Industry 4.0 transition strategies for Ukrainian construction SME's

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ABSTRACT,
Industry 4.0 is an arising technological landscape, that promises to enhance production and management processes in many business sectors. The transition towards new technologies is on the agenda of the vast majority of business fields nowadays, and the construction sector is not an exception. The successful adoption is increasingly important for Small-Medium Sized Enterprises (SME), that face more challenges than large organizations since they possess fewer recourses and experience to benefit from the new technologies, and yet comprise the backbone of any country's economy. This research aims to provide a better understanding of how Ukrainian construction SME's can anticipate the Industry 4.0 revolution strategically and responsibly. This was done by means of exploring the main obstacles between the SME's and the Industry 4.0 technologies and what could be done to overcome them. As the research tool, the extended Smart scan was applied to a case study company, which was designed to determine the company's maturity level across 15 business aspects. The results of the scan were further analyzed and then discussed with the construction company's employees during the workshop. Next to that, theoretical and conceptual frameworks were built to provide construction SME's with practical guidelines on how to start the Industry 4.0 journey.

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Industry 4.0, Smart Industry, Construction industry, SME, construction, maturity scan, case study, Industry 4.0 Ukraine

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1. INTRODUCTION

1.1 Relevance

Industry 4.0 is an umbrella term for describing the fourth industrial revolution, it includes a wide variety of concepts, such as Smart Factory, Cyber-physical Systems, Self-organization, Individualization, IoT, Resource efficiency (*Lasi et al, 2014*). In essence, that means the technological integration of cyber-physical systems (CPS) in the production process. CPS enables (internet-based) networking with all participants in the value creation process (*Schroder, 2016*). Many researchers stress the importance of such a topic as the Maturity level of a company in the context of Industry 4.0. *Leuh et al. (2016)* defines the maturity concept as" how an IT landscape must be designed, recognizing and evaluating what systems are needed so that a company can "move" in the field of Industry 4.0"

Industry 4.0 raises big expectations within manufacturing sectors and nowadays the majority of the companies are striving to prepare themselves for this transition. However, the vast majority of the research done on the topic is aimed towards large enterprises and the dimension of SMEs still has room for research (*Müller et al, 2018*). *Matt et al (2020)* also suggest that there is a scientific gap in the research of implementation of the concepts of Industry 4.0 in SMEs. Preliminary research has shown that there is both positive and negative evidence for and against SMEs and their role in the Industry 4.0:

On the one hand, according to *Müller et al (2018*), small and medium enterprises retain the status of the driving force of many manufacturing economies *(Schiersch 2013*). On top of that, in the research of German manufacturing industry, *Mittal et al (2018)* found significant evidence that supports the hypothesis of a positive relationship between the company size and its efficiency, in favor of the smaller scales;

On the other hand, *Mittal et al* (2016) emphasize the sufficiency of financial recourses as well as reaching the economy of scale as the reasons why small and medium companies may find it more difficult to make the transition towards Industry 4.0. According to *Schroder,2016*, the main obstacles for the technological implementation of industry 4.0 for SMEs are the development of an appropriate strategy, cost-benefit analysis of the relevant technologies, lack of data security, and uniform standards. *Matt et al (2020)* state that nowadays most SMEs are not ready for the transition and smaller companies risk not to benefit from the revolution.

1.2 Construction sector and industry 4.0

The construction sector is an important element of the economy of almost any modern country. The sector generates employment and incomes for the people and therefore the effects of changes in the construction industry on the economy occur at all levels and in virtually all aspects of life (Chen, 1998). In return, that leads to higher GDP of a country. Many studies have proven a positive relationship between construction output and positive economic growth (Ali Khan, 2005). Additionally, due to the high growth of population and global urbanization processes around the world, the demand for affordable housing has never been higher *(Adabre et al, 2019).*

Despite the economic benefits that the construction sector provides, it faces certain innovation challenges. Hampson et. Al (2015), First of all, construction projects are complex ventures that require a deep level of multi-dimensional knowledge by its nature. They are comprised of multiple dynamic elements that involve numerous participants, and all of them require a high degree of cooperation. The entire construction value chain is highly affected by tight collaborations with customers, subcontractors, and other stakeholders (Oesterreich et al. 2016). The fragmented supply chain of the construction industry, which includes several small- and medium-sized enterprises (SMEs), limits the ability to invest in innovative technologies. (*Maskuriy el al, 2019)*

The other factors that jeopardize the development of the construction sector are intense competition, limited investment in R&D, due to the project-based nature of the industry, limited usage of digital modeling and electronic transactions, and increased community expectations regarding social and environmental performance. (Hampson et. Al,2015). The author also defines characteristics of the industry that reflect the need for a change, such as Segmentation into silos of interests; Little alignment of objectives among the silos; Poor information flow; Significant duplication of effort; process inefficiency. However, these characteristics lack practical suggestions on how companies can improve their current state of the business. On top of that, the construction area faces research & development (R&D) underinvestment comparing to the other sectors. (Oesterreich et

al. 2016). According to the 2015 EU R&D Scoreboard, the construction & materials industry is amongst the lowest R&D intensity sectors with less than 1% of net sales.

Maskuriy el al (2019) suggest that despite the growing number of publications on the topic of Industry 4.0 and the Construction industry, there is still space for exploration, since "pattern and structure in this area of study are still in their infancy and conceptual.". Additionally, a very little number of the researchers address the issue of maturity levels in the construction sector context. There is also a lack of practical research on how organizations can effectively adopt and benefit from technologies of industry 4.0 and which specific business dimensions have to be emphasized.

Therefore, there is a clear necessity in researching the topic of adoption of Industry 4.0 technologies by construction SMEs and the possible strategies to ease its adoption.

1.3 Research objective

The objective of this research is to provide relevant scientific insights into how construction SME firms can ease the transition towards Industry 4.0 and what important aspects of the business should be emphasized. Another side of the study is providing practical insights on overcoming Industry 4.0 adoption challenges for construction SMEs in Ukraine. Additionally, the research will provide a deep audit of a Ukrainian construction company, whereas the Chief executives and other top-level managers from all the business departments are going to take part in. This research will provide additional support for the topic of implementation of Industry 4.0 by small and medium construction enterprises since many studies admit that the vast majority of the researches is devoted to large enterprises and the SME topic is yet less explored. The audit is going to be conducted using the Extended Science-Based Multi-Dimensional Industry 4.0 Scan *(Ungerer, 2019)* which was developed to assess the maturity level of a company in the context of Industry 4.0, identify to what extent a company is ready to make the transition to the new technologies and identify the business dimensions that should be elaborated to achieve the transition. The results of the scan are going to be elaborated and they will comprise the basis of future discussions. The results should clearly show the company's performance across different business dimensions and possibly, evoke initial thoughts on what could be improved. Then, the objective is to conduct a workshop where the results of the scan are going to be presented. At this point, the role of the researcher is to steer the discussion wheel in the right direction and inform the company regarding possible strategies that can be employed to achieve a better transition towards Industry 4.0. Additionally, the research is aiming to contribute and to bring new insights for further development of the Extended Science-Based Multi-Dimensional Industry 4.0 Scan in the context of construction companies. These steps are going to create the foundation for answering the research question of this study and producing relevant both practical and theoretical insights in construction SME's anticipation of Industry 4.0.

