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Risk in Innovative Technological Projects

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ABSTRACT: *The article concerns the risk analysis in innovative technological projects in the metal industry. The paper defines the concept of innovation and compares the risk in innovative and traditional projects. The implementation of a technological innovative project involves a greater risk than a traditional project due to greater uncertainty in achieving the goal in the innovative project. This makes it more difficult to achieve success in an innovation project.*

For research and risk assessment, a risk map was selected as a tool that perfectly visualizes possible threats in the project. On the basis of 10 technological projects (implemented in the metal industry), key risk areas were identified and the most dangerous events, the expected consequences of which would be catastrophic, were identified. Attention was paid to the impact of the economic environment on the project implementation, and in particular to the implementation of its results. The external risk is unpredictable and dynamic, which requires flexible risk management, in particular in innovative projects with a high degree of uncertainty.

The occurrence of unfavorable changes on the sales market may significantly disturb the implementation of the project, and even prevent the introduction of the developed product on the market and generate irreversible losses. In innovative projects the time to achieve the project goal is also important due to the fact that a specific technological solution usually makes business sense only within a specific time range.

KEY WORD*: risk management, technological projects, innovation,*

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I. INTRODUCTION

Risk research and management is an essential part of any project. In particular, the risk should be monitored in innovative projects which, as a rule, are associated with greater uncertainty of achieving the goal assumed for implementation. (Milutnović andStošić , 2013). Incremental projects are more linear, predictable, encounter less resource uncertainties, and include less complex collaboration relations (Keizer andHalman, 2009). An potential risks associated with radical innovation projects is high and has source in internal and external happenings. In order to control the risk, subsequent phases of the project's life should be monitored through risk identification and coordination of risk prevention activities.

Risk analysis is a tool that, on the one hand, helps to determine possible future threats, and on the other hand, the probability of their occurrence. The need for research on risk has already been born in modern times, however, it was not until the 20th century that it was possible to professionally measure and control risk (Stahel, 2017; Dionne,2013; Crockford, 1982). Risk is an ambiguous and complex concept. It should be understood as a choice, not an inevitable destiny. Outreville E.J (Outreville, 1998)citing an article by Pfeffer and Klock (Pffefer andKlock, 1974), defined the relationship between risk and uncertainty by saying: "risk is a combination of hazard and is measured by probability; uncertainty is measured by the level of faith ".Risk is the state of the world; uncertainty is a state of mind. Today, most authors define risk as a state in which the possibilities and chances of its occurrence are unknown, and the concept of risk is used when the result that will be achieved in the future is unknown, but it is possible to identify future situations and the probability is known. the realization of particular possibilities in the future (Heckmann et al., 2015; Fischhoff, 1984).

With regard to projects, risk can identify any potential event that may delay the project, increase its costs, or act against the project. Risks for the project are specific events that may not only hinder but also hinder the successful completion of the project. When proceeding to risk identification, it is important to identify the risks that can be ignored, and that must be addressed and prevented.

To determine and identify risk, tools such as: own experiences, Delphi group, documentation, heuristics, independent experts, simulations, a set of tools including computer calculations for risk assessment (Aven, 2016; Valis andKoucky, 2009). Each threat should be analyzed in terms of its impact, the aim of which is to examine how much impact the occurrence of a given threat will have on the project and the probability - examining how likely the occurrence of a given threat is (Caliste andHeitor, 2020).

These two key parameters presented in the form of a risk map fully reflect the state of threat and inform about the degree of potential danger threatening the project. Risk research and its assessment in innovative projects related to the creation of new products or technologies is extremely important. Projects of this type are very sensitive to any events that threaten their success. They are characterized by variability and uncertainty, so the risk assessment in these projects should be carried out on an ongoing basis, so that possible reactions can be taken to prevent the worst effects of risk-generating events.

The aim of the work is to present relationships resulting from the occurrence of events that may generate key risks in innovative technology projects.

II. Conceptual Framework

The article presents selected issues related to the risk of carrying out innovative projects in the metal industry. There is a little data on the risk of projects implemented in this type industry. The research is based on data from 10 projects carried out in cooperation with the metal industry. A high risk is associated with the realization and implementation of the results of innovative projects, which are characterized by high uncertainty in achieving the project goal and the time regime. Risk management in these projects requires an innovative approach and flexible changes following the changing internal and external conditions.

Due to such changes as changes in the sales market, changes in the economic environment, internal changes in the company, external administrative changes and uncertainty in achieving innovative risk solutions in this type of projects, they require continuous monitoring and determination of key factors threatening the success of the project. It has been hypothesized that the most dangerous risk is the lack of implementation of the project results into industrial practice. The key risk factors were analyzed and presented on the risk map. Visualization of risk using a risk map perfectly illustrates threats and can be repeated many times during the project implementation, which facilitates risk management and making corrective decisions.

III. Background

a. Innovation in economy and technology

One of the principles underlying the regulations on the European Social Fund (ESF) is the important role of innovation, as well as the exchange of good practices and the incorporation of the effects of innovative projects into the mainstream of economic policy and practice. The concept of innovation is associated with the name of Joseph Schumpeter (Maślak E, 2002, Godin, 2008), who drew attention to the importance of introducing new technologies and innovative products to the economy by entrepreneurs as a development impulse for other producers. Innovations flowing into the economy favor the development of the economic situation, and the innovative activity of entrepreneurs is the source of economic growth (Schumpeter, 1912). Schumpeter also drew attention to the cyclical nature of economic processes.

