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TECHNOLOGY ENTREPRENEURSHIP AS A SOURCE OF MODERN INNOVATIVE SOLUTIONS

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Purpose: The purpose of the present article is to identify and assess the impact of technology entrepreneurship on the creation of product innovation of an improving nature, using the example of the products of a selected enterprise. The example used will be the process of improving a PGN-plus 80 universal gripper. This is an interesting case of improved innovative product in tradition sector of industry which causes many processes more effective and efficient.
Design/methodology/approach: In this article the qualitative method, based on case studies procedure was used. Moreover, the aforementioned challenges of the modern world caused significant realignments in the functioning of enterprises. This applies especially to academic enterprises operating in the advanced technology sector. The effects of these challenges will be shown on the example of enterprises X, Y, and Z from the photonics industry.
Findings: This relatively simple example from this article shows that even unspectacular product or process innovations play a significant role in building potential or actual competitive advantages. At the same time, it can point out the right path that companies should follow.
Research limitations/implications: The article also discusses the issue of the impact of unforeseen events of the past several years (the COVID-19 pandemic and armed conflict in Ukraine) on shaping workers' entrepreneurial attitudes and the potential to generate innovative solutions, not just of a breakthrough character but also incremental innovations leading to the improvement of existing products or processes in the spirit of the philosophy of continuous improvement.
Practical implications: In order to maintain their competitive position in the global market, enterprises must effectively and efficiently manage technological change. The ability to perceive the right time to change is a fundamental problem in managing technological innovation.
Social implications: The events of the last few years have allowed for the creation of new entrepreneurial attitudes among employees of the studied high-tech companies representing the photonics industry.
Originality/value: Understanding the seriousness of the situation, as well as perceiving it not only in terms of threats but also technological opportunities, resulted in a greater level of consolidation of the staff and brought a deeper understanding of the mission and shared values.
Keywords: technology entrepreneurship, innovation, high-technology, innovative products.
Category of the paper: Research paper, Case study.

Introduction

In today's economy, an enterprise that wants to maintain – and especially, improve – its competitive position must implement innovation, especially in the area of technology. This is true not only for radical breakthrough innovation but also, and perhaps primarily, gradual, incremental innovation that leads to improvement of existing products. One of the means of increasing an organization's innovation level is technology entrepreneurship – both on an individual and organizational level. Currently, technology entrepreneurship is increasingly a prerequisite for achieving success in the global market.

The purpose of the present article is to identify and assess the impact of technology entrepreneurship on the creation of product innovation of an improving nature, using the example of the products of a selected enterprise. The example used will be the process of improving a PGN-plus 80 universal gripper. This is an interesting case of improved innovative product in tradition sector of industry which causes many processes more effective and efficient. In this case we can refer to an innovation of an improving nature, which will significantly increase the usability of an old-generation product and provide it with a kind of "second life". Incremental innovations are often underestimated, and yet most of the new solutions introduced in the day-to-day operations of many enterprises are precisely this type of innovation.

The essence and origins of technology entrepreneurship

In the conditions of the technological race and the shortening of product and technology life cycles, technology entrepreneurship is gaining particular importance as one of the key manifestations of entrepreneurship. 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.

Technology Entrepreneurship 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 over half a century (the first conference on the topic took place in 1970), the number of publications on the subject did not increase significantly until the second decade of the 21st century. The theoretical foundations of the concept appeared in "Technology Entrepreneurship", a special issue of Strategic Management Journal from 2012 (Beckman et al., 2012; Kordel, 2018, pp. 9-10). Attempts to define the concept were also presented by (Bailetti,

2012, pp. 2-25). The subject of technology entrepreneurship was also undertaken in many other papers, including by (Muegge et al., 2012, pp. 5-16; Bailetti et al., 2012; pp. 28-34).

