

HUMAN CAPITAL IN CREATING TECHNOLOGY ENTREPRENEURSHIP OF ORGANIZATIONS

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Purpose: The purpose of the present paper is to identify and evaluate the role of human capital in creating technology entrepreneurship within organizations operating in entirely new circumstances.

Design/methodology/approach: In this article the qualitative method was used. Case studies of three photonics enterprises were evaluated. They are the top firms in this part of the high-technology sector. The employees of these firms have core competences and higher education degrees. Many of them are former scientists.

Findings: The Covid pandemic has had a certain impact on disrupting the operation of high-tech companies' supply chains. On the other hand, however, the threat of an international armed conflict caused by the aggression of the Russian Federation against Ukraine resulted in many competitors leaving Russia and Ukraine, which creates an opportunity for the studied companies to develop the "liberated market area" and, consequently, to expand into new markets.

Originality/value: Unexpected events like the COVID-19 pandemic, conventional armed conflict may constitute a special opportunity in the context of developing technology entrepreneurship within an organization.

Keywords: intellectual capital, human capital, technology entrepreneurship, "black swans".

Category of the paper: research paper.

1. Introduction

The technological development of organizations is largely determined by the entrepreneurial behavior of their employees, which results in technology entrepreneurship, enabling the use of opportunities in the organizations' surroundings. An organization's human capital which may become the source of innovation in enterprises and/or on the market is one of the key factors determining the effectiveness of technology entrepreneurship.

The events of the last few years have fundamentally reevaluated our thinking about contemporary organizations and contributed to establishing new rules of the game. The COVID-19 pandemic and the subsequent outbreak of a full-scale conventional armed

conflict caused by the aggression of the Russian Federation against Ukraine forced organizations, including their employees, to completely new behaviors and a different way of functioning. They were often an impulse to spark new activities and use new reserves of energy that had previously been, as it were, dormant.

The purpose of the present paper is to identify and evaluate the role of human capital – the main component of an organization’s intellectual capital – in shaping an organization’s technology entrepreneurship under completely new conditions. The impact of unexpected events, frequently referred to as “black swans” on employees’ entrepreneurial behavior, including creativity and innovativeness, is difficult to overstate. In this article the qualitative method was used. Case studies of three photonics enterprises were evaluated. There are the top firms in this part of high-technology sector. The employees of mentioned firms have core competences are high education degrees. Many of them are the former scientists.

2. Human capital in an organization as a component of intellectual capital

Intellectual capital is a concept which is not clearly defined within management theory, even though many different concepts of definitions have appeared. In economics, capital signifies an asset that brings added value in the form of industrial or commercial profit. Intellect, mind, reason, intelligence (as opposed to feelings, will, senses) - the sum of a person's mental abilities, experience and knowledge. Intelligence in mental terms is the ability to understand and associate; competence, acumen, the ability to find appropriate, purposeful responses to new tasks and living conditions, to efficiently acquire and use knowledge (Mroziewski, 2008, pp. 26-27). Capital can be classified according to different criteria: ownership rights, the capital’s location, or the types of funds. Selected proposed definitions of intellectual capital are presented in Table 1.

Table 1.
Intellectual capital. Overview of selected definitions

| No. | Author | Concept definition |
|-----|-------------------------------|---|
| 1 | Bratnicki M., Strużyna J. | Intellectual capital is the sum of knowledge possessed by the people who make up the enterprise's community and the practical transformation of this knowledge into the components of its value. It includes all unmeasurable elements that determine the difference between the total value of the company and its financial value. |
| 2 | Bukowitz W.R. Wiliams R.L. | Intellectual capital is a form of intangible asset that has the potential to create greater wealth through knowledge flows. Its three basic components are: human capital (individual capabilities of people and employee teams - meeting customer needs, competences, mental models), customer capital (strength of relationships with the customer), organizational capital (organizational ability located in codified knowledge coming from all resources - database data, processes, technical infrastructure, culture, norms and values). |