1.4 Research question

Based on the research objective, the research question is:
"How can SMEs in the construction industry in Ukraine mature towards industry 4.0 in a responsible way across multiple levels?"

The research aims to answer the following sub-questions:

1. What are the strategies to achieve Industry 4.0 adoption for SME's in Ukraine?
2. What are the main Industry 4.0 technologies a construction SME can benefit from?
3. What are the main challenges that jeopardize companies?
4. What are the benefits of Industry 4.0 technologies for construction SMEs?

2. THEORETICAL FRAMEWORK

This section aims to set establish the scope of the research, which is going to include: Ukrainian construction SME's in the context of Industry 4.0, current strategies for construction companies to achieve Industry 4.0 standards, and maturity tools for assessing the state of SMEs.

2.1 Industry 4.0 in Ukraine

According to the research of Andriuschenko et al (2018), the main problem of Ukraine's accession to the fourth industrial revolution is that the concept «Industry 4.0», which combines advanced development into a single system, is a new phenomenon for the country's economy. There is a gap between the current state of the economy and industry of Ukraine and the target level of development, which ensures the formation of the digital economy and Industry 4.0 at the macro level. The other major challenge for Industry 4.0 to be widely adopted in Ukraine is the lack of awareness of business entities about the concept and technology of Industry 4.0, the benefits and complexity of its implementation. On top of that, the development of the I4.0 technologies requires significant investment in several directions: development of infrastructure for the digital economy, formation of the regulatory framework, support for innovation and training for the digital economy. Currently, the economy of the country is rather turbulent, and solid investments in these fields are not very optimistic. Another possible reason for slow investment pace in the Industry 4.0 in Ukraine, that significant development of the technologies will not necessarily lead to new job creation for the people, which in turn may become a socio-economic problem for the country.

2.2 Construction sector and Industry 4.0

Regardless of the vitality of the construction sector for the economy of any modern country, the field encounters many structural problems that jeopardize the adoption of Industry 4.0. The main issues on the way to Industry 4.0 according to Osterreich (2019) are:

- Complexity: a construction project is comprised of a high amount of tightly interrelated processes that involve many participants (suppliers, customers, investors, contractors, architect, city municipalities) at different stages and locations
- Uncertainty: given the high complexity, time constraints for each construction project (which might lead to customer bargaining pressure if the company doesn't deliver the project on time), lack of complete specification for processes and sub-processes, and uniformity of building materials, construction companies usually operate in an unpredictable environment.
- Fragmented supply chain: high fragmentation in the supply chain in terms of a high amount of small- and medium-sized firms with undifferentiated products and services and limited capabilities for investments in new technologies
- Short-term thinking: The structure of the construction

industry has been described as a loosely coupled system with tight couplings in individual projects and loose couplings in the permanent network, which supports short-term thinking but hampers long-term innovation and learning. Hence, the decentralized organization of the construction companies as well as the temporary nature of the construction projects is a barrier to innovation.

- Culture: The construction industry is well-known for its strong and rigid culture as well as its strong resistance to changes

Maskuriy et al (2019) conducted a holistic review of 547 scientific papers in the last five years on the topic of Industry 4.0 and the construction sector. He suggests that there is still a lack of a complete understanding of what Industry 4.0 entails for the construction industry, existing studies merely provide a theoretical foundation for the industry to be implemented. The researcher proposes, that there are three main clusters of the industry 4.0 development in the construction sector:

- Technology cluster: completes the cyber-planning-physical ecosystem by integrating physical machinery and devices, non-physical technologies
- Security cluster: includes cyber-physical system, data, environment, and legislative aspects
- Management cluster: includes management, innovation, design performance, quality, and digital transformation

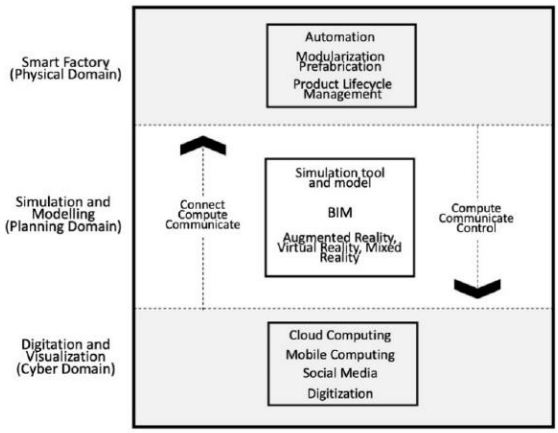

Figure 1, The relationships in the cyber-planning-physical system with BIM as its core (Maskuriy et al. 2019)

The author defines Building Information Modelling (BIM) as the key concept that creates bi-directional coordination between the physical domain, which represents the Smart Factory domain and includes Automation, Modularization, Prefabrication, Product Lifecycle Management; and the cyber domain of the sector, which stands for Digitation and Visualization and includes such concepts, as Cloud Computing, Mobile Computing, Social Media, Digitization. It has the potential to improve real-time progress monitoring and control the construction process, track changes, model updates, and exchange information between the design and operational stages. (Andriushchenko, Shergina, et al. 2018)

Similarly to the research by Maskyriy, Osterreich et al (2016) break down Industry 4.0 technologies in the construction context into three main clusters:

Smart Factory - depicts automatization technologies that create a "Smart Factory". The cluster proposes certain I 4.0 technologies that can be beneficial in the construction sector, such as *Cyber-Physical-Systems* (CPS) – used for validation of project prototypes, they coordinate virtual models and physical construction; *Radio-Frequency-Identification* (RFID) – offers solutions for the automation of the construction process, it enables tracking and management of construction assets like tools, materials, equipment. RFID could be also used for inventory management and theft prevention since the sensors allow to track down the equipment; *The Internet of Things and Services* (IoT and IoS) – creating virtual networks to support a smart factory environment, this approach helps to move away from reactive maintenance to predictive maintenance, where machines can be repaired before damage occurs; *Additive Manufacturing* allows automatization of the most complex architectural components based on 3-D printing; *Robotics* – in the context of construction field, the robotics could be used for automation of the steel beam assembly to replace human workers. Additionally, drones are used for capturing the construction process for the sake of progress reports and monitoring deliveries. Although, due to the low level of standards, robotics concept hasn't been widely represented in the industry yet; *Product-Lifecycle-Management* – deals with the integration of all information produced throughout all phases of the whole lifecycle of a company's product; *Human-Computer Interaction* (HCI) – is focused on the aspects concerning to the increasing use of. ICT.