In recent years many publications on the topic have also appeared in Polish. The term "technology entrepreneurship" is given different definitions by Polish authors. According to (Flaszewska, Lachiewicz, 2013; Lachiewicz, Matejun, Walecka et al., 2013, p. 18) "technology entrepreneurship can be understood as a process combining elements of academic and intellectual entrepreneurship with entrepreneurship of commercial and business support organizations and with entrepreneurship of owners, managers and employees implementing new technologies and accompanying innovations in the sense of application and distribution of their effects in the market environment". According to (Grudzewski, Hejduk, 2008, p. 80) "technology entrepreneurship is a prerequisite for company success. It implies the process of new product development, using modern technologies, flexible response to changes taking place on the market, as well as introducing innovations in all areas of the company's operation, as well as its co-operators". According to (Kordel, 2018, p. 37) "the phenomenon of technology entrepreneurship occurs when scientific or engineering development creates a key element of an opportunity, which is later transformed into a new investment. A technological venture, based on the latest engineering knowledge, is a direct result of technology entrepreneurship". Still quoting the above-mentioned author (Kordel, 2015, p. 272) "technology entrepreneurship, by combining social dynamics with the dynamics created by the development of new technologies, gives a new perspective on the development of the economy, especially that part of it which is composed of high technology enterprises and which is used to be called the knowledge-based economy". Technology entrepreneurship should be considered in the broader context of an organization's strategy, especially a company's development strategy. Therefore, measures of efficiency and effectiveness of technology entrepreneurship can be those measures that relate to competitive advantage (share of market, profitability ratios, etc.) (Chyba, 2016, pp. 103-104).

An overview of selected definitions of technology entrepreneurship is presented in Table 1.

Table 1.
Technology entrepreneurship. Overview of selected definitions

Authors	Definition
Ch. Beckman, K. Eisenhardt, S. Kotha, A. Meyer, N. Rajagopolan	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.
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.

Cont. table 1.

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 Beckman, Eisenhardt, Kotha, Meyer, Rajagopolan, 2015, pp. 271-282; Grudzewski, Hejduk, 2008; Flaszewska, Lachiewicz, 2013, p. 18.

The concept of technology entrepreneurship should be placed in the field of strategic management issues, including innovation theory and entrepreneurship theory. 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.

Technological entrepreneurship is an innovative process that can be considered on two levels. The first is the stage of creating change for innovation and the chances of using it. The second is to implement and commercialize the innovation. Hence, it follows that technological entrepreneurship is also a specific, multi-stage execution, non-routine actions that are often undertaken, as well as a specific definition in the field of project management. It is necessary that technological entrepreneurship be considered in the context of business decisions and the determinants of its formulation.

According to (Kordel, 2015, pp. 271-282) "a central role in the phenomenon of technological entrepreneurship is played by a 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 exploiting it". According to (Korpysa, 2023; KUcęba, Jędzrejczyk, Smoląg et al., 2023, pp. 176-177) "technological entrepreneurship as a paradigm of agile entrepreneurship does not have a single, universal definition. In relation to the organization, it should be considered in the broader context of the development strategy".

Technological entrepreneurship levels and determinants

Among the factors influencing the technological entrepreneurship of an organization, it is necessary to distinguish internal determinants, i.e. the conditions of the organization's internal environment (organizational culture, intellectual capital, etc.) as well as the technological potential of the enterprise, including not only its technological portfolio, but also the creativity of its employees, and in particular the effectiveness of R&D activities. Technological potential may, but does not have to, translate into technological entrepreneurship

and market effects of the enterprise. An important role should also be played by institutions from the surroundings of enterprises, which are established to directly or indirectly support the entrepreneurial aspirations of organizations (scientific institutions, including universities, research institutes, R&D units, as well as innovation and entrepreneurship centers, training and consulting centers, etc.). When talking about technological entrepreneurship, the conditions of the internal environment and the environment of the organization should be taken into account. Table 2 presents a summary of the determinants of technological entrepreneurship in a three-level configuration.

Table 2.
Technological entrepreneurship levels and their key determinants

Technological entrepreneurship levels	Key determinants
Environmental (external) determinants	Scientific institutions
	Centers supporting commercial implementation
	Commercial partners
Internal environment conditions	Organizational culture
	Intellectual capital
	Decision-making efficiency
Enterprise's technology potential	Technology portfolio
	R&D effectiveness
	Management's creativity and technology competences

Source: own development based on Chyba, 2015, Chapter 7, pp. 87-96.

Technological entrepreneurship is strongly conditioned by the organization's environment, especially those entities that support the commercialization of new technology solutions. An important role is also played by the internal environment, including the specific characteristics and identity of the organization expressed by the created organizational culture, as well as the intellectual capital of the organization, with particular emphasis on its human capital. Also emphasized should be the importance of the technological potential of the company with its current portfolio (set) of technologies and the possibility of creating technologies thanks to the effectiveness of the R&D department and the creative activity of employees.