Cont. table 1.

| | | |
|---|--------------|---|
| 3 | Edvinsson L. | Intellectual capital is the knowledge, experience, technology, customer relations, and professional skills that give an organization a competitive advantage on the market. In other words, it is knowledge that can be converted into value. |
| 4 | Steward T.A. | Intellectual capital is the knowledge, information, intellectual property and experience that can be used to create wealth. It's something you can't touch but which can make you rich. |

Source: Developed based on (Chyba, Grudzewski, 2011, p. 129; Jurczak, 2006, pp. 40-41; Bratnicki, Strużyna, 2001; Bukowitz, Williams, 2000; Edvinsson, Malone, 2001; Steward, 2001).

One of the main components of an organization's intellectual capital is the human capital it possesses. This consists of the employees' knowledge, skills and experience as well as their creativity and entrepreneurship, particularly under the conditions of elevated uncertainty and risk which we encounter in today's world. These conditions are further exacerbated by unexpected event, mostly with negative impacts, referred to as "black swans". Such events will be described in more detail further on in the present paper.

The two basic categories of methods of measuring or at least estimating an organization's intellectual capital are quantitative and qualitative methods. In the opinion of M. Mroziewski, individual components of intellectual capital, including human capital, can be assigned specific qualitative indicators (Mroziewski, 2008, pp. 63-64). Table 2 presents the components of human capital together with their qualitative indicators.

Table 2.

Elements of human capital and their indicators

| Elements of human capital | Intellectual capital component indicators |
|----------------------------------|--|
| Employee competences | <ul style="list-style-type: none"> • management's strategic leadership; • employee quality; • employees' ability to learn; • employee training effectiveness; • employees' capacity to take part in policymaking and management; • training of key technical employees and managers |
| Employee attitude | <ul style="list-style-type: none"> • identifying with the values of the enterprise; • degree of satisfaction; • employee turnover rate; • average useful life (usefulness) of employees; • reactions to conditions of elevated uncertainty and risk; • the impact of unexpected events, so-called black swans. |
| Employee creativity | <ul style="list-style-type: none"> • employees' creative ability; • revenue from employees' original ideas; • employees' technology entrepreneurship. |

Source: developed based on (Mroziewski, 2008, p. 63; Chen, Zhu, Xie, 2004, pp. 195-212).

Competences include the employees' knowledge, skills and competences, which are the so-called "hard" portion of intellectual capital. Knowledge consists of technical and academic (theoretical) knowledge, acquired mainly through the process of education and therefore mainly theoretical in character, and qualifications and skills, acquired mainly through practice.

Employee attitudes constitute the so-called soft components of intellectual capital and include motivation to work and the satisfaction derived from work. Attitudes are a prerequisite for freeing up the workers' skills. What should be pointed out at this juncture is the employees'

reactions to contemporary economic conditions, characterized by increased uncertainty and risk.

Creativity is considered a key factor in the development of an enterprise's intellectual capital, enabling employees to flexibly use knowledge to continuously create innovations. The effect of this creativity may be the entrepreneurial attitudes of employees and entire organizations, which may result in the phenomenon of technology entrepreneurship as a special opportunity to use the opportunity offered by broadly understood scientific and technological development. This phenomenon will be presented more extensively further on in the present paper.

3. Technology entrepreneurship, its levels and conditions

Technology entrepreneurship is interdisciplinary and multi-faceted in character and can be considered both at the level of individual initiatives and innovative undertakings in the organizational dimension. It is a phenomenon that still arouses wide interest, both among theoreticians and researchers of management and quality science, as well as managers and practitioners. Even though "Technology entrepreneurship" is a term which has been present in the world literature for several decades, the number of publications on the subject did not increase significantly until the second decade of the 21st century (Chyba, 2021, pp. 62-65). The theoretical foundations of the concept appeared in "Technology Entrepreneurship", a special issue of Strategic Management Journal from 2012, edited by Ch. Beckman, K. Eisenhardt, S. Kotha, A. Meyer and N. Rajagopalan. (Beckman, Eisenhardt, Kotha, Meyer, Rajagopalan, 2012; Kordel, 2018, pp. 9-10). Attempts to define the concept were also presented by T. Bailetti (2012, pp. 2-25). The subject of technology entrepreneurship was also undertaken in many other papers, including by S. Muegge (2012, pp. 5-16), T. Bailetti et al. (2012, pp. 28-34). In recent years, many publications on this subject have also appeared in Polish. An overview of selected definitions of technological entrepreneurship is presented in Table 3.

