*Corresponding Author's Email: irshan.kz@gmail.com, https://orcid.org/0009-0007-7765-997X, syed.mubaraz@tuni.fi, https://orcid.org/0009-0007-6861-6206
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Effects of Industry 4.0 on Business Models: Case of the Finnish Industry

Irshan Khan[1*] and Syed Mubaraz[2*]
[1] Nokia Solutions and Networks, Finland
[2] Tampere University of Applied Sciences, Finland

Abstract

This research investigates the effects of Industry 4.0 (I4.0) on business models arising from the deployment of I4.0 technologies in the Finnish industry landscape. The study attempts to answer a key question that how the implementation of I4.0 technologies influence the business models of companies. The research avails qualitative and explorative research method using semi-structures interviews as empirical evidence from the Finnish industries. The results suggest that organizations are eliminating old ways of conducting businesses. New ways and manners are being tested and used to gain sustainable desired economic advantages over competitors. Within the scope of business model canvas, value proposition takes the lead. This factor means enhancing performance of business operations to offer customized solutions often within autonomous operations and closed-loop manufacturing. This factor is followed by customer relationships and partnerships. The other two factors which are considered important include revenue and resources. Nowadays, organizations use advanced machines which collect data from their day-to-day operations. Data analysis provides avenues for developing new solutions and services for customers belonging to various industrial sectors including health sciences, telecommunication, maintenance facilitation and consultation. With I4.0 in place, solution providers can offer customized solutions to their customers based on their specific business needs. In order to avoid competition, the Finnish service and solution providers tend to develop strong relationships with their customers. At the same time, organizations are trying to reduce heavy investments for the implementation of I4.0.

Keywords: business transformation, customer satisfaction, innovation, networks, value

1. Introduction

The industries are increasingly adopting digital technologies to modernize their operations and enhance performance, a phenomenon known as Industry 4.0 (I4.0). Technologies such as the Internet of Things (IoT), cloud services, 5G networks, positioning technologies, artificial intelligence, and augmented reality are pivotal in enabling I4.0. The I4.0 emphasizes digitalization, intelligent automation, and the autonomous behavior of machines. It has facilitated the development of concepts like Cyber-Physical Systems (CPS) and Digital Twins.

The I4.0 introduces several key features, including industrial automation that equips machines to learn from their environments, conduct self-diagnostics, and identify their service needs. Additional features include remote operational control, tracking and monitoring of supply chain operations, and enhanced customer interaction and understanding of customer needs. Furthermore, I4.0 enables companies to adapt their value propositions to different customer segments. According to Grabowska and Saniuk (2022), within the domain of business models in the contemporary industrial landscape, the apparent effects of I4.0 on business models are that these become possible methods of utilizing organizations' resources and achieving competitive advantage.

Despite the widespread implications of I4.0, extant research on its impact on business models remains limited. Implementing I4.0 technologies without updating traditional business models fails to unlock substantial economic benefits, as these traditional models often lack the capacity to leverage the I4.0. Such a situation presents newness. Some studies have explored the impact of I4.0 on business models; for instance, literature reviews by Ibarra, Ganzarain, and Igartua (2018) and qualitative research focusing on small and medium-sized enterprises (SMEs) in Germany by Müller (2019). Unlike prior studies focused on German SMEs by Müller (2019), Finland presents a unique context due to its advanced telecom infrastructure, government-supported digitalization programs, such as Sustainable Industry X, which creates a unique setting for I4.0 deployment. This academic work examines the effect of I4.0 on the business models of Finnish industries, utilizing the business model canvas. It contributes empirical evidence from Finnish industries, addressing a gap in the literature regarding how I4.0 reshapes business models in Finland and presents a valuable avenue for further exploration.

This research explores business models arising from the deployment of I4.0 technologies in the Finnish industry landscape. The findings of this research contribute to academic understanding by addressing a key question of how the implementation of I4.0 technologies influences the business models of companies. The research also touches upon the role of I4.0 in current industrial business activities in the context of the Finnish industries. We present the theoretical background in the next section.

2. Theoretical Background

A business model describes how an organization does business by creating, delivering, and capturing value. It is essential for extracting the potential of the latest technologies to serve humanity. Business model innovation for industries for securing the desired benefits of the use of I4.0 technologies for businesses. Osterwalder and Pigneur (2010) describe the business model canvas using nine building blocks. The same is summarized in the following Table 1.