Determinants relating to the organization's internal environment play a significant role. Internal factors that determine technological entrepreneurship development include intellectual capital and organizational culture. The soft aspects of management, especially those mentioned above, are significant inputs into an enterprise's strategic resources. At the same time, the competences and resources at the disposal of enterprises are an important component of their technological potential. After all, it is difficult to build the technological potential of the company without the appropriate knowledge of employees, their technological competences, as well as creativity and commitment.

Barriers to the development of technological entrepreneurship can be both institutional and mental in nature. On the one hand, they result from the limitations of the political, legal and economic environment, and on the other hand, they are conditioned culturally and

sociologically. Each country or region has its own specificity of entrepreneurship conditioned by history, culture, religion or finally resulting from local and family traditions. The limited volume of this article does not, in my opinion, allow for a broader development of these issues. However, it should be assumed a priori that such conditions play an important role.

Currently technological entrepreneurship is largely limited by the economic slowdown of the past several years. In such conditions, especially in the context of the idea of sustainable development of enterprises and the entire economy, the criteria for generating and implementing innovations undergo re-evaluation. According to the above idea, all innovations implemented should not only fulfill economic objectives by increasing revenue but also play a social and environmental-protection role. This means that technological entrepreneurship should also lead to the implementation of the goals outlined by the concept of sustainable development of enterprises. In crisis conditions, this is particularly difficult, taking into account the uncertainty and increased risk of business operations. Environment-friendly technologies that also directly support social objectives do not meet the criterion of economic efficiency. In view of the above it can be stated that technological entrepreneurship is significantly dependent on those conditions and new ideas of economic development. Any considerations on technological entrepreneurship should take them into account.

Impact of technological entrepreneurship on developing technology innovation

Technological entrepreneurship as a specific ability to make use of key elements of technological opportunity and recognizing its appearance on the market is very effective in implementing new solutions, both in the enterprise and on the market. This brings us to the key issue of implementing innovations.

Innovation is a concept that still cannot be clearly defined in the form of a precise and at the same time universal economic theory (Chyba, Sieczka, 2023; Wiśniewska, Janasz et al., 2023; Sieczka, 2019). J.A. Schumpeter is considered an early champion of the subject of innovation because he defined five categories of innovation, all of them based on so-called "creative destruction". They include:

- „development of a new product or introduction of goods with new properties,
- introduction of a new production method not yet tested in practice in a given industry,
- opening up a new market,
- acquiring new sources of raw materials or half-products,
- the reorganization of an industry, e.g. creation or breaking of a monopoly" (Schumpeter, 1960).

Currently, there are many definitions describing innovation, depending on the field of science they concern. Selected definitions are presented in Table 3.

Table 3.
Innovation. Overview of selected definitions

Authors	Definition
Brdulak H., Gołębiewski T., „Wspólna Europa. Innowacyjność w działalności przedsiębiorstw" Wyd. Difin, Warszawa 2003.	Innovation means any idea, behavior or object which is new, i.e. qualitatively different from existing and known forms.
Pomykalski A., „Innowacje", Wyd. Politechniki Łódzkiej, Łódź 2001.	Immovation is a process that covers all the activities connected with the development of an idea, the creation of an invention and the subsequent implementation of a new (or improved) product, process or service.
Ratajczak Z., „Człowiek w sytuacji innowacyjnej", Wyd. PWN, Warszawa 1980.	Innovation is a product (idea, method, thing) perceived by the entity acquiring it new, information about which is transmitted through specific means of communication. This entity can be either an individual or a social group
Pietrasiński Z., „Ogólne i psychologiczne zagadnienia innowacji", Wyd. PWN, Warszawa 1971.	Innovations are changes intentionally introduced by people or cybernetic systems designed by them, which consist in replacing existing conditions with new ones.
Galanakis K. „Innovation process. Make sense using system thinking", Technovation, vol. 26, 11/2006, p. 1223.	Innovation is the creation, on the basis of new or existing scientific or technological knowledge, of new products, processes, knowledge or services that constitute a novelty from the point of view of the discoverer, the industrial sector, the national economy or the global economy and achieve significant market success.
OECD/Eurostat, "Zasady gromadzenia i interpretacji danych dotyczących innowacji", Wyd. Komisja Europejska, Third edition, Warsaw 2008.	Innovation is the introduction of a new or significantly improved product (good or service) to the market or the implementation of a new or significantly improved process, marketing method or organisational method in business practice, the organisation's activities or in relations with the environment.