Table 3.

Technology entrepreneurship. Overview of selected definitions

| Authors | Definition |
|--|--|
| Ch. Beckman, K. Eisenhardt, S. Kotha, A. Meyer, N. Rajagopalan | Technological entrepreneurship occurs when advances in science or engineering create a key element of an opportunity that then forms the core of a new venture, product or service, enterprise or even an entire industry. |
| P. Kordel | The central role in the phenomenon of technological entrepreneurship is played by technological opportunity, i.e. an entrepreneurial opportunity based on the development of technology. The process of technological entrepreneurship consists of the stage of formulating a technological opportunity and the stage of its exploitation. |

Cont. table 3.

| | |
|---------------------------------|--|
| W. Grudzewski, I. Hejduk | Technological entrepreneurship is a prerequisite for the success of an enterprise. It signifies the process of creating new products, using modern technologies, reacting flexibly to changes on the market, as well as introducing innovations in all areas of the company's operation, as well as at its subcontractors. |
| S. Flaszewska, S. Lachiewicz | The process of ensuring greater practical utility of scientific research results through effective cooperation between research and research and development centers, capital market institutions and the surroundings of business, as well as enterprises involved in the production and sale of technologically advanced products or services. |

Source: own development based on (Chyba, 2021, p. 64; Beckman, Eisenhardt, Kotha, Meyer, Rajagopalan, 2015; Kordel, 2015, pp. 271-282; Grudzewski, Hejduk, 2008; Lachiewicz, Matejun, Walecka, 2013, pp. 15)

Technology entrepreneurship is most applicable to high-tech industries, although it can also be applied to traditional industries. It is a process consisting of entrepreneurial actions by an innovation leader, team members, and members of the entire organization. It is a special process that is characterized primarily by creative, collaboration-oriented activities or processes, innovation, a willingness to take risks, and a positive orientation on their results, primarily for social benefit.

4. Research methods. Characterization of the study sample

In this article the qualitative method was used. Case studies of three photonics enterprises were evaluated. There are the top firms in this part of high-technology sector. The employees of mentioned firms have core competences are high education degrees. Many of them are the former scientists.

The mentioned challenges of the modern world caused significant re-evaluations in the functioning of enterprises. This applies in particular to academic enterprises operating in the high-tech sector. The effects of these challenges will be shown using the example of organizations from the photonics industry (Chyba, 2023, pp. 79-83; Chyba, Wachnik, Adamiak, 2023, pp. 293-305).

Company X was founded in 1987 by a group of scientists from the Military University of Technology. It is an innovation enterprise operating in the high technology sector. It makes use of its own research and development resources. The company's customers are industrial enterprises that manufacture their own products based on its output and the research sector, which constructs scientific equipment. This last group includes enterprises working for the military. Since the company follows a market niche strategy, its sales are conducted through an international distributors' network. Company X is a world leader in the production of uncooled photon infrared detectors. Its mission is to replace cryogenically cooled mid- and far-infrared photon detectors with new generation detectors.

Company Y was established in 1991 by employees of the University of Warsaw Faculty of Physics. It is a manufacturer of precision components, optical components and subcomponents for laser technology, medicine, lithography, telecommunications, metrology, aviation and the aviation and space industries. The company specializes in the production of prototypes and atypical precision elements (Weresa, 2007, pp. 161-165). It currently occupies a high market position, also internationally. It sells its products on practically every continent. It has no competitors in Poland and in Europe it is able to successfully compete with the best companies, manufacturing highly scientifically and technologically advanced products.

