

# Implementing the Industry 4.0 concept in family firms - a case study from Poland

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**Abstract:** Family firms constitute an important element of the modern economy, combining the values of tradition, intergenerational continuity, and social responsibility. Their activities are often characterized by a conservative approach to strategic decision-making and a cautious attitude toward innovation. However, in the face of increasing global competition and rapid technological change, maintaining a sustainable market position requires openness to digital transformation and the implementation of the Industry 4.0 concept. Industry 4.0 represents a new paradigm of business activity, combining digital technologies and the Internet with conventional manufacturing processes, in order to enhance their efficiency and flexibility. The aim of this paper is to analyze the implementation of the Industry 4.0 concept in a medium-sized family enterprise located in north-eastern Poland. Over its more than forty-year history, the company has undergone a profound transformation from a manufacturer of simple metal products and agricultural tools, through a producer of cable connectors for the shipbuilding industry, to a specialized supplier of components for the aviation, automotive, and railway sectors. In recent years, the company, supported by grants from European Union funds, has established an R&D department as well as a Center for Robotics and Automation, forming the foundation of its digital transformation process. The results of the study indicate that the implementation of Industry 4.0 solutions has contributed to strengthening the company's competitive position and facilitating its expansion into international markets. The key determinants of success were effective intergenerational succession, the pro-innovative attitudes of family members, and cooperation with universities and research entities.

**Keywords:** FAMILY BUSINESS, INDUSTRY 4.0, INNOVATION, MANUFACTURING SECTOR

## 1. Introduction

Family firms constitute an important component of the contemporary economic landscape and predominant form of business activity. They substantially contribute to GDP growth, provide a significant share of workplaces and foster economic stability, while also sustaining long-term business values [1]. Family businesses represent a unique combination of tradition, intergenerational continuity and social responsibility. By mixing family and business aspects, they create an organizational form characterized by distinctive dynamics and management style [2].

Family firms are often deeply rooted in tradition and focused on long-term goals. This can result in a conservative approach to strategic decision-making and cautious attitude towards radical change. However, these entities also face various external shocks (e.g. the coronavirus pandemic), rapid technological progress and strong global competition, which means that innovation is no longer an opportunity for family firms, but rather a necessity for surviving in highly competitive environment and ensuring business continuity across generations. For this reason, managing the tensions between tradition and innovation seems to be one of the most challenging tasks for family businesses [3, 4].

One of the most promising paths for the transformation of family businesses is the implementation of Industry 4.0. This new paradigm of business activity integrates digital technologies, automation, and the Internet of Things (IoT) with traditional manufacturing processes to enhance efficiency and flexibility [5, 6]. However, implementing Industry 4.0 is not without its challenges. Family firms often face limited resources and shortage of the necessary skills, risk-averse decision-making, and generational differences in technological readiness, which can slow down digital transformation [7-9]. Therefore, it is important to understand how these enterprises can overcome such obstacles while leveraging their inherent strengths.

The aim of this paper is to analyze the implementation of the Industry 4.0 concept in a medium-sized family enterprise located in north-eastern Poland. Over its more than forty-year history, the company has undergone a profound transformation from a manufacturer of simple metal products and agricultural tools, through a producer of cable terminals and connectors for the shipbuilding industry, to a specialized supplier of components for the aviation, automotive, and railway sectors. In recent years, the company has established an R&D department as well as a Center for Robotics and Automation, laying the groundwork for its own digital transformation process and supporting the adoption of Industry 4.0 in other enterprises.

## 2. Literature Review

The concept of Industry 4.0 is commonly associated with profound changes in industry, also known as the Fourth Industrial Revolution, which began in many countries around the world during the 2010s [8, 10-12]. The term of Industry 4.0 was first publicly used at the 2011 Hanover Fair by a working group announcing a comprehensive project of digitization of manufacturing processes in the German economy [13].

The rise of Industry 4.0 is driven by a wide range of key enabling technologies, including: the Internet of Things (IoT), cloud technology, big data analysis, artificial intelligence (AI), simulation, augmented and virtual reality, autonomous and collaborative robots, blockchain, and additive manufacturing [14].

