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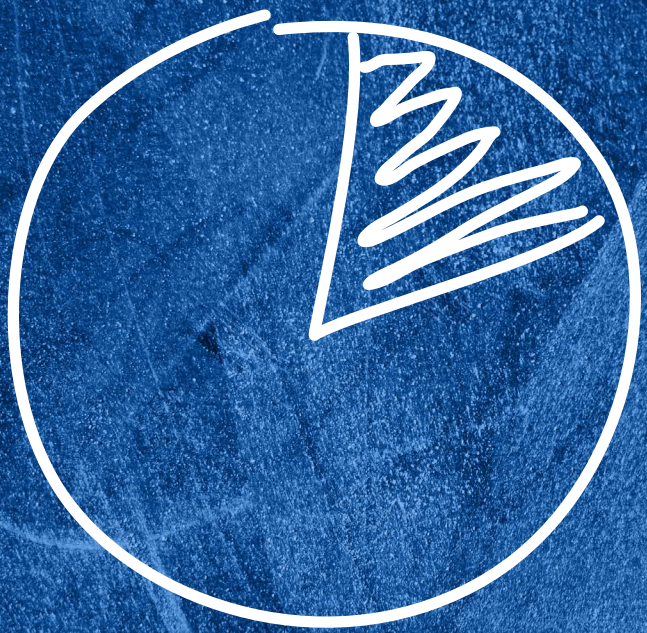
Editors

ACADEMIC ENTREPRENEURSHIP IN THEORY AND PRACTICE



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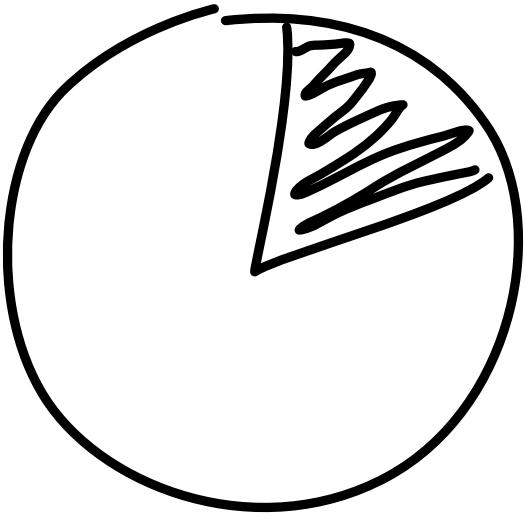

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PREFACE

Academic entrepreneurship (AE) is an interdisciplinary and complex socio-economic phenomenon that has gained the growing interest of scientists all over the world, however, research in this domain is still insufficient. From the scientific perspective, there is not a commonly used definition identifiable in international studies, and the practice shows different levels of AE according to the institutional context or geographical location.

The lack of common understanding of the AE concept within the scientific community raises the opportunity for the discussion about the different aspects of the phenomenon and encourages the interchange of experiences from diverse institutional environments. Notably, scientific contribution to the understanding of AE from the CEE countries is rather scarce, but we believe that the presentation of this collection of context-related cases could give a new insight into the AE phenomenon.

The present book is intended to contribute to the discussion on different issues related to AE from both theoretical and practical perspectives, on the basis of experiences drawn from the Polish higher education context. The subsequent chapters of the book present the interdisciplinary approaches of the authors who are all professionally associated with the Poznań University of Economic and Business in Poland (PUEB). The idea of the book development appeared within the project entitled 'Academic Initiative on Entrepreneurship and Innovation at PUEB', financed by Santander Universidades.

The book consists of three parts. The first part refers to the theoretical issues related to defining AE as a socio-economic phenomenon. In the first chapter, the author aims to present the current advancements in AE conceptualization and studies as based upon international literature review. AE is presented here as an evolving concept with a distinction between traditional and emerging perspectives, which are also connected to a narrow vs. broader scope of the concept. The second chapter presents AE as a process related to the commercialisation of knowledge generated at the universities in line with the Knowledge Spillover Theory of Entrepreneurship. The author highlights university invention as the source of

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entrepreneurial opportunities that are further leveraged by entrepreneurial resources and reconfigured to develop entrepreneurial competences leading to knowledge and technology commercialisation. In this way, the author proposes an integrative process model of academic entrepreneurship.