Source: own development based on Brdulak, Gołębiewski, 2003; Pomykalski, 2001; Ratajczak, 1980; Pietrasiński Z., 1971; Galanakis, 2006, p. 1223; OECD/Eurostat, 2008.

The above definitions point to the conclusion that the concept of innovation can be considered in the objective approach as an effect or in the functional approach as a transformation. Depending on the authors' approach to the size of changes that concern innovations, some of them consider innovations as small improvements, while for others innovation is associated with a breakthrough discovery (patent).

However, there are several universal characteristic features that indicate an innovative product. First of all, innovations are introduced consciously to alter the current state, the effect of which is a practical means of achieving enterprises' development goals. Innovative improvements may concern processes, products, organization, or management methods. In order to introduce such innovations, appropriate scientific, technical, economic and market knowledge is necessary. Apart from beneficial results introducing innovations is also associated with high risk related to difficult-to-predict market demand, needs and reactions of potential consumers and competitors, as well as the risk related to the costs of carrying out such an operation.

Due to the diverse definitions of the term, there are a number of methods of classifying innovation.

Based on the object of the innovation, they can be divided into four groups:

- Product innovation – new or modified goods or services.
- Process innovation – new or significantly modified production method.
- Organizational innovations – new methods of managing a company or plant, new organization of contacts with the surroundings.
- Marketing innovations – new marketing instruments relating to changes in the creation or design of goods, their packaging, promotion or pricing.

The following categories can be defined based on an innovation's significance:

- Breakthrough innovations – as their name implies, these are fundamental innovations involving the creation of previously unknown products or the use of new processes, organizational and management methods.
- Basic innovations – they possess the most important features of breakthrough innovations, although they have a much lesser impact on changes that occur in the product or the manner of work.
- Incremental innovations – they impact product or process modification gradually.

Process innovations and product innovations are closely related and have an equal impact on an enterprise's results. Classifying them into two separate groups is necessary for a detailed analysis regarding the enterprise's areas and activities. In the first stages of the innovation process, it is product innovation that is the most important because the actual physical and material possibilities of innovation most strongly reflect the effects of the organization. However, when the product has passed the growth, maturity and decline phases, it is process innovations that allow revenues to be maintained at least at a constant level.

An interesting and important phenomenon today is the diffusion of innovations between different industries and economic sectors (Brzeziński, 2001). We can talk about the diffusion of innovations when, after their first application, they lose their local character and find further applications in the organization or outside it (including organizations from the industry or sector, as well as from other industries or sectors, both in the country and at the international level). Brzeziński, defining the diffusion of innovations, states that it is "the process of spreading, popularizing innovations in the company and the economy, occurring when, after the first successful application of a new technical or organizational solution, it is adopted by other enterprises". Such a definition does not refer in any way to the scope of dissemination (in the industry or sector, or outside the industry or sector of first application). The scope of considerations in this chapter does not include the process of diffusion of innovations as such, i.e. in the sense of the dissemination (or rejection) of innovations in the categories of reasoning initiated by E.M. Rogers. Further considerations will be narrowed down to discussing examples and factors influencing the diffusion of innovations across industries and sectors. An attempt will be made to:

- answer the question of what factors limit and promote the dissemination of innovations between sectors and industries,
- illustrate the process of this dissemination with selected examples.

As technologies in different industries develop ever-faster to ensure improved economic outcomes, it becomes necessary to support the dissemination of these modern solutions into other sectors. Factors that may support innovation transfer between industries and sectors are:

- removal of legal barriers,
- removal of organizational barriers,
- institutional securing of transfer of science and technology,
- adoption of a holistic approach to preferred solutions,
- flow of employees between companies from different industries and sectors,
- adoption of an open innovation approach,
- favoring a commercial approach.

A diagram of innovation transfer is presented in Fig. 1 and Fig. 2.