Company Z was founded in 2002 by employees of the Institute of High Pressure Physics of the Polish Academy of Sciences. He specializes in advanced laser manufacturing technologies. Like companies X and Y, it is an example of an entity with roots as an academic spin-off. The enterprise has used and continues to benefit from the help and support of so-called "Business Angels". Due to the niche nature of the business, it has difficulties in obtaining venture capital. The company has very limited possibilities of increasing the scale of production and therefore remains an entity operating in a narrowly specialized global niche. One of the contemporary challenges for Company Z is operating in the field of quantum technologies with a very high level of technology development, which in the future may contribute to the development of so-called quantum computers. The company has a stable team of top-class specialists. It is in the process of acquiring new specialists with appropriate experience in research work, preferably with at least a doctoral degree.

5. Results and discussion

Table 4 presents the characteristics of the surveyed organizations and the determinants of uncertainty in the short and long term, as well as technology entrepreneurship in the macro- and microeconomic environment and the enterprises' internal structure.

Table 4, beneath the description of the enterprises, presents a catalogue of short-term uncertainty factors, due mainly to "black swan" events treated as presenting a high degree of uncertainty, i.e. Covid and the outbreak of war in Ukraine. The synthesizing research indicates that in the short term, the occurrence of external uncertainties from Covid forced organizational changes in the field of business processes, procedures, in ways of performing tasks and in interpersonal relations. These were enforced changes aimed at adapting to new conditions, mainly in the area of supply chain management which collapsed temporarily, and the sales process. The period of the pandemic stimulated the enterprises to alter their management of highly unique and specialized human resources (Chyba, 2023, pp. 86-89; Chyba, Wachnik, Adamiak, 2023, pp. 293-305).

Table 4.*Characteristics of enterprises – conditions of entrepreneurship and employee behaviors*

| | Company X | Company Y | Company Z |
|--|---|--|---|
| Established | 1987 | 1991 | 2002 |
| Number of employees | ca. 120 | ca. 70 | ca. 25 |
| Company profile | The enterprise produces primarily MOCVD (Metal Organic Chemical Vapor Deposition) technology uncooled photon infrared detectors for industry, medicine and in the area of military technology; it conducts R&D work in the area of infrared technology. | The enterprise produces general-purpose precision optical elements. The technologies used cover the full production cycle of optical elements from almost all types of optical glasses, quartz glasses, optical ceramics and crystals. | The company produces semiconductor laser diodes that emit light with a wavelength of 400-420 nm. This technology is based on the GaN crystal growth method under high pressure developed at the Institute of High Pressure Physics of the Polish Academy of Sciences. |
| Determinants of technological entrepreneurship at the micro- and macroeconomic level | Technological progress Limitations in availability of development funding for the enterprise. Verification of the semiconductor production policy in the EU (EU Chip-act). | Limitations in availability of development funding for the enterprise. Pressure of low margins Succession related to change in company management The enterprise's place in the supply chain. | Poland lacks a laser production ecosystem; this is due to a lack of traditions in this area. Lack of funding sources for the development of enterprise. |
| Management's and staff's entrepreneurial behaviors | Employees' better understanding for intensification and consolidation of activity in the face of unexpected threats. Employees' increased involvement due to management's care for the staff. | Large consolidation, integration of activities and mobilization of the team. Employees' greater understanding of the need for personnel changes implemented previously by the management. | Increase in employee involvement in entrepreneurial activities under the influence of the situation. Employees' understanding for greater activity, while appreciating the management's efforts to maintain staff consistency. |

Source: own development based on interviews with representatives of the companies' managements, see (Chyba, 2023, pp. 85-86; Chyba, Wachnik, Adamiak, 2023, pp. 293-305).