Innovations are usually perceived as: - novelty, invention on a global scale, something that has not existed before (e.g. steam engine, computer, CD, COVID 19 vaccine); - novelty in a given country, institution / organization, method of operation , phenomenon, resource, which has not existed before or which a given organization has not used so far. Innovation can be also defined as a new idea or method, or the use of new ideas and methods (Vandenberg, 2008)

According Gawlikand Kiełbus(Gawlik and Kiełbus, 2010) innovation product and process relates to such technologically new product whose technological characteristics or intended use differ significantly from those of previously manufactured products.

Innovation represents the core renewal process in any organization. Unless it changes what it offers the world and the way in which it creates and delivers those offerings it risks its survival and growth prospects (Bareghehet.,2009). Innovation is the generation, acceptance and implementation of new ideas, processes products or services.

Innovation is - implementation of a new or significantly improved product (or service), or process or a new marketing or organizational method (StosicandMilutinovic, 2017).

Innovation is characterized by: - the degree of novelty (scale of the enterprise, country, world); - degree of diffusion (diffusion) - the potential scope of innovation, which from the first implementation in a certain enterprise is disseminated in other enterprises, regions, countries, etc., through market and non-market channels (imitation, adaptation). (Nieminen, 2020; Blok andLemmens, 2015).

Green innovation is another area of innovation indirectly related also to industrial activities. It can be defined as- the creation or implementation of new, or significantly improved, products (goods and services),

processes, marketing methods, organizational structures and institutional arrangements which - with or without intent - lead to environmental improvements compared to relevant alternatives(Calza, et al., 2017).
The concept of sustainable development is closely related to the development of innovation in industrial technologies and concerns the innovative development of industry 4.0 (Schiederig et al., 2011). This is reflected in the idea of the symbiosis industry, which requires innovative actions and solutions (Nevesa et al., 2020). Therefore, the impact of innovative projects with bold technological and product solutions is the future of the world economy and its driving force.

The implementation of symbiosis approaches is recognized as an effective industrial strategy towards the optimization of resource exploitation and the improvement of collaboration in the context of Industry 4.0. An industrial system can be considered as a complex environment in which material, energy, machine, and human resources should cooperate towards the improvement of efficiency and the creation of value. According to this visionindustrial symbiosis models, which mainly aim at the sharing of resources among different companies, and human symbiosis, which focuses on how to effectively strengthen the synergy among humans and machines is very important (Fraccascia et al., 2016).

All definitions of innovation, appearing in the description of activities of almost all sectors of the economy, emphasize its creative and steady impact on the progress of civilization and the emergence of new technological solutions. In technological projects, creative solutions relate to process or product innovations. In these projects, risk analysis and management are particularly important. This is due to a much higher risk of uncertainty during the implementation of an innovative project, problems with the reception of an innovative product, possible incorrect assumptions in the project, and sometimes even project failure (Batkovskiy et al., 2015).

In the case of technological innovative projects, the key role is played by the time of implementing the solution (Almgren, 2014) This time is characteristic of all innovative activities. Time to solve the problem is important due to the fact that a specific technological solution usually makes business sense, only in a specific time range. Therefore, it is customary to identify projects that have a limited time window within which to deliver a certain value as innovative projects. It should be added that managing in such unstable conditions also requires an innovative approach.

Innovative projects usually have a very general purpose. The project starts with a vision that becomes clearer as the project progresses (Zhang, 2018). Uncertainty in an innovation project is a feature that makes it impossible to define all the features and scope of the solution in advance. It is a risk on the one hand and an opportunity on the other. Risk, because the project may fail, and an opportunity, because accepting the uncertainty means the need to flexibly react to any circumstances that may arise during the project, which may lead to a new, positive solution (Kaka et al., 2003)

Variability, which is a feature of an innovative project, makes it impossible to fully predict the final solution of the implemented project. The features of an innovative project influence the differences between traditional and innovative project management. They are best seen in relation to its aspects such as the final goal of the project and the method of achieving it.

In the traditional approach, a specific, known solution is implemented. The main way to achieve this is to establish a detailed action plan at the start of the project, which then has to be carried out in sequence. This goal is achieved by controlling variables such as time and budget. It happens that creating a solution takes more time than planned, then it is necessary to extend the project or increase its budget. All this to implement a fixed solution. (Špundak, 2014)

The traditional model is also called the cascade model as the project is viewed as one large object that is broken down into tasks that must be performed in order. Traditional management, despite numerous changes requiring flexible solutions, is still the dominant way of implementing projects in industry (Spalek, 2016). The implementation of large, complex projects with an innovative approach to solving problems caused changes in project management (Kwak, 2003). Various methods of agile project management appeared, corresponding to the need of their modern management (Attarzadehand Ow, 2008)

In the agile approach, which, among other things, is used to implement innovation, the project is seen as a set of short stages. The design team does not follow a predetermined plan, but a changing business need. The solution evolves as the project progresses to get closer to the best possible solution within the time / cost / quality framework. The traditional project manager focuses on delivering a defined product, while the innovative project manager focuses on achieving a result, delivering some value (Akhmetshin, 2019)

In an innovation project environment, it is essential that the team be able to freely communicate both good and bad news. During the implementation of the project, new information appears that affects the project. Changes should be accepted as they help to deliver a better end product (Hummel, 2013).

