



Opportunities and Challenges of Implementing Industry 4.0 Technologies in Business Operations

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Abstract

This research addresses implementation of Industry 4.0 (I4.0) technologies in business operations. Using Finnish businesses as the context of research, the study presents the answer to vital questions including how industries are adopting I4.0 in Finland and what are some of the opportunities and challenges in the implementation of I4.0 technologies. We bank on Porter's five forces model as theoretical framework. The study is explorative in nature and uses qualitative research methodology. The empirical data is collected through semi-structures interviews with personnel from several industries located in Finland. The results show that implementation of I4.0 has created integrated value-creation networks and ecosystems across various market segments. These ecosystems are reshaping market dynamics and competitive landscapes for companies involved. This new environment offers opportunities for growth, value capture. This approach has prompted organizations re-evaluate roles within an ecosystem. Manufacturers, partners, suppliers, and customers are collaborating to build ecosystems for mutually beneficial objectives. The I4.0 is a crucial area for future business development in the Finnish industries. It's a growth area that is focused on I4.0. Besides, results also highlight some challenges industries have faced during the implementation of I4.0 technologies in business operations including immediate requirement of improved cyber security solutions, lack of industry-specific standardization, prevailing resistance to change, and dire need for trained human resources capable of working with I4.0 technologies.

Keywords: business development, ecosystem, Nordic countries, Porter's five forces, value networks

1. Introduction

Industry 4.0 (I4.0) broadly means utilizing technical competence and digitalization in businesses. This concept has gained significant attention in various industries and academia. particularly for the use of the I4.0 technologies for modernization of industries. I4.0 technologies have enabled new functionalities for industries, increasing operational efficiencies and introducing new services with traditional products. This is a global phenomenon where industrial companies adopt, implement, and collaborate to extend their traditional business and improve their operational performance. A recent systematic literature

review conducted by Zheng et al. (2020), using 186 articles, highlights that implementation of I4.0 technologies is directly related to business operations.

This study aims to address how industries are adopting I4.0 and what are some of opportunities and challenges in implementation of I4.0 technologies. This presented research offers a perspective pertaining to the implementation of I4.0 technologies in business operations. Besides, it touches upon some of the opportunities and challenges arising from such adaptation.

These focus areas warrant research to ascertain valuable insights for academia and practitioners into the implementation of I4.0 technologies in business operations. Although the topic of innovation in business model is widely accepted in academia, only a handful of researchers have offered exploratory studies in this topic area (Cavalieri and Pezzotta, 2012; Ibarra et al., 2018; Müller et al., 2018; Ghabakhloo, 2018).

This has hindered companies from obtaining significant economic benefits from I4.0 deployments. Several researchers have discussed the implementation of I4.0 and its impact on business operations. Nevertheless, this topic warrants more exploration.

This framework provides suitable viewpoint when exploring the implementation of I4.0 technologies in business operations. It is widely used in similar settings and with similar research objectives. Despite global widespread implications of I4.0 technologies, empirical research on its impact on business operations remains unexplored and limited.

The research findings contribute to expanding our understanding of the knowledge in this area as well provide valuable practical implications for the decision makers and managers working in organizations.

The rest of the study is designed as such that we present the theoretical background in the following section. Then, we present research methods. Later, we illustrate the results of the study, and a discussion section is provided. Lastly, the conclusion of the research and some limitations are mentioned.

2. Porter's Five Force Model for I4.0

This model is useful for understanding main components of business landscape in terms of setup, competitive position and economic position (Porter, 2008). Implementation of the I4.0 technologies can be viewed using theoretical frameworks like five forces model. Such frameworks could be useful for exploring I4.0 technologies in business operations. It not only supports exploration of the topic but also enables researchers to better understand competition among organizations (Schilling, 2013).

This model can be used to analyze activities for the implementation of I4.0 technologies in business operations as well as an impact of change in industries with implementation of I4.0. Several earlier studies have availed similar approach to previous work. Porter's five forces based on their explanation in Schilling (2013) are described in the following Figure 1.