The widespread adoption of the Industry 4.0 concept has given rise to numerous concerns, including high investment cost of implementing advanced solutions, a shortage of qualified staff, dependence on complex technologies, high maintenance costs, and cybersecurity issues. However, family firms should seize the opportunities offered by digital transformation. In particular, they should recognize the benefits of optimizing manufacturing processes, improving efficiency, reducing operating costs, as well as increasing their flexibility and adaptability to changes in the environment [15].

A survey of 1,142 Argentine SMEs has indicated that the incorporation of Industry 4.0 tools is related to factors such as company age and size, manager gender and educational level (university degree), as well as the presence of personnel with technical training in digital technologies. However, no significant differences between family and non-family companies have been found [16]. In turn, research on 3,000 Italian family SMEs has shown that the adoption of Industry 4.0 depends on management type (family vs. non-family) and investment in R&D. Interestingly, the effect of these factors may vary depending on the geographical context (i.e., the level of regional development) [17].

The existing literature on family business also emphasizes the importance of succession and intergenerational involvement for technological innovation. In general, the presence of multiple generations in a company positively influences the propensity for innovation and new technology adoption [18-19]. However, the results of the research in this area are not entirely consistent [20-21].

### 3. Methodology of the Research

The study adopts a qualitative orientation and employs the case study method, which is commonly used in management sciences. This approach is particularly useful for analysing complex socio-economic phenomena and explanatory research issues [22].

For the purposes of this analysis, a medium-sized family enterprise located in north-eastern Poland was selected. The company has successfully undergone digital transformation and adopted the Industry 4.0 concept. It provides an instructive example of the evolution of a family-owned enterprise operating under the changing socio-economic conditions in Poland over the past several decades.

Information concerning the company's activities was obtained from various sources, including available company materials, press and media publications, patent databases, and registers of research projects.

## 4. Results

### 4.1. History and Characteristics of the Surveyed Company

The company was established in 1981 after its founder, formerly a technical director at a state-owned factory, had been dismissed from his job for political reasons related to his involvement in the Solidarity movement. Driven by the need to provide for his family, he set up a small metal workshop, initially producing small heating stoves and basic agricultural tools (e.g. pitchforks and hoes). However, this activity offered limited opportunities for growth.

A key strategic shift occurred when the founder used his previous professional contacts in the shipbuilding industry. Recognizing a domestic shortage of cable connectors - a vital component in marine and electrical installations - he moved the company to a more specialized and higher-value area of production. Despite the restrictive political conditions and resource constraints, the new products successfully met industry quality standards. This transformation turned the company into a specialized manufacturer of electrical installation equipment. In next years, the founder's brothers joined the business, further strengthening the company's family roots.

During the period of political transformation and market liberalization in the 1990s, the company expanded its product portfolio and systematically built its market presence. Improvements in product quality, coupled with proactive participation in trade fairs, supported customer acquisition and contributed to brand strengthening. A turning point came in 2000 with the unexpected death of the company's founder. Following a sudden succession process, his thirty-year-old son, a graduate engineer, became the company's CEO. Under his leadership, the company placed a stronger focus on innovation, internationalization and modern manufacturing technologies. Access to European Union funds enabled investments in new production halls and the development of advanced product lines.

**Table 1:** The main areas of company's activity

Division	Description
ELECTRO	products dedicated to electrical installers, power companies and industrial enterprises: tools, equipment, and accessories, busbar and mounting rails, cable terminals and connectors
AERO	manufacturing parts from difficult-to-machine metal alloys for the aerospace, medical, and military industries
ROBOTICS	designing and building devices and lines to automate and robotize production processes

Currently, the company employs over 200 highly qualified staff and is managed by a four-person team of second generation family-members. Its products are sold to clients in dozens of countries

around the world, including global corporations operating in the aerospace, automotive and power engineering sectors.