In practice, projects with a higher level of innovation may include projects introducing new products, research and development projects, or, for example, projects for the development of startups and the creation of new companies.

A number of challenges may arise in implementing projects with a high level of innovation. They mainly result from the high level of uncertainty accompanying the project and the variability of its course. This results in the limited ability to define the scope of work (as well as other project parameters) at the beginning of the project and the need to adapt as more and more information becomes available. Innovative projects are often characterized by high complexity, the need for continuous learning and verification of initial assumptions, as well as incurring high capital expenditure, which is also difficult to predict at the beginning.

During implementation, it may turn out that the product is not working or that the customer is not buying the designed solution. It is possible that the project plan may not work. Then it has to be changed on an ongoing basis through iterative development in small planning steps, the integration of different thinking styles, experimenting and testing.

In the technological innovative projects actions have been focused on solving technological problems in companies (Carbonella, and Rodriguez-Escudero, 2009). Realization of project requires multidirectional work based on the knowledge of various fields; hence they are usually carried out in industrial - scientific consortia. The collaboration with scientists is advantageous because it gives the possibility to carry out diversified research and provides results that help to develop and implement the project objective(s). However, it can increase the scope of research and, consequently, costs and implementation risk. It is also well known that capitalization and transfer of knowledge gained through projects is one of the most important tasks leading to successful development of company.

There is little data on projects in the field of materials engineering, plastic processing of metals and alloys, as these are usually confidential projects. The confidentiality of technological information and new solutions results from competition on the market of materials, semi-finished products and metal products. Companies often have their own research centers, where projects dedicated to the use only in the company financing the project are implemented.

The risk analysis and assessment carried out using the risk map method contains some degree of subjectivity. Therefore, it should be carried out on the basis of a well-recognized project situation by experienced specialists, in particular practitioners who have carried out several projects. It should be stressed that in the risk analysis, it is very important to rely on experienced staff who are able to quickly identify the threat and respond adequately to its gravity in order to prevent adverse consequences of the event. Apart from clear signs of disturbing events that increase the risk, there may also be minor events that may turn into higher risks. Therefore, for example, in the Prince 2 methodology, it is necessary to keep a risk register and monitor it on an ongoing basis to react to the existing threats and to conduct continuous preventive and corrective actions during the project (TomanekandJuricek, 2015).

In the agile project management method, the increased risk is inherent in the project implementation due to the management style, which, unlike the Prince 2 method, is fuzzy (Cervone,2011;Dyba et al., 2014;Lasek et al., 2015;Soroka-Potrzebna, 2019).

The agile approach assumes that the team has the appropriate competences and is motivated to carry out the project and therefore does not require strong management supervision. The role of the manager is reduced to eliminating obstacles in the work of the team, suggesting effective techniques for dealing with problems and indicating business objectives of the solution being created.

b. Risk management in technological projects

There are various risks that can occur. These include financial risk, strategic risk and operational risk.Therefore there are different definitions of risk. In economy risk implies future uncertainty about deviation from expected earnings or expected outcome. Risk measures the uncertainty that an investor is willing to take to realize a gain from an investment.(Doff, 2008)

Enterprise risk management (ERM) takes abroad perspective on identifying the risks thatcould cause an organization to fail to meet itsstrategies and objectives(Beasley,2007). Operational risk is a risk arising from execution of company's business functions.(Kostyunina, 2018)

Business risk is a broad category. It applies to any event or circumstance that has the potential to prevent achieving business goals or objective s. Business risk can be internal (such as industry strategy) or external (such as the global economy). Risk is often described by an event, a change in circumstances or a consequence. A common definition of risk suggests that risk is the effect of uncertainty on achieving or surpassing business objectives. This effect may be positive, negative or a deviation from the expected, for example in forecasts and projections.

Uncertainty, which is indissolubly bound with risk, is one of the major inherent difficulties in developing innovative products, due to their highly dynamic markets and technologies (Wang et al.,2010). The conflict between new ideas and improvements and the realities of the market can increase the risk of innovation projects. This risk originates, among other things, in the possibility of changing the market demand for the product, whose launch usually takes place 3-5 years after the start of the project.Changes on the market may lead to a complete lack of demand for an innovative product, which destroys the work of the design team. There

may also be a risk that despite the solution achieved, the costs of its application may exceed the level of allowable investment.Even in a stable economic market such event can appeared. It should be believed in a stable economic market such a risk is low.Therefore, e.g. companies cooperating in the production chain of the car industry or the construction industry may predict future demand with a high probability. Still, 3-5 years after the start of a project, there is always a probability of a change in demand, which creates the risk that the company will quit the implementation when facing a significant drop in demand, even despite prior declarations of implementation. As it turned out in recent months, nothing in the economy is certain and unexpected circumstances and external events (for example Covid-19) can also completely change the market situation. So, the issue of risk is now taking on a new meaning. In this context, a flexible approach to project implementation needs to be considered.

The wide variety of risk may adversely affect every technological project at all times. Therefore, anticipating and preventing the risk is of great importance for the success of projects. Zero risk does not exist, and it is also dynamic and variable, especially in diversified conditions, which may significantly affect the project implementation. The definition of risk is the effect of uncertainty on the achievement of the project goal.Project risk defined by theProject Management Instituteis an uncertain event or condition that, if it occurs, has a positive of negative effect on one or more project objectives.(Roseke, 2016)Risk can be broken down into two basic components. The formula is:risk = probability x impact (probability: the likelihood of the event happening, impact: the potential impact of the risk event).