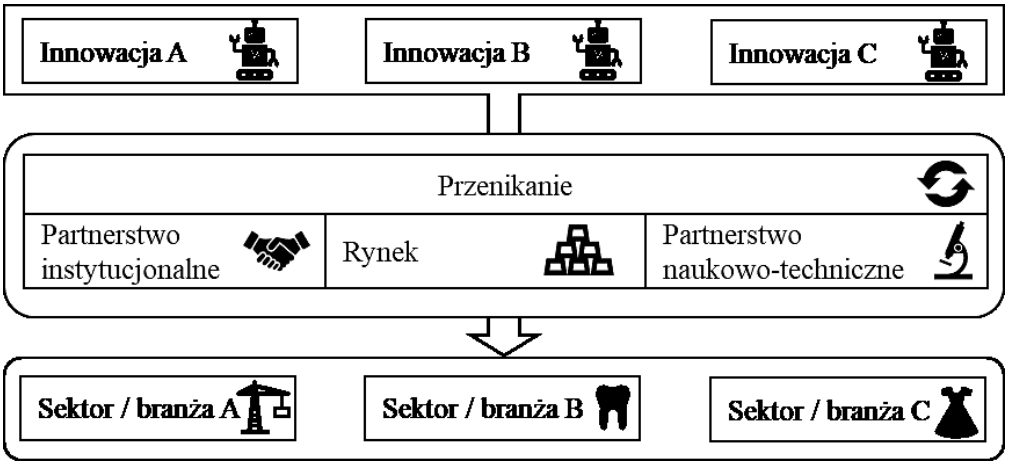

Figure 1. Innovation transfer between industries and sectors.

Source: Marciniak, Gładysz, 2019, p. 23.

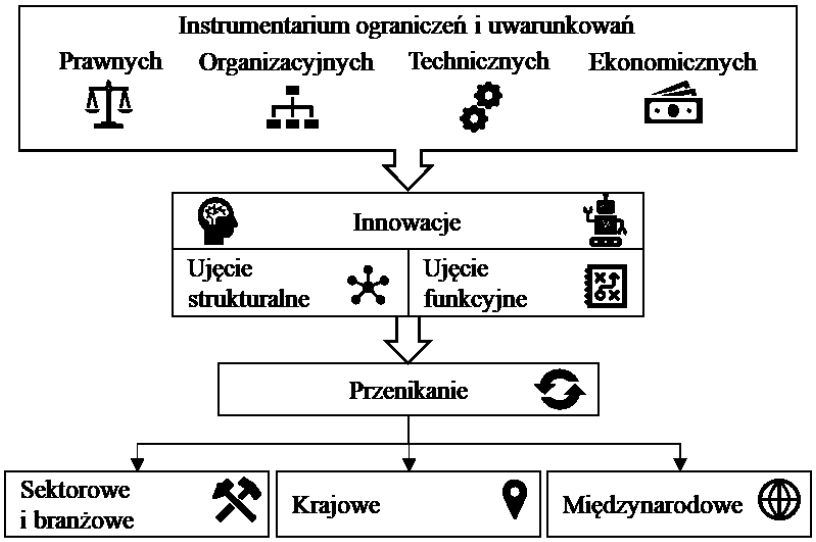

Figure 2. The idea of innovation transfer.

Source: Marciniak, Gładysz, 2019, p. 24.

Innovations can be transferred between sectors and industries in different ways, including through a common market or various types of partnerships (strategic networks and alliances, or scientific and technical partnerships), as well as the flow of knowledge, including that related to employee development or inflow from other organizations. A factor that allows innovations to penetrate between sectors and industries is meeting a need that occurs in various fields of activity. For example, access control systems, which first became popular in the hotel industry, meet the need to supervise access to rooms. And the problem of access control (on a varying scale) occurs in practically every activity. It should be noted that innovations, regardless of their type (process, product, organizational, marketing), can be transferred between different fields of activity when they meet similar needs occurring in different areas.

The fundamental requirement for introducing any product innovation is knowledge (Sieczka, 2019, pp.6-8). Due to the constant changes in the environment, technological progress and the influx of new information every day, this knowledge is an unlimited resource. Operational knowledge is not only an element necessary to introduce product innovation but also its outcome, because implementing a new product allows for obtaining information about the market, the customer can and acquiring new know-how. The ever-changing market requires flexible adaptation of the implementation process. That is why skillful and efficient evaluation of new product implementation is so important. If it is overlooked, an enterprise may fail at a later stage of product implementation, leading to outcomes such as loss of customer trust in its products. This, in turn leads to a decrease in market competitiveness. Figure 3 shows the impact of operational knowledge on an enterprise's success in new product implementation.