Simulation and Modelling: this cluster deals mostly with various simulations that could be used for testing construction projects on the influence of external factors, such as weather, worker performance, and supply fluctuations. Simulations can be also used to enhance the design of construction operations. The most widely used technologies in this cluster are related to simulation-tools, frameworks for project planning resource planning, and project management. *Virtual Reality* (VR) can be used as a tool for conducting risk-free safety training. The emerging field of *Building Information Modelling* (BIM) allows to design and manage construction projects by simulating a virtual model of a building using the information as project scheduling, cost estimates, material inventories as the input. As well as Maskyriy (2019), Osterreich et al. emphasize Building Information Modelling as the key technology that can support the idea of Industry 4.0.

Digitization and virtualization: *Cloud Computing* is responsible for the provision of integrated services with the opportunity to be accessed via the Internet, e.g. for cross-company collaboration on construction site; *Big Data* solution can be used to combine all the data from the devices and people as well as external data and make it accessible for all participants of a project. The collection of historical big data allow to ease the degree of uncertainty during decision-making processes. *Mobile computing* – refers to the use of mobile devices to support collaboration and communication during the construction process. *Social media* is another technology that can be used to improve efficiency in the construction sector in terms of communication, recruitment, project management, and client networking.

The study of Osterreich et al (2016) defines main benefits of Industry 4.0 for the construction industry in the PESTEL Framework (P – political, E – economic, S – social, T – technological, Env – environmental, L – legal, Eth- ethical): Cost savings (E), time savings (E), On-time and on-budget delivery (E), improving quality(E), improving collaboration and communication(E), improving customer relationship(E), enhancing safety (S), improving the image of the industry (S),

improving sustainability (Env). Thus, it is clear that Industry 4.0 implementation carries mostly an economic benefit for the companies. The main challenges a construction industry has to overcome to successfully implement Industry 4.0 practices are Hesitation to adopt, High Implementation cost, Organizational and process changes, Knowledge management, Acceptance, Lack of standards and reference architectures, Higher requirements for computing equipment, Data security and data protection, Enhancement of existing communication networks, regulatory compliance, legal and construction uncertainty.

2.3 Industry 4.0 strategy

In the research of Germany's industry 4.0 strategy, *Schroeder (2016)* suggests that there are four dimensions manufacturing companies should focus on for the sale of improved competitiveness, such as Production process, Logistics, Customer retention, and Hybrid products.

Erol et al (2016) have developed strategic guidance towards Industry 4.0 that addresses the main challenges SMEs encounter attempting to adopt new technologies, such as low awareness of the Industry 4.0 as a term, problems with identifying the strategic fields of action, the lack of understanding for the concrete relevance and benefits of Industry 4.0. The proposed model consists of three stages: Envision, Enable, Enact.

The goal of the Envision stage is to familiarize the organization with the concept of Industry 4.0, align the general idea of Industry 4.0 with the company's specific objectives and customer needs. In this phase, top-management employees of the organization are involved, but inviting strategic partners to the discussion table can be beneficial as well. Stage 1 synergizes with the Smart Scan by Ungerer (2019), since it serves as an overview of an organization in the context of Industry 4.0 and can be used to narrow down the scope of development.

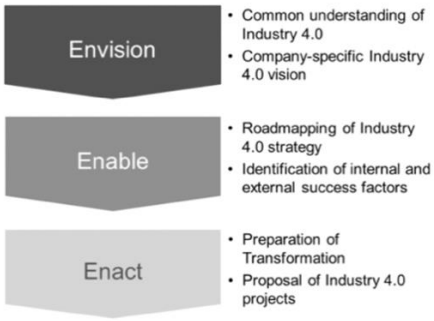

Figure 2: Three-stage model for Industry 4.0 transformation, Erol at al (2016)

Stage 2 is essentially a road-mapping technique of the strategies for the Industry 4.0 adoption. There is a distinction between four strategic perspectives: market, product, process, and value network. Each layer is used to sketch the expected development of the market perspective (customer segments), the product perspective (value proposition), the process perspective (the key resources, technology, and activities), and the network perspective (necessary partners needed to fulfill the value proposition). During the "Enact" stage the company is supposed to transform the strategies creating in the Enable stage into concrete projects. In order to do so, project goals, milestones, teams have to be defined and weighted against the available recourses and potential risks.

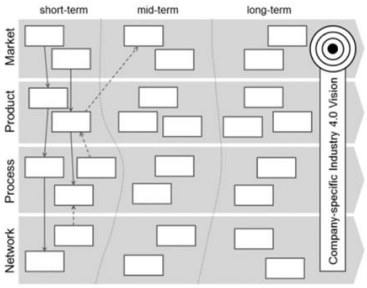

Figure 3: Exemplary Industry 4.0 Roadmap Erol et al (2016)

3. CONCEPTUAL FRAMEWORK

The foundation of this research is going to be built on the Extended Science-Based Multi-Dimensional Industry 4.0 Scan and its research of Maturity levels in the context of Industry 4.0. "*The scan consists of 15 different business aspects, that provide the respondent with an extended overview of the industry 4.0 implementation within their organization. In different aspects, this implementation is measured to give a very detailed result at the end. In order to get to such a detailed result, the scan consists of 86 different measurement questions that each measure different subjects that are of major importance for becoming a full-scale adaptor of industry 4.*

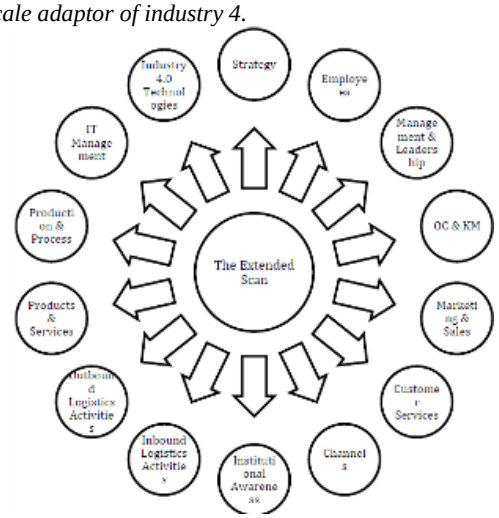

Figure 4: Business aspects (Ungerer, 2019)

Based on the score a company gets after answering the scan survey, it is distributed among 5 levels and 5 types of maturity level." (Ungerer, 2019). The full questionnaire can be found in the Appendix A.

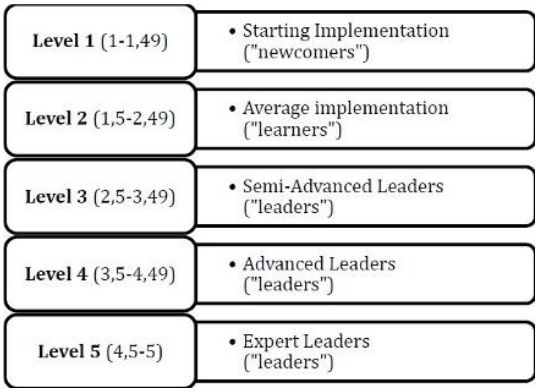

Figure 5, the Maturity levels (Ungerer, 2019)

The research *of Bakkari et al. (2017)* on sustainable strategies in SMEs defines main requirements for the migration to the industry 4.0 as the technological condition, the cultural condition, and the organizational condition. Furthermore, it is planned to explore Industry 4.0 in the context of the construction industry. After the audit and workshop are conducted and the weak points of the companies are detected, the research is going to dive more into the specific aspects of the business that scored lower than others, based on the 15 business aspects suggested by Ungerer (2019). After the company's scanning is conducted, I'm going to present the Three-Stage Framework of Erol et al (2016), to give the organization an idea of how to approach the Industry 4.0 transition. Given the aspects that scored lower or the aspects, the organization found strategically vital for their context, I'm going then to propose the technologies from the theoretical framework section that could be used for the company's Industry 4.0 journey.