The amount of acceptable risk on a project depends on the organization's as well as individual stakeholders risk tolerance.

In the innovative projects the risk tolerance must be greater, because both the probability of an event and its effects have a greater range, which results from greater uncertainty in achieving the project goal. If it is assumed that the probability of risk occurrence is comparable in the innovative and traditional project, then the effects of risk occurrence in the innovative project are much higher. For example, due to the higher commitment of funds for their implementation. Innovative projects are placed in the scope of a higher risk, but on the other hand also in the scope of a higher return on invested funds, in case of success and achievement of the project goal.

The task of innovative projects' risk management is one of the most difficult in project management due to significant degree of uncertainty regarding future result (Batkovskiy et al., 2015). Authors analyzed approaches to innovative projects' risk management. Risk is considered as a probability of occurrence of adverse conditions, which are related either to: failure to achieve the expected results from innovations; deficit of planned resources. Risk situations may be divided into four types: the result was not achieved at all due to impossibility to implement an innovative idea; technical or economic characteristics of innovation turned out to be worse than the characteristics expected by the company's management; innovative project was implemented, but its costs exceeded the original budget; innovations' objective was achieved, but later than expected. .

Each innovative project is unique. The higher the innovativeness of the product, the more confusion at the beginning of the project and therefore estimates are less accurate and the risk is higher. The task of innovative projects risks management is one of the most difficult in project management due to such a specific peculiarity of innovations as high degree of uncertainty in respect of the future result of their realization (Schieg, 2006).Innovative activity always involves a risk, associated with a number of factors whose effect on performance results and approaches of company risk of cannot be accurately determined in advance.

The risk characterization must take into account both the internal and external conditions in which the project is carried out (Kardeset al., 2013).It is important to assess and monitor the impact of internal and external factors on the project (Dunovic et al., 2016). Authorssugest that project uncertainty can decreasing or increasing during the project development. Assessment of the development of this tendency facilitates the creation of a project management strategy. Secondary risk may also arise during project implementation. It is a new risk that is the result risk treatment (Zuoand Zhang, 2018). Hence, it is necessary to anticipate various possibilities for the development of a crisis situation, which may create secondary risk by inappropriate response to the root cause of the crisis.

c. Risk assessment

A project may be considered successful if the completion date and budget are not exceeded (Aloininiet al., 2007). It is ensured by a good project management. The effective management of a project has to use the well-defined risk indicators, stability and danger margins as well as review frequency. Risk management can help project managers to anticipate delay that prevents the timely delivery of projects. Various methods have been proposed for risk assessment in the projects (Marcelino-Sadaba et al., 2014). The authors proposed a review and control mechanism at the beginning of the project. They suggest various techniques and tools such as checklists and strategies to manage the most common risks. The application of a specific method depends on the type of risk assessment conducted and its feasibility. Expert assessment and professional experience of the expert carrying out the assessment is of great importance, as well as access to data that determine the risk. The

methods used for risk assessment include risk matrix, risk register, Ishikawa diagram, brainstorming, Delphic technique, internal audit in a company and others (Guo, 2015;EQuIPNational Resource risk management & quality improvement handbook 2013;DziedoszandRejment, 2015).

Risk management is an important part of all investment projects, including research projects. It is a major challenge, especially in technological projects that have to be finalized with their implementation. The Failure Mode and Effect Analysis (FMEA or RFMEA) technique is an effective tool to identify the main causes of risk (Lavastreet al., 2012). Two projects were examined by assessing their risk through the RFMEA methodology, using 5 parameters such as: 1 - probability of risk occurrence, 2 - significance of the risk impact on the project if it occurs, 3 - risk scope (RS), 4 - predictability of risk occurrence and 5 - risk priority number (RPN) of risks (RPN = RS x detected risk factors) (Luppinoet al.,2014). The obtained results showed that a significant number of risk causes can be limited to a few key reasons that need to be addressed in order for the project to be implemented effectively.

It should be stressed that risk has a financial dimension and therefore it is possible to assess it through the estimation of profits or losses resulting from the project. This is an important remark because from the very beginning of the project, after determining the risk, it can be decided whether the project should be started or abandoned. A frequently used financial assessments of projects are Net Present Value *(*NPV) and IRR (internal rate of return) parameters (MaravasandPantouvakis, 2018).

The assessment which starts with a positive NPV (net present value) and the rate of return higher than expected may result in the decision to invest. However, the probability of achieving these values may in fact be low. The project will therefore be profitable, but too risky to implement due to too high a risk of future loss of the invested capital.

Some of the data used in risk analysis must be, out of necessity, based on subjective assessments instead of statistical observations, e.g. as they may not be available, which means that the estimates do not always check out. Parameters helpful in risk assessment are also, among others,the standard deviation of the market rate of return, the standard deviation of the achievable rate of return, the correlation coefficient between the rate of return on the project under consideration and the average rate of return on existing assets.

A good indicator is also the sensitivity analysis, which shows how NPV and IRR change when a single variable explains planned cash flows from the investment with other factors unchanged. Thanks to this method, information is obtained which variables have the greatest impact on the profitability of the investment.