Another issue is the entrepreneurial behavior of employees under the impact of unexpected events, known as "black swans". Here we can observe a high level of agreement in the opinions of the employees of all the enterprises. All the organizations experienced an increase in the commitment and creativity of employees, which proves they understood the seriousness of the situation. Representatives of companies X and Z took steps to protect and maintain the numbers of their employees, which the latter appreciated. In the case of company Y, in the period preceding the analyzed events, there were significant personnel changes, which contributed to the increase in technology entrepreneurship of the employees, who undertook numerous creative and innovative activities.

In the case of Company Y, the pandemic and the military threat are perceived less optimistically. Protecting workers in pandemic involved additional costs for the company. According to Company Y's president, "the pandemic hit the company hard". The potential armed conflict is perceived as more of an opportunity due to the company's cooperation with

the arms sector. The opportunity for the company is the withdrawal of its competitors from Russia and the possibility to expand operations in Ukraine. The aforementioned short-term conditions (Covid, armed conflict) prompted the company's employees to greater integration, consolidation of activities and stronger mobilization and motivation of the team. The processes of integrating employees with the organization have intensified and the understanding of the company's mission and strategic goals has deepened. The company's problem at the moment is the need for greater automation of production processes, which would enable an increase in the scale of production due to the growing demand and favorable economic conditions for the company's products.

In the case of Company Z, the impact of uncertainty in relation to the so-called "Black swans" manifested itself mainly in impeding direct physical contact with potential users of its products, which, by affecting the effectiveness of research and development activities, translated into the functioning of the supply chain and, as a result, diminished the effectiveness and efficiency of market activities. With regard to the armed conflict, in the long term Company Z sees its effects as a development opportunity. This makes Z's way of thinking similar to the previously analyzed companies X and Y. In this case, adopting the strategic perspective may increase the company's sense of uncertainty by limiting access to modern devices that use new methodologies for the use of modern technologies. This concerns primarily the uncertainty resulting from the lack of sufficient information about new devices, as well as the lack of fuller communication between the leading scientific and research centers.

Summary

Modern management, conducted in conditions of increased uncertainty, has recently become even more difficult, mainly due to unexpected events, sometimes referred to as "black swans" which belong to categories 4a and 4b of deep uncertainty. The most significant factors are the COVID-19 pandemic, which swept the world in spring 2020, and the armed conflict in Ukraine, caused by the aggression of the Russian Federation and the related threat of an international armed conflict. The entrepreneurial behavior of employees and entire organizations is the basis for the success or failure of the studied companies in the photonic industry. The senior management together with the owners of the companies was determined to undertake entrepreneurial activities in the area of reorganization of relations with employees, sales activities aimed at winning new contracts, reorganization, including the reduction of operating costs, and ensuring financial liquidity. Additionally, the increased uncertainty resulted in a greater consolidation of employee teams, and also generated additional resources of entrepreneurial opportunities and behaviors, in addition, employees were inclined to build more flexible relations with employers.

The Covid pandemic has had a certain impact on disrupting the operation of high-tech companies' supply chains. On the other hand, however, the threat of an international armed conflict caused by the aggression of the Russian Federation against Ukraine, resulted in many competitors leaving Russia and Ukraine, which creates an opportunity for the studied companies to develop the "liberated market area" and, consequently, to expand into new markets. The products of the studied companies, to large extent products of a niche character, are currently attracting increased market demand. The development of the arms industry and increasing expenditure on modernizing and arming the military creates additional sales opportunities for products manufactured by companies in the photonics industry in Poland.

The events of the last few years have allowed for the development of new entrepreneurial attitudes among employees of the surveyed high-tech companies representing the photonics industry. Understanding the seriousness of the situation, and viewing it in terms of not only threats but also technological opportunities, resulted in a greater level of workforce consolidation and a deeper understanding of the mission and shared values. The attitudes of employees who, on their own initiative, took many actions for the development of the company, often giving up their own benefits, including non-financial ones, were a kind of spontaneous test of ethical and entrepreneurial attitudes from the point of view of the company's management.

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