4. METHODOLOGY

4.1 Research approach

The research is based on the literature review on construction SMEs in the Industry 4.0 (I 4.0) context, the strategies of transitioning towards I 4.0, and the current state of development of Industry 4.0 in the context of Ukraine. The foundation of the conceptual framework is based on the research of Ungerer (2019) on the Extended Science-Based Multi-Dimensional Scan for assessing the company's maturity level. Then it will be followed by a company audit applying the SIMS scan. The results of the scan are going to be studied to come up with a preliminary conclusion regarding the company's Industry 4.0 maturity level. Collected empirical data is going to be discussed during a workshop with the high-profile employees of the company and used to facilitate creating a strategy of improving the company's readiness to Industry 4.0.

4.2 Research method

In order to conduct the audit and the following workshop efficiently and in a professional manner, I have decided to create a methodology that aims to keep the research structured:

1. Select a Ukrainian construction company that fits the description of a small or medium enterprise
2. Get in touch with the company's representative to present the research and make it appealing for the company to spend its time on
3. Translate the scan into the Ukrainian language to eliminate the possible language barrier
4. Conduct an introductive presentation of the scan and the idea of Industry 4.0 so every employee is acknowledged with the topic of the research
5. Request from two to three top-level employees from each business department, including the CEO and directors, to pass the scan. Ideally, there should be around 20 respondents to objectively grasp current business maturity level and provide useful feedback
6. Present the results and implication of the audit and take part in a collective discussion of possible solutions
7. Conduct additional research on the company's topics of interest
8. Conduct a second-round workshop
9. Use the findings to answer the research question: *how can SME's in the construction industry mature towards industry 4.0 in a responsible way across multiple levels?*
10. Share the company's feedback on the Smart Scan and therefore contribute to its future development.

4.3 Selection

The unit of analysis is going to be an SME that operates in the construction sector. According to the European Commission (2018), Small and medium-sized enterprises (SMEs) are determined by two factors: the annual turnover should be less than 50m € and the staff headcount should be less than 250.

According to the Organization for Economic Co-operation and Development (OECD), The United Nations defines construction as comprising "economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature, and other such engineering constructions as roads, bridges, dams and so forth." The sector can be divided into three distinctive categories: Construction of buildings, Civil engineering, Specialized construction activities (Standard Industrial Classification (SIC) code). For the sake of narrowing the research down, I have decided to focus on the Construction of buildings dimension of the sector. Extensive research has also been done on the topic of Industry 4.0 development in Ukraine.

4.4 Data collection

There two main sources for the data collection:

- *The SIMS scan:*

the Smart Scan, which consists of 15 business aspects, 86 measurement questions divided amongst these business aspects, five maturity levels, and three maturity types. (Ungerer, 2019). It is used to evaluate the readiness of a manufacturing SME in regard of transitioning to Industry 4.0 paradigm. Results of the scan position a company on the scan of five maturity levels from one to five and three maturity types. These types are: Newcomers – correspond to maturity level one; Learners – correspond to level two; and Leaders – correspond to levels three, four, and five. Dimensions the scan examines are Strategy, Employees, Management & leadership, Organizational culture & Knowledge management, Marketing & Sales, Customer services, Channels, Institutional awareness, Sustainability, Inbound logistics activities, Outbound logistics activities, Products & Services, Production & process, IT management, and Industry 4.0 technologies.

- *The workshop:*

Results of the scan are going to be presented during informal workshops, where employees of the company could also be interviewed regarding focal topics (business aspects that would score lower than others). The role of the researcher is mediating the discussion, acknowledging the participants about possible industry 4.0 technical solutions, as well as the strategies that could be employed. Additionally, the employees will be able to give feedback on the scan process to contribute to its further improvement.

5. DATA COLLECTION AND ANALYSIS

5.1 Description of the company

For this research, I have gotten in touch with a Ukrainian construction SME "ND Group Development". Directors of the company found it interesting to take part in the research since they are seeking new technological solutions which could help them to gain a competitive advantage over the competitors and improve their market position. On top of that, they believe that using the modern solution can become a powerful marketing tool for attracting new clients and self-distinguishing themselves among

other construction companies. From their words, the construction market is going through hard times due to a high degree of market saturation and unstable economic as well as the political situation in the country, so the organization is ready to take drastic measures. The company has been operating for 20 years in the industry, they operate in two regions of Ukraine, their team counts over 50 employees in the office and they also have various contracts with other organizations that are involved in the building process, such as companies that provide field workers, building material suppliers, construction vehicles services and so on. Given these facts, ND Group Development can be justified as a legitimate company in terms of the research. On top of that, it perfectly fits the description of a small-medium enterprise. The human resource manager of the company widely facilitated the scanning process and I ended up with 18 employees that agreed to fill in the SIMS scan. The chosen company members are the high-profile employees that represent all the business departments: the CEO, Directors, Project managers, Accountants, Construction managers, Human Resource Manager, Legal counsel, Sales manager, Supply Chain managers.

5.2 Maturity assessment

The 18 employees have filled in the Extended Multi-Dimensional Smart Scan. The scores for each Aspect are averages of the scores of each Measurement question. The introductory part of the Scan scored 2.23. A1, which stands for Strategy, scored 1,89. A2 – Employees, scored 2,1. A3 – Management & Leadership, has a score of 2,186. A4 – Organizational culture & Knowledge management, scored 2,44. A5 – Marketing & Sales, scored 3,04. A6 – Customer services, scored 1.9. A7 – Channels, scored 2,162. A8 – Institutional awareness, scored 1,746. A9 – Sustainability, scored 1,4. A10 – Inbound Logistic activities, scored 1,826. A11 – Outbound logistics activities, scored 1,654. A12 – Products & Services, scored 1,83. A13 – Production & Process, scored 1,378. A14 – IT management, scored 2.02. A15 – Industry 4.0 technologies cannot be averaged due to its nature, but the most common answers were: Automated controlled vehicles/drones – 33% of total response, AR/VR/Smart Vision – 21%, Advanced materials – 18%, 3D Printing – 12% of the response.

In order to assess the maturity level of the company, scores of every Aspect are summed up and then divided by the number of Aspects. Maturity levels are comprised of three types: “newcomers”, “learners” and “leaders”. Level 1 (“newcomers”) indicates an average score of (1-1,49). Level 2 (“learners”) indicates an average score of (1,5-2,49). Level 3 (“leaders”) indicates an average score of (2,5-3,49). Level 4 (“leaders”) indicates an average score of (3,5-4,49). Level 5 (“leaders”) indicates an average score of 4,5 or higher.