### 4.2. Towards Industry 4.0

The company began its transformation towards Industry 4.0 at the start of the 21st century. At that time, the young successor initiated the purchase of the first CNC machine. This decision initiated a continuous automation process, largely based on projects designed and built in-house. One of the first such solutions was a machine created for producing cable connectors. The chosen strategy focused on creating smart, well-designed systems that increased operational efficiency, reduced the risk of errors, and enhanced occupational safety. Further improvements in subsequent years enabled the company to enter into challenging areas such as the production of difficult-to-machine alloys for the aerospace industry, including components for aircraft engines.

The company has also expanded its operations to encompass the design and construction of automated machinery and production lines. On the one hand, this was a rational application of many years of engineering expertise, and on the other - a response to the growing market demand driven by dynamic industrial transformation. The company's offer is aimed at both large international corporations seeking solutions to unusual operational problems, as well as at small and medium-sized enterprises willing to strengthen their competitive position through automation. In the latter case, the company recognizes that small firms often face barriers related to limited resources and insufficient technological expertise. Therefore, the scope of services provided for this group covers the comprehensive support, including needs assessment, the design and construction of customized solutions, implementation, and advice on obtaining funds.

Another important stage in the company's development was the construction of the modern factory facilities, equipped with mobile robots for internal transport, automated stations for hazardous or burdensome tasks, and solutions that improve ergonomics and workplace safety. Environmental sustainability was also prioritized: gas-based soldering processes were replaced by photovoltaic-powered technologies. This investment project was carried out between 2020 and 2022. In addition to production and warehouse spaces, the facility houses a research and development centre that conducts projects in industrial automation and robotics. The centre also supports the training of in-demand specialists, including CNC machine operators.

The company actively promotes the idea of Industry 4.0 by organizing industrial conferences, that provide a platform to exchange experiences among business practitioners, technology partners and experts. It also collaborates with the research entities, particularly the AGH University of Science and Technology in Krakow, and participates in cluster initiatives such as the Evoluma Industrial Cluster.

### 4.3. Findings and Discussion

The transformation towards Industry 4.0 is not a distinct endeavor but rather a cumulative, multi-stage process that requires strategic coherence, organizational learning and the ability to align technological initiatives with market opportunities.

The results of the research indicate that the implementation of Industry 4.0 concept can contribute to strengthening company's competitive advantage as well as to facilitating its expansion into global markets. However, the successful digital transformation of the family business requires a shared vision among family members of various generations. Therefore, careful succession planning is a crucial for ensuring continuity of leadership, maintaining organizational stability, and facilitating successful knowledge transfer across generations. In addition, a proactive and innovation-oriented attitude among family members is crucial, as investment in new technology shapes a culture of risk-taking, experimentation and seeking for continuous improvements.

In the case of the studied company, the internal readiness for innovation was also reinforced by collaboration with research institutions industrial partners. This highlights the potential synergy between family governance, innovation-oriented organizational culture, and external knowledge networks, which collectively influence the successful digital transformation of family firms.

## 5. Conclusion

This paper contributes to the growing body of research on digital transformation in family firms by demonstrating how the unique characteristics of these organizations (e.g. long-term orientation and intergenerational continuity) can facilitate rather than hinder the adoption of the Industry 4.0 concept. The results of the study emphasize the vital role of innovation-oriented organizational culture and intergenerational knowledge transfer in supporting technological progress. The study also highlights the importance of sourcing external knowledge, suggesting that extensive collaboration with research institutions and industrial partners affects the innovation readiness of the enterprises.

The study also offers some recommendations for business practitioners. First, family firms should aim to develop a shared vision for their future and clearly communicate their goals related to technological transformation. Second, it is also important to encourage an attitude of innovation among family members and managers, fostering a culture that supports risk-taking and continuous learning. Third, forming strategic partnerships with research entities should accelerate the adoption of new technologies and reduce the risk of failure.

However, the study is not without limitations. The research focuses on a single company, which means that the results cannot be broader generalized. Moreover, it is largely based on qualitative data, which may contain some degree of subjectivity. Future research should therefore include multiple comparative case studies and quantitative research assessing the impact of Industry 4.0 tools on the performance of family firms. It may also be interesting to investigate how cultural and sector-specific factors influence the digital transformation of family businesses.

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