The process map is one of the very useful tools for risk assessment in projects. It allows the identification of risk sources (Lavanya andMalarvizhi, 2008; Jordan et al., 2013;LandwójtowiczandKnosala, 2011, Richert et.al., 2020). In particular, it concerns innovative, technological projects. Each project assumes the introduction of a process or a product improvement. The risk related to the implementation of innovations can be treated as a product of the probability of occurrence of a specific event and the effects of its impact in relation to losses. The occurrence of internal and external risk should be taken into account. It is also necessary to define an acceptable level of risk that is associated with risk management practices. This level depends to a large extent on the subjective assessment of the owner of the risk. The analysis of risk map must include an event assessment that introduces several levels of its description from a very low risk to a catastrophic risk. The following 5 levels of risk of the event are usually established: a very small risk, a small risk, a medium risk, a serious risk, a catastrophic risk. Risk maps are a very useful tool for the risk analysis.The risk map is a tool that clearly and comprehensibly presents the scopes and effects of phenomena that may threaten the project with disturbances. Preparation of a risk map requires the knowledge of experienced specialists in the field covered by the project. The advantage of creating a risk map is to identify the range of possible threats. Therefore, this method is very helpful in the correct interpretation of the difficulty scale of a given project. It enables a preliminary risk assessment at the beginning of the project, allows for early identification of potential weaknesses and facilitates risk interpretation. By creating a risk map, the persons making decisions or consenting to the project implementation have a solid basis for making decisions (Oroń, 2012).The Risk Map (also known as a Risk Heat Map) is one of the best ways to visually display risks. .This is a good way to visualize the risk in the innovative projects that have been identified for deeper analysis and review. By multiplying the risk impact and probability you can come up with arisk rating that can be used to compare and prioritize different types of risks for the development of mitigation plans. Risk maps form the basis of risk assessment and enable further research. Therefore, they are the first risk assessment tool. The greatest threats identified on the basis of the map can then be subjected to further research. One of the benefits of this method of displaying risks is that it's easy to see how risky the program or project is. If all the risks are clustered in the top right of the diagram it is clear that the project is very risky.

IV. Construction of risk map for project

4.1. **Methodology of risk map construction**

The construction of a risk map requires the creation of a risk register by determining the degree of risk and determining the effects of the risk. There are numerous examples of the use of this type of risk visualization and attempts to modify the risk maps in various ways (Caliste andHeitor,2020; https://expertprogrammanagement.com/2009/06/visualise-risks-using-a-risk-map/)

A Risk Map is a very simply diagram which very quickly highlights the key risks to programs or projects.This is an advantage of the risk map over other risk assessment methods.On the vertical axis a given risk occurring is located, that is, the likelihood that the risk will materialize and become an Issue. On the horizontal axis is located the impact that the risk will have on the project or program should it materialize (Table 1).

Table 1. Risk map with probability of risk events occurrence and its impact on project

Probability of risk	**Catastrophic**					
	High					
	Medium					
	Small					
	Very small					
		Very small	**Small**	**Medium**	**High**	**Catastrophic**
		impact				

Next it is necessary to determine the key risks in project. It could be: technology risk, market risk, organizing risk and exterior environment risk (Arabshahi, 2019). Risk in projects may also be related to the time of completing a project or its part, obtaining the right technological solutions in a timely manner, costs in the project, the possibility of implementing the solution, implementation costs. There are also external risks, such as: market demand for a manufactured product or technology. The profitability of introducing changes that will be a consequence of the project implementation should also be considered.Based on the experience of running 10 innovative projects for industry, the following risk ranges with regard to its individual levels have been proposed.

A register of risk levels created in relation to technological project realization:

1. Very small risk - possible to be removed in a short period of time and not causing a change in the project schedule (e.g. slight delay of work, lack of studies facilitating the analysis of results, etc.).
2. Small risk - influencing the project schedule, but not causing significant changes in the project implementation and falling within the limits of the allowed changes (e.g. postponement of the task completion date within the allowed limits, transfer of amounts, etc.).
3. Medium risk - affecting the change of the project schedule, requiring annexes to the contract (e.g. impossibility of effective and timely execution of the tender, serious negligence in timely execution of the project works),
4. High risk - threatening the timely completion of the project (e.g. withdrawal of the company from the project, staff shortages causing inability to carry out the intended works, random accidents disrupting the work schedule),
5. Catastrophic risk - leading to discontinuance or non-completion of the project (e.g. discontinuation of disbursement of funds, causing inability to apply for further tranches of money, withdrawal of the consortium member from the project, change of external conditions resulting in termination of funding, negative audit of the project phase)

Each category in the risk register can be assigned a probability assessment of a given event (Table 2). The construction of the risk map requires multiplying the point values of probability and effect of a given event (Table 3).

Table 2. Point-based assessment of the probability of a given event

Points	1	2	3	4	5
Risk level	Very small	Small	Medium	High	Catastrophic
The probability range	0-20%	21-40%	41-60%	61-80%	81-100%

Table 3. Risk map schemefilled with numerical values of the probability of risk occurrence

impact	**Catastrophic**	**5**	**10**	**15**	**20**	**25**
	High	**4**	**8**	**12**	**16**	**20**
	Medium	**3**	**6**	**9**	**12**	**15**
	Small	**2**	**4**	**6**	**8**	**10**
	Very small	**1**	**2**	**3**	**4**	**5**
		Very small	**Small**	**Medium**	**High**	**Catastrophic**

		probability

	Low risk
	Medium risk
	High risk

4.2. Risk identification in implemented technological projects

With the described risk map, you can analyze the current situation by placing the events taking place in individual fields of the map. At this point, the subjectivity of assessment of the situation and the experience and rationality of a person monitoring the risk come into play.