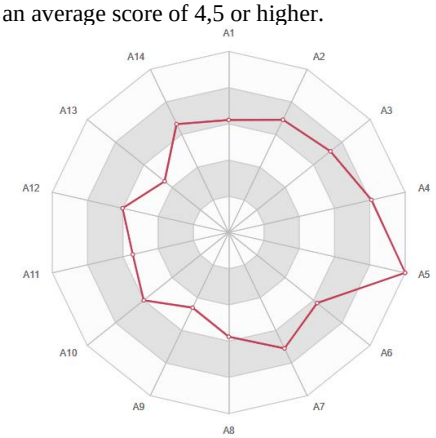

Figure 6, Radar chart of the average score for ND group Development

The total average score for ND group development is 1,99, which fits into Level 2, learners. Taking a deeper look at each Aspect provides us with clear information regarding the company's position on the scale of Industry 4.0 readiness. To a certain extent, the majority of the aspects retain similar scores, which deviate from 1.8 to 2.2. The highest scored aspect is Marketing (3.04), which means that the company utilizes the marketing potential of Industry 4.0 technologies to the level of Semi-advanced leaders. However, some of the aspects are falling behind the average numbers: A13 (Production & Process) has the lowest score – 1.37. A9 (Sustainability) is quite low as well, it scores only 1,4.

During the preliminary discussions of the scan results with one of the employees, she said that digital marketing plays a crucial role in the company’s strategy due to high market competition. Low scores on Production & Process were explained as the construction process involves various technologies and other organizations, which are equally important for the final output so it is difficult to invest in research & development of all the elements of the value chain. This statement supports the research of Hampson et al. (2015), discussed in the Introduction section. Regarding the low Sustainability score, the manager said that this policy is not yet powerful enough in Ukraine to be a subject of high-priority.

5.3 Aspects analysis

In this section, I'm going to analyze the results of the Smart Scan for the case study company based on the knowledge obtained from the literature review and discussing the Scan with the employees. Additionally, I’m going to add notes collected during the workshop for the sake of clarification of some of the results.

***Strategy* (1.89):**

After reviewing the results for this aspect, it becomes clear that, on the one hand, majority of top-level employees perceive the necessity of the Industry 4.0 implementation, but on the other hand, there is no clear vision of how the concept should be approached, nor is the company investing or has a separated budget for the Research & Development. For example, Question 1 scores 3.06, which means that employees of the company perceive Industry 4.0 as a potential source of competitive advantage and value creation, whilst Question 5 has the lowest score in the strategy aspect – 1.44, which stands for the coherent digital strategy level. Such differences in scores can be treated as the signal of a low level of fostering the adoption of Industry 4.0 from the Directors' perspective.

***Employees* (2.1):**

Aspect 2 sheds light on the current state of Industry 4.0 acknowledgment within the organization's community. In general, the results of this aspect support the Strategy results and indicate low awareness of Industry 4.0 technologies and support the main Industry 4.0 challenges defined in the Theoretical framework section. Besides that, Question 4 has the highest score (2.69), which means that employees meet frequently to discuss new events in the industry. At the same time, other results imply that employees don't have a standardized platform for such a discussion. The digitalization and Virtualization cluster from Osterreich’s (2019) framework proposes the introduction of mobile computing technologies in order to improve communication and collaboration within the organization.

***Management & Leadership* (2.186):**

The lowest scored questions in this aspect are questions about fostering the usage of Industry 4.0 techniques in day-to-day activities (Q2 - 1.88) and the question about the usage of data analytics in decision making (Q4 – 1.88). If the organization desired to improve the decision-making process, Big Data technologies could be implemented. Another feature of such a solution is its horizontal integration, which enables all the

employees to gain access to the data and, thus address the issue of collaboration. A Building Information Modelling (BIM) could be used as well since it allows to create simulations of a construction project and test it with different external factors and threats, and therefore, improve the decision-making.

***Organizational culture & Knowledge* (2.44):**

Question 1 (3.5) indicates a high level of organizational adaptivity, which can be explained by an unstable political and economic situation in the country. Since 2004, Ukraine has been through two political revolutions and two economic crises. Employees of New House believe that their ability to adapt to the rapidly changing environment is a core trait that any Ukrainian construction company must possess. According to Erol et al (2016), during the adoption of Industry 4.0, organizations might need to adapt their business models in order to strengthen the value chain. Question 2 (2.06) could be addressed by offering employees relevant training and seminars on the topic of Industry 4.0.

***Marketing & Sales* (3.04):**

Marketing is an aspect the company has heavily invested in. The chief marketing manager of the organization believes that due to construction market saturation and tight economic conditions, this department is crucial and deserves higher investments comparing to the other departments. This aspect has the highest score of the Scan, which supports the idea that investing in Industry 4.0 technologies pays off.

***Customer services* (1.9):**

The results of these aspects could be biased due to the universal nature of the SIMS scan. Employees of the company admitted, that Question 4 (1.31), which has the lowest score among all the aspects, is hardly relatable to the needs of the construction industry since it is about technical maintenance of the organization's products, which is not feasible in their case. Additionally, 62% of respondents scored Question 1 (usage of Industry 4.0 technologies for customer services) as 1 out of 5, although the questions on the online presence and the website of the company scored substantially higher. **T**hat can be explained as low awareness of the employees regarding the dimensions that the term Industry 4.0 is comprised of.

***Channels* (2,16):**

This aspect represents the degree to which the organization is able to communicate with the customers via different mediums. Questions that scored the lowest are Question 2 (1.75) and Question 3 (1.81). These questions test the ability to use collected data for the sake of improving customers' satisfaction. It is clear that given the maturity level of the organization (Learners), currently Big Data and the Internet of Things technologies are not employed, and the only data that gets analyzed are the website and social media customers' activity.

***Institutional awareness* (1.75):**

The legal aspect scored lower than other aspects of the organization due to its low utilization of the technologies that might require specific legal actions to be undertaken. On top of that, Ukraine is not covered by the GDPR regulations and the current state of affairs in this domain is far from European countries. Additionally, products of construction companies are mostly apartments or commercial premises, that are not covered by intellectual property. As a result, legal department employees found it difficult to objectively assess the organization in this respect. On top of that, Industry 4.0 is mainly focused on cyber-physical-systems, so socio-cultural dimensions are researched to a lower extent.

***Sustainability* (1.4):**

This aspect has the lowest score for the organization. The organization is not utilizing 4.0 technologies that would require a specific sustainability strategy, and from the words of the employees, the current sustainability legislation framework is "dead" and simply neither works nor being controlled by the authorities. ND group development only uses basic recycling of the construction wastes, as well as their competitors and the majority of the market players.