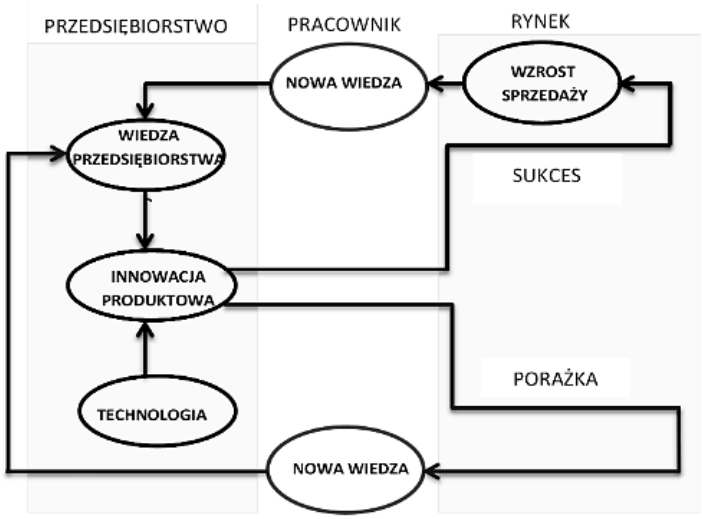

Figure 3. Implementation of innovation as a source of knowledge in the company.
Source: Chyba, Sieczka, 2023, pp. 31-57; Sieczka, 2019, p. 6; Drozd, Kucharska, 2012.

A person as an employee of an enterprise is a key factor in the production system. Skillful management of the human factor, which is the main generator of operational knowledge, has an impact on the company's level of success. Therefore, it is important to properly motivate, reward and invest in such employees. The approach of employees to the company as a partnership, encouraging them to share their knowledge contributes to the creation of innovations (Perechuda, 2005).

The introduction of new products on the market represents expenses of several to more than 10 million zlotys. These costs can concern not only new materials and production equipment but sometimes also the expense of implementing a new technological line. In addition, it is also necessary to take into account listing fees related to building distribution and the cost of promoting a new product. It must be noted that a mature and hence competitive segment involves higher financial outlays. Successful market implementation of a new product requires the efforts of the entire enterprise. This means close cooperation of such functions as production, logistics, marketing and sales.

The literature presents a wide range of product innovation cycle models, differing in the number and names of individual stages. In most cases, the first stages of the models are the stages of generating ideas for a new product and their initial selection. Less frequently, one can find publications that consider the planning stage of the new product creation process as the first one. The product life cycle shows, first of all, that the time a product exists on the market is limited. Each stage of the cycle is characterized by certain opportunities or threats for the product resulting from the market dynamics, which is associated with different levels of financial results. Such different phases require different marketing, production, financial, sales and personnel decisions. The length of the product life cycle depends on micro- and macro-marketing environment factors. The product life cycle also points out that product sales, cost and profit structure are subject to fluctuations and are closely related to the stages of the product

life cycle. Long-term stabilization of the company's profits is ensured by introducing new products and simultaneously withdrawing older ones from the market that are in a declining stage.

The impact of unexpected events on organizations' entrepreneurial behavior and innovativeness

Due to specific conditions of a turbulent environment, today's enterprises are forced to operate under conditions of heightened uncertainty and risk. These exceptional circumstances have intensified especially in recent years due to new unexpected events which were difficult or even impossible to foresee. These unexpected events are frequently referred to as "black swans". These events completely changed the perception of reality not only by enterprises but also by communities almost all over the world. They became game changers. The effects of these events also affected the entrepreneurial behaviors of employees of high-technology enterprises, which perceived these challenges in different ways. In certain cases they reacted with higher worker involvement, stronger identification with the enterprise and an appreciation of management decisions and actions aimed at maintaining jobs. Some high-tech enterprises even saw these unexpected events as a growth opportunity, enabling them to diversify their operations and expand onto new markets.