Porter and Heppelmann (2014) presented analysis for smart products using Porter's five forces model that has many resemblances with I4.0 market forces. Analyzing the literature reveals that exploring I4.0 with the lens of five forces framework is a suitable thing to undertake.

Besides, exploring business operations within I4.0 implementation in Finland could be useful for expanding our understanding of the topic with respect to possible opportunities and challenges of implementing I4.0 technologies in business operations in the Nordic landscape. Finland is a forerunner in providing connectivity and computation technologies which are key

enablers for I4.0 implementation in several industrial sectors. We present the research method in the following section.

Competitive rivalry	Determines competitiveness and profitability of the industry. It is affected by the number of competitors, their strengths and weaknesses, and their operational efficiency in doing activities.
Threat of substitute products or services	Determines the ability of customers to find substitutes. This is influenced by several substitutes in the market, their quality, price, availability, and switching cost.
Bargaining power of buyers	Power of the customers to influence product prices and quality. It is influenced by the number of buyers in the market, the size of the orders, the buyers' position in the market, and the switching cost of the buyer to a substitute.
Bargaining power of suppliers	Determines the power of suppliers and how they could influence prices and quality which could affect products or services. Supplier power is affected by the number of potential suppliers in the market, availability of their offering, switching cost, and availability of substitute offering.
The threat of new entrants	The threat of new entrants determines the barrier to entering and establishing a business in the industry. The barrier is affected by finances and resources needed for entering the market, rules and regulations, and access to suppliers and distributors.

Figure 1: Porter's Five Forces with respective description

3. Research Method

This study is explorative in nature and uses qualitative research methodology. The empirical data is collected through semi-structured interviews with personnel from selected industries in Finland. The sampling strategy followed a goal-directed approach aimed at capturing a diverse cross-section of Industry 4.0 stakeholders. Interview participants were senior-level decision makers, including business executives, R&D managers, and product or technology leads, representing sectors such as mining, logistics, agricultural machinery, factory automation, software integration, and private wireless networks. These firms ranged from large multinational manufacturers to medium-sized technology and service providers, ensuring variation in organizational scale and digital maturity.

The organizations included major industry actors in Finland across areas such as pulp and paper, logistics, ports and terminals, energy, agricultural and mining machinery, wireless network deployment, software integration, and I4.0 solution provision. Respondents were primarily located in or near the city of Tampere in the Pirkanmaa region. In total, seventeen interviews were conducted with members of higher management, executives, and senior managers from seven major industrial companies. The interview questions were designed to explore how industries are adopting Industry 4.0 (I4.0) and to identify the opportunities and challenges associated with implementing I4.0 technologies.

Microsoft Teams was used as a tool for recording and transcribing interviews. The research data collected from the interviews and literature were thematically analyzed using a combined approach based on Braun and Clarke (2006) and Maguire and Delahunt (2017). Initial themes were created using six-step framework proposed by Braun and Clarke (2006), and post-analysis themes were refined using the questions proposed by Maguire and Delahunt (2017).

The following Figure 2 shows the steps:

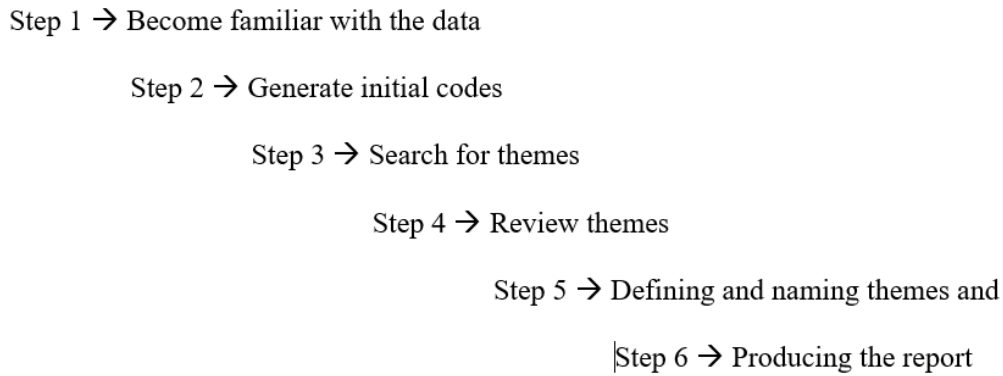


Figure 2: Six-step process of thematic analysis

Ethical considerations were addressed by informing interviewees about the purpose of the research and ensuring that all personal information was anonymized. Practical issues were managed by utilizing publicly available company data and voluntary participation in interviews. The authors noted that there were repetitive responses among participants in the final interviews, which indicated that a degree of thematic saturation had been achieved. Additionally, a practical limitation of the research was the challenge of securing more interview participants within the available timeframe. We present the results of the research in the following section.

The interview acceptance rate was quite satisfactory. Responses were analyzed using both quantitative methods and thematic analysis. Authors designed the interview questions in relation to theoretical frameworks. Respondents were able to explain and open-up prevailing I4.0 implementation related scenarios and express future possibilities. The research used empirical methods, discussing I4.0's impact on business operations through Porter's Five Force model.

Themes were identified through thematic analysis. The responses from the interviews were consolidated to summarize the main ideas relevant to the research questions. 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 following Figure 3 illustrates the thematic map of I4.0 themes according to the account of data collected from the interviews. These themes were then linked to the research questions and the theoretical framework to guide the analysis. The analysis was further strengthened by integrating insight from existing literature, affording more in-depth data interpretation (Braun and Clarke, 2006). For the descriptive quantitative summaries presented in the results, qualitative responses were first mapped to standardized statements within each theme. The frequency of each statement was then counted and normalized by dividing the number of responses associated with that statement by the total number of responses within the corresponding theme, producing the ratios and percentages reported in Figure 4. This approach allowed qualitative insights to be systematically summarized while preserving the interpretive depth of the interview data.

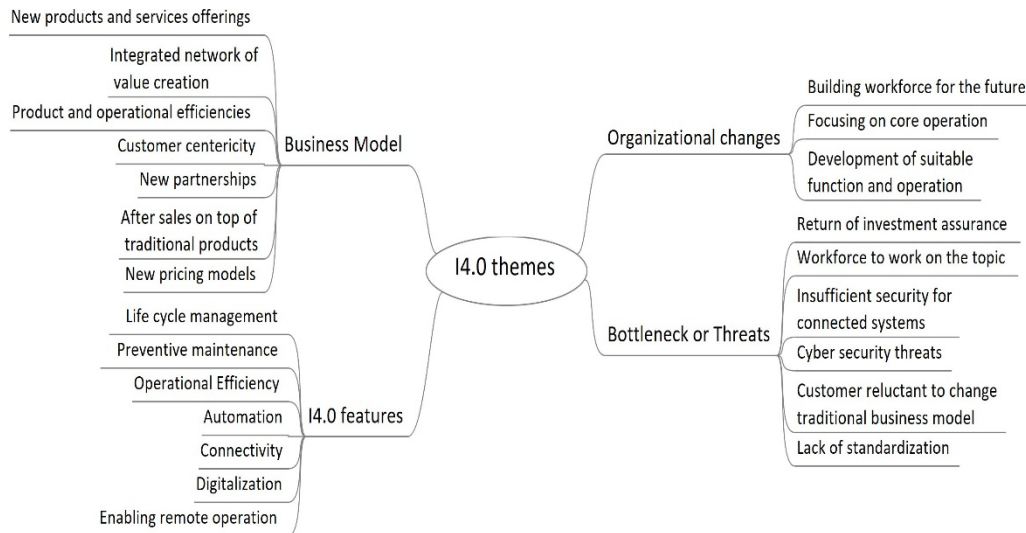


Figure 3: Thematic map of I4.0 themes from interviews

Questions / Themes	Responses	Percentage
Initiatives being undertaken by organizations to implement I4.0 technologies		
Digitalization and connectivity	5	45%
Autonomous machines development	5	36%
Development of services	2	18%
Opportunities for implementing I4.0 technologies		
Improve worker safety	2	33%
Increase productivity	3	50%
Emergency services	1	17%
Challenges of implementing I4.0 technologies		
Cyber security	4	36%
Lack of expertise, need for new workforce	3	27%
Lack of standards	3	27%
Return of investment	1	9%

Figure 4: Summary of Interviews with response percentages

Authors aim to connect primary and secondary empirical data with the Porter’s model after each session of interviews with respondents. The results of the analysis are hereunder.