***Inbound logistic activities* (1.83):**

Results for this aspect clearly show that the organization doesn't utilize the option of collaborating with its suppliers in order to enhance the value chain. 75 % of the respondents scored Question 1 (1.56) – cooperation with suppliers, as 1/5**.** Industry 4.0 offers technologies of inventory management (Radio-Frequency-Identification), Osterreich et al (2019), that allow to establishment lean inventory approach, e.g. order building materials just in time. During the workshop, it has been said that logistics don't have a strategic value for the organization since the organization has highly trusted and established relationships with its suppliers, so the suppliers are keeping track of the materials by themselves.

***Outbound logistic activities* (1.65):**

This sector has one of the lowest scores since outbound logistics is not part of the construction business, thus, this aspect was difficult for the employees to evaluate.

***Products & Services* (1.83):**

Low results in this aspect show that the organization is not utilizing or collecting customer data sufficiently. That has been explained by the fact, that ND group development doesn't possess appropriate modeling frameworks to use the data as input. Secondly, Question 1 (1.26) shows that the current state of technologies doesn't support product servitization, although the organization is seeking for solutions in this domain. For the next project, they are considering to introduce an apartment type with customizable planning. That would allow them to attract a type of customer, that likes to co-operate with a product's manufacturer.

***Production & Process* (1.378):**

The production aspect has the lowest score in the scan for a number of reasons. First of all, manpower remains the main tool in the field, since more advanced machinery is either too expensive or immature for mass production and exist only as prototypes. Secondly, the organization is not using modern construction machines with sensors, since they find them too costly for an SME. Contrary, most of the machines used in the field are rented out from other organizations or those are old broken machines that have been fixed. Surprisingly, the organization did not find this aspect strategically important, because "there is no need to upgrade the tools if they suffice our needs yet". Nor found they beneficial to invest in new types of machines from the long-term perspective.

***IT management* (2.02):**

The results support the previous conclusion regarding little-to-no utilization of collected data for decision-making and future products/services improvements. Again, the organization doesn't have a developed IT framework that would be implemented throughout the value chain.

5.4 Follow-up workshop

After the scan was filled in, I conducted a workshop with employees that took part in the scan. I decided to conduct the workshop in a semi-structured manner because I didn't what to constrain the employees with a frame and the goal was to let the express their opinions on the topic of Industry 4.0. To begin with, I did a short presentation on what Industry 4.0 means for the industry, what possible technologies are, and what challenges construction companies usually encounter. The presentation was requested by the organization in order to clarify the subject matter of the discussion. Afterward, I briefly presented the results and proposed Industry 4.0 technologies that could be used if the organization found it necessary to improve the situation of certain aspects. The next step was a discussion of each aspect of the Scan. From my observations, some of the aspects were much more appealing to the audience while some of them were only

briefly discussed. The hottest topics for discussion were Strategy, Employees, Management & Leadership, Organizational Culture, and Marketing & Sales. In general, I received positive feedback on the Scan as a concept, although some of the aspects didn't match the exact needs of the industry. Additionally, the SIMS scan was mentioned as a useful tool not only for the maturity level measurement but also as an instrument for checking the current state of affairs in the organization and giving an overview of business departments. At the end of the workshop, I presented the Three-Stage transformation model, that summed up our conversation and gave a practical approach of moving towards Industry 4.0.

Adoption challenges

The main reasons why the organization hasn't developed a coherent digital strategy can be defined as:

- *Short-termism* – currently, the main goal of the company is surviving rather than development, due to the economic situation. This approach prevents them from making long-term plans and allocates finances towards technologies that can provide them with a competitive advantage in the long run;
- *Resistance to change* – construction industry is notorious for its non-desire to change things that are not required to be repaired urgently, and the case company is a representative example of such an organizational mentality;
- *Financial constraints* – this aspect is tightly interrelated with the short-termism concept, as a very limited budget makes the organization to trade-off between day-to-day needs and long-term plans. As a result, the organization is stuck in the loop of not investing in technological development because of being constantly short on budget, and, at the same time, not increasing sales margins, and therefore, budgets, due to low investment in new technologies that might lead to improvements of efficiency of the business processes;
- *Vertical cooperation* – during the workshop, it was revealed that many employees of the organization have thoughts on how technologies 4.0 could be implemented in regard of their departments, or at least, discussed with other colleagues, but the innovative behavior wasn't fostered by the directors, so the voices remained silent. Nor has been created a communication mechanism between hierarchical levels, that would help to collect and organize these innovative ideas;
- *Lack of standards* – the subject matter requires in-depth research because the main SME competitors of the organization barely adopt Industry 4.0 technologies either. The only companies that successfully benefit from I 4.0 are large construction organizations, which can't be used as a role model due to huge budget gaps between SMEs and large enterprises;
- *Economic environment* – this issue is tightly linked to other reasons that prevent the organization from adopting new technologies since high external environment feeds the "surviving" organizational culture and hinders international partners to invest in Ukrainian business.;
- *Low technological awareness* – similar to the lack of standards issues, the organization is not fully familiar with all possible options. Whilst the proposed framework could be used as a good starting point, personnel training or professional seminars could strengthen the company's vision;
- *Lack of strategic vision* – employees in charge of decision-making lack on a clear long-term understanding of the subject matter, which, therefore, hinders the innovative potential of lower hierarchical layers.

Overcoming these challenges should substantially ease the transition towards technological development.

Industry 4.0 anticipation

Before conducting the scanning, the organization wasn't going to directly invest in the Industry 4.0 due to its low awareness of the potential benefits. Based on the workshop's results, ND Group Development considered the Industry 4.0 as the opportunity to improve its long-term planning strategy, create a horizontal integration across the business departments. Secondly, the company emphasized the importance of implementing a BIM system, that would allow every employee to have direct access to the project information, keep track of interrelated business processes. On top of that, the company struggles with a large amount of paperwork that substantially hinders the speed of decision making and doesn't allow them to view a construction project as a solid living organism, especially concerning financial and project management departments. A BIM or ERP system would enable them to make changes in some project parts on go and see how these changes can potentially affect other dimensions of the project.

Industry 4.0 anticipation Strategy

A combination of the SIMS Scan (Ungerer, 2019), the Three-Stage transformation model (Erol at al., 2019), and the theoretical framework, that represents possible technological options to choose from was approved a real practical foundation for anticipation Industry 4.0 revolution. Results of the Scan and the first step of the Three-Stage mode should provide the organization with information, to begin with, the Industry 4.0 journey. After the weak spots of the organization are defined, the sea of Industry 4.0 technologies is explored, and technologies that fit the company's needs are chosen, the organization can start drafting roadmap strategies, considering short-, mid-, and long-term goals, as well as Process, Product, Market, and Network dimensions. After the strategies are weighed against possible risks and constraints, the best strategy should be chosen and the implementation should be started.

Besides the direct anticipation strategy, the organization has to consider the social aspect of Industry 4.0. Organizational culture should be changed towards personal innovative behavior. It would be beneficial to create a communication platform, where employees could propose and discuss ideas, championing, and killing the strongest and the weakest ideas respectively. Moreover, the SME context of the Industry 4.0 anticipation requires collective efforts and collaboration of nearly all employees in order to overcome the financial barrier and successfully progress in technological respect. On top of that, the CEO of the organization or other person in charge of strategic decision-making has to create a strong vision and guide the organization through the Industry 4.0 journey.

