Progress. Journal of Young Researchers 17/2025
ISSN 2543-8638 DOI: https://doi.org/10.26881/prog.2025.17.10

High Risk Research and Development Projects as an Opportunity for Polish Start-Up Enterprises

Łukasz Budynek | Łukasz Budynek Business Consulting
ORCID: 0009-0005-4683-5251

Abstract

Keywords:
start-up, R&D, project risk

The aim of this paper is to present the possibility of using high-risk R&D projects as an opportunity for Polish start-ups to succeed. Start-up organisations, alike R&D projects, are characterised by uncertain or non-existent demand and extremely limited internal resources. These projects are a system of activities defined by their scope, deadline and resources; they are subject to a high degree of risk, which directly affects the subsequent phases of their development. Polish start-ups engaging high-risk R&D can turn it into a genuine lever of advantage when they combine portfolio discipline, rapid iterations coupled with risk metrics, integration with requirements processes, and a supportive, predictable institutional environment. The research methods used included a critical review of literature on the subject (compact books, scientific papers, thematic press, specialised reports) and a case study (selected examples of Polish start-ups that implement high-risk projects).

Projekty badawczo-rozwojowe o wysokim ryzyku jako szansa dla polskich start-upów (Streszczenie)

Słowa kluczowe:
start-up, R&D, ryzyko projektu

Celem niniejszego artykułu jest przedstawienie możliwości wykorzystania projektów badawczo-rozwojowych o wysokim ryzyku jako szansy na osiągnięcie sukcesu dla polskich start-upów. Start-upy, jako projekty badawczo-rozwojowe, charakteryzują się niepewnym lub nieistniejącym popytem oraz niezwykle ograniczonymi zasobami wewnętrznymi. Projekty te stanowią system działań zdefiniowany przez ich zakres, czas wykonania oraz zasoby. Podlegają one wysokiemu stopniu ryzyka, które bezpośrednio wpływa na kolejne fazy ich rozwoju. Polskie start-upowe projekty B+R o podwyższonym ryzyku stają się realną dźwignią przewagi, gdy łączy się dyscyplinę portfelową, szybkie iteracje i metryki ryzyka, integrację z procesami wymagań oraz sprzyjające, przewidywalne otoczenie instytucjonalne. Metody badawcze wykorzystane w pracy obejmowały: analizę krytyczną literatury z zakresu tematu (książki, artykuły naukowe, prasa tematyczna, specjalistyczne raporty) oraz studium przypadku (wybrane przykłady polskich start-upów realizujących projekty o wysokim ryzyku).

Introduction

Today's economic conditions often compel projects to be undertaken with a higher level of risk than usual. At the same time, a higher risk also provides an opportunity for a greater success. The implementation of such research and development projects in Poland is currently necessary from the point of view of a broadly understood innovation policy. However, the scale of implementation of these projects in the country is too low. This is particularly true of high-risk projects, which, despite the fact that they have the potential to produce highly desirable results, are in many cases abandoned due to the significant level of risk involved in their implementation. Many investors choose not to follow such business models precisely due to problems of managing and financing risky activities.

In practice, however, the risks of such R&D (Research and Development) projects can be mitigated through appropriate risk management that allows a kind of balance to be struck between the possible risks of a given project and the expected results. Start-ups, among others, can benefit greatly in this area as they are a special category of entities that are constantly looking for new, innovative development paths and business models. Various types of high-risk research and development projects, when properly managed and funded, offer a very good chance of success. This issue will be addressed in the present paper.

The aim of the analysis is to present the potential of high-risk R&D projects as an opportunity for the success of Polish start-ups.

This objective will be achieved through two research methods. The first is a critical analysis of the literature on the subject. In this respect, the author will make use of sources of knowledge such as reference books, scientific papers and articles in the thematic press, as well as specialised reports. The second research method used is the case study method. It will include selected examples of Polish start-ups that implement high-risk projects.

The paper is divided into sections, starting with an introduction, which presents the basic methodological assumptions, through development of the topic and ending with a summary and conclusions. The development of the topic will mainly include issues such as the essence and characteristics of start-ups, a discussion of the distinctive features of high-risk R&D projects, the issue of project risk management, as well as examples of selected Polish start-ups that implement high-risk R&D projects.

Special Features of Start-Ups

In practice, there are many different definitions of a start-up company; each person may understand this concept quite differently. This is clearly pointed out by, among others, Kałowski and Wysocki (2017). They emphasise that start-up can be interpreted

as one of the stages in the process of operation of an organisation or venture. Various typologies can also be used to identify it, for example, based on the purpose of its establishment, the market or environment in which it operates or the way in which a given venture is financed.

To date, a relatively popular interpretation immanently links start-up activity with technological innovation (above all, IT innovation). The authors of a specialised report on Latin American start-ups prepared for the OECD in 2013 have summarised various definitions of start-ups used to explain the above phenomenon. They have defined them based on qualitative criteria, namely: dynamically growing companies, innovative start-ups, so-called "gazelle" companies, organisations with high impact on their environment, and dynamic entrepreneurship. The literature also identifies start-up in the context of innovation. As a rule, the above businesses are defined according to two key criteria, namely: growth rate and innovation (Kałowski, Wysocki 2017).

However, it should be noted that the above interpretation restricts the concept of a start-up. According to another definition, a start-up is a form of a temporary organisation in its early stage of the life cycle, created for the purpose of seeking a replicable and scalable model of a business. In this case, scalability is interpreted as a relatively proportional increase in market share within a given market and, consequently, leads to a multiplication of the invested funds, for instance, within a VC fund or by Business Angels (Blank, Dorf 2012).

The literature on the subject also emphasises that a start-up operates under high uncertainty and is primarily based on a business model and MVP testing. Start-ups are characterised by low initiation costs, relatively high risk, but at the same time a higher return on investment. It should be noted that start-ups operate on the basis of a business model which defines how an organisation intends to create and deliver value to its own target customers. In other words, the model outlines the methods and channels for distribution of, for example, products and services, the cost structures of specific departments, as well as the methods for achieving the set goals (e.g. acquiring the required number of users within a set time, increasing web traffic, and other similar features) (Blank, Dorf 2012).

Start-ups operate under the conditions of uncertainty, not only technological, but also in terms of demand. In order to obtain adequate information as to whether a particular product stands the chance of becoming popular with customers, a so-called MVP (*Minimum Viable Product*), i.e., a working product with minimal functionalities, which allows maximum information to be collected from customers at the lowest possible cost, is created. Through successive iterations in the product's development process, the objective is to deliver a fully functional product that will satisfy customer requirements (Łopusiewicz 2013).

The issue of start-ups has also been examined by, among others, Skała (2017) who emphasised that the definition of start-ups is slightly different for ventures

at the initial phase of their development and for those that are already mature organisations. At the very beginning of a start-up organisation, the key features include an uncertain or non-existent demand and extremely limited resources of an internal nature, while at an advanced stage of development, a start-up will be a venture that exploits a situation of so-called disruption in the market, through which hyperscalability and a high valuation of the company are achieved. Some start-up enterprises find a suitable business model right from the very beginning and develop over time into different organisations, such as micro-enterprises, non-profit foundations or corporations. Others remain at the start-up phase for much longer, all the while operating in an extremely unstable and uncertain market environment (Skała 2017).

The key characteristics of a start-up organisation can also be categorised into external and internal factors. The first category can include an initially uncertain level of demand, an emerging opportunity for a disruptive market situation, and the possibility of raising a large amount of funding during the advanced development phase (Skała 2017).

The second category includes severely limited resources at the start of operations, a high level of operational capacity within the team to test individual business models, and strong leadership (Skała 2017).

The basic feature of start-ups is considered to be hyperscalability, which a start-up may achieve at a later stage of development thanks to the appropriate use of technologies that automate selected activities or actions within its market offer. Therefore, a special feature of start-ups is that they use advanced digital technologies, primarily those related to information processing in the broadest sense (Skała 2017).

Characteristics of High-Risk R&D Projects

R&D projects are commonly designated by the abbreviations R&D or R+D. In terms of the general characteristics of projects, R&D projects can be defined as a system of activities that is characterised by a triad, namely:

- project scope,
- the deadline for its implementation (time),
- resources that are needed for the implementation (execution) of that project (for example, human, material, capital, technological and information resources) (Karasakal, Aker 2017).

The basic parameters that characterise new R&D projects may also include criteria that relate to quality, cost, and risk. A wide variety of criteria can therefore be used in the evaluation of different R&D projects. These can be divided into general (applicable to any type of project) as well as specific ones. For the projects discussed in this paper, these specific criteria can include, for example, uniqueness, complexity, and traceability (Karasakal, Aker 2017).

Research and development always carries an element of risk, as it involves trying out new and untested ideas. Typical risks associated with research and development include:

- new or modified products or services turn out to be more difficult or costly to develop than initially expected,
- developing a product or service that has not been commercially successful,
- initiating product or service development that proves to be unfeasible.

Research projects by their very nature are high risk, and risk itself is uncertainty. Consequently, risk analysis plays an extremely important role both in the planning process of an R&D project and during its implementation. "Uncertainty" is the key word for properly interpreting the concept of risk. In the simplest terms, a risk is any potential event that may take place in the future, while its aftermath may induce various negative or positive changes within the project itself. When risk is associated with potential losses, it is determined by two basic parameters. Firstly, it is necessary to reasonably assess the probability of a specific event that is triggered by a specific risk. Secondly, it is necessary to estimate the magnitude of potential losses that result from the occurrence of particular negative events (Wysocki, McGary 2017).

It is by no means possible to be certain that all the potential events that may occur have been foreseen. This is because the R&D project environment is constantly changing and the events that cause high project risks can have highly diverse sources. These risks may be of political, economic, technical, commercial, or operational nature. The complexity of the various elements that occur in R&D projects, as well as the variety of risks involved, creates the need for an effective management of the emerging high level of risk in these projects (Wysocki, McGary 2017).

In essence, R&D project risk is quite similar to general risk. It can be defined as an objective event that harms the value creation of a company that may run through each stage of an R&D project. The high risk of R&D projects in companies, for example in the med-tech industry, is mainly due to the uncertainty as to the research of the project itself, the inconsistency of skills of the developer of the solution, and the difficulty and complexity of applying the technology. For these reasons, the likelihood of risks in R&D projects in progress is much greater than in other projects. At the same time, these projects may fail to achieve the objectives that were initially envisaged (Yu 2021).

Essentially, R&D activity is a process that cannot be separated from continuous exploration and discovery, and the progression of this process is always associated with a wide variety of uncertainties. These uncertainties are not only a source of corporate risk for med-tech companies, but also for the viability of the company undertaking developmental change. As a result, risk in an R&D project is objective and cannot be completely avoided.

The R&D phase of a project is extremely important in this context, as later stages of the project depend on the outcomes of the earlier phase. According to the literature, during the continuous ramp-up of R&D projects, risk can be characterised as a one-way forward transfer effect, and this means that individual risks from the previous stage can have an impact on subsequent phases of research development. With increasing stabilisation of the technology within the R&D project, or the formation of the finished product or service, many uncertainties will gradually be eliminated. This will be associated with the process of continuous progress and improvement of R&D projects. Consequently, as the project progresses, the uncertainty factors leading to high risk will gradually diminish. The rate at which these uncertainties are reduced is itself a project-specific characteristic influenced, among other things, by the product category, the technical complexity, or the qualifications of project team members (Yu 2021).

Project Risk Management

The project risk management process includes: risk identification, risk analysis, risk response, and risk control. The stages of project risk management are shown in Figure 1.

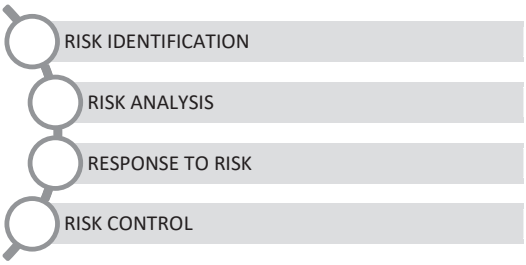

Figure 1. Basic steps in project risk management
Source: (Wysocki, McGary 2017).

At the risk identification stage, project managers should combine perceptual knowledge and experimentation with appropriate statistical methods. This approach is employed in order to adequately identify and classify potential risks. In the risk analysis phase, on the other hand, it is necessary to objectively analyse the likelihood of a given risk and assess its impact on the project itself, and then to sort the risks accordingly to create a risk prioritisation list. In the risk response phase, the main risk response strategies should be selected and implemented for high-priority risks. Risk control, in turn, is the continuation of risk management activities throughout the project life cycle (Gu et al. 2009).

In order to ensure that high risk factors are adequately identified within an R&D project, a holistic assessment of the project is essential. This is because it is extremely difficult to identify the actual sources of factors that might threaten the project. The categorisation of risks that has been proposed within the PMBOK (Project Management Body of Knowledge) Guide (PMBOK 2009) can be particularly useful in this context.

A risk analysis should be carried out when planning an R&D project. Already at the first stage, during the so-called project start-up, the scope of the project is defined. However, the next stage of the analysis should include components such as the characteristics of the R&D project in question, its definition of the environment, and a thorough assessment of the stakeholders (interested parties) of the project. At this stage, issues related to the identification of the likely level of risks that may arise during the course of the project should also be addressed. The third phase is the so-called design phase (Chong, Brown 2001).

At this level, a great deal of attention should be given to personnel and financial issues, in addition to technical matters and the clarification of the project's risk management methodology. The fourth stage of implementation is the phase during which the right resources are used. This is when the appropriate administration of the R&D project becomes necessary. This is also when the essential risk factors are encountered in practice. The next, fifth stage focuses on testing issues and quality assessment. Its primary task is to appropriately verify the progress of the R&D projects, and make correct acceptance or rejection decisions. During this stage, various adjustments to the original project plan may also be made. The objective of the sixth stage, or the so-called production, is the acceptance by the client. Then comes the final phase, which determines whether the R&D project has achieved the desired objective. A project review is then carried out. Through such planning, the R&D project can be completed on time, within the confines of its budget and fulfil most of the criteria that are referred to as "project success criteria" (Chong, Brown 2001).

When proceeding to properly identify the risks of an R&D project, all kinds of risks should be traced in order to be able to decide, on this basis, which ones are to be ignored and which ones should be dealt with more thoroughly. This will make it possible to avoid a situation in which the project team members are unprepared for the upcoming difficulties and, at the same time, have limited resources, thus facing a high risk of failure in the project. Therefore, it is necessary to analyse in greater detail which of the risks are very serious and which have a rather minor impact on the project in question. As an iterative process, risk analysis must always have certain characteristics that will enable an adequate risk perception for a specific task (Chong, Brown 2001).

In addition to this, as part of the process of high-risk analysis of research and development projects, probability issues should also be anticipated. Namely, it is possible

to distinguish here factors with a negligible level of occurrence probability and those that are almost certain to occur. In such a case, given the few resources available, it is necessary to manage them appropriately.

It is therefore necessary to carefully analyse all risks taking into account two basic parameters:

- impact, the main aim of which is to examine how significant will be the impact of a particular hazard on a project, and
- probability, which involves examining the likelihood of a particular hazard (Jones 2009).

Selected Examples of Polish Start-Ups Implementing High-Risk R&D Projects

An example of a Polish start-up that carries out high-risk R&D projects is DevSkiller, founded by Satim, a Krakow-based company that operates in the IT field. In 2023, the start-up raised €1.2 million (≈ PLN 5.2 million) from Movens Capital and business angels, on top of an earlier €1 million bridge financing from 2020 (AIN 2023; Tech.eu 2020). DevSkiller is a start-up that offers a platform for assessing and managing employee skills. In this context, it should be pointed out that TalentBoost – which is an innovative tool operating within DevSkiller – allows companies to implement an operational model that is based on skills (so-called "skills-based organisations"). This solution allows already existing talent to be matched to the current needs of the company and prioritises internal candidates, thus improving retention and at the same time reducing the costs associated with hiring and onboarding new employees. Data on new employees is contained in modern ontologies relating to their skills – these are structured trees that categorise and describe the relationships between individual skills. These ontologies are provided in the form of transparent and interactive skills maps as well as ready-to-use competency-based models (Dobroszek 2023).

The above-mentioned TalentBoost tool fulfils an essential function within the framework of a skills and human resources management strategy. Its advanced insight into the profiles of individual employees enables their precise placement in specific projects selected according to their respective competences and interests. In this case, the matching of activities to the employees' actual competences makes it possible to increase their motivation, productivity and job satisfaction. It should be noted that the global market for HR Tech reaches approximately USD 170 billion, which clearly confirms that the market in which DevSkiller operates is one of by far the most promising sectors in the world today. Based on artificial intelligence, DevSkiller's solution is fully viable for companies and employees alike. From the company's point of view, it provides the right digital skills that are essential for the implementation of the strategy, while it allows employees to have "tailor-made" development

activities. The TalentBoost tool helps both to attract talent and to reduce possible competence gaps of existing staff (Dobroszek 2023).

At this point, it should be noted that the revenue generated by DevSkiller amounted to PLN 10 million in 2022, while the company expected to grow by up to PLN 20 million in 2023. More than 50% of this start-up company's revenue comes from the United States. The above HR tech solution is used by numerous companies, such as Roche, Deloitte, Orange Warsaw or Schneider Electric (Dobroszek 2023).

Another start-up engaged in high-risk R&D projects is the NeuroON project, along with its associated device, the ZizZ mask. According to the literature on the subject, this represents one of the Polish R&D solutions in the field of medicine that has achieved the greatest international success in the previous decade. Created by Interclinic, the project has found recognition not only in the domestic and European markets, but also in the United States. NeuroON was the first consumer device available in the global market to automatically analyse sleep by providing brainwave monitoring and increasing its efficiency level through the use of pulsed light therapy. In its initial phase, the project aimed at creating a device that could analyse sleep and provide appropriate advice to people who want to sleep in a polyphasic manner (sleep that consists of several shorter naps instead of a continuous night sleep) (Komputer Świat 2016).

NeuroON has three main components: a comfortable mask made of soft and hypoallergenic material, a smartpack with the electronic components of the device, which are coated with medically approved silicone, and the NeuroON mobile application to operate the mask. The mobile application communicates directly with the mask via Bluetooth. NeuroON provides measurement of basic biological parameters of the human body, including individual brain waves (provided by a 1-channel EEG), pulse (using a pulse oximeter), body temperature, and body movement during sleep (using actigraphy). Following the collection of relevant data, the NeuroON mask provides the individual user with personalised pulsed light therapy to improve their sleep quality. Using so-called artificial dawn, i.e., a continuous light therapy with increasing intensity, the device supports the individual in a gentle and gradual awakening, while reducing the discomfort typically experienced upon waking (so-called sleep inertia) (Komputer Świat 2016).

NeuroON has six key functions to improve the quality of life of the device user. First and foremost, it offers the Sleep Analytics function, which provides a highly accurate and advanced analysis of the user's sleep. This is the primary utility of this mask. Immediately after establishing a connection with the appropriate mobile application, NeuroON starts sending the so-called sleep reports with very precise data concerning, among others, the time of falling asleep, the length of sleep and its architecture, and calculating the Sleep Score, i.e., evaluating sleep based on data objectively measured by the device, as well as on the user's subjective experience

during sleep. The above information is collected and measured throughout the sleep period through three gold-coated dry electrodes, which remain in contact with the skin in the forehead area. According to source material, NeuroON is the first such highly advanced sleep sensor to be made available in the consumer market, which has contributed to the start-up's market success. The currently available consumer devices used to measure sleep are mainly based on the user's movements (so-called actigraphy), as well as measuring pulse during sleep. The NeuroON significantly extends these functionalities. It is worth emphasising, however, that the so-called gold standard for sleep measurement in modern medicine is polysomnography, with brainwave measurement being its inherent and permanent component (Komputer Świat 2016).

Another of the device's functions is Light Boost, i.e., light therapy. The device provides the appropriate dose of energy for the user to continue working, increases concentration and reduces sleepiness. The light source is located in the so-called smartpack and acts directly on the eyelids, thus allowing light therapy to be used in a very comfortable and discreet manner. A single treatment lasts approximately twenty minutes. Another solution is the NeuroON sunrise, a kind of "intelligent wake-up call" function. Its user no longer needs the traditional alarm clock, which very often wakes people during the deep sleep phase, resulting in a very unpleasant awakening (Komputer Świat 2016).

Among the functionalities of this device, the Jet Lag Blocker function is also noteworthy. This solution helps to counteract sleep disorders after changing time zones. All the user has to do is to set their travel destination in the mobile app and the mask adapts the therapy and makes a series of recommendations to optimise the sleep pattern during travel. Another feature, Personal Pause, is a programme for personalised, intelligent naps, monitored by NeuroON, which prevents the user from entering the deepest phase of sleep. Through its mobile application, the mask plans the optimal nap based on the individual's needs (Komputer Świat 2016).

The last of the important functionalities is the Biorhythm Adjuster. Its primary purpose is to adapt the sleep cycle to the user's ever-changing daily schedule. Thanks to the above option, the analysed mask helps its user to adapt their biological clock to a pre-planned wake-up time. In addition, this device facilitates getting used to an irregular lifestyle during shift work and also supports the process of falling asleep, which is disturbed, among other things, by the artificial blue light that is emitted by electronic devices (Komputer Świat 2016).

Recent literature converges on addressing the high uncertainty of R&D at the portfolio level, integrating selection, design, and portfolio-maintenance routines (Si, Kavadias, Loch 2022; Martinsuo, Vuorinen, Killen 2024; Bagno et al. 2023; Azenha, Fleury 2024). Effective approaches deploy robust optimization and efficiency – uncertainty maps to balance value with C-VaR and inter-project interdependencies (Wang

et al. 2024; Namazi et al. 2023; Li et al. 2022). Uncertainty reduction is accelerated by controlled experimentation and A/B testing, which deepen organizational learning and enable faster "scale-or-abandon" decisions (Koning, Hasan, Chatterji 2022). In early phases, uncertainty management should be integrated with requirements engineering and agile practices (Barrett et al. 2021; Heimes et al. 2023; Klaus-Rosińska, Pliński 2023; Hölttä-Otto et al. 2023). In circular ecosystems and partnership networks, portfolio choices must reflect ecosystem logic and organizational ambidexterity (de Vasconcelos Gomes et al. 2023; Spanjol et al. 2024).

From an institutional perspective, Poland remains a "moderate innovator," implying the need to upgrade both the quality and financing of high-risk projects (European Commission 2024; WIPO 2024; OECD 2023). Domestic evidence shows rising entrepreneurship and VC activity, yet sensitivity to cyclicality and policy uncertainty that shape exit paths (PARP 2024; GEM 2024; PFR Ventures 2025; Dealroom 2024; Cotei, Farhat, Khurana 2022; Pollman 2023). R&D support policies should minimize risks of policy failure and strengthen SME–FDI linkages to shorten learning and diffusion cycles (Bleda, Krupnik 2024; OECD 2025). For Polish start-ups, high-risk R&D becomes a genuine lever of advantage when firms combine portfolio discipline, rapid iterations and risk metrics, integration with requirements processes, and a supportive, predictable institutional environment (Kapoor, Klueter 2021; Li et al. 2025).

Summary and Conclusions

During the analysis, the research objective outlined in the introduction was achieved. The objective was to present the potential of high-risk research and development projects as an opportunity for Polish start-ups to succeed. This objective was accomplished applying the research method of a critical review of the subject, and a case study of Polish enterprises that can be classified as start-ups implementing high-risk research and development projects.

Based on the foregoing considerations, the following observations can be made:

- There is no uniform definition of a start-up company in the literature on the subject. The term can be applied in the context of organisations at their early stages of development, as well as to existing companies that are embarking on new ventures. However, despite the differences in the literature as to how start-ups are interpreted, it is possible to identify a set of certain common characteristics that are associated with this type of entity.
- At the very beginning of a start-up, uncertain or non-existent demand and extremely limited internal resources should be regarded as key characteristics of this type of organisation; while at an advanced stage of development, a start-up will be a venture that exploits a so-called disruption in the market, thereby achieving hyper-scalability and a high valuation of the company.

- As compared to the general characteristics of projects, R&D projects can be defined as a system of activities that are characterised by a triad including the scope of the project, the timing of the project (time), and the resources that are needed to implement (execute) this project (for example, human, material, capital, technological, and information resources).
- Research and development always carries an element of risk as it involves trying out new and untested ideas.
- During the continuous ramp-up of R&D projects, risk can be characterised as a one-way forward transfer effect, and this means that individual risks from the previous stage can have an impact on subsequent phases of research development.
- The project risk management process includes: risk identification, risk analysis, risk response, and risk control.

References

Azenha F.C., Fleury A.L., 2024, *Unlocking breakthroughs in portfolio strategies for radical projects: a literature review*, "Production", No. 34, e20240060, doi: 10.1590/0103-6513.20240060.

Bagno R.B., Freitas J.S., 2023, *Setting the three-stage R&D shared portfolio methodology: an innovative approach to industry–university collaboration*, "REGE – Revista de Gestão", Vol. 30, No. 3, doi: 10.1108/REGE-07-2021-0108.

Blank S., Dorf B., 2012, *Podręcznik start up-u. Budowa wielkiej firmy krok po kroku*, Gliwice.

Bleda M., Krupnik S., 2024, *Risks of policy failure in direct R&D support*, "Technological Forecasting and Social Change", 209, 123654. doi: 10.1016/j.techfore.2024.123654.

Chong Y., Brown E., 2001, *Zarządzanie ryzykiem projektu*, Warszawa.

Cotei C., Farhat J., Khurana, I., 2022, *The impact of policy uncertainty on the M&A exit of startup firms*, "Journal of Economics and Finance", Vol. 46, No. 1, doi: 10.1007/s12197-021-09553-9.

Dealroom, 2024, *Central and Eastern European Startups – 2024*, Dealroom.co, 19 March 2024, https://dealroom.co/reports/central-and-eastern-european-startups-2024 [access: 1.10.2025].

Dobroszek K., 2023, *DevSkiller pozyskuje 5 mln zł finansowania. Nowe technologie HR podbiją rynek pracy?* „My Company Polska", nr 8.

European Commission, 2024, *European Innovation Scoreboard 2024*, Publications Office of the European Union, Luxembourg, https://op.europa.eu/en/publication-detail/-/publication/8a4a4a1f-3e68-11ef-ab8f-01aa75ed71a1 [access: 3.10.2025].

Global Entrepreneurship Monitor (GEM), 2024, *GEM Poland 2024 Report* (National report, 13th edition; English version), https://www.gemconsortium.org/report/gem-poland-2024-report [access: 4.10.2025].

Gomes L.A. de V., Castillo-Ospina D.A., Figueiredo Facin A.L., dos Santos Ferreira C., Ometto A.R., 2023, *Circular ecosystem innovation portfolio management*, "Technovation", No. 124, 102745. doi.org/10.1016/j.technovation.2023.102745.

Gu X., Cai Ch., Song G., Song J., 2009, "Research on R&D Project Risk Management Model", No. 35, doi.org/10.1007/978-3-642-02298-2_81.

Heimes H.H., Kampker A., Kehrer M., Gerz J., Salerno M., Zancul E., 2023, *Bridging Uncertainty Management and Requirements Engineering in R&D projects: a case in the e-mobility sector,* "Procedia CIRP", No. 119, doi:10.1016/j.procir.2023.02.139.

Hölttä-Otto K., Björklund T.A., Klipper, M., Otto K., Krause D., Eckert C., Nespoli O., Albers A., 2023, *Facing extreme uncertainty – how the onset of the COVID-19 pandemic influenced product development*, "International Journal of Design Creativity and Innovation", Vol. 11, No. 2, doi:10.1080/21650349.2022.2157888.

Jones J., 2009, *Zarządzanie projektami. Sztuka przetrwania,* Warszawa.

Kałowski A., Wysocki J., 2017, *Start-up a uwarunkowania sukcesu, Wymiar teoretyczno-praktyczny,* Warszawa.

Kapoor R., Klueter T., 2021, *Unbundling and Managing Uncertainty Surrounding Emerging Technologies,* "Strategy Science", Vol. 6, No. 4, doi:10.1287/stsc.2020.0118.

Karasakal E., Aker P., 2017, *Multicriteria Sorting Approach Based on Data Envelopment Analysis for R&D project selection problem*, "Omega-Elsevier", No. 73, doi: 10.1016/j.omega.2016.12.006.

Klaus-Rosińska A., Pliński W., 2023, *Management of R&D projects in the early phases of the project life cycle – empirical research*, "Procedia Computer Science", No. 219, doi.org/10.1016/j.procs.2023.01.500.

Koning R., Hasan S., Chatterji A., 2022, *Experimentation and Start-up Performance: Evidence from A/B Testing*, "Management Science", Vol. 68, No. 9, doi.org/10.1287/mnsc.2021.4209.

Komputer Świat, 2016, *Neuroon – polska maska do „inteligentnego" spania już dostępna*, „Komputer Świat", nr 1.

Li D., Fu X., Narula R., von Zedtwitz M., Wagner B., 2025, *R&D Management under disruption and uncertainty*, "R&D Management", Vol. 55, No. 4, doi: 10.1111/radm.12747.

Li H., Chen R., Zhang X., 2022, *Uncertain Public R&D Project Portfolio Selection Considering Sectoral Balancing and Project Failure*, "Sustainability", Vol. 14, No. 23, 15774. doi.org/10.3390/su142315774.

Łopusiewicz A., 2013. *Start-up Od Pomysłu Do Sukcesu*, Warszawa.

Martinsuo M., Vuorinen L., Killen C.P., 2024, *Project portfolio formation as an organizational routine: Patterns of actions in implementing innovation strategy*, "International Journal of Project Management", Vol. 42, No. 4, doi.org/10.1016/j.ijproman.2024.102592.

Namazi M., Tavana M., Mohammadi E., Bonyadi Naeini A., 2023, *A new strategic approach for R&D project portfolio selection using efficiency–uncertainty maps*, "Benchmarking: An International Journal", Vol. 30, No. 10, doi.org/10.1108/BIJ-02-2022-0129.

OECD, 2023, *OECD Science, Technology and Innovation Outlook 2023*, OECD Publishing, https://www.oecd.org/en/publications/oecd-science-technology-and-innovation-outlook-2023_0b55736e-en.html [access: 4.10.2025].

OECD, 2025, *Strengthening FDI and SME Linkages in Poland*, Paris, OECD Publishing, https://www.oecd.org/en/publications/strengthening-fdi-and-sme-linkages-in-poland_cb08eb93-en.html [access: 6.10.2025].

PFR Ventures and Inovo Venture Partners, 2025, *Polish VC Market Outlook 2024*, Warsaw, PFR Ventures, https://pfrventures.pl/en/artykul/polish-vc-market-outlook-2024 [access: 4.10.2025].

PMBOK, 2009, *PMBOK Guide* (Fourth Edition), Project Management Institute.

Pollman E., 2023, *Startup Failure*. "Duke Law Journal", Vol. 73, No. 2, https://scholarship.law.duke.edu/dlj/vol73/iss2/2/ [access: 5.10.2025].

Polska Agencja Rozwoju Przedsiębiorczości (PARP), 2024, *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce 2024*, Warszawa, https://www.parp.gov.pl/component/publications/publication/raport-o-stanie-sektora-malych-i-srednich-przedsiebiorstw-w-polsce-2024 [access: 1.10.2025].

Si H., Kavadias S., Loch C., 2022, *Managing innovation portfolios: From project selection to portfolio design*, "Production and Operations Management", Vol. 31, No. 12, doi.org/10.1111/poms.13860.

Skała A., 2017, *Spiralna definicja startupu*, „Przegląd Organizacji", nr 9.

Sobachynskyi R., 2023, *Polish startup DevSkiller raises €1.2M from Movens Capital and angels*, AIN, 31 August 2023, https://en.ain.ua/2023/08/31/polish-devskiller-raises-1-2m-movens-capital/ [access: 7.03.2024].

Spanjol J., Noble C.H., Baer M., Bogers M.L.A.M., Bohlmann J., Bouncken R.B., Bstieler L., De Luca L.M., Garcia R., Gemser G., Grewal D., Hoegl M., Kuester S., Kumar M., Lee R., Mahr D., Nakata C., Ordanini A., Rindfleisch A., Seidel V.P., Sorescu A., Verganti R., Wetzels M., 2024, *Fueling innovation management research: Future directions and five forward-looking paths*, "Journal of Product Innovation Management", Vol. 41, No. 5, doi.org/10.1111/jpim.12754.

Tech.eu (2020), *DevSkiller raises €1 M bridge funding*.

Wang Z., Bai S., Zhang X., 2024, *A robust optimization model for R&D project portfolio risk response decision-making considering risk interaction and regret perception*. "Journal of Industrial & Management Optimization", Vol. 20, No. 12, doi.org/10.3934/jimo.2024073.

World Intellectual Property Organization (WIPO), 2024, *Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship*, Geneva: WIPO. https://www.wipo.int/publications/en/details.jsp?id=4756 [access: 6.10.2025].

Wysocki R.K., McGary R., 2017, *Efektywne zarządzanie projektem*, Gliwice.

Yoo H.S., Jung Y.L., Jun S.-P., 2023, *Prediction of SMEs' R&D performances by machine learning for project selection*, "Scientific Reports", No. 13, doi.org/10.1038/s41598-023-34684-w.

Yu P., 2021, *R&D project risk management research*. "E3S Web of Conferences", Vol. 251, No. 3, doi:10.1051/e3sconf/202125101100.

Biogram

Łukasz Budynek – magister Wydziału Zarządzania Uniwersytetu Warszawskiego, doktorant nauk ekonomicznych w dyscyplinie o zarządzaniu i jakości na Wydziale Organizacji i Zarządzania Politechniki Śląskiej. Przedsiębiorca, właściciel firmy consultingowej. Jako menedżer międzynarodowej korporacji zrealizował projekty end-to-end w sektorze FinTech, w tym o wielomilionowych budżetach, na rynkach EMEA oraz w Kanadzie, zarządzając międzynarodowymi zespołami oraz interesariuszami w strukturze matrix. Dodatkowo zrealizował projekty R&D w sektorze MedTech przy funduszu inwestycyjnym typu venture capital o wielomilionowym budżecie. Autor artykułów naukowych na temat zarządzania i jakości. Zainteresowania badawcze: nauki o zarządzaniu i jakości, prawo korporacyjne, prawo podatkowe.

Łukasz Budynek holds an MSc from the Faculty of Management, University of Warsaw and is a PhD candidate in Economics (Discipline of Management and Quality) at the Faculty of Organization and Management, Silesian University of Technology. An entrepreneur and owner of a consulting firm. As a manager for an international corporation, he delivered end-to-end FinTech projects including multi-million budgets across EMEA and Canada, leading international teams and stakeholders in a matrix structure. Furthermore, he delivered R&D projects in the MedTech sector for a Venture Capital Investment Fund with multi-million budget. He has published articles in peer-reviewed journals in the Management & Quality discipline. Research interests: management and quality sciences, corporate law, and tax law.