
Exploring Critical Factors for Academic Start-ups towards the Development of Technological Entrepreneurship: Preliminary Research Findings

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Abstract:

Purpose: The purpose of the study is to present a discussion of the theoretical framework that illustrates a great variety of defining the concept of technological entrepreneurship in the management science literature. The empirical research aims at evaluation of critical factors supporting the creation and development of academic start-ups as well as obstacles to setting up academic ventures.

Design/Methodology/Approach: The paper draws on a broad literature review, covering various approaches to the concept of technological entrepreneurship. The author tries to critically analyze and synthesize the views of scholars on this phenomenon using the following methods: exploration, interpretation, comparing, analysing features, and inferring. The empirical research applies the method of in-depth structured direct interviews with experts in the field of commercialization and technology transfer, academic entrepreneurship, and start-up incubation. Both descriptive and explanatory techniques were used in the presented study.

Findings: The research findings provide insightful guidance for the ways of supporting start-ups with academic origin and for more effective business-science cooperation. The current reflections on the concept of technological entrepreneurship in management sciences confirm the multidimensionality of the phenomenon and two main research lines, namely one focused on technological innovations created and implemented mainly by high-tech enterprises, and the other one on academic entrepreneurship and the intellectual potential of universities and R&D institutes for commercialization of research findings leading to development of innovative products and services.

Practical Implications: The synthesis of the current reflections on the concept of technological entrepreneurship and the research findings reflected here can benefit both entrepreneurship teachers' practice at HEIs, researchers, and employees of business incubators as a source for further analysis and the relevance of the methods used.

Originality/Value: The originality of the conducted exploratory research lies in presenting the factors supporting operations of academic start-ups diagnosed by the author and their evaluation by experts with many years of experience in the field of business-science collaboration. Moreover, the paper provides an integrated research framework that build on and add value to the previous research on technological entrepreneurship in management sciences.

Keywords: Academic start-ups, business-science collaboration, entrepreneurial ecosystem, entrepreneurial university, technological entrepreneurship.

JEL codes: O31, O32, O33.

Paper Type: Research article.

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1. Introduction

The interrelationships among technological entrepreneurship, entrepreneurial universities, and contemporary businesses in a broad spectrum of an entrepreneurial ecosystem create a complex phenomenon that encompasses multiple disciplines and levels of analysis by using different perspectives (Badzińska and Mrugalska, 2021). Undoubtedly, the concept of technological entrepreneurship is focused on increasing innovation, intellectual capital, and enterprise competitiveness through the more efficient use of the latest research results which lead to the development of innovative business solutions. In its essence, this process is based on the effective cooperation of technology-oriented companies with the science sector (universities and R&D institutes) within the entrepreneurial ecosystem, which means favorable environments of interdependent actors and resources that ensure the emergence of high growth business activities through specific policies and instruments (Mason and Brown, 2014). All types of entities within this ecosystem create an activity network that composes the development of technological entrepreneurship. Thus, science and technology are critical for the execution and operations of modern businesses.

To contribute to the spread of practice in the field of technological entrepreneurship and more effective business-science collaboration, this article, inspired by the prior work of the author on technological entrepreneurship and entrepreneurial university (Badzińska, 2016; 2017; 2020), attempts to advance a framework of factors and obstacles significant for the creation and development of academic ventures (start-ups), thus entities that are an important source of knowledge spillover and transfer of research outcomes from universities to business practice. Academic startups are undoubtedly an important link in the process of shaping technological entrepreneurship, therefore supporting their development is one of the challenges of entrepreneurial universities which provide commercialization of new knowledge in the form of patents, licenses, and university-sanctioned startups for economic development (Etzkowitz *et al.*, 2000).

Contemporary, universities are more and more faced with sudden changes in the business environment that require them to be real active players that are linked to the business sphere having a strong presence in local and regional environment. For example, they should provide opportunities for regional startups or established companies, participate in regional clusters, and take an active role in determining the strategic direction of local development (OECD, 2012).

The purpose of the study is to present a discussion of the theoretical framework that illustrates a great variety of defining the concept of technological entrepreneurship in the

management science literature. In the epistemological layer, the author tries to critically analyze and synthesize the views of scholars on this phenomenon in order to present the existing insights and show new achievements to clarify the area of research on the technological entrepreneurship. In turn, empirical research includes the evaluation of critical factors supporting the creation and development of academic startups using the method of in-depth structured direct interviews with experts in the field of commercialization and technology transfer, academic entrepreneurship, and startup incubation. It is now generally accepted that academic startups are a crucial link in the facilitation of technology transfer, knowledge spillover, and creation of innovative business solutions. Furthermore, they are important accelerators for regional, economic, and social development (Badzińska, 2017).

Due to the qualitative, descriptive, and mostly subjective nature of the research, the results cannot be generalized. The preliminary research presented here is experimental and requires benchmarking with experts from other Higher Education Institutions (HEIs) and adaptation to the current conditions on the Polish market. Despite these limitations, this study illustrates real opinions of experts about knowledge transfer, mentoring, capital support, infrastructure and other facilities required to boost the process of technological entrepreneurship through start-up founders and their innovative business solutions. The originality of the conducted exploratory research lies in presenting the factors supporting operations of academic start-ups diagnosed by the author and their evaluation by experts with many years of experience in the field of business-science collaboration.

Moreover, the contribution consists of providing an integrated research framework that build on and add value to the previous research on technological entrepreneurship in management sciences. The paper is organized as follows: (i) research design and methods; (ii) theoretical framework concerning technological entrepreneurship; (iii) research findings and discussion (iv); and (v) conclusions and future research lines.

2. Research Design and Methods

For the theoretical-cognitive goal of this paper, a review of the Polish and foreign literature on the nature of technological entrepreneurship was conducted. The author benefited mainly from such publication databases as Google Scholar, Scopus, Web of Science, and BazEkon to cover the related publications. To gain a wider scope of publications some other literature found on the Internet (e.g., on ResearchGate) was also reviewed for its contribution to the related topic. The search keywords were “technological entrepreneurship” and “technology entrepreneurship”. The critical analysis of the research on technological entrepreneurship in the management science literature and the attempted synthesis of the views of scholars indicates two main streams of considerations which are discussed in the theoretical framework of this paper. To present the existing insights and show new achievements in the concept of technological entrepreneurship, the following methods were used: exploration, interpretation, comparing, analyzing features, and inferring.

In turn, the exploratory research was designed to identify the problem of supporting the creation and development of academic startups, reducing the obstacles in this process and

to define the direction for further in-depth research. The empirical part of the paper aims to evaluate the significance of factors which support academic startups and thus accelerate the knowledge spillover as well as enable the more effective commercialization of research findings and inventions through effective cooperation with the university and business environment.

Furthermore, the most critical obstacles in this process are also evaluated. Both descriptive and explanatory techniques were applied in the presented study. Therefore, to achieve the research objective, the following questions were posed: What factors of support for the creation and development of academic startups are the most conducive in the seed stage, startup stage and the expansion (growth) stage to ensure the more effective practice-oriented and university-based operations? What are the most critical obstacles in the process of startup creation and development?

As a result of the previously conducted research and the author's experience gained as part of the cooperation with German academic business incubators in the years 2018-2021 (e.g. European University Viadrina Startup Center, Dr Dieterle Founding Network, TH Wildau Startup Center) critical factors were diagnosed that favor the creation and development of academic start-ups at individual stages of the evolution – from the seed stage, through the start-up stage for acceleration (the expansion/growth). In total, 32 factors were presented. In addition, a list of factors inhibiting the creation of this type of ventures was developed (21 factors).

The research findings presented in this paper are the result of research on technological entrepreneurship (with particular emphasis on the role of academic start-ups) conducted as part of a research internship at the Chair of Economic Sciences at the Faculty of Law and Administration at Adam Mickiewicz University (AMU) in Poznan in the period March-June 2020. The necessity to confront a variety of data sources forced the application of the principle of triangulation (a multimethod research approach) (Sułkowski, 2012). Data from secondary sources did not provide sufficient saturation of information for the research objective.

The confrontation of multiple data sources justifies the iterative nature of data collection. To achieve the research goal, qualitative data was obtained from in-depth structured direct interviews conducted with six experts in the field of commercialization and technology transfer, academic entrepreneurship and start-up incubation, as well as intellectual property management. The experts represented, inter alia, the University Center for Innovation and Technology Transfer of AMU, Poznan Science and Technology Park (PSTP) of Adam Mickiewicz University Foundation, and Foundation for Creating Shared Value by Students. The selection of respondents (experts) was purposeful (Patton, 2002) and resulted from: (i) expert knowledge and practical experience of interview participants in the studied area; (ii) their long-term cooperation with the academic community in Poznań; (iii) their employment in institutes / foundations closely related to the transfer of knowledge and commercialization of research results; (iv) the pragmatic criterion of availability of data during the internship at AMU. The above criteria lead to the conclusion that data obtained from the surveyed experts would help to attain the objective of the research.

The structured interview guide contained the following: (i) general questions about the professional experiences, years of work, position, scope of responsibility; (ii) assessment of the significance of diagnosed factors supporting the creation and development of startups; (iii) questions about the role of entities of the entrepreneurial ecosystem offering substantive, financial and organizational support; (iv) assessment of the significance of obstacles in the process of creating and developing start-ups.

The experts were asked to rate the significance of individual factors of support / obstacles for academic start-ups on a scale of 1–5, where the factor significance is respectively: 1 – irrelevant / definitely low and 5 important / definitely high. To verify the gathered information, further online conversations were conducted, and interview questionnaires were sent in an electronic form. The discussion of the results is presented in the subsection.

3. Theoretical Framework Concerning Technological Entrepreneurship

The contemporary far-reaching challenges in the business environment and society (Industry 4.0, smart technology, among others) shed new light on the technological and practice-oriented contribution of universities to their local and regional development by strengthening the dynamics of innovation through their startups and more effective collaboration with interdependent stakeholders. A critical analysis of the literature on the subject reveals that the concept of technological entrepreneurship is becoming more and more popular among researchers of organizational management sciences, especially in the Polish literature from the last five years. The terms: technological entrepreneurship, technology entrepreneurship, technical entrepreneurship, and techno-entrepreneurship are used synonymously in the literature (Petti, 2012).

Based on the review, the author notices two lines of research related to technological entrepreneurship, namely one focused on technological opportunities and innovations created and implemented by technology-oriented enterprises (Byers *et al.*, 2005; Lindenberg and Foss, 2011; Spiegel and Marxt 2011; Petti, 2012; Kordel, 2014; 2018; Staniec *et al.*, 2018; Chyba, 2021), and the other one on efforts of academic entrepreneurship and the scientific potential of universities and R&D units for more efficient use and commercialization of research findings (Matusiak and Matusiak, 2007; Poznańska, 2010; Lachiewicz and Matejun, 2010; Bailetti, 2012; Beckman *et al.*, 2012; Motyka, 2015; Badzińska 2016; 2017; 2020). An essential element of this process is effective cooperation between scientific institutions, R&D centers, capital market institutions, business-related sphere, and technology-oriented enterprises. The above conditions enable the transformation of research and scientific potential into marketable products and services.

Moreover, a crucial role is played here by technology startups which represent the mainstream of academic entrepreneurship and one of the active mechanisms of the commercialization and diffusion of scientific knowledge into the business sphere (Badzińska, 2016). On the other hand, it is the high-tech enterprise that constitutes a core element of the concept of technological entrepreneurship. Such a subject of considerations of this phenomenon provides a different cognitive perspective for the

understanding of this process and focuses more on gathering and reorganizing resources, exploring technological opportunities, and developing strategies within the organization. According to Kordel and Wolniak (2021), *“a key feature of the organizational configuration of technological entrepreneurship is the ability to dynamically allocate resources within a constantly created portfolio of business models as a response to unpredictable changes in the environment.”*

The author claims that inventions, discoveries, new technologies and knowledge transformed from science, implemented, and developed further by commercial innovation-oriented companies form the process of technological entrepreneurship. In addition, Bailetti (2012) clearly highlights that the crucial difference between technology entrepreneurship and other entrepreneurship types is *“the collaborative experimentation and production of new products, assets, and their attributes, which are intricately related to advances in scientific and technological knowledge and the firm’s asset ownership rights.”*

The selected definitions concerning the concept of technological entrepreneurship in the subject literature from 2005-2021 are presented in Table 1. The definitions identify and incorporate the various distinctive aspects of technological entrepreneurship and its links with the fields of innovations, organization management, and entrepreneurship. The particular attention should be paid to the interdependence of business and science towards the development of smart technologies. Taking into account the above-mentioned theoretical foundations of technological entrepreneurship, this phenomenon can be considered as a process involving greater practical usefulness of scientific research findings on modern technologies, the absorption and creation capability of technology-oriented companies, and joint exploration and exploitation of technological opportunities and innovations within an effective entrepreneurial ecosystem.

Moreover, a significant response to the challenges of the modern market economy can be seen in the formation and development of entrepreneurial universities, which bring internal and external stakeholders together to look for a cooperation mechanism to ensure more efficient knowledge-sharing between business and science and facilitate the absorption of innovative solutions in society and the economy (Badzińska, 2020). For almost a decade ago Audretsch (2014) pointed out that to accelerate the transfer of technology and generate a sufficient knowledge spillover from universities for commercialization, innovation, and economic growth, an absorptive capacity mechanism is necessary in the environment.

Table 1. Review of the definition of *“technological / technology entrepreneurship”* in the management science literature

Author	Definitions related to exploration and exploitation of entrepreneurial and technological opportunities and the innovative potential of enterprises	Author	Definitions related to business-science collaboration, commercialization of research findings, intellectual and technological potential of scientific institutions

Garud & Karnøe (2003)	Technological entrepreneurship focuses on investing in and executing the firms' projects, not just recognizing technology or market opportunities. It is understood therefore, as a joint-production phenomenon that draws from a team of specialized individuals from multiple domains, some or all of whom become embedded in the technology path they try to shape in real time.	Matusiak & Matusiak (2007)	Technological entrepreneurship is a tool for transforming research and the potential of scientific institutions into goods and services, which directly or indirectly increases the benefits of consumers and realizes faster growth of the economy in the future. As a result, new knowledge is transferred to private enterprises, which increases their productivity, and, as a consequence, the creation of new companies – increases investment and employment, also in the fields of high technology.
Shane & Venkataraman (2003)	Technology entrepreneurship is the processes by which entrepreneurs assemble organizational resources, technical systems and the strategies used by entrepreneurial firms to pursue opportunities.	Poznańska (2010)	Technological entrepreneurship provides more practical usability of research results through an effective collaboration between science, technology and the commercial world.
Byers, Dorf, & Nelson, (2005)	Technology entrepreneurship is a style of business leadership that involves identifying high-potential, technology intensive commercial opportunities, gathering resources such as talent and capital, and managing rapid growth and significant risks using principled decision-making skills.	Lachiewicz & Matejun (2010)	Technology entrepreneurship is based on cooperation between commercial enterprises and institutions of business environment functioning mostly in the field of science and technology, oriented towards transformation of research and scientific potential into commercial technology innovations leading to development of products and services.
Zhang, Peng, & Li, (2008)	Technological entrepreneurship is of the character of opportunity entrepreneurship, and can be defined from the point of view of opportunity discovery and exploitation, namely discover and exploit market opportunity of technology.	Beckman, Eisenhardt, Kotha, Meyer & Rajagopalan (2012)	Technology entrepreneurship is the process of motivating and steering research towards greater practical usefulness, and then transferring research results to the economic sphere in order to increase innovation and competitiveness of goods and services.
Lindenberg & Foss (2011)	Technology entrepreneurship is about managing joint exploration and exploitation, where each individual has roles and responsibilities in collaboratively and cooperatively moving forward toward accomplishing shared goals.	Bailetti (2012)	Technology entrepreneurship is an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm.

Spiegel & Marxt (2011)	Technology entrepreneurship investigates all questions related to the successful formation, exploitation and renewal of products, services and processes in technology-oriented firms.	Flaszewski & Lachiewicz (2013)	Technology entrepreneurship connects the scientific potential of universities and research and development centers with capital market institutions and business activities.
Petti (2012)	Technological entrepreneurship relates to the identification of potential entrepreneurial opportunities arising from technological developments, and the exploitation of these opportunities through the successful commercialization of innovative products.	Motyka (2015)	Technological entrepreneurship focuses on research and development activities that lead to combining the scientific potential of universities and research and development centers with the market and business activities.
Kordel (2014)	Technology entrepreneurship is a process by which enterprises explore and exploit technological opportunities, reorganizing their external and internal structures (including ties and entities of these ties) within internal and external business processes.	Badzińska (2016)	Technological entrepreneurship is a process that combines the elements of academic and intellectual entrepreneurship with the entrepreneurship of commercial organizations – owners, managers and employees implementing new technologies and innovative business solutions in the market environment.
Ławecki (2014)	Technology entrepreneurship is a combination of issues related to entrepreneurship and the management of technology and innovation.	Badzińska & Mrugalska (2021)	The concept of technological entrepreneurship is based on increasing innovation, new assets, and competitiveness through the more efficient use of the research results that lead to the development of products and services.
Rostek & Skala (2016)	The process of technological entrepreneurship can be understood as a development strategy based on creating, discovering and exploiting technological opportunities.		
Staniec, Klimczak, Machowiak & Shachmurov (2018)	Technology entrepreneurship is a company from the sector of micro, small and medium-sized enterprises, using in its activities new technical solutions (including material and ICT), resulting from its own R&D works or using solutions developed in cooperation or by other units (universities and research institutes, research and development units, etc.), as well as ideas of individuals.		
Chyba (2021)	Technology entrepreneurship is an innovative process consisting of the entrepreneurial activities of the leader-innovator, team members and members of the entire organization, and to the greatest extent concerns high technology sectors.		

Kordel & Wolniak (2021)	Technological entrepreneurship is defined as the specific configuration of strategy and organizational structure around the core of new technologies.		
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Source: Own study.

4. Research Findings and Discussion

The research internship at Adam Mickiewicz University (AMU) in Poznan in the Department of Economic Sciences involved four months (March-June 2020) of working on technological entrepreneurship (with particular emphasis on the role of academic startups) as well as on designing the research procedure and obtaining data from both secondary and primary sources. The discussion reflects the main findings gathered from direct (in-depth) interviews conducted with six experts in the field of commercialization and technology transfer, academic entrepreneurship, and start-up incubation, as well as intellectual property management.

The diagnosis of 32 factors supporting academic start-ups at different stages of their development is based on the author's experience, observation, and reflection during the collaboration with academic business incubators in the years 2018-2021. Thus, together with the experts' assessment of the significance of the diagnosed factors, they constitute the main achievement of the empirical research.

Table 2. The significance of factors supporting the creation and development of academic start-ups according to the surveyed experts

Factors supporting the creation and development of academic start-ups		arithmetic mean	mode	St. dev.
Seed Stage	Basic knowledge of self-employment as part of studies (e.g. curricula, internships)	4,67	5	0,52
	Knowledge acquisition through specialized consultancy in the field of:			
	a) commercial and tax matters	3,83	4	0,98
	b) finance and controlling	4,00	4	0,63
	c) legal form of business activity and founding formalities	4,17	4	0,75
	d) marketing and sales	4,83	5	0,41
	e) business modelling: idea creation, concept development, market potential testing	4,83	5	0,41
	f) technical aspects of the business idea	4,17	4	0,75
	g) team building, team roles	4,67	5	0,52
	Founder networking and experiences of other founders	4,83	5	0,41
	The startup culture at the university / in the region	3,67	4	0,52
	Local activation of the start-up environment (hackathons, events, lectures, workshops)	3,67	4	0,52
Creation and notification of coworking spaces	3,33	3	0,52	
Start-up stage	Capital raising:			
	a) scholarships to start an academic startup (central support programs)	4,33	4	0,52
	b) EU funds	3,33	3	0,52
	c) bank loans	3,33	3	0,52
	d) grants / awards in competitions	4,00	4	0,89

	e) crowdfunding	3,50	4	0,55
	f) Business Angels	4,00	4	0,89
	g) investors / venture capital	3,33	4	0,82
	h) local entrepreneurship support programs	3,33	3	0,52
	Business Networking	4,17	4	0,75
	Support from government agencies (also image-related)	2,83	3	0,98
	Start-up events, regional competitions	3,50	3	0,55
	Further knowledge acquisition through specialized consultancy	3,50	3	0,55
	Close founder networking / Stronger collaboration with startup communities	4,17	4	0,75
Expansion (Growth Stage)	Cooperation between the private and the public sector (e.g. business-science relation)	3,50	4	0,55
	Entrepreneurship acceleration programs in the region	4,17	4	0,41
	Amount of R&D spending by start-ups	4,33	5	0,82
	Tax breaks for innovative companies	3,67	4	0,52
	Acquiring more external capital	3,83	4	0,75
	Foreign trade advice (e.g., in internationalization strategies)	3,67	4	0,82
	Monitoring the development of start-ups	3,17	3	0,75

Source: Own study based on research results.

In order to evaluate the individual factors the experts were asked to rate their significance on a scale of 1–5, where the value is respectively: 1 – definitely irrelevant, 2 – rather irrelevant, 3 – neutral, 4 – rather important, 5 – definitely important. The results of the empirical research are presented synthetically in Table 2. The arithmetic mean (average), the mode (the most common numerical value) and the standard deviation were calculated for each factor.

Undoubtedly, an important factor in creating a start-up at the seed stage is acquiring professional knowledge in the field of business. Experts especially emphasized knowledge in the field of: (i) marketing and sales; (ii) business modelling: idea creation, concept development, market potential testing, etc. (each: average 4.83, mode 5, standard deviation only 0.41, indicating a high agreement of opinions), and (iii) team building, team roles (average 4.67, mode 5, standard deviation 0.52). Acquiring professional knowledge of: (i) technical aspects of the business idea; (ii) legal form of business activity and founding formalities (average 4.17); (iii) finance and controlling (average 4.0); and (iv) commercial and tax matters (average 3.83) were also assessed as significant factors (mode 4), but the opinions of experts are slightly more varied here (standard deviation is even 0.98).

According to experts, an important role in the process of creating start-ups is also played by basic knowledge of self-employment acquired during studies (e.g., practice-oriented curricula, internships) (average 4.67, mode 5, standard deviation 0.52). The current changes in the surrounding environment require new competencies and, therefore, new ways of teaching and learning. The relevance and applicability of the knowledge generated at universities and passed on to students has become a key value on the way to building entrepreneurial attitudes, awareness of the benefits of self-employment and

creating added value. For this reason, the need for competency development is relevant in any field of higher education. Therefore, it should be clearly emphasized that the successful implementation of a creative idea or invention into the marketplace depends largely on expert knowledge and managerial skills.

In addition, founder networking and experiences of other founders (average 4.83, mode 5, standard deviation 0.41) are also definitely critical factors in the seed phase. This confirms the importance and benefits that result from building relationships and sharing knowledge with other start-up founders, for example in terms of customer expectations, the market situation or negative experiences and threats.

In turn, as factors rather important (mode 4), the experts indicated: (i) the start-up culture at the university / in the region (e.g., innovative image, social recognition), and (ii) local activation of the start-up environment (hackathons, events, lectures, workshops). These factors were rated slightly lower (average 3.67) than those discussed above. Perhaps the fact that the surveyed experts work daily in institutes closely related to commercialization and technology transfer and often observe activities supporting entrepreneurship, so they do not see the lack of building a culture of entrepreneurship at universities, hence their slightly lower assessment of the significance of these factors.

However, the author's observational research reveals that there are many areas for improvement in the field of activation of the start-up community and entrepreneurship culture at universities. Students often do not even know about the existence of a business incubator at their university. There is also a lack of activities promoting start-up creation and entrepreneurial attitudes. The next factor, the need for creation and notification of coworking spaces, was rated relatively low (average 3.33, mode 3, standard deviation 0.52). It was assumed that students have many opportunities to meet at the university (e.g., shared work rooms in the library), hence the creation of subsequent coworking spaces is not a very important factor, but rather a neutral one.

In the start-up stage, a lot of attention was paid to the methods of raising capital. Among several potential options, experts found the most important scholarships within central support programs to start an academic start-up (average 4.33, mode 4, standard deviation 0.52). Unfortunately, there are not centrally launched long-term start-up financing programs at Polish public universities, such as e.g. the EXIST² Business Start-ups Grant in Germany directed to students, graduates and scientists from universities and research institutes. If potential entrepreneurs (students) in Poland can apply for some financial support, e.g., for the construction of a prototype, these are most often programs offered individually by selected universities and only for a limited time. Undoubtedly, the creation of central support programs at Polish universities to support academic entrepreneurship would be a welcome, expected solution.

² EXIST is a support program of the German Federal Ministry for Economic Affairs and Energy (BMWi). It aims at improving the entrepreneurial environment at universities and research institutes as well as at increasing the number and success of technology and knowledge-based university business start-ups. <https://www.exist.de/EN/Programme/EXIST-Business-Startup-Grant/content.html>

Another possibility of raising capital, assessed as rather important (average 4.0, mode 4), is the support from Business Angels. However, the opinions of experts vary somewhat on this point – the standard deviation is 0.89. Moreover, the significance of the factor with a value of mode 4 was also indicated for the following forms of raising capital: (i) grants / awards in competitions (average 4.0); (ii) crowdfunding (average 3.5); and (iii) investors / venture capital (average 3.33). In turn, EU funds, bank loans, and local entrepreneurship support programs were most often rated for the value 3.

Other critical factors in the start-up stage assessed by experts as rather important include: (i) business networking; and (ii) close founder networking / stronger collaboration with start-up communities. Once again, the respondents confirmed the high importance of building relationships with business representatives and other founders (average 4.17) to ensure the development of their ventures. On the other hand, factors such as: (i) events supporting entrepreneurship, regional competitions, and activation of the local environment; and (ii) further knowledge acquisition through specialized consultancy were rated at an average of 3.5 (mode 3). The lowest rated factor by experts was the support from government agencies (also image-related), but the difference of opinions was quite significant (average 2.83, mode 3, standard deviation 0.98).

Low activity of government agencies and regional authorities in supporting academic start-ups in the studied region of Poland and leaving this responsibility to universities and academic business incubators translate into a low assessment of the significance of this factor for the creation of academic ventures.

The last of the studied stages of start-ups' development is the growth phase, also known as the acceleration phase. Experts underlined the high importance of expenditure on research and development by start-ups (average 4.33, mode 5). On the next places, for mode 4, there were such factors as: (i) entrepreneurship acceleration programs in the region (average 4.17); (ii) acquiring more external capital (average 3.83); (iii) tax breaks for innovative companies (average 3.67); (iv) foreign trade advice (e.g., in internationalization strategies) (average 3.67); and (v) cooperation between the private and the public sector (e.g., business-science relation) (average 3.5). The lowest rated factor is monitoring the development of start-ups (average 3.17, mode 3).

Summing up, it should be noted that none of the diagnosed factors was assessed as 1 or 2, i.e., irrelevant or rather irrelevant. Out of 32 factors, experts considered 18 factors to be rather important and 6 to be important (based on the mode value). The significance of 8 factors was given a value of 3. The experts did not suggest any additional factors. In the author's opinion, the assessment of the significance of cooperation between the private and the public sector is surprisingly low (average 3.5, mode 4). It probably results from the real situation of the local market and the lack of effective cooperation and trust between representatives of science and business.

This confirms the need for changes, because effective support for academic start-ups and the implementation of their innovative business solutions to the economy will not take place without effective collaboration between business, science, and government. Furthermore, to facilitate the generation and commercialization of university research

and help set up new academic ventures, universities must build their strong entrepreneurial culture and combine future-oriented entities within the entrepreneurial ecosystem. It should be also emphasized that higher education institutions are expected to benefit their regions in many ways, not only by educating competent graduates but also by actively stimulating business-science relationships towards increased innovation and competitiveness.

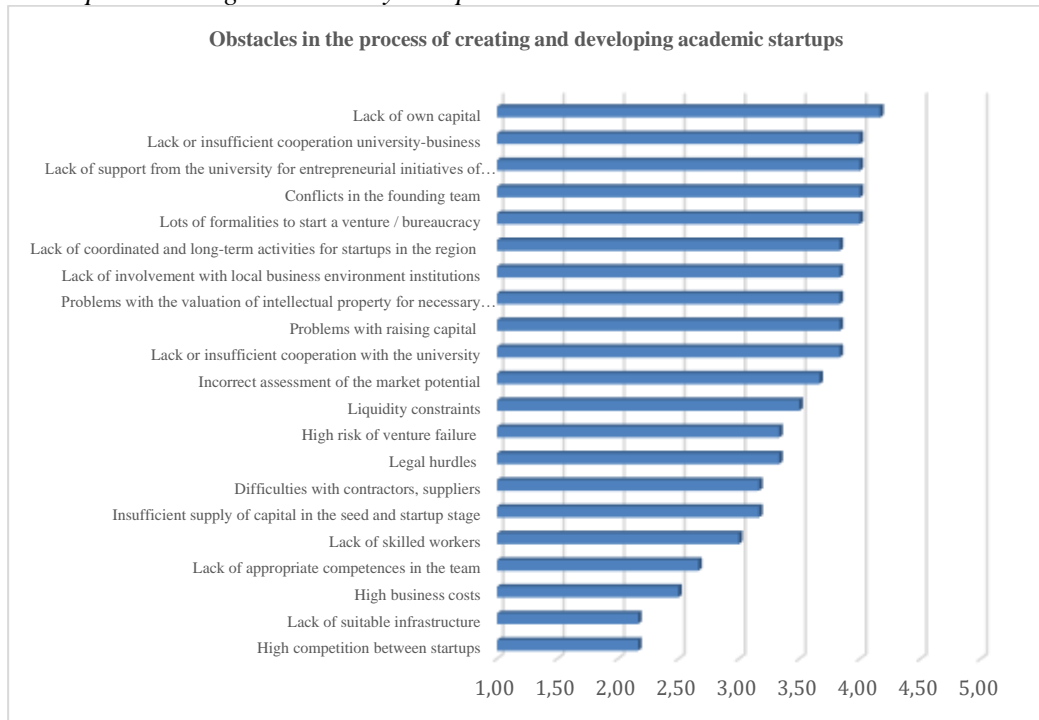
The next part of the research concerns the assessment of obstacles or threats in the process of creating and developing academic start-ups. The author attempted to answer the question of what the most important obstacles for start-up founders are. To achieve this goal, the experts were asked to assess the obstacles (21 factors) on a scale of 1–5, where the factor significance is respectively: 1 – definitely low, 2 – rather low, 3 – neutral, 4 – rather high, 5 definitely high. The research findings are presented synthetically in Figure. 1. The arithmetic mean (average), the mode and the standard deviation were calculated for each factor.

According to the experts, the main obstacles in the process of creating academic ventures by students include (mode 4): (i) lack of own capital (average 4.17); (ii) lack or insufficient cooperation between the university and business (average 4.0); (iii) lack of support from the university for entrepreneurial initiatives of students / alumni (average 4.0); and (iv) lack or insufficient cooperation with the university (average 3.83). In addition, it was indicated that both conflicts in the founding team and lots of formalities to start a venture / bureaucracy (each: average 4.0) are among the rather high obstacles to start-up operations. The obtained results confirm the need for changes in promoting and supporting academic entrepreneurship. A significant increase in support from universities, both in terms of content and finance, is necessary.

Moreover, team and conflict management competencies, including the appropriate division of roles and responsibilities, is the next critical area for improvement on the path to creating a sustainable start-up. Furthermore, the formalities related to the establishment of a start-up were assessed by experts as a rather high obstacle. Slightly lower values were given for the following factors: (i) problems with the valuation of intellectual property for necessary funding (average 3.83); (ii) liquidity constraints (average 3.5); and (iii) insufficient supply of capital for start-ups in the seed and start-up stage (average 3.17). Experts rated them most often as rather high obstacles (mode 4), but their opinions differed significantly (standard deviation from 0.41 to 0.98).

In turn, the significance of the obstacles with the value of mode 3 was indicated for: (i) lack of involvement with local business environment institutions; (ii) lack of coordinated and long-term activities for the start-up community in the region; and (iii) problems with raising capital (each: average 3.83, standard deviation 0.98). Although the average score indicates a higher significance of these obstacles, but the experts' opinions were divergent on these issues (the lowest value was 3, the highest 5). The above obstacles once again confirm insufficient cooperation between academic start-ups and business environment entities and the lack of long-term activities for the local start-up community. In addition, obstacles, and threats such as legal hurdles and high risk of venture failure were rated 3.33 on average.

Figure 1. The significance of obstacles for the creation and development of academic start-ups according to the surveyed experts



Source: Own study based on research results.

Next factors concerning the competences of team members or infrastructure were assessed as rather low (mode 2). This may confirm that start-up founders are highly qualified and develop their competences in relation to market needs. The lowest mean values (2.17) were indicated for high competition between start-ups and lack of suitable infrastructure, while slightly higher for high business costs (2.5) and lack of appropriate competences in the team (2.67).

The preliminary research findings confirm the need to develop academic fields and areas of research that are oriented towards professional knowledge and competencies required by start-up founders for solving the specific and compelling problems confronting the business and society. Universities are supposed to be a driving force for the development of technological entrepreneurship through the commercialization of new knowledge and inventions in the form of patents, licenses, as well as academic start-ups. For the above reasons, close cooperation between business and science becomes necessary to facilitate and accelerate knowledge spill over from universities and absorb innovative solutions in the environment.

5. Conclusions and Future Research Lines

The economy's demand for innovative solutions and greater usability of research in the form of patents, licenses, and knowledge transfer requires effective and sustainable

cooperation within the entrepreneurial ecosystem. It should be emphasized that technological entrepreneurship combines the intellectual potential of scientific institutions and entities of the entrepreneurial ecosystem which provides the necessary conditions for the effective commercialization of research findings to create and capture value for a firm and its customers.

The literature review reveals that the considerations about technological entrepreneurship collectively offer a coherent statement of the essential role of advances in scientific and technological knowledge as well as collaborative exploration and exploitation of technological opportunities and innovations. However, while some authors focus mainly on technology-oriented companies, their organizational resources and strategies or technology intensive commercial opportunities, others emphasize above all the potential of scientific institutions and transformation of the latest research outcomes into commercial solutions related to technological innovations. In addition, the author stresses the importance of regional and international business-science collaboration, university-based start-ups, and beneficial relationships in the entrepreneurial ecosystem.

The relevance and usefulness of knowledge created at universities also translates into the success of technology start-ups and more. Furthermore, a creative and innovative ability of knowledge-based academic ventures who are the strong drivers of employment and wealth creation should be supported by regular institutional and financial incentives, substantive support, and different types of business-science cooperation. Moreover, an effort should be made to build up the absorptive capacity mechanism for applied research and provide support measures as well as appropriate policies to effectively facilitate academic entrepreneurship.

Referring to the opinions of the surveyed experts, factors that are definitely important to support the creation of start-ups in the seed stage include basic knowledge of self-employment acquired during studies through a practice-oriented approach to teaching and learning as well as internships in enterprises, professional knowledge obtained from specialized consultants mostly in the field of marketing, sales, and business modelling, as well as team building and sustaining. In addition, founder networking and experiences of other founders are critical factors in the seed stage for building relationships and sharing knowledge in the start-up community. In turn, in the start-up stage, a lot of attention was paid to the methods of raising capital. Among the most conducive forms are mentioned scholarships/grants within central support programs, awards in competitions, and then financing by Business Angels, crowdfunding, and investors (e.g., venture capital). It is also worth noting that among factors with high significance are business and founder networking as well as stronger collaboration with startup communities.

On the other hand, the expansion (growth stage) is largely conditioned by R&D expenditure by start-ups. Moreover, the experts underlined the need of entrepreneurship acceleration programs in the region, tax breaks for innovative companies, and actions to acquire more external capital and create internationalization strategies.

In turn, the following were identified among the critical obstacles in the process of creating and developing academic start-ups, lack of own capital, insufficient cooperation between the university and business, and lack of support from the university for entrepreneurial initiatives of students and alumni. Additionally, both team conflicts and administrative bureaucracy pose great difficulties for start-ups. The situation, which strongly inhibits the growth of start-ups is the lack of coordinated and long-term activities for the start-up community in the region, insufficient involvement with local business environment institutions as well as problems with raising capital, often due to the problems with the valuation of intellectual property of innovative solutions.

The right understanding of the role of science and technology must be provided to the sphere of business so that entrepreneurs notice the measurable benefits of cooperation with academics from universities. The introduced framework can be useful in identifying and understanding the needs of start-up founders and creating effective policies for their innovation development. To obtain a deeper insight into factors supporting the creation and development of academic start-ups as well as entities of the entrepreneurial ecosystem, future investigations will be targeted at a wider range of actors using the qualitative comparative analysis.

Moreover, a comparative study confirming the significance of factors influencing the operations of academic start-ups would have a greater cognitive value and impact on the business practice relevant not only for the Polish context. The findings reflected here can benefit both entrepreneurship teachers' practice at HEIs, researchers, and employees of business incubators as a source for further analysis and the relevance of the methods used.

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