The aforementioned challenges of the modern world caused significant realignments in the functioning of enterprises. This applies especially to academic enterprises operating in the advanced technology sector. The effects of these challenges will be shown on the example of enterprises X, Y, and Z from the photonics industry (Chyba, Wachnik, Adamiak, 2023, pp. 521-553; Chyba, 2023, pp. 69-93).

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 Institute 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). The company currently holds a high market position, also internationally. It sells its products practically in all the world's continents. It has no Polish competitors and Europe it is able to compete successfully with the best enterprises, manufacturing with a high degree of technological and scientific advancement.

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 current 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 hiring new specialists with appropriate experience in research work, preferably with at least a doctoral degree.

On a short-term scale, the occurrence of external uncertainties in the form of COVID-19 forced organizational changes in terms of business processes, procedures, methods of performing tasks and interpersonal relations. These were forced changes aimed at adapting to new conditions mainly in the area of supply chain management, which temporarily partially collapsed, and of the sales process. The period of the pandemic stimulated the enterprise to change the processes of managing its unique and specialized workforce.

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 crushed the company". Certain supply chains – mosty those from the German market – were disrupted. Regarding the armed conflict, the situation is perceived as more of an opportunity due to the company's cooperation with the defense industry. The company sees another opportunity in the flight of competing organizations from Russia and the possibility of expanding the company's operations in Ukraine. The short-term conditions mentioned (COVID, armed conflict) have prompted the

company's employees to integrate more, consolidate activities and mobilize and motivate the team more strongly. The processes of integrating employees from the organization have intensified and 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 the scale of production to be increased due to the growing demand and favorable economic situation 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 (Chyba, 2024, pp. 61-70).

In summary it can be stated that the COVID-19 pandemic had a certain impact on interrupting or disrupting supply chains at high-tech enterprises. On the other hand, the threat of international armed conflict caused by the Russian Federation's invasion of Ukraine has caused the outflow of many competing companies from Russia and Ukraine, which created an opportunity for the companies to develop the newly freed-up markets and, as a consequence, for the expansion of these companies in new markets. The companies' products, which are largely niche in nature, generate increased market demand in the current situation. The development of the arms industry and the increase in expenditures for the modernization and rearmament of the army create additional sales opportunities for products manufactured by photonics industry companies in Poland.

The events of the last few years have allowed for the creation of new entrepreneurial attitudes among employees of the studied high-tech companies representing the photonics industry. Understanding the seriousness of the situation, as well as perceiving it not only in terms of threats but also technological opportunities, resulted in a greater level of consolidation of the staff and brought a deeper understanding of the mission and shared values. The attitudes of employees who, on their own initiative, undertook 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.

Summary

In order to maintain their competitive position in the global market, enterprises must effectively and efficiently manage technological change. The ability to perceive the right time to change is a fundamental problem in managing technological innovation. Scientific and technological developments create a technological opportunity that can be used to make a change. This is the essence of technological entrepreneurship, which enables the introduction of innovations, both product and process-related. This does not only apply to breakthrough or radical innovations, but much more often to those of a gradual nature, improving on existing solutions.

This article presents an example of incremental innovation using the example of improvement of a gripper. The technological entrepreneurship of the enterprise's management and all its employees made it possible to utilize a technological opportunity and implement an innovation consisting of the improvement of an existing product. This allowed the company not only to streamline the production organization process, but also to improve the company's competitive position and the effectiveness of its functioning on the global market.

This relatively simple example shows that even unspectacular product or process innovations play a significant role in building potential or actual competitive advantages. At the same time, it can point out the right path that companies should follow. It is necessary to work in parallel, within the limits of resources and potential, both on breakthrough solutions and on improving existing ones. Such a dual track of technological change management is the most effective way to both survive on the market and, as a consequence, strengthen an organization's competitive position and perpetuate its brand.

The article also discusses the issue of the impact of unforeseen events of the past several years (the COVID-19 pandemic and armed conflict in Ukraine) on shaping workers' entrepreneurial attitudes and the potential to generate innovative solutions, not just of a breakthrough character but also incremental innovations leading to the improvement of existing products or processes in the spirit of the philosophy of continuous improvement. Such events, frequently referred to as "black swans", have had a significant impact on changing the thinking and operating of workers and entire organizations which in turn led to increased entrepreneurship and innovativeness and enabled them to compete more effectively on the global market.

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