4. Results

This study aims to address how industries are adopting I4.0 and what are some of the opportunities and challenges in the implementation of I4.0 technologies in the Finnish industry landscape. Finnish industries are actively deploying I4.0 technologies across various business activities. Companies are at different implementation stages, from developing proof-of-concept systems to delivering advanced automation solutions. These activities include enhancing products and operational efficiency. This proportion represents 38% of the responses. Secondly, offering new I4.0 features, which represents also 38% of the responses and finally, investment in modernizing operations. This proportion is 23% of the responses.

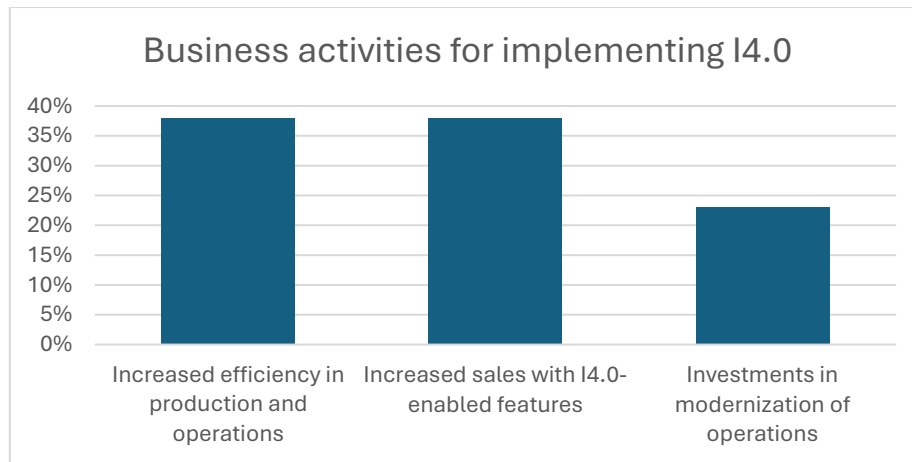


Figure 5: Business activities for implementing I4.0 technologies

The above Figure 5 presents a chart summarizing the relative proportions of three major business activities in these industries for I4.0 implementation. Interviewees reported that several actions have been taken towards desired digitalization and connectivity. This initiative represents 42% of the responses. Noticeably, some 42% of the responses are directly related to automation in business operations. Similarly, 16% of responses are related to providing services for maintenance based on data analysis.

Following Figure 6 provides illustration of the same:

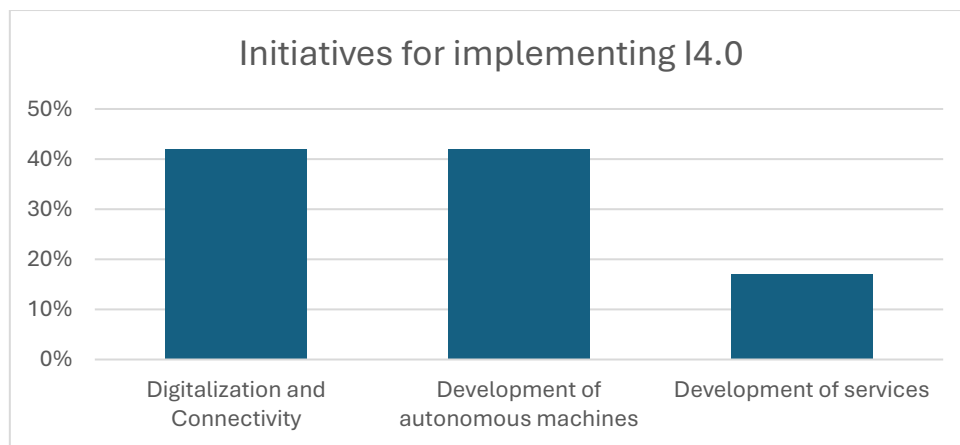


Figure 6: Initiatives for implementing I4.0 technologies

For example, in the Ports and container handling industries, one of the selected organizations wants to implement I4.0 technologies to:

“Optimize the loading, unloading times, and transfer of vessels to the next destination, that is digitalization, automation, and remotely operated equipment such as cranes, and straddle carriers”.

This will allow the organization to:

“Manage fluctuating demands, volumes of containers entering and leaving the port with the least disruption, and highest efficiency while maintaining the safety of on-site personnel”.

To our interest, absence of adequate expertise meaning capable workforce is another challenge that was highlighted by the respondents during the interviews. This challenge represents 27% of responses. The lack of standards for I4.0 were found in the interviews. This challenge represents 27% of responses.

The lack of standardization of I4.0 technologies has been seen as a main challenge. Another respondent reported as follows:

“We are connecting our operation which will enable automation and collaboration of machines for handling the next coming job at the port”.

The new capabilities enabled by I4.0 technologies require the transformation of the workforce. The industries see the lack of a suitable workforce in the market and the long time for training existing employees as a challenge for the deployment of I4.0.

Furthermore, another challenge is the lack of the I4.0 implementation strategy of the company by higher management. The slow adaptation of new business models as a challenge represents 10% of responses. This slowness makes it a challenge to alter business operations.

One participant identified the availability of a common platform for collaboration and culture of big industrial solution providers companies as:

“One of the reasons for the slow standardization of I4.0 is the culture of big industrial companies of not collaborating actively. – mobile manufacturers collaborate actively in the 3GPP platform for the standardization of technology which results in the availability of multiple vendors, and cheap price of the technology compared to the technology used in industrial segments”.

Furthermore, the I4.0 technologies are still evolving, and there are no widely accepted standards for the industries. The absence of standards is a result of developing more customized solutions for business needs.

Finally, the cyber security of information is key requirement of the deployment of I4.0 technologies in business operations, which links value creating with stakeholders. One of the respondents commented that:

“Security of our system is very important. We aim to use very advanced security methods to secure our machines”.

“The connectivity of the value chains is increasing exposure to cyber security threats”.

The challenge of cyber security was highlighted as the most important one. This challenge represents 35% of responses. The distribution of identified challenges is illustrated in the following Figure 7:

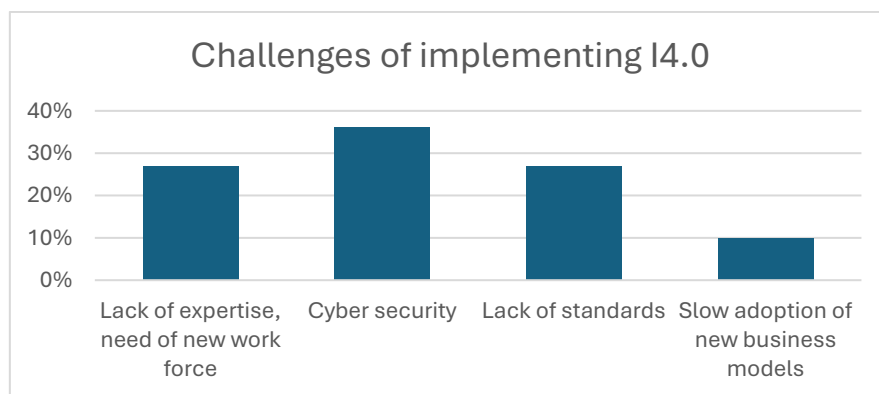


Figure 7: Challenges in implementing I4.0 technologies

While commenting on the opportunities of implementing I4.0 technologies in business operations, respondents stated that:

“Operational efficiencies, the safety of human resources by reducing interactions with heavy machinery and working in difficult environments are value drivers for us”.

Another respondent emphasized that:

“Differentiation of solution, operational efficiency, and the possibility of using collected data for improving operational, and business outcomes is good for operations”.

“We want value-added services for connected operations for customers”.

One interviewee noted,

“I4.0 has enabled us to collect data from our machines, use AI and data analyses...to plan machine maintenance”.

The results of the data analysis are discussed in the following section.

5. Discussion

Impact of implementation of I4.0 technologies in business operations is an observable global phenomenon, which is changing how organizations conduct their business operations nowadays. Such new way of business demands newer approach to business and use of competence and technology to achieve desired economic value and monetary benefits. Organizations are revising their long-term visions and operational strategies.

The authors analyzed the impact of I4.0 deployment on the Finnish industries business operations and challenges with the implementation of I4.0 technologies. The research results are summarized in the following sub-sections.

5.1. Porter’s Five Forces Model for I4.0

Organizations own hierarchies and structures are being changed with the implementation of I4.0 technologies to achieve value. Such change warrants newer forms of competition being faced by all stakeholders in an ecosystem regardless of those players having traditional business as well as those offering newer advanced services and solutions to their customers. Each player tries to achieve a desired position in the ecosystem by offering state-of-the-art value propositions (Porter and Heppelmann, 2014). A closer examination of the interview themes reveals that each force is influenced in distinct and sometimes contradictory ways. These nuances emerged strongly in the qualitative data. For example, interviewees emphasized that “I4.0 is forcing us to rethink our entire role in the value chain,” which highlights how digital ecosystems are reshaping competitive boundaries. On the other hand, some respondents noted that their competitive position has remained largely unchanged, stating, “our customers still buy based on long-term contracts, not digital features.” This illustrates a case where I4.0 has not yet influenced competitive dynamics. These contrasting experiences highlight the uneven adoption of I4.0 across Finnish industries and emphasize the need to interpret each force with contextual sensitivity.

5.1.1 Bargaining Power of Buyers

Empirical findings demonstrate that deployment of I4.0 has generated new opportunities for industries. These opportunities have led to revenue growth through product differentiation enabled by I4.0 features, the development of new services derived from collected data, and the

customization of products to meet customer needs. This shift in the competitive landscape moves industries away from solely competing on price for similar offerings.

The collection of data from the connected value network provides industries with insights into customer usage patterns, enabling them to create more refined customer segments, enhance value propositions, and ultimately improve customer satisfaction. This enhanced customer satisfaction increases the cost of switching to a new supplier for buyers, mitigating or reducing their bargaining power (Cavalieri and Pezzotta, 2012). I4.0-enabled services increased customer lock in by embedding analytics, predictive maintenance, and remote monitoring into the product lifecycle, indicating reduced buyer power.

However, I4.0 deployment also brings about closer proximity to customers, making them satisfied with the services and solutions provided to them for their business needs. This increased customer knowledge translates into greater bargaining power, enabling them to explore alternative solutions and negotiate better prices. Furthermore, reliance on partners for I4.0 deployment can empower these partners with a deeper understanding of value propositions and potential offerings. This increases bargaining power of buyers, allowing them to switch manufacturers and negotiate features and pricing more effectively.

5.1.2 Rivalry Among Competitors

As such competition in the ecosystem is also being changed by the implementation of I4.0 technologies in business operations. Analysis of empirical data shows that there is an increase in rivalry towards differentiation and value adding services. Organizations tend to offer more and more customized solutions to their specific customers. Organizations are also competing in terms of their in-house competencies and skills. They are trying to get more such skills which are better and cheaper than their rivals and competitors (Porter and Heppelmann, 2014). A contrasting perspective arose from firms where competition remained stable, as these companies collaborated with their rivals to establish standards that address common integration challenges. The findings suggest that rivalry does not increase uniformly; instead, it varies depending on technological readiness and the maturity of the ecosystem.

5.1.3 Threat of Substitute

The threat of substitutes is yet another topic to be discussed with perspective of implementation of I4.0 technologies in business operations. organizations are willing to offer new solutions replacing the traditional ones which are basically based on customers' needs including 'Product-as-a-Service' (PaaS) and 'Manufacturing-as-a-Service' (MaaS) to avoid and reduce the threat of substitutes. The shift towards service-based models is often seen as a strategic response to the threat of substitutes. However, some companies have mentioned that substitutes aren't currently a significant threat because customers still prefer owning their equipment. Additionally, service providers have expressed reluctance to offer these new services globally due to challenges stemming from varying regulatory and legislative environments, as well as constraints related to export and import controls. This variation suggests that while pressures from substitutes are emerging, there is no clear front-runner yet.

5.1.4 Bargaining Power of Suppliers

The bargaining power of suppliers is another factor in Porter's five forces model. This particular force is being observed to reach higher level power among stakeholders including service providers and their partners in the ecosystem. With newer approach to the implementation of I4.0 technologies in business operations, organizations have a chance to create higher bargaining power over their competitors in the market. Supplier power significantly increased

when companies relied on specialized and proprietary technologies related to Industry 4.0, such as cloud platforms, cybersecurity providers, and connectivity vendors. However, companies that opted for open standards or modular architectures were able to reduce supplier power. This shows that architectural choices have a direct impact on supplier influence.

5.1.5 Opportunities of Implementing I4.0 Technologies in Business Operations

I4.0 deployments have shown several opportunities, for example, it fostered an ecosystem and culture for network value creation. This ecosystem is developing through increased collaboration among industries, partners, and customers. The ecosystems necessitate cooperation between companies to acquire the necessary capabilities. No single company can enable an industry's ecosystem alone. Industries strategically choose which parts of the value creation network they want to position themselves in and subsequently develop competencies for growth. They rely on partners for other competencies. Interviewees identified two main opportunity categories for I4.0 implementation in business operations: 1) core competencies and 2) foundational or enabling competencies.

Core competencies involve research and development of products and solutions for specific industries. These competencies are necessary for growth and profitability. Foundational or enabling competencies are needed to work with I4.0 enabler technologies, such as connectivity, computation, and applications like '*Artificial Intelligence*' (AI) and '*Machine Learning*' (ML). Organizations try to keep their eyes on their own core competencies there by designing new features based on ML & AI. They also develop key partnerships to acquire foundational I4.0 capabilities, connecting their operations, value networks, and customers. All stakeholders involved become means to achieve value-added services.

The opportunities identified in the interviews align closely with the emergence of ecosystem-based value creation. Respondents consistently emphasized that "no single company can build an I4.0 solution alone," underscoring the central role of partnerships.

5.1.6 Challenges in Implementing I4.0 Technologies in Business Operations

As shown in the previous section, I4.0 adoption has faced challenges, including lack of standards, cybersecurity threats, slow adoption of new business models, and workforce needs. Lack of standardization was the most frequently mentioned challenge in interviews, aligning with findings by Müller et al. (2018); Nagy et al. (2018). This lack creates interpretability issues among vendors and hinders I4.0 technology adoption. Industry-specific requirements and standardization efforts within workgroups contribute to slow standardization.

Insufficient security was the second most cited challenge along with shortage of suitable I4.0 workforce. Information security is crucial for integrated value networks with increasing stakeholders. Cybersecurity threats for I4.0 deployments are highlighted by Ghobakhloo (2018). Developing robust security mechanisms is essential to meet industry security demands. Government-funded programs like '*Digital Trust Finland*' as well as cyber security initiatives related to manufacturing and facilitation packages could help secure I4.0 industries in the longer run.

Industries are also facing a shortage of suitable I4.0 workforce. Upgrading existing workforces through training and job redesign, leveraging human-machine capabilities, is necessary. Leaders of human capital play vital part in developing organization's vision and guidelines needed to implement I4.0 technologies in business operations. Management must take the lead in defining strategies, evaluating I4.0 technology needs, and training workforces. Change resistance, identified by Cavalieri and Pezzotta (2012) is another barrier.

I4.0 deployments significantly alter industry operations, affecting existing workforces and leading to change resistance. Ethical concerns about use of technology also contribute to resistance. Technologies should be used to enhance workforces, improve lives, and serve humanity, rather than unethically monitor or spy on employees.

Furthermore, organizations face challenges in terms of taking up new business models promptly. They take long time to get on board with newer ways of working and creating new business cases which support implementation of I4.0 technologies in business operations.

Another significant challenge in implementing I4.0 and competition between companies would be acquiring the right skills and resources. The workforce demand could be met by training the existing workforce, hiring new employees for new capabilities, and redesigning existing jobs to leverage complementary capabilities of people and machines. Organizations should think about reskilling employees, not only to make them relevant in the market but also to help the transformation of the organization and business.

The transformation of the workforce should be given similar importance to the usage of technologies. Managers and policymakers should look beyond individuals to the entirety of the organization and ecosystem. They should evaluate the implementation of I4.0 technologies with multiple perspectives of sustainability, economic, environmental, social, and people for successful technology adoption and diffusion (Bai et al., 2020). Human resource managers have a very key role in defining the implementation of I4.0 strategy of the company. Management must take the first step in defining the strategy and evaluating the need for I4.0 technologies and training of a workforce for their business operations.

We present the conclusion of the study in the next section.

6. Conclusion

This study aims to address how industries are adopting Industry 4.0 and what are some of the opportunities and challenges in the implementation of I4.0 technologies in the Finnish industry landscape. I4.0 has created integrated value-creation networks and ecosystems across various market segments. These ecosystems are reshaping market dynamics and competitive landscapes for companies within them. This new environment offers companies opportunities for growth and value capture. Interestingly, value networks prompted organizations to re-evaluate own position and roles within certain partnerships and collaborations in entire ecosystem where they belong.

Manufacturers, partners, suppliers, and customers are collaborating to build ecosystems. I4.0 is a crucial area for future business development in Finnish industries. It's a growth area that can be directed towards a focus on investing in I4.0 product and service development and selling solutions to industries. As identified in this study, organizations need to skill up their human capital. The commitment from the leadership as well as from the higher management should be clearly visible. Besides, human resource department should further improve job descriptions of the roles in an organization.

Our study results show that lack of standardization is one of the most demanding challenges in the implementation of I4.0 technologies in business operations. Such lack gives birth to several operational issues in company's day-to-day operations. One such issue raises concerns related to absence of globally accepted platforms to address certain topics pertaining to standardization. Furthermore, organizations face critical challenges with respect to fool proof IT and cyber security. Desired security is also required to sage guard customers' needs and to protect customized solutions created to cater for specific customers. These results lead o several actionable recommendations for companies:

- **Standards Engagement:** Firms should participate in international standardization efforts to reduce integration challenges and supplier dependency.
- **Cybersecurity Measures:** Companies need to implement enhanced security practices, establish continuous monitoring processes, and provide mandatory cybersecurity training to mitigate risks associated with interconnected value networks.
- **Workforce Upskilling:** A structured reskilling roadmap is essential, focusing on areas such as data literacy, fundamental concepts of AI and machine learning, and human-machine collaboration. This will help address skill shortages and lessen resistance to change.
- **Leadership Alignment:** Senior management must clearly communicate a comprehensive Industry 4.0 strategy, allocate appropriate resources, and drive cultural change to support the successful adoption of these initiatives.

Within the scope of research limitations, authors acknowledge that generalization could be achieved with care in terms of qualitative methods and increasing the number of interview respondents. The quantification of results could be improved by conducting surveys with more participants using the findings of the research results. Finally, the research was focusing on Finnish industries and companies that have offices in Finland, which is another limitation of the findings, it could be useful for analyzing and comparing the research on other countries on the topic.

Quantitative methods like surveys and quantitative research tools could be availed in future to quantify results of similar studies. Validating the defined Porter's five forces model with industrial solution providers is yet another avenue for future research. Conducting more interviews with Finnish companies and exploring global I4.0 impacts on businesses are also potential research directions. Future research could focus on industry-specific business models, as discussed in trade union workgroups. Investigating how business operations change within vertical industries like farming, ports, mining, and factory automation is valuable for academia and practitioners. Detailed case studies of successful I4.0 deployments in Finnish industries would also provide valuable insights into the implementation of I4.0 technologies in business operations.

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