Table 4 shows risk assessment identified ~~occurring~~ in implemented technological projects. The table contains events that actually occur in such projects carried out in consortia consisting of research units and enterprises. The presented data is based on the expert experience of running 10 innovative technology projects. Most of the events considered fall within the medium risk range (blue field – Table 5). There is also a high risk with regard to events 6 and 7. These events should be given special attention as they endanger the project. It is also necessary to take remedial actions to counteract this risk. The arrangement of the project implementation schedule imposes a certain timeframe on its implementation, which entails the risk of failure to meet the deadline for research works (Table 5, No 2) and the risk of unrealistic project implementation deadline (Table 5, No 8).

Delays in tenders (Table 5, No 1) or failure to spend the earmarked amounts on the project objectives (Table 5, No 3) create a risk of failure to meet deadlines and jeopardize the project implementation. A poor cooperation between the management team and the research team may result in the lack of coordination in the conduct of the project (Table 5, No 4).

The completed project should be implemented in industrial practice. If there is no demand for the product on the market (Table 5, No 6), one should expect the withdrawal of the industrial partner from the implementation (Table 5, No 7). In the aspect of the lack of market demand, an unrealistic deadline for the project completion and implementation may also appear (Table 5, No 8). The events that have occurred lead to threats that will hinder the proper implementation of the project.

The subject matter of the project also determines the possibility of achieving it, and if the project receives funding, also its implementation. At this stage there may be a risk of unrealistic research assumptions (Table 5, No 5).

Table 5 shows probability of the occurrence of the events in question. The most dangerous is almost certainly catastrophic event No 7. Catastrophic events No 5 and No 6 have a very small probability. The focus should be especially directed at high and almost certain probability and some actions preventing these events should be taken.

The implementation of an innovative project in the area of industrial technology is associated with the risks presented collectively in Table 5. The analysis carried out in the examined cases defined the risk as medium. Therefore, starting the project is possible. Had the risk been located within the upper right corner of the map, it is likely that decision makers would not have taken the risk of implementing the project.

The greatest risk identified in the studied projects was related to the implementation of the project results (No7 in Table5). The emergence of an innovative solution in technological projects is related to the creation of a new product or new technology. It may consist in modernizing the technology or improving the product. Experience shows that achieving the scientific goal of an innovative project is not tantamount to putting a product or technology into practice. This is due to various reasons.

Table 4. Assessment of the possibility of key risk in technological projects

No	Main risk	Risk owner	Cause of risk	Result	Risk assessment			Risk response strategy	Cost of the recovery strategy
					Probability	Impact	Risk level		
1	Delay in tenders	investor	Delay in the announcement of the tender, no applications	Delayed work, rescheduled work	41-60% - medium (3 points)	Medium (3)	Medium (9 points in the risk matrix)	Staff training, alternative contracts, reformulating procedure	Medium
2	Delay in research work	investor	Negligence of consortium members, inappropriate test methodology	Delayed work, rescheduled work	5-20% - unlikely (2 points)	Medium (3)	Small (9 points in the risk matrix)	Consortia meetings, ongoing reporting requirement	small
3	Non-spending of the amounts foreseen for the project	Consortium members	Little progress of works, neglect of spending, not taking care of realization of purchases and expenses foreseen in the project	Distortion of the project schedule, failure to obtain further financing	5-20% - unlikely (2 points)	High (4 points)	Medium (8 points in the risk matrix)	On-going financial control, requirement for timely reporting	small
4	Lack of coordination in project management	investor	No project management meetings, no working meetings with task managers	Disturbances in the design work schedule	5-20% - unlikely (2 points)	High (4 points)	Medium - (8 points in the risk matrix)	Strengthening management supervision	small
5	Unrealistic research assumptions	investor	Lack of proper recognition of the issue, false information and data, incorrect definition of the purpose and schedule of the project implementation	Inability to achieve the project objective	2-10% Very small (1 point)	Catastrophic (5 points)	Medium - (5 points in the risk matrix)	Change of project assumptions, verification of the project schedule and objective	High
6	No market demand for the product	investor	Poor recognition of the sales market, unexpected external phenomena affecting the stability of the sales market, changes in the demand for the product	Inability to implement and start production	4-20% - very small (1 points)	Catastrophic (5 points)	High - (15 points in the risk matrix)	Searching for alternative sales markets, lowering the product price, withdrawal from implementation, interruption of the project	High
7	Failure to implement the project	investor	Lack of demand for the product, financial collapse of the company, adverse effects of external factors	Failure to complete the project according to the schedule,	41-60% - medium (3 points)	Catastrophic (5 points)	High - (15 points in the risk matrix)	Financial analysis of the investment before the implementation, economic analysis of the project taking into account the situation, identification of the sales market	High
8	Acceptance of unrealistic deadline for project and implementation	investor	Lack of ability to anticipate changes in the project schedule, underestimation of the duration of project work	Extension of the project duration	5-20% Small (2 points)	Small (2 points)	Average (4 points in the risk matrix)	Good identification of weaknesses in the project	Small

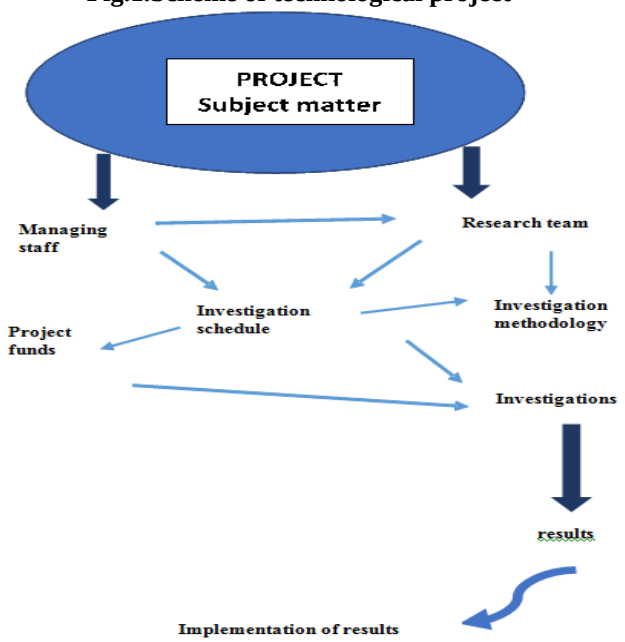
Table 5. Positioning the risk on the probability map of its occurrence

Impact	**Catastrophic**	**5 – No 5 No 6, ~~No 7~~**	**10**	**15 No 7**	**20**	**25**
	High	**4**	**8**	**12**	**16**	**20**
	Medium	**3**	**6**	**9 – No 1**	**12**	**15**
	Small	**2**	**4 – No 8**	**6 – No 2**	**8 – No 3, No 4**	**10**
	Very small	**1**	**2**	**3**	**4**	**5**
		Very small	**Small**	**Medium**	**High**	**Almost certain**
		Probability				

Implementation of results is often conditioned by external factors, in particular, the demand for the product, which varies over time and is associated with the greatest risk, although the probability of such an event occurring is small or medium (Table 5). A wide range of factors influencing the final success of an innovative project makes them difficult to implement. The duration of the project and its implementation is very important in them.

Defining a subject that meets the definition of innovation is the first stage of creating a future project. At the same time, it is an important moment due to the risk of making a mistake by misdirecting research. Risk assessment at this stage should include a comparison with other subjects that coincide or are close to the proposed one and should be based on the experience of the management team (Fig.1).

Fig.1.Scheme of technological project



In the implementation phase, external risk prevails, because implementation makes sense only when there is a demand for the manufactured product. The demand for products depends on the market situation, the political situation and the industrial environment. Various types of administrative regulations changing the economic situation (e.g. an epidemic) may change the conditions of implementation. Due to the impact of various variables, the economic situation may deteriorate, but also improve, depending on the industry. Also the industrial environment - suppliers, raw material costs, etc. affect the possibility of implementation. The currency ratio and implementation costs are also important. As external risk is largely unpredictable, the implementation phase is one of the most difficult stages of a project. Predicting and assessing risk at this stage must be dynamic and flexible, reacting quickly to changes that occur. Risk effects can be both positive and negative (Denney, 2020). A quick response to prevent the negative effects of risk can reduce possible losses.

Every successfully implemented idea or product is a result of a long and painstakingly supervised innovation process. While principles and methods of idea development are universal for all industries, there is no strict rule regarding the steps from idea generation to implementation.

V. Discussion

Kaplan and Mikes proposed the introduction of three risk types: preventable, strategic and external risk (Kaplan and Mikes, 2016). Among these threats, external risk is currently one of the important issues that must be taken into account in the project risk assessment. The discussion of Kaplan and Mikes article (https://www.resolver.com/blog/strategic-risks/,Modified April 17, 2020) focuses precisely on the consideration of the external risk in relation to political situation, geographical events (environment) and other unexpected external events. Specialists also pay attention to the financial side of risk and diverse sources of threats (Miccolis, 2000).

Risk management must anticipate the possibility of risk occurrence and ways of preventing them. Predicting future events is difficult, therefore a certain level of risk resulting from the risk appetite in the organization is acceptable (Miccolis, 2000).

The already mentioned external risk plays a significant role in the risk analysis, especially in implementation of innovation project results (Baunanand Berge, 2016;Klovienė, 2012). Many companies incorrectly assess the risk in their organizations, in particular with regard to management (Hanggraeniet al. 2019). It seems that the possibility of implementing project results is primarily closely related to the external risk, the assessment of which is the most difficult task and creates the greatest problems. The long-time perspective from the beginning of the project to the implementation stage is also a risk element which is difficult to predict in the changing external conditions of the enterprise.

Risk is inherent in any project. The way the risk is assessed and managed depends on the type of project and the style of conduct of the team implementing it. Numerous threats that appear or may appear during the project are predictable in terms of subjective assessment of experts cooperating with the research group, who should be part of the project management team.

The source of risk may be both internal and external activities of the company or organization implementing the project. One can distinguish between factors that the team implementing the project has influence on (e.g. deadlines for the completion of tasks) and independent factors that the team has no influence on, e.g. a change in the market situation. The knowledge of these factors and the identification of the threat is an essential element enabling risk management. Flexible solutions of problems resulting from emerging threats may be an approach to prevent or mitigate the effects of risk.

The company's appetite for risk should also be taken into account, which offers positive premises for possible success, manifesting itself in the production of an innovative product and increasing the company's competitiveness in the sales market (Aven, 2013). J. Yang's work (Young, 2014), based on the example of banking, shows the view that the risk appetite is a separate area that is governed by its own laws. This view can be transposed to technological projects, which are carried out on the basis of indications that the profit of the company may be increased by the production of a new and better product but, on the other hand, there is a serious risk of the project's extension in time, which may change the external sales market and cause the lack of demand for the product. Significant costs of research and implementation undertaken in technological projects make it necessary to estimate future profit carefully. Nevertheless, the lack of investment in innovation in the context of the expansion of new products worldwide and the constant growth of market requirements does not allow to abandon the research and development work in industry. Therefore, the better the expert assessment of a project and its risks, the higher the expectations of determining an appropriate level of risk.

Undoubtedly, it is important to identify key risk indicators, which should take place before the project starts. It is necessary to precisely define the factors influencing the appearance of risk by using various tools that will enable the identification of risk - the strengths and weaknesses of the project in terms of quality and quantity. Such identification is the basis for determining the risk appetite. The management of the risk appetite and the benefits of monitoring this risk were studied in the paper of Korombel (Korombel, 2017). It was found

that risk appetite management increases the likelihood of achieving business goals and results by companies. However, it was found that the risk management and the determination of risk appetite was not carried out in too many companies investigated by the author, despite the fact that the appetite for risk is a fundamental element of risk management, shaping the effectiveness of this process.

It can be claimed that, in particular in enterprises implementing innovative research and development projects, the increase of interest in the issue of risk, the appetite for risk and related issues should be one of the important elements that will contribute to the success of undertaken activities leading to the increase of the enterprise's competitiveness.

The stage of implementing innovation is the weakest link in the innovation process (Jagoda-Sobalak, 2017). Therefore it is necessary to have sustainability plan: a narrative description of how a project and its benefits will continue after grant funding is complete. Preparing project stage is very important because the purpose of the project and the way to achieve it must be defined. If the project results in an innovative product, it is necessary to recognize the demand for this product in the next few years. The project execution time is extremely important if the investor wants to hit the most favorable sales period.

The project implementation plan is another important stage that should be divided into a series of research and industrial stages aimed at developing a prototype for use in practice. The last stage is the implementation of the manufactured product into practice. There is a legitimate question whether the demand for the solution developed in the project will be the same after several years of project implementation. as to the possible implementation of the results, even taking into account project interruption.

Implementation of the innovative product or technology requires knowledge of the sales market, development and forecasting the profitability of starting production and developing a schedule of activities ensuring the launch of the product on the market.

Research on the application of the results of the implemented projects in the metal industry has shown that despite the participation of an industrial partner in the project, which would indicate his commitment, the implementation of the results caused numerous problems. They were related to the lack of interest in investing new solutions due to the low return on invested funds, changes in market demand, changes within the company related to changes in the company's strategy, changes in the local, national and world economy market. This phenomenon is growing especially now, as is the trend towards conservative actions and cautious investments.

VI. Conclusions

The presented analysis covers the issue of risk related to the implementation and implementation of innovative technological projects in the metal industry. The key causes of risk in these projects were identified on the basis of 10 completed technological projects. These projects were carried out in the metal industry and concerned various issues, however, they had an innovative goal, which was to develop new solutions, which were then to be put into practice.

Many years of experience in managing projects and practice in their implementation has become the basis for selecting key threats related to their implementation and then implementation. The implementation threat was identified as the highest risk with an average probability of occurrence. The experience, literature data and analysis of the problem show that the duration of the project, which is usually 2-3 years, is a parameter that strongly influences the implementation of the results. Possible threats are presented, such as changes in the market demand for the manufactured product, changes inside the enterprise, which is likely to take a long time for the project, external changes, which nowadays may be associated not only with a reduction in the number of contractors but also with changes in administrative regulations.

The presented factors, which are not exhaustive, may become significant obstacles to the implementation of the results of innovative projects. An innovative product requires marketing, advertising and tests to confirm its usefulness. This generates additional costs, which may also become a damage and failure to act despite the earlier expenditure on project implementation. Therefore, there are even cases of abandoning the implementation of innovative projects during their implementation after conducting a risk analysis of its further continuation.

The visualization of threats, the probability of their occurrence and their impact on the project was presented using a risk map. The construction of the risk map and the accuracy of the assessment largely depends on the experience of the expert and his practice in the studied field. However, the possibility of flexible changes means that the risk map constructed many times during the implementation and implementation of the project can perfectly reflect the progress and threats that appear and disappear during the project development. This particularly applies to innovative projects with high variability and high risk management requirements. It is precisely because of the variability and the time regime that innovative projects are more demanding and pose greater risks. On the other hand, despite the higher risk of innovative projects, if they are successful, it guarantees a potentially higher return on funds spent.

Risk analysis in innovative projects in the metal industry is subject to constant changes, therefore in the future it would be beneficial to expand the research in terms of determining how the current external conditions and to what extent affect the risk in these projects, and to conduct research on the impact of risk on the condition of companies in the metal industry.

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