6. DISCUSSION

In this section, the theoretical findings are compared with the practical results, based on the application of the SIMS scan and the following workshop with a case study company.

6.1 Theoretical implication

The main aim of this research was to provide practical insights on how small and medium enterprises can successfully anticipate Industry 4.0 in Ukraine. In order to answer the research question, I created a theoretical framework of the current state of Industry 4.0 technologies in the construction industry, Industry 4.0 development in Ukraine, and what strategies have already been applied for Industry 4.0 to be adopted. Afterward, the conceptual

framework was created, which was based on the Smart Industry Scan by Ungerer (2019) and the Three-Stage-Transformation Industry 4.0 Model by Erol et al. (2019). Combining these models provides small and medium construction enterprises with a starting point in the Industry 4.0 journey. In order to validate the findings, a case study company scanning was conducted, accompanied by a workshop, where the results were discussed.

The case study generally supports the theoretical findings of the main challenges for construction SMEs in Industry 4.0 adoption, what technologies could be beneficial for the industry, and what the current state of Industry 4.0 in Ukraine is. I'd like to emphasize the importance of the social aspect of Industry 4.0 adoption since this aspect wasn't covered much in the literature I've reviewed for this research, whilst practical part of the research has shown its importance. Although Industry 4.0 deals mostly with Cyber-Physical Systems, the technologies are being adopted and used by human beings. Thus, many human factors, such as resistance to change, short-termism in behavior, organizational culture, incentivization of innovation behavior, and the importance of strong leadership can be overlooked. Another reason why SMEs might struggle to standardize Industry 4.0 transition can be the uniqueness of every organization and its value proposition, which is affected by multiple external and internal factors, from economic factors to personal risk-taking acceptance of the top management. Although every company requires a customized approach, the proposed framework can be used as a solid practical foundation for low maturity level construction SMEs to begin or continue the Industry 4.0 journey.
Additionally, the Smart scan developed by Ungerer (2019) was found beneficial not only as a maturity assessment tool but also as a driver of discussions within the organization. Moreover, I received valuable feedback on how the SIMS scan could be tailored for the construction sector assessment.

6.2 Limitations and future research

Unfortunately, due to the pandemical complications, I managed to collaborate with only one construction SME. Although 18 employees agreed to take part in the scanning and the following workshop, the collected data is not sufficient for drawing a generalized conclusion. On top of that, due to the novelty of Industry 4.0 in the construction context, implementation of the technologies requires a customized approach, since different companies are on different maturity stages and perceive the value chain differently. In future research, I'd like to apply the combination of the Smart Scan, Three-Step Industry 4.0 framework, and the theoretical framework for a larger number of Ukrainian construction SMEs in order to come up with a more standardized framework which would cover more scenarios. From a scientific point of view, it would be very beneficial to work with a small or medium enterprise, that has already adopted Industry 4.0 technologies to a larger extent to compare their Scan results and organizational approach with Maturity level 1-3 companies. On top of that, it would be insightful to interview CEOs or Change managers of those companies, so they could share their experience of what challenges they encountered on the way to Industry 4.0, how they overcame them, and whether they had to deal with organizational culture resistance.
Another limitation was the universal nature of the SIMS scan. Some of the questions and aspects are not clearly relatable to the construction context and, thus need to be customized for such an application. Also, working with low maturity level organizations is more complicated, due to their low awareness of the possible technological options. From the feedback of the respondents, the results could be partly biased because of the low awareness of the concept. Additionally, inviting a large number of respondents has its limitations. A substantial amount of the employees wasn't aware of how other departments work in technological respect, so this could be another reason for the maturity level assessment to be imprecise. To improve the precision of the SIMS scan, I'd recommend creating a short introduction on the topic of Industry 4.0. The introduction could have an option to choose the industry of interest (manufacturing, steel industry, construction industry, etc.). That would significantly effective since one of my findings was that organizations might utilize certain Industry 4.0 technologies (such as Social Media, drones, mobile computing) but be unaware of its affiliation to the subject matter.

6.3 Conclusion

In this research, I set out to contribute to giving practical insights for Ukrainian construction SMEs in the adoption of Industry 4.0 technologies and overcoming main challenges that are associated with the Industry 4.0 journey. For this sake, I developed a theoretical and a conceptual framework built on the current research of Industry 4.0 in the construction context, the SIMS scan for assessing maturity level developed by Ungerer, and the Three-Stage Industry 4.0 transformation framework developed by Erol et al. Established the frameworks, they were tested with a case study Ukrainian medium construction enterprise ND Group Development. The main challenges on the way to the Industry 4.0 adoption were defined as low awareness of the concept, lack of strategic vision, constant need to balance between short-term wins and long-term improvements, turbulent Ukrainian economic environment, lack of standards within construction SMEs. Besides these factors, the social aspect of Industry 4.0 adoption turned out to be important as well. Organizational culture plays a crucial role in the ability of an organization to adopt new technologies and champion innovative behavior. Additionally, the personnel has to be guided and supported by the strong and long-term vision of high-profile employees. On top of that, it was found important for the organizations to have a proper communication platform, where the employees could share and debate on the potentially beneficial technologies and their added values in the long run. Plus, the issue of bridging innovation propositions between regular employees and the decision-makers was found vital as well. Given budgeting constraints for Research & Development and turbulent economic situation in Ukraine, the organizations have to operate as solid organisms to ease the Industry 4.0 transition.

6.4 Acknowledgments

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8. APPENDIX

8.1 Aspects results radars:

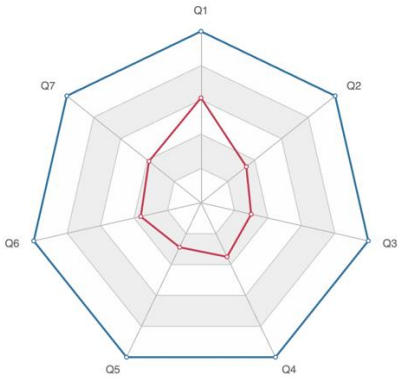

Figure 6, Strategy Aspect

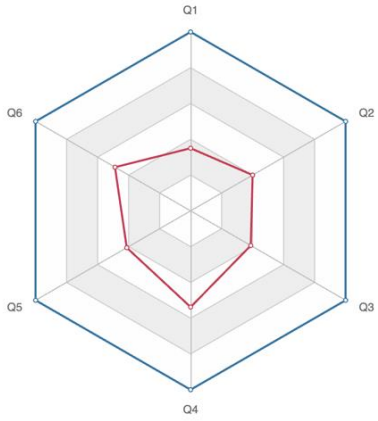

Figure 7, Employees Aspect

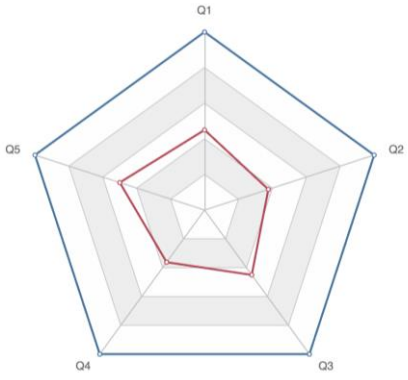

Figure 8, Management & Leadership Aspect

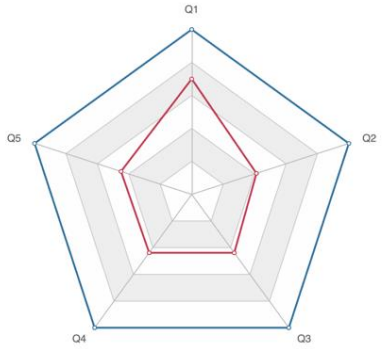

Figure 9, Organizational culture & Knowledge Aspect

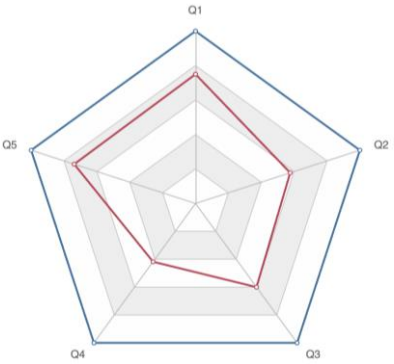

Figure 10, Marketing & Sales Aspect

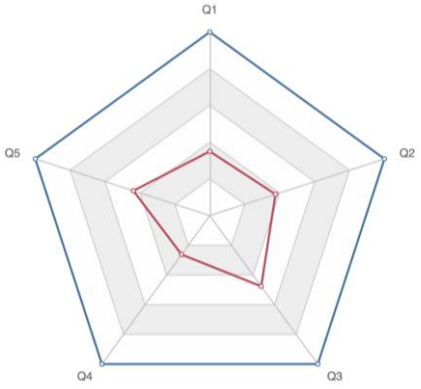

Figure 11, Customer services Aspect

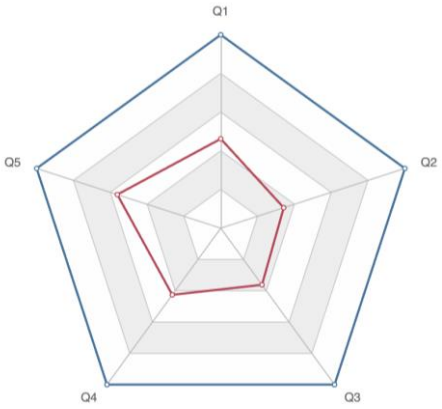

Figure 12, Channels Aspect

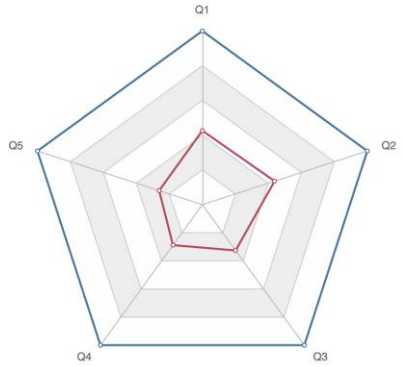

Figure 13, Institutional awareness Aspect

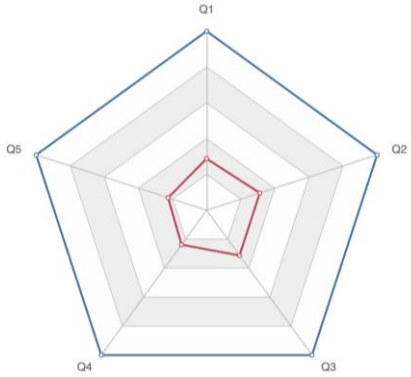

Figure 14, Sustainability Aspect

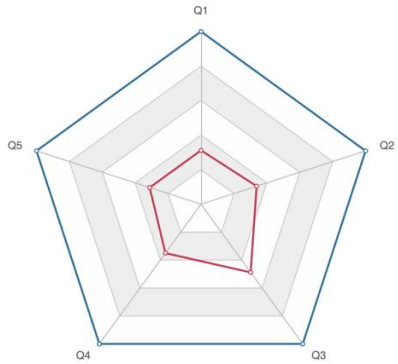

Figure 15, Inbound logistics Aspect

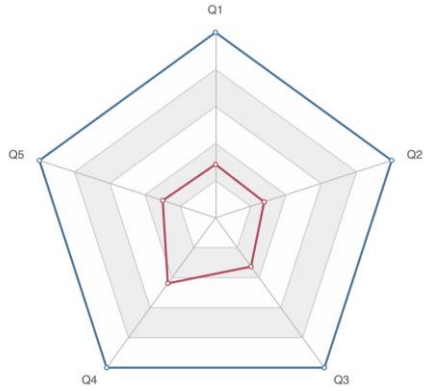

Figure 16, Outbound logistics Aspect

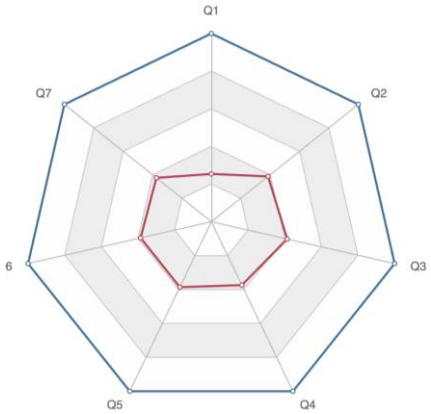

Figure 17, Products & Services Aspect

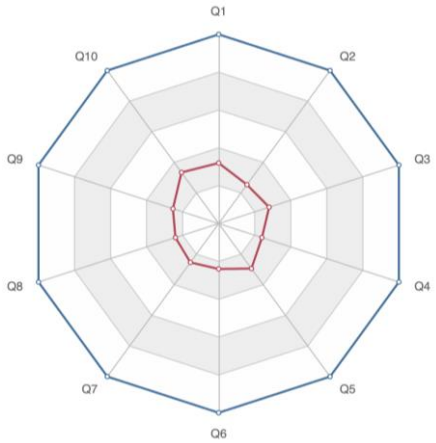

Figure 18, Production & Process Aspect

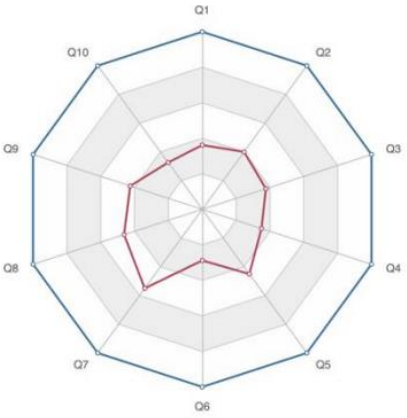

Figure 19, IT management Aspect

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