The second part of the book presents AE from the practical point of view, taking into account experiences from PUEB. According to the traditional view of AE as the commercialisation of university invention, the author of the first chapter of this part presents a case study with the subsequent stages of the commercialisation process, on the example of active packaging as developed at PUEB, from basic research, to the attempts of proper commercialisation. The next two chapters in this part refer to the entrepreneurial attitudes and perspectives of running own businesses in the COVID-19 pandemic context, as experienced by students of the economic faculties at PUEB. In this sense, the authors refer to the broader definition of AE that also covers students as actors of the phenomenon.

The last part of the book contains two chapters that show the broader perspective of relations between universities and business partners and the outcomes of such cooperation for society and economy. Given the applied nature of the field of academic entrepreneurship, in the first chapter, the authors argue for application diploma theses at Polish universities, thus, providing a discussion of the entrepreneurial model of universities. The second chapter refers to the new skills, such as data analysis and processing skills, required in the digital economy and in entrepreneurship for the development of innovative products and services. Moreover, the authors consider the role of universities and university programs in the education of future specialists in this field.

This book was designed for university students and researchers, as well as for others in industry and public service that are interested in the academic entrepreneurship phenomena. Therefore, it offers a framework to interpret and understand academic entrepreneurship as a multi-level approach and opens up a wide range of research opportunities and policy-maker recommendations for the future.

Hanna Nowak-Mizgalska, Aleksandra Szulczewska-Remi

PART I
DEFINING ACADEMIC ENTREPRENEURSHIP

1. ADVANCEMENTS IN CONCEPTUALISATION AND STUDIES ON ACADEMIC ENTREPRENEURSHIP PHENOMENON

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Abstract

Academic entrepreneurship is a specific type of entrepreneurship relating to science and knowledge, the role of universities and the commercialisation of research results. The aim of the chapter is to present the current state of advancement of research on this issue in international literature. In particular, the aim is to present the way of conceptualizing this phenomenon in scientific research, as well as the methods used and theoretical approaches taken by the authors. A review of the literature indicates the evolution of the concept of academic entrepreneurship and the expansion of the scope of its application in scientific works. In a narrow sense, this term is mainly used to describe activities undertaken by scientists based on academic knowledge and the technology obtained from university resources. The broader approach also covers the development of entrepreneurial attitudes among students through entrepreneurship education, support for the creation of start-ups and wider cooperation with stakeholders in order to build an ecosystem for the development of academic entrepreneurship. The effects of academic entrepreneurial activities in a new, wider perspective are assessed from the point of view of the value created for society and the economy.

Keywords: academic entrepreneurship, definitions, theoretical background, methodological issues.

Introduction

Entrepreneurship as a socio-economic phenomenon has a multifaceted nature, and this statement is also accurate when we consider the concept of academic entrepreneurship (AE). The existing stream of study on AE in international journals cannot be ignored, however, that scientific interest in the topic has been observed

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only relatively recently is manifested in the growing number of publications (Kobylińska, 2020). The scope of the concept is thus still evolving (Siegel & Wright, 2015). AE refers to the complete set of diverse research disciplines, perspectives and theories, and is not limited only to the field of entrepreneurship research (Balven, Fenters, Siegel, & Waldman, 2018). The concept of AE is especially closely related to the role of universities, education, university-industry collaboration, science commercialisation, technology transfer and innovation (Audretsch, Lehmann, & Paleari, 2015; Davey, Rossano, & Sijde, 2016; Wadhwani, Galvez-Behar, Mercelis, & Guagnini, 2017; Fischer, Schaeffer, Vonortas, & