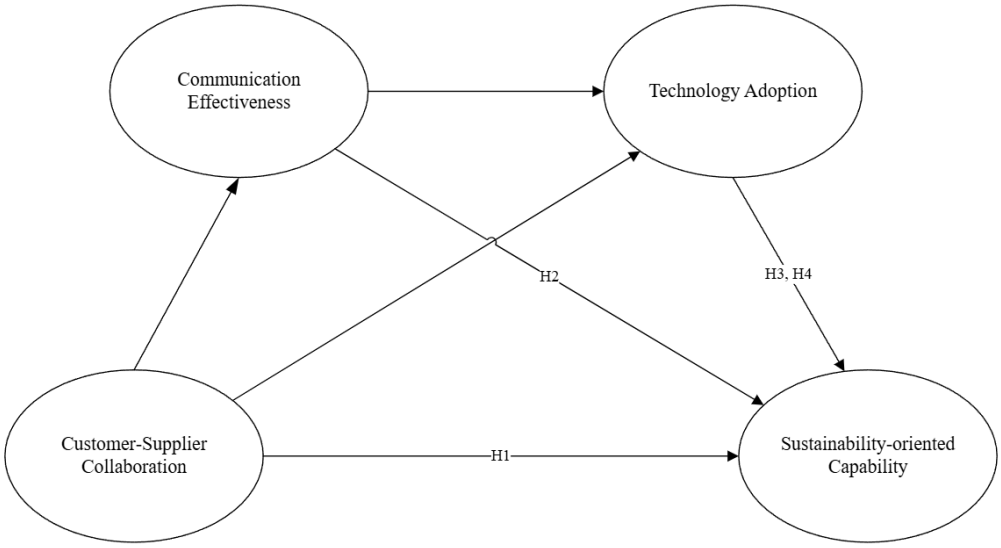

Figure 1. Conceptual Model

The conceptual framework presented in this study differs from previous studies in several ways. First, it combines all four variables including supplier-customer collaboration, communication effectiveness, technology adoption, and sustainability capability of small businesses with meager resources and limited negotiation power in the supply chain. Second, unlike the overwhelming majority of publications that scrutinize only a relationship between two variables, or in the context of large organizations [3], [5], [7], this study investigates the simultaneous direct and indirect effects of supplier-customer collaboration on sustainability capability through two mediators: communication effectiveness and technology adoption. Third, this framework offers insights into the mechanisms and processes by which small businesses can develop their sustainability capability under constraints, unlike previous studies that often assume that the relationships between variables are linear and straightforward [4], [28], [42], while in reality these relationships can be complex and dependent on the specific business context [20], [31], [48]. Thus, this study attempts to address this gap in the existing literature by proposing an integrative conceptual framework that contributes to a better understanding of the mediating role of two variables, including communication effectiveness and technology adoption,

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between supplier-customer collaboration and sustainability capability in small businesses, which are characterized by their least efficiency but most constraints in respect of resource endowments.

3. Methodology

This study focuses on micro, small, and medium enterprises in Bangkok and its vicinity, as this area is not only the economic center of Thailand but also hosts a significant concentration of micro-enterprises compared to other regions [55]. Bangkok's unique socio-economic landscape offers a diverse business environment where micro-entrepreneurs operate across various sectors, facing distinct urban challenges that differ from those in rural or provincial areas. According to Phukamchanoad [56], the metropolitan area's economic influence extends beyond its geographical boundaries, with micro-entrepreneurs contributing substantially to both employment generation and economic value in the urban ecosystem. Previous research by Li et al. [55] has established that urban micro-enterprises, particularly in capital cities of developing economies, provide valuable insights into sustainability factors that can be applicable in similar urban contexts. The selection of Bangkok aligns with the research objectives of examining sustainability factors in a competitive, resource-constrained environment where micro-enterprises must navigate complex business relationships and technological changes. Micro-entrepreneurs are defined as businesses with no more than 10 employees or operated by a single owner. The sample size used in this study was 400, calculated using Cochran's [57] formula, which is appropriate for cases where the total population is not clearly known. Stratified sampling was used, divided by business type—manufacturing, servicing, and trading—to obtain a sample that is comprehensive and truly representative of the target population. The stratification was conducted based on the proportional representation of these business sectors in Bangkok's micro-enterprise landscape, with manufacturing representing 25%, service businesses 45%, and trading enterprises 30%. This distribution reflects the economic structure of urban micro-businesses in Bangkok, according to Toothong et al. [58], where service micro-enterprises predominate due to lower capital requirements and higher demand in urban settings. The stratification ensures adequate representation of each sector, allowing for both within-sector analysis and cross-sector comparisons of sustainability factors, while maintaining the study's external validity for the broader micro-enterprise population in urban Thailand.

Data was collected using a questionnaire, which was divided into five sections. Part 1: personal and business information about the respondents; gender, age, education level, business experience, number of employees, and average monthly income. Part 2: customer-supplier collaboration measuring how closely the business collaborates with and works with its suppliers and customers. Part 3: communication effectiveness measuring how clearly and effectively communication is enacted. Part 4: technology adoption—measuring business technology adoption; and Part 5: sustainability-oriented capability—measuring the ability to run an aware, sustainable business. The measurement items were developed through a comprehensive process involving both adaptation from established scales and creation of new items specific to the micro-enterprise context. The measurement items from Cao and Zhang [16] and Li et al. [3] are used to adjust the phrasing for the micro-business context while retaining the underlying theoretical constructs. The items for communication effectiveness were adapted from Mohr and Nevin [25] and Shaikh et al. [31] and integrated some further items derived from Grunig and Hunt's organizational communication theory [26]. Measurement items for technology adoption from Davis's technology acceptance model [37] and Rogers's diffusion of innovation theory [38] were adapted with specific considerations to achieve consistency with resource constraints typically experienced by micro-enterprises. Lastly, items for sustainability-related capability were adapted from the natural-resource-based view framework by Hart [51] and recent empirical work by Koval et al. [45] and Sun et al. [5]. The linguistic adjustments of all adapted output items were performed to provide the best match without compromising the conceptual meaning for the Thai micro-business background. Three experts checked the quality of the questionnaire using content validity and the index of Item-Objective Congruence (IOC), which if the obtained IOC was over 0.5, indicated an acceptable question. Furthermore, the reliability was also verified. Cronbach's alpha coefficient was used to test the reliability of the questionnaire, and the acceptable value should be more than 0.7 to make sure that the questionnaire has good internal consistency. The data was collected by administering a questionnaire to define the sample group.

The data analysis in this research used PLS-SEM analysis. The selection of PLS-SEM is appropriate for research with multiple latent variables and complex indicators, including the analysis of causal relationships between related

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variables, such as digital transformation strategies, supplier-customer relationships, entrepreneurial capabilities, and small business sustainability. The main advantage of PLS-SEM is that it can handle non-normally distributed data and can be used even in cases where the sample size is not very large. The data analysis process begins with checking the quality of the measurement model, which consists of assessing the convergent validity and discriminant validity by considering the indicator loadings that should be no less than 0.7 and the Average Variance Extracted (AVE) that should be no less than 0.5. In addition, the reliability value was assessed. The Composite Reliability (CR) value of the indicators must be not less than 0.7 [59], [60], [61]. After checking the measurement model, we assessed potential multicollinearity issues by examining the Variance Inflation Factor (VIF) values, where values below 5.0 indicate absence of serious multicollinearity problems [61]. Then, the structural model analysis was performed to test the hypothesis and evaluate the relationship between the variables. In the structural model analysis, the statistical significance values and path coefficients obtained from bootstrapping 5,000 samples were considered, and the explained variance (R^2) was considered to measure the ability of the independent variables to explain the variance of the dependent variable. Finally, the model fit was evaluated using the standardized root mean square residual (SRMR), with values below 0.08 indicating adequate model fit [62].

4. Results and Discussion

4.1. Profile of Respondents

To determine the profile of respondents, this study collected data on gender, age, education, business period, number of employees, and average monthly revenue from business, which are detailed in table 1. From table 1, the analysis of the demographic data of 400 respondents found that females accounted for more than males, at 71.3% and 28.8%, respectively. The largest age group was 20-29 years old (39.2%), followed by 30-39 years old (24.5%), and the group aged 50 years and over had the smallest proportion (14.5%). In terms of education, most had a lower degree than a bachelor's degree (51.0%), followed by a bachelor's degree (48.3%), and only 0.8% had a higher degree than a bachelor's degree. The length of business found that entrepreneurs who had been in business for 1-3 years had the highest number (38.8%), followed by 4-6 years (28.2%). In terms of the number of employees, small businesses with 1-3 employees had the highest proportion at 88.5%. For average monthly income, the majority had an income of less than 10,000 baht (38.0%), followed by 10,000-20,000 baht (32.5%), reflecting those micro-businesses in the sample still have limited income and face growth challenges.

Table 1. Respondent's Profile

Category	Profile of Respondents	Person(s)	Percentage (%)
Gender	Male	115	28.8
	Female	285	71.3
Age	20–29 years old	157	39.2
	30–39 years old	98	24.5
	40–49 years old	87	21.8
	50 years and older	58	14.5
Education	Lower than Bachelor's Degree	204	51.0
	Bachelor's Degree	193	48.3
	Postgraduate	3	0.8
Business Period	Less than 1 year	75	18.8
	1–3 years	155	38.8
	4–6 years	113	28.2
	7–10 years	22	5.5
	More than 10 years	35	8.8
Number of Employees	1–3 people	354	88.5
	4–6 people	31	7.8
	7–10 people	15	3.8

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	Below 10,000 Baht	152	38.0
	10,000–20,000 Baht	130	32.5
Monthly Business Revenue	20,001–30,000 Baht	38	9.5
	30,001–50,000 Baht	54	13.5
	More than 50,000 Baht	26	6.5
Total		400	100.0

This demographic profile presents features that may affect the generalizability of this study's results. It is important to highlight that the respondents were made up of a significantly higher percentage of females (71.3%) compared to males (28.8%), and thus the results should be interpreted as relatively more indicative of the opinion and experience of the female part of the micro-entrepreneur population. Prior research suggests that gender can impact management style, risk tolerance, and growth strategies in business management. Moreover, the data that most businesses are very small (88.5% are size 1-3 employees) and also relatively low in monthly revenue (70.5% sell under 20,000 baht) indicates that the finding is most reflective of very small-sized operations and the beginning of the business.

4.2. Descriptive Statistics and Measurement Validation

The measurement items used in this study were rigorously developed through a systematic approach combining theoretical foundation and methodological precision. For customer-supplier collaboration (SCCO), five items were adapted from the collaborative supply chain framework by Cao and Zhang [16] and green supply chain management practices by Li et al. [3], with modifications to suit the micro-enterprise context. Communication effectiveness (SCCE) measurement items were derived from Mohr and Nevin's [25] communication strategy framework and Grunig and Hunt's symmetrical communication theory [26], with specific adjustments to capture the communication dynamics in resource-constrained businesses. Technology adoption (DTCC) measurements were based on Davis's technology acceptance model [37] and Rogers's diffusion of innovation theory [38], focusing on perceived usefulness, ease of use, and compatibility aspects particularly relevant to micro-enterprises. Finally, sustainability-oriented capability (ECSO) was measured using items adapted from Hart's natural-resource-based view framework [51] and recent empirical studies on sustainability capabilities in small businesses [5], [45].

In the descriptive analysis of four groups of variables, consisting of customer-supplier collaboration, communication effectiveness, technology adoption, and sustainability-oriented capability, the researcher used the mean, standard deviation (S.D.), CV, Kurtosis, and Skewness. In addition, in the model development, the researcher assessed the reliability of the analytical variables by considering various indices such as loading, which indicates the relationship between the observed variables and the latent variables, rho_c (composite reliability) and rho_a (reliability of average variance extracted) to measure the internal consistency of the variables, AVE (average variance extracted) which reflects the amount of variance in the variables explained by the latent variables, and α (Cronbach's Alpha), which is a measure of reliability in terms of consistency within the group of variables, as shown in table 2. In addition, the discriminant validity was assessed separately using the Fornell-Larcker Criterion, which considers that the square root of the AVE in each variable must be higher than the correlation value with other variables. If this criterion is met, it will confirm that each dimension of measurement is clearly different and not too correlated, as shown in table 3.

Table 2. Descriptive Statistics and First-order Confirmatory Factor Analysis

Measure	Mean	S.D.	CV	Kur	Skew	Loading	t-value	rho_c	rho_a	AVE	α
SCCO1	3.680	1.106	0.301	0.224	-0.801	0.915	89.339				
SCCO2	3.627	1.104	0.304	0.156	-0.756	0.848	34.098				
SCCO3	3.635	1.103	0.303	0.066	-0.699	0.911	82.219	0.953	0.940	0.801	0.938
SCCO4	3.645	1.100	0.302	0.012	-0.678	0.908	87.304				
SCCO5	3.600	1.131	0.314	0.010	-0.697	0.891	43.760				
SCCE1	3.620	1.134	0.313	-0.237	-0.588	0.920	94.848				
SCCE2	3.717	1.081	0.291	0.137	-0.780	0.897	63.955				
SCCE3	3.663	1.135	0.310	-0.251	-0.617	0.927	113.371	0.964	0.954	0.844	0.954
SCCE4	3.705	1.126	0.304	-0.029	-0.740	0.925	104.509				

 ISSN 2723-6471

SCCE5	3.703	1.148	0.310	-0.063	-0.732	0.923	100.586				
DTCC1	3.335	1.289	0.387	-0.855	-0.334	0.859	47.291				
DTCC2	3.632	1.207	0.332	-0.311	-0.728	0.860	63.829				
DTCC3	3.598	1.231	0.342	-0.354	-0.674	0.880	80.460	0.933	0.926	0.736	0.912
DTCC4	3.380	1.271	0.376	-0.662	-0.536	0.844	36.860				
DTCC5	3.315	1.296	0.391	-0.838	-0.401	0.847	37.920				
ECSO1	3.638	1.158	0.318	-0.278	-0.599	0.861	37.393				
ECSO2	3.697	1.068	0.289	0.273	-0.770	0.891	63.650				
ECSO3	3.680	1.108	0.301	-0.264	-0.571	0.911	92.602	0.951	0.937	0.796	0.936
ECSO4	3.655	1.114	0.305	-0.022	-0.682	0.893	61.847				
ECSO5	3.683	1.143	0.310	-0.158	-0.686	0.904	66.063				

Note: SCCO 1-5 = Customer-Supplier Collaboration, SCCE 1-5 = Communication Effectiveness, DTCC 1-5 = Technology Adoption, ECSO 1-5 = Sustainability-oriented Capability

The results of descriptive analysis and quality control of indicators are presented in table 2, where the mean scores of all variables ranged from 3.315 to 3.717, S.D. from 1.068 to 1.296. This indicates that the respondents in this study have a moderate to high awareness of the studied variables. Meanwhile, the minimum and maximum values of the Coefficient of Variance (CV) are 0.289 and 0.391, respectively, which shows an acceptable consistency of data. Similarly, skewness and kurtosis values were in the acceptable range, which means that the distribution of the data is also appropriate. Values of factor loadings were in the range of 0.844 to 0.927, which is considered an acceptable value. The statistical significance of the t-value indicates that the indicator is of high quality. The composite reliability values were between 0.933 and 0.964, and Cronbach's alpha (α) values were between 0.912 and 0.954, superior to the minimum level of 0.7, demonstrating a good internal consistency for the latent variables. The AVE value ranged from 0.736 to 0.844, confirming that indicators could efficiently explain the variance of latent variables.

It is worth noting that all measurement items originally developed for this study demonstrated strong psychometric properties during the initial confirmatory factor analysis. Unlike many studies that often require item elimination during the validation phase, all items in our measurement model exhibited factor loadings above the recommended threshold of 0.7 from the outset. This exceptional result can be attributed to the rigorous item development process, which involved careful adaptation from established scales, expert review, and thorough pilot testing. The questionnaire was designed with exactly five items per construct based on comprehensive theoretical foundations, and all these items were retained in the final measurement model due to their strong statistical performance. The high factor loadings and AVE values reported in table 2 thus reflect the effectiveness of our preliminary development and validation procedures rather than a post-hoc item refinement process. Consequently, the findings of this study validated that the indicators employed had excellent reliability and validity and could be utilized to verify the hypotheses of subsequent studies. According to table 3, the discriminant validity was analyzed using the Fornell-Larcker criterion [31], which confirms that the square root of the AVE of each latent variable is greater than the correlation value between that variable and other variables in the model, through which it can be confirmed that each variable can be distinguished clearly from each other.

Table 3. Discriminant validity by Fornell-Larcker Criterion

Variables	SCCO	SCCE	DTCC	ECSO
Customer-Supplier Collaboration (SCCO)	**0.895**			
Communication Effectiveness (SCCE)	0.826	**0.919**		
Technology Adoption (DTCC)	0.721	0.747	**0.858**	
Sustainability-oriented Capability (ECSO)	0.809	0.831	0.714	**0.892**

Note: Bold values in diagonal line display the square root of AVE meanwhile the others are correlation matrix

The square root of the AVE value in the bold diagonal in table 3 ranging from 0.858 to 0.919, higher than all correlation values, indicating that the indicators of each variable are specific to the construct to be measured [59]. The high correlation value, indicates that relationships between business sustainability variables are strong. As a result, the

 ISSN 2723-6471

results of this study provide clear confirmation of the relationship between latent variables, as they all distinguish from one another, making it permitted to test that relationship in the context of structural equation model analysis.

4.3. Finalized Model and Hypothesis Analysis

In figure 2, the results indicate that SCCO influences ECSO through SCCE and DTCC. The model demonstrates adequate fit with an SRMR value of 0.064, which is below the recommended threshold of 0.08. The assessment of multicollinearity through VIF values revealed no serious issues, with all values ranging from 1.000 to 3.695, well below the critical threshold of 5.0. The explanatory power of the model is substantial, as evidenced by the R^2 values of the dependent variables SCCE (0.681), DTCC (0.592), and ECSO (0.745). These values indicate that the independent variables explain a significant portion of the variance in the dependent variables, particularly for ECSO with the highest R^2 value (0.745). This confirms that customer-supplier collaboration, effective communication, and technology adoption are important factors influencing sustainability-oriented capability.

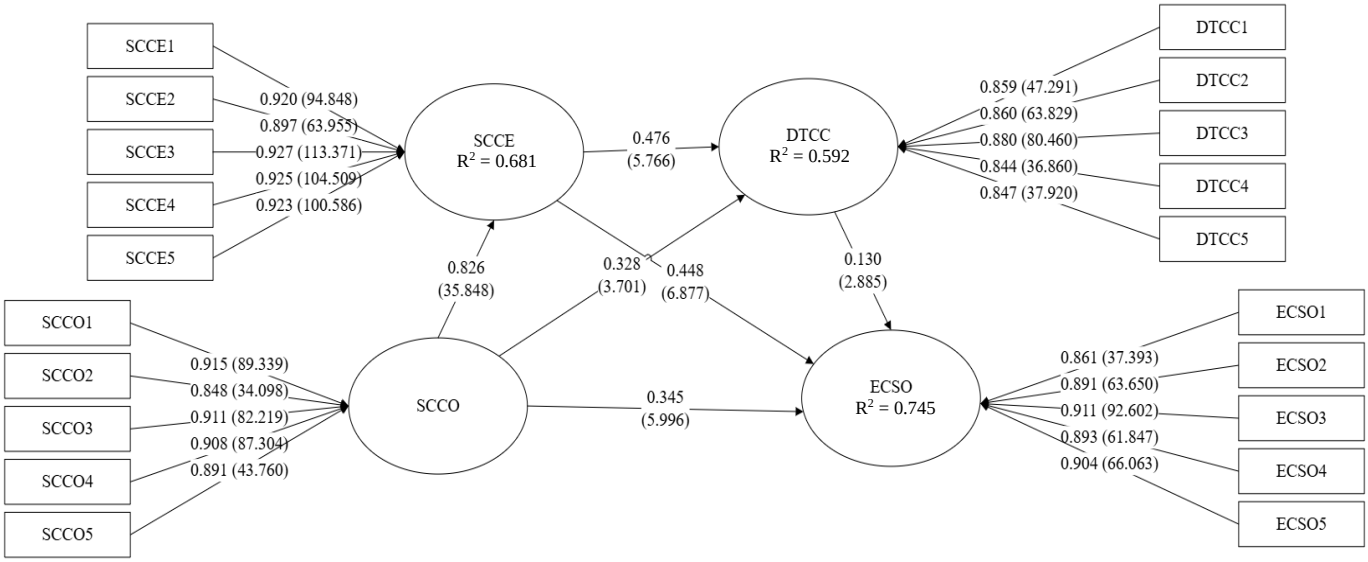

Figure 2. Finalized Model

Note: SCCO = Customer-Supplier Collaboration, SCCE = Communication Effectiveness, DTCC = Technology Adoption, ECSO = Sustainability-oriented Capability, the numbers on the paths outside parentheses represent path coefficients, the numbers on the paths inside parentheses ( ) represent t-values

In table 4, the hypothesis testing results show that SCCO has a direct effect on ECSO and through the mediator variables, SCCE and DTCC. The β value is 0.345, t = 5.996, $p < 0.001$, with 95% CI [0.231, 0.460]. H1 confirms that SCCO has a direct effect on ECSO. Hypothesis H2 (β = 0.370, t = 6.583, $p < 0.001$, 95% CI [0.261, 0.483]) indicates that SCCE plays a strong mediator role, while H3 (β = 0.043, t = 2.272, $p < 0.001$, 95% CI [0.011, 0.085]) indicates that DTCC has a smaller but still significant impact. Furthermore, H4 (β = 0.051, t = 2.524, p = 0.012, 95% CI [0.015, 0.095]) shows that the combination of SCCE and DTCC as mediators jointly enhances the effect of SCCO on ECSO, reflecting that both communication and technology adoption plays an important role in promoting sustainability-oriented capability. The confidence intervals for all hypotheses exclude zero, further supporting the statistical significance of these relationships.

Table 4. Hypothesis Testing

Hypotheses	β	*t*-Value	*p*-values	Confidence Interval		Result
				2.5%	97.5%	
H1: SCCO → →ECSO	0.345	5.996	0.000	0.231	0.460	Accepted
H2: SCCO → SCCE → ECSO	0.370	6.583	0.000	0.261	0.483	Accepted
H3: SCCO → DTCC → ECSO	0.043	2.272	0.000	0.011	0.085	Accepted
H4: SCCO → SCCE → DTCC → ECSO	0.051	2.524	0.012	0.015	0.095	Accepted

Note: SCCO = Customer-Supplier Collaboration, SCCE = Communication Effectiveness, DTCC = Technology Adoption, ECSO = Sustainability-oriented Capability, β = Path Coefficient

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As shown in table 5, the analysis results of Direct Effect (DE), Indirect Effect (IE), and Total Effect (TE) indicated that SCCO had both direct and indirect effects on ECSO, where the DE value of SCCO on ECSO was 0.345 ($p < 0.001$), which means that SCCO played a significant direct role in influencing ECSO, and at the same time, the IE value of SCCO on ECSO was 0.464 ($p < 0.001$), representing a larger indirect effect via SCCE and DTCC when compared to the DE, yielding superior definite effects with the TE value being 0.809 ($p < 0.001$), which reflects the high impact overall. Meanwhile, there was a positive direct effect of SCCO on SCCE (DE = 0.826, $p < 0.001$) and on DTCC (DE = 0.328, $p < 0.001$) with their fictive impact on ECSO through mediating variables, especially; SCCE served as a link with DTCC (DE = 0.476, $p < 0.001$) and ECSO (DE = 0.448, $p < 0.001$, IE = 0.062, $p < 0.05$), establishing that better communication enhances the role of technology in achieving sustainability-oriented capability of the business.

Table 5. Direct Effect, Indirect Effect, Total Effect

Variables	SCCE			DTCC			ECSO		
	DE	IE	TE	DE	IE	TE	DE	IE	TE
SCCO	0.826**	-	0.826***	0.328***	0.393***	0.721***	0.345***	0.464***	0.809***
SCCE	-	-	-	0.476***	-	0.476***	0.448***	0.062*	0.510***
DTCC	-	-	-	-	-	-	0.130**	-	0.130**

*Note: SCCO = Customer-Supplier Collaboration, SCCE = Communication Effectiveness, DTCC = Technology Adoption, ECSO = Sustainability-oriented Capability, * = p-value at 0.05, ** = p-value at 0.01, *** = p-value at 0.001*

5. Discussions

With respect to testing of H1 stating that customer-supplier collaboration affects sustainability-oriented capability, the study findings indicate that intrinsic to customer-supplier collaboration is its direct effect on sustainability-oriented capability. Similar to other research that has shown that working together between supply chain partners can help save resources, decrease waste, and make supply chains more flexible for a circular economy [3], [7], customer-supplier collaboration had a big impact on sustainability-oriented capability in this study. Moreover, strong business partners can facilitate changes to environmental trends and enable organizations to function more responsibly [30], particularly in industries with high levels of process complexity like manufacturing and logistics. Urbancová and Vrabcová [48] and Ahmad et al. [18] have also contributed to this discussion. The foundation punishes people who break sustainability core standards, which are the basis of sustainability standards. These standards work well for ESG policies, which work with suppliers that follow sustainability laws. ESG policies promote higher quality products, quick information sharing in the supply chain, and environmental sustainability. Nonetheless, a strong partner network alone is insufficient to guarantee successful supply chain collaboration. It needs possible ways and technologies for communication that can work well with operational processes [5], [19], things that would make the customer-supplier collaboration more effective on sustainability-oriented capability. Moreover, Triguero et al. [6] and Heredia et al. [2] further pointed out that organizations with associated supply chain management systems could develop green innovations and improve their business competitiveness better than those organizations that did not cooperate with suppliers. The findings from this study are in line with the green supply chain management theory, which posits that business-supplier cooperation will enhance the resource management efficiency and decrease the environmental expenses over the long term [3], [8]. However, these upward trends in trust and supplier preparedness are still matters that need additional consideration. For if suppliers or entrepreneurs cannot keep pace with sustainability practices, it may undermine the positive contribution of supplier cooperation [5], [7].

From H2: Customer-supplier collaboration impacts sustainability-oriented capability through communication effectiveness; The study findings supported customer-supplier collaboration to have significantly impacted sustainability-oriented capability through communication effectiveness, reinforcing the belief that effective communication enablers enhance the efficiency of supply chain management [28], [29]. Fewer working errors and rapid customer response [30] are beneficial consequences of excellent communication, which aligns with earlier research showing that effective data management related to the supply chain facilitates better business performance [32], [33]. Furthermore, the work of Mehrabi et al. [7] found that information sharing among suppliers enabled firms to create more sustainable products and processes. Though communication is key to supply chain collaboration, many of the challenges involve trust between organizations and data management. The situation has yet to change [31], [36].

This study's findings support the integrated communication management approach, which asserts that if a business can manage communication between partners properly, the chances of developing sustainable strategies are higher [34], [35]. However, technology remains the centerpiece of communication integration to facilitate information sharing [5], [20].

The results of the study of H3: Customer-supplier collaboration affects sustainability-oriented capability through technology adoption, customer-supplier collaboration had a positive and significant impact on sustainability-oriented capability, supporting technology adoption as an important tool to improve supply chain efficiency and to enhance sustainable business capability. Using automation and digital platforms in shipping businesses could assist them in monitoring inventory status and analyzing customer data, resulting in lower operating costs [44], [45]. Additionally, digital technology must enable organizations to align with the circular economy and decrease their environmental consequences [46]. Despite the statistical significance, the results show that technology adoption is a mediator with a relatively small effect size on sustainability-oriented capability compared to communication effectiveness. This surprisingly low effect size warrants further exploration, particularly in the context of micro-enterprises. Several potential explanations exist for this finding. First, digital literacy limitations among micro-enterprise owners and employees may hinder the effective implementation of adopted technologies. As Ghobakhloo et al. [41] identified, technology adoption in small businesses is influenced by owner factors, including technical knowledge and skills. Second, infrastructure constraints common in small businesses may prevent full utilization of technological solutions, as noted by Shaikh et al. [31] regarding SMEs' challenges in building adequate technological infrastructure. Third, there may be reluctance to adopt new technologies due to perceived complexity, high implementation costs, or uncertainty about returns on investment—factors particularly relevant to resource-constrained micro-enterprises operating with limited capital and specialized personnel. Additionally, the integration of IT may not be sufficient for achieving organizational commitment to technological firm performance without proper communication strategies and technological embedding [20], [48]. This aligns with the task-technology fit theory, which suggests that technology must be appropriately aligned with organizational needs and capabilities to be effective. Furthermore, Faasolo and Sumarliah [47] emphasize the need for government incentives and supportive policies to facilitate more effective technology adoption and utilization among small businesses. Future research should investigate these barriers to technology adoption in micro-enterprises more thoroughly and explore incremental technology adoption approaches that are appropriate for their resource constraints and organizational context.

Finally, H4, indicating that the influence of customer-supplier collaboration on sustainability-oriented capability is initiated through communication effectiveness and technology adoption, was found to be statistically validated, highlighting the fact that the combined presence of both technological adoption and communication effectiveness could heighten the assessment of influence between customer-supplier collaboration and sustainability-oriented capability more than otherwise individually. Yang et al. [28] and Griffin et al. [29] identified that effective communication is one of the key factors that have reduced information disparity and improved supply chain collaboration. On the other hand, technology allows us to communicate at scale. For instance, the supply chain system prioritizes the exchange of timely and accurate information [30], [32]. For example, the work of Mehrabi et al. [7] further argued that companies that can blend communication and technology will be more successful in creating sustainable innovations for production and distribution processes and reducing costs by doing so. However, the level of influence of this path is still low compared with the path of communication effectiveness acting as a single intermediary, which may reflect that small and micro businesses still face restrictions on investing in technology, although the results support the role that communication effectiveness and technology adoption play in promoting customer-supplier collaboration's influence on sustainability-oriented capability. This underscores the need for targeted support from government agencies and supply chain partners to bridge capability gaps in micro-enterprises [18], [47]. Scipioni et al. [19] and Sun et al. [5] also found that digital infrastructure and the ability for partners to invest or build trust are important factors that encourage full use of technology and communication. While the combination of communication effectiveness and technology adoption can increase a business's ability to operate sustainably, structural factors such as support policies from the government, investment incentives related to technology, and organizational culture that facilitates effective communication all play a role in the productivity of this process [20], [35], [36].

In terms of research contributions, this research has noteworthy contributions to three primary aspects, namely managerial contribution, academic contribution, and policy contribution. From the management perspective, the findings demonstrate that small and micro enterprises can strengthen their sustainabilization process through cooperation in the supply chain, proper communication, and the use of technology. The results have a statement about the merger of communication effectiveness and adoption of technology. It is worth noting for managers that implementing both strategies for communication and technology adoption simultaneously does not inherently lead to proportionate increases in sustainability outcomes without addressing underlying challenges. Investments in technology must be strategically aligned with communication capabilities and well-tailored to the constraints of resources that microenterprises typically face. Compared to larger enterprises and SMEs, it is believed that micro-enterprises have significantly influenced their results with efficient communication systems over technology investment, and it is recommended that they go for gradual adoption of technology by building a solid training infrastructure first rather than investing money in technologies. In addition, put managers need to potentially explore partnership strategies with larger firms or industry associations that could lend the larger, more scalable technology resources and expertise to their businesses that, if approached individually, would otherwise be out of reach for resource-insecure micro-enterprises.

From an academic contribution perspective, this research enriches the demand for research work around supply chain and sustainability in the small business context, which has received little attention in the extant body of knowledge. The study serves to enhance understanding of the complex interplay between communication effectiveness and technology adoption towards sustainability implementation in the specific context of micro-enterprises. In fact, the results challenge the conventional wisdom that simultaneous seeding of multiple enabling factors necessarily yields a stronger cumulative impact on sustainable capabilities. In resource-constrained settings, in particular, they contend that the relationship between enablers of health might be more complicated and, in fact, that we may face diminishing returns or implementation obstructions. Furthermore, these findings can further strengthen green supply chain management and circular economy concepts as well as highlight the necessity for theoretical models to better account for micro-enterprise-specific constraints and operational aspects.

Regarding the policy contribution, this research provides insights for policymakers about the integration of communication and technology in sustainability efforts. The findings suggest that blanket policies promoting both technology adoption and communication improvements may yield limited returns without addressing the specific barriers micro-enterprises face in implementation. Instead of providing a one-size-fits-all solution, this research demonstrates how micro-enterprises face considerable obstacles in the realization of ESG standards, such as financial issues, shortage of know-how, diverse sectoral specifications, and multifaceted regulatory environments. These results suggest the need for the government and pertinent institutions to adopt more particularized strategies: (1) offer tiered tax breaks and financial conveniences aligned with the degree of technological readiness of micro-enterprises; (2) design technology diffusion programs with suitable technical support and training attuned to micro-enterprises' unique conditions; (3) create simplified and sector-specific ESG frameworks considering the diverse operational and resource constraints faced by micro-enterprises; and (4) formulate incentives for large enterprises to mentor micro-enterprises within their supply chains on technology sharing and capability building. Furthermore, governments need to create a centralized marketplace to advertise green suppliers so that small businesses can find environmental suppliers, along with communications mechanisms that are within everyone's technological reach. Unlike one-size-fits-all neoclassical methods, these contextualized policy approaches recognize that achieving sustainability practices entails trade-offs regarding financial viability, legal capacity, and sector-specific dynamics at the micro-enterprise level.

For future research recommendations, first of all, future research needs to explore the effects of sociocultural factors on customer-supplier collaboration and technology in each country's small business supply chain. Additionally, studies should capture categories of current technologies adopted by small businesses, such as blockchain or the Internet of Things, in order to assess their contribution to increasing capabilities for sustainability. It is also highly encouraged to conduct qualitative research that covers behavioral factors and the influence of implementation barriers in the sustainability practices of micro-enterprises. Qualitative research of this kind should use methodological approaches such as in-depth interviews with micro-entrepreneurs and key suppliers, focus group discussions with industry associations, and comparative case studies of successful and failing micro-enterprises. Since all five themes covered

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factors potentially driving technology adoption, these should be explored qualitatively for key variables such as how decisions are made regarding technology investments, communication difficulties between supply chain participants, power relations between suppliers and customers, and the effects of psychological components on sustainability adoption. The qualitative component must center especially on contextual factors such as organizational culture, sustainability leadership styles, and informal mechanisms for knowledge exchange that quantitative approaches tend to overlook. Furthermore, further exploration may include services, tourism, and platform-based economies that provide evidence to deduce that these hypotheses are not confined to manufacturing industries but can apply to different types of businesses collectively, leading to a broader understanding of customer-supplier collaboration and organizational sustainability across different types of business settings.

6. Conclusion

The research reveals customer-supplier collaboration and sustainability-oriented capability relationships. The research finds that both technology adoption and communication effectiveness mediates this relationship, yet the stronger mediating variable is the effectiveness of communication practices, which is challenging to quantify through self-reported data. The results may be further validated with more objective communication assessment methods in future research. Technology adoption widens the perspectives of how information management processes are executed, therefore enabling the scope of decision-making participation, while the correlation of effective communication and suitable technology enhances the full functionality of collaboration in business. Trust between partners and the desire to apply appropriate technology and communication strategies are also essential for sustainable business capability development. This research therefore contributes to the literature of customer-supplier collaboration, technological adoption, and communication management when it comes to sustainability-oriented capability in micro and small enterprises. It offers actionable advice for entrepreneurs, governments, and support agencies on what to do to level the playing field to ensure small businesses can remain competitive in the longer term. Future research could investigate differences between industries and how cultural and technological factors play a role in supply chain collaboration effectiveness.

7. Declarations

7.1. Author Contributions

Conceptualization: S.G., S.O.; Methodology: S.G., S.O.; Software: S.G.; Validation: S.O.; Formal Analysis: S.G.; Investigation: S.G.; Resources: S.O.; Data Curation: S.G.; Writing – Original Draft Preparation: S.G.; Writing – Review and Editing: S.O.; Visualization: S.G.; All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.3. Funding

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7.4. Institutional Review Board Statement

Not applicable.

7.5. Informed Consent Statement

Not applicable.

7.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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