Table 1: Nine Building Blocks of Business Model Canvas

Building Block	Description
Value Propositions	Satisfying customer needs
Customer Segments	Selecting customers
Channels	Reaching customers
Customer Relationships	Connecting with customers
Revenue Streams	Getting economic value
Key Resources	Having required competences
Key Activities	Business operations

Building Block	Description
Key Partners	Acquiring resources
Cost Structure	Business model elements result in cost structure

Source: (Osterwalder and Pigneur, 2010)

Chesbrough and Rosenbloom (2002) describe a business model as a mechanism that converts technological characteristics and potential, through customers and markets, into economic outputs. Chesbrough and Rosenbloom (2002); Rappa (2004); Weking et al. (2020) emphasize that a business model specifies a firm's position in the value chain to conduct business.

Several authors highlight the role of business models in defining strategy. We avail business model canvas presented by Osterwalder (2010) in this study as a theoretical ground.

2.1 Business Models for I4.0

Organizations are revising their existing business models using I4.0 technologies and initiatives. Researchers like Pereira and Romero (2017), and Weking et al. (2020) have studied similar topics related to I4.0 in the past.

A summary of available literature on I4.0 for Business Model Canvas is described in the following Table 2.

Table 2: Summary of literature on I4.0 for Business Model Canvas

Business Model Components	Changes with the implementation of I4.0
Value Propositions	Services and solutions → Müller (2019) customization → Müller (2019)
Customer Segments	Data driven customer selection → Müller (2019)
Channels	Customer and partners provide various channels → Nagy et al. (2018)
Customer Relationships	Value is created with customers → Kiel et al. (2016)
Revenue Streams	Subscription, revenue sharing rent/lease → Weking et al. (2020) Manufacturing as a Service and Production as a Service → Ghobakhloo (2018)
Key Resources	Human capital → Müller (2019) Networks → Kiel et al. (2016)
Key Activities	Customer integration → Kiel et al. (2016)
Key Partners	Intensified partnerships between customer and supplier, new partners with IT or data expertise → Ibarra et al. (2018); Müller (2019) 3rd parties → Weking et al. (2020)
Cost Structure	Large investments for a new production system → Müller (2019)

Ibarra et at. (2018) identified three I4.0 business model innovation patterns: i) service orientation, ii) networked ecosystems, and iii) customer orientation, based on an analysis of I4.0 business model literature. Müller et al. (2018) conducted qualitative research on the impact of I4.0 business models on small enterprises. Kohtamäki et al. (2024) conducted a literature review and explored the connection between digitalization and business models, focusing on digital technologies such as artificial intelligence (AI).

2.1.1 Service Orientation

A growing phenomenon can be seen that service and solution providers are integrating their offers using I4.0, for example, remote monitoring, predictive maintenance, and system upgrades Ghobakhloo (2018). This integration allows manufacturers to play a larger role in the value chain by capturing additional value through services, rather than relying solely on product manufacturing (Ibarra et al., 2018). With these services on offer, organizations compete for customers and a larger share of the value chain Cavalieri and Pezzotta (2012).

2.1.2 Ecosystems and Integrated Value Networks

The ecosystems and integrated value networks are critical to I4.0. Through partnerships. Organizations are increasing their share of value capture through I4.0. Connected value networks have the potential to optimize production processes, enhance product quality, strengthen stakeholder relationships, and offer new business models and ways of operating Pereira and Romero (2017). Effective collaboration and well-defined value propositions from all stakeholders are essential for successful integrated value networks.

2.1.3 Increase in Customization of Value Propositions

Flexible and customized business solutions are offered to customers, leveraging I4.0 to reconfigure operations and improve customer interfaces Müller et al. (2018). These customized offers connect with each other, allowing them to better understand their needs and create better customer segmentation. Each segmentation could be offered a specific value proposition to meet the prevailing business needs as well as future prospects.

2.1.4 Innovative Revenue Streams and Value Capture

I4.0 has led to new innovative methods for revenue streams and value capture in business models. Companies are now implementing new approaches, including *'pay-per-use'* and *'pay-per-result'*. Additionally, models like *'Production-as-a-Service'* (PaaS) and *'Manufacturing-as-a-Service'* (MaaS) have emerged in the industrial landscape Ghobakhloo (2018). We present the research method in the following section.

3. Research Method

Since I4.0 the business environment evolves; therefore, a qualitative, exploratory approach is used to gather insights from industry experts through semi-structured interviews. Data is analyzed using thematic and quantitative methods. Selected industries cover various industrial sectors. Industries located in the city of Tampere, Finland, were prioritized due to accessibility for interviews. The interview questions were designed based on the aim of the research. Themes were derived post-analysis, avoiding the common pitfall of using questions as themes (Maguire and Delahunt, 2017). Open questions allowed interviewees to discuss current I4.0 deployments and future expectations. Literature is used to enhance the analysis, allowing for more nuanced data interpretation Braun and Clarke (2006).

The study aims to link primary and secondary data within a theoretical framework, following each interview. The researchers used empirical methods, discussing the effects of I4.0 on businesses through the business model canvas. The authors conducted interviews with senior management in decision-making and managerial roles to collect primary data. A goal-directed sampling strategy was employed to ensure that participants had direct experience with the deployment of I4.0. The selected companies represented seven industrial sectors: ports and terminals, mining, pulp and paper, agriculture machinery, industrial machinery manufacturing,

systems integration, and research and development. This selection reflects the diversity of Finnish industrial operations. Fourteen interviewees participated in the study, all holding senior managerial or technical leadership roles, which provided access to both strategic and operational perspectives.

A semi-structured interview protocol was utilized to maintain consistency across participants. In the invitation to the interviews, Industry 4.0 was defined as the integration of digitalization, automation, artificial intelligence, robotics, scalable networks, and cloud computing. The business model was defined according to Chesbrough and Rosenbloom (2002) as the heuristic logic that connects technical potential to economic value. At the beginning of each interview, these definitions were reiterated, and participants were informed that the questions would focus on business model innovation enabled by Industry 4.0. To facilitate the conversation, a semi-structured interview guide was employed, organized around Osterwalder's (2010) business model framework. The protocol consisted of five open-ended questions covering organizational context, Industry 4.0 initiatives, impacts on business models, and national-level activities. This structure ensured comparability across interviews while allowing respondents to elaborate freely based on their sector-specific experiences.

Interviews were conducted via Microsoft Teams, with recordings and automatically generated transcripts. A thematic analysis was then carried out on notes and transcripts, using the six-step framework proposed by Braun and Clarke (2006). Initial codes were developed manually by organizing all interview data and focusing on key terms and recurring ideas. These codes were subsequently grouped into themes using the thematic analysis framework. The researchers reviewed the codes together. The resulting themes were organized into a mind map, illustrated in Figure 1. These themes were then linked to the research questions and the theoretical framework to guide the analysis.

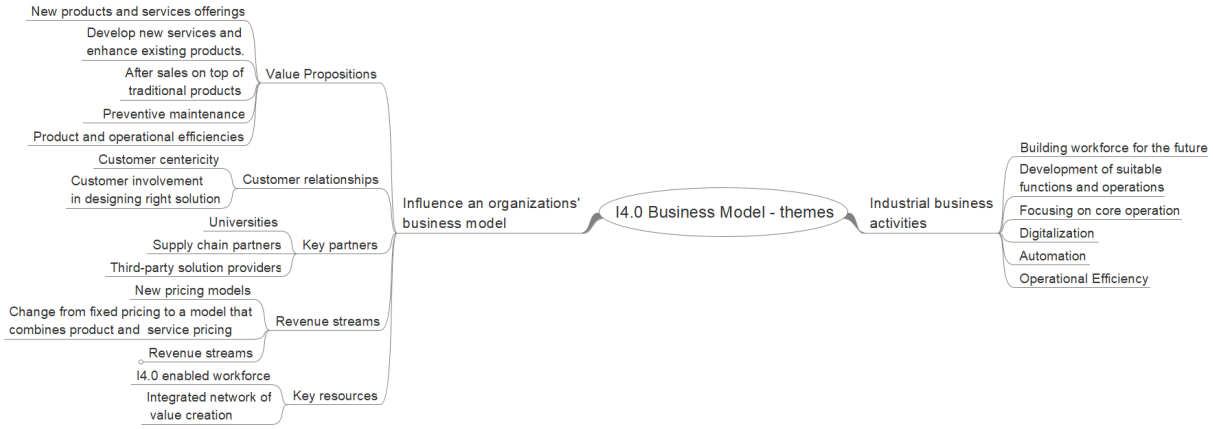

Figure 1: Thematic Map from the interviews' data

Descriptive quantitative summaries were created based on qualitative responses. First, these responses were categorized into standardized statements within each theme. Then, the frequency of each statement was counted and normalized by dividing the number of responses associated with that statement by the total number of responses within the corresponding theme. This process produced the ratios and percentages reported in Table 3. This approach allowed us to summarize qualitative insights systematically while maintaining the interpretive depth of the interview data.

Table 3: Summary of interviews

Questions / Themes	Responses	Normalized Percentage
I4.0 current industrial business activities		
Increasing efficiency of operations and production	5	38%
Increasing sales with I4.0 enabled features	5	38%
Investing in modernization of operations	3	24%
I4.0 influences an organization's current business model		
Value propositions	5	26%
Customer relationships	4	21%
Revenue streams	4	21%
Key partners	3	16%
Key resources	3	16%

Ethical considerations were addressed by informing interviewees about the purpose of the research and anonymizing all personal information. Practical issues were managed by relying on publicly available company data and voluntary participation in interviews. The authors found repetitive responses across participants after the twelfth interview, when no new theme or code appeared in subsequent transcripts, indicating that a degree of thematic saturation had been reached. The final two interviews were used to confirm saturation and validate the stability of the identified themes. Moreover, a practical limitation of the research was the difficulty in securing additional interview participants within the available timeframe. We present the results of the research in the following section.

4. Results

This research aims to investigate the effects of I4.0 on business models arising from the deployment of I4.0 technologies in the Finnish industry landscape.

4.1 Effects of I4.0 on Business Models

Many firms, belonging to industrial sectors including logistics and mining, have already implemented I4.0 technologies, while others are investing in further development. I4.0 impacts value creation, delivery, and capture within business models. Figure 2 illustrates the relative proportion of business model components impacted by I4.0 implementation based on interview data.

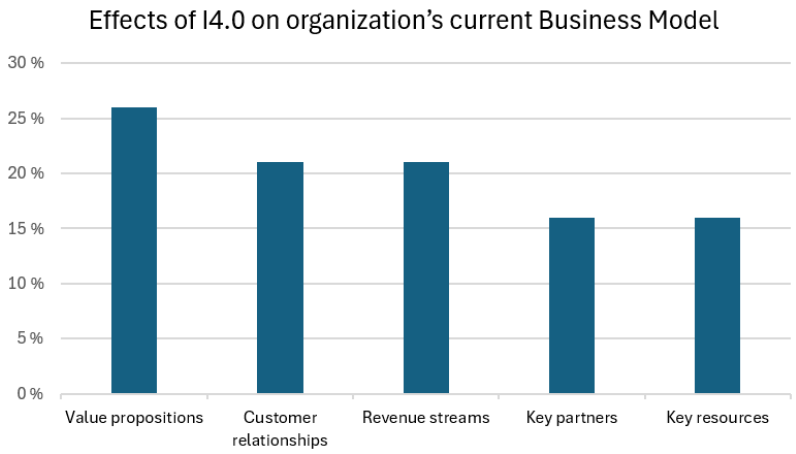

Figure 2: Effects of I4.0 on the organization's current Business Model

The analysis highlights the above-mentioned key areas. Autonomous solutions and data-driven services were highlighted as the main innovations. One interviewee noted,

> *"I4.0 has enabled us to collect data from our machines, use AI and data analyses...to plan machines' maintenance".*

Closed-loop manufacturing was also emphasized, combining PLM, ERP, and factory operations for product design, manufacturing, and recycling.

I4.0 technologies have strengthened customer relationships by integrating them into the value chain. This early engagement allows companies to gather requirements, co-create, and customize production. One interviewee mentioned,

> *"Our marketing, sales, and product design teams are increasingly involving customers in designing new machines for their needs".*

I4.0 has also transformed revenue streams, reducing initial investment costs with models like pay-per-use and profit-sharing. The interviewee noted,

> *"New pricing models of pay-per-result and as a service model... allow even small companies to utilize the technologies".*

Empirical evidence highlighted network providers and third parties specializing in AI and ML as key partners. One interviewee emphasized that "no company can do it alone" and that I4.0 will require collaborative ecosystems to maximize capabilities. Third parties will also help create value-added services from machine data, as stated:

> *"We see opportunities to work with third parties... to drive new values from the data".*

Furthermore, the deployment of I4.0 demands workforce upgrades, with IT (Information Technologies) and OT (Operation Technologies) departments increasingly merging due to the growing role of digital technologies.

Additionally, Table 4 presents a summary of the business model canvas for the Finnish industrial solution providers. This canvas was derived from interview responses and analyzed in line with the theoretical framework of business models. The discussion on the study results is presented in the next section.

Table 4: Summary of Business Model Canvas for the Finnish industrial solution providers

Business Model Components	Factors for Finnish Industrial Solution Providers
Value Propositions	Autonomous mobile machines (Industrial machinery manufacturing; Mining; ports & terminals)
	Autonomous factory operations (Industrial machinery manufacturing)
	Value-added service using data collected from machines (Pulp & paper & mining)
	Flexibility for customized production and products (Pulp & paper & agriculture machinery)
	Close-loop manufacturing (Systems integration & industrial machinery manufacturing)
	Self-organizing operations (Industrial machinery manufacturing; agricultural machinery)
Customer Segments	Several Industrial companies working in different industry segments are deploying I4.0 solutions
Channels	• R&D Channels • Integrated channels of suppliers, partners, and customers
Customer Relationships	• Co-creation with customers • Long-term Partnership
Revenue Streams	• Avoiding large investments • Securing funding to enhance business operations • Using smaller investments
Key Resources	• I4.0 enabled manufacturing facilities • Integrated value networks • I4.0 enabled workforce
Key Activities	• Development of production facilities with I4.0 technologies • Creation of integrated value creation networks with partners • Creation of new value propositions enabled by I4.0
Key Partners	• Connectivity and computation resources providers • Supply chain partners • Universities • Third-party solution providers • Customers as a partner
Cost Structure	• Investing in research related to I4.0 • Fee paid to purchase licenses

5. Discussion

The I4.0 deployment is changing the structures of industries. These structures are changing the competition between the traditional players in the market, who are providing traditional products specific to their industries, but also for new features and value-added services

providers who are created through a network of partners, suppliers, and customers. Companies whose products and services have the greatest impact on overall system performance will possibly be in the best position to drive the processes.

The implementation of I4.0 is transforming business models for industrial companies. Industries recognize the need for business model innovations to scale up and gain strategic advantages, leading to new capabilities and revised ways of creating, delivering, and capturing value. The findings also reveal contrasting examples of business model innovation enabled by I4.0. While several companies are adopting new models such as pay-per-use and pay-per-result, other sectors have shown reluctance due to unpredictable operational cycles, concerns about long-term cost visibility, varying regulatory and legislative environments, and constraints related to export and import controls for example, one interviewee highlighted that our customers want all new features using the model they understand and have been using for long time. Additionally, although co-creation with customers is highly valued, one interviewee noted that "not all customers are ready to engage deeply in design processes," indicating that customer readiness can act as a limiting factor. These variations highlight that the benefits of I4.0 depend strongly on the specific characteristics of the sector, the maturity of customers, and the organizational capabilities of the firms involved. We summarized the impact on industry business models in the previous section. We present specific business model factors in the following sub-sections:

5.1 Value Propositions

The implementation of I4.0 brings value propositions. This topic was the most frequently discussed business model component in interviews. This aligns with the primary focus of I4.0: solving industry problems and meeting customer needs through technology. Industries see opportunities for new products and services, performance improvements, customization, and reaching new customer segments. The analysis of operational data aligned with findings and propositions of Cavalieri and Pezzotta (2012).

Examples include targeted preventive maintenance, real-time health checks, condition-based monitoring, and optimization services like closed-loop manufacturing (Müller, 2019). Companies use collected data to learn from operations, reconfigure processes, and enhance performance.

Furthermore, I4.0 technologies enable product customization through customization (Müller, 2019). However, Several interviewees noted that customers are hesitant to adopt new service-based models due to unclear value propositions. Cavalieri and Pezzotta (2012) highlighted under-designed and inefficient services as a problem for Product Service System adoption. Systematic methods for service design and delivery could increase customer adoption of service-oriented business models by clarifying value propositions and how they meet customer needs.

The empirical result shows that industries differed in how I4.0 reshaped their value propositions. For example, Industrial Machinery Manufacturers emphasized advanced automation: "production will be self-organizing…". In contrast, Agriculture Machinery highlighted customer-facing digital services: "We started implementing gateways to send machine CAN data to the cloud… to improve after-sales and fleet management". These contrasting cases show how I4.0 enables both operational and service-oriented value creation.

5.2 Customer Relationships

Industrial relationships with customers have improved through co-design and new I4.0-enabled communication methods. I4.0 production systems can tailor products to individual customer

needs, increasing customer engagement. Industries are collaborating with customers early in the design process to understand their requirements and develop customized solutions. This growing customer role in design aligns with earlier findings.

Organizations tend to maintain strong relationships with their close customers by addressing their specific needs. Such relationships produce results of increased use of new methods and concepts like social media, online communities, open source, and open innovation (Kiel et al., 2016).

Customer co-creation emerged strongly across interviews. One participant explained: "Our marketing, sales, and product design teams are increasingly involving customers for designing new machines for their needs" (Industrial Machinery Manufacturing). Similarly, Ports & Terminals solution provider noted that open interfaces now allow customers to integrate machine data directly into their own systems, strengthening long-term collaboration.

5.3 Revenue Streams

Respondents mentioned different revenue models that have been used with the deployment of I4.0 in operations and their impact on business models. The reasons for this difference could be summarized as avoiding large investments dedicated to the implementation of I4.0 in businesses. Besides, securing sufficient funding that could be utilized to implement I4.0 as a critical part of business. Certain models, for example, 'pay per result' and 'pay per use' are valid methods of this kind of revenue streams as proposed by Weking et al. (2020) and Müller (2019), respectively. Furthermore, analysis shows that smaller initial investments help new businesses to implement I4.0 initiatives. An interviewee described the use of profit sharing model in the food and beverage industries as: "the improvement program was turned into a profit-sharing contract… paid by the output of the work".

5.4 Key Partners

Analysis of data shows that cooperation and collaboration with 3rd party service providers is seen as a significant way to achieve value in business. This was also highlighted by previous research, see for example Müller (2019). Additionally, businesses could consider their own customers as partners in collaboration. Such collaboration could result in innovation and the development of new designs as proposed by Keil et al. (2016).

Organizations with close networks, including service providers with capabilities of artificial intelligence and machine learning, could become partners in gaining value. For instance, service providers would become key partners in business operations related to computation and, as such, become enablers of I4.0 technology implementation in organizations with new business models.

Partnerships were repeatedly emphasized in the interviews. As the interviewee stated, "no company can do it alone… ecosystems are essential". Another interviewee working in Pulp & Paper sector highlighted interoperability testing with two network operators: "We are testing private network offerings .... to ensure secure connectivity for automation". These examples show how I4.0 expands the partner landscape beyond traditional suppliers.

5.5 Key Resources

Acquisition of certain resources encapsulating human capital, machinery, and partners are significant to implement I4.0. The findings align with new production equipment and a new workforce found in the works of Müller (2019). Having the above-mentioned key resources makes it easier for an organization to be aware of its customers and their needs. Subsequently,

service providers can offer the best value propositions to address those business needs. Key resources, especially human capital combined with I4.0 technologies, bring desired benefits and value to service providers as well as to solution providers. These become key resources for the deployment of I4.0 technologies.

Several interviewees stressed the need for new competencies. An interviewee working in a system integrator company noted: “Finnish industry lacks skilled personnel who understand both IT and OT… this slows adoption”. Another interviewee working in the agricultural machinery sector described internal restructuring: “We created a global software team to accelerate smart feature development”. These insights reinforce the centrality of human capital and digital infrastructure. We present the conclusion in the next section.

6. Conclusion

The aim of the research is to investigate the effects of I4.0 on business models arising from the deployment of I4.0 technologies in the Finnish industry landscape. The study attempts to answer a key question about how the implementation of I4.0 technologies influences the business models of companies.

Organizations are eliminating old ways of conducting business. New ways and manners are being tested and used to gain sustainable desired economic advantages over competitors. Within the scope of the business model canvas, factors including value proposition take the lead. This factor means enhancing the performance of business operations to offer customized solutions, often with autonomous operations and closed-loop manufacturing. This factor is followed by customer relationships and partnerships. The other two factors, which are considered important, include revenue and resources.

Nowadays, organizations use advanced machines that collect data from their day-to-day operations. Data analysis provides avenues for developing new solutions and services for customers belonging to various industrial sectors, including health sciences, telecommunication, maintenance facilitation, and consultation. With I4.0 in place, solution providers can offer customized solutions to their customers based on their specific business needs.

In order to avoid competition, service providers tend to develop strong relationships with their customers. At the same time, organizations are trying to reduce heavy investments for the implementation of I4.0. Organizations see their customers and subcontractors as partners. These partners help organizations gain value creation within a specific value network. Finally, human capital is a key to overall business success when it comes to the implementation of I4.0 technologies.

This study contributes to the growing I4.0 research by offering empirically grounded insights into how Finnish industries are reshaping their business models. Nevertheless, the research provides limited empirical data; therefore, care should be taken in generalizing the results. Similar research would be conducted with a different data set as a possible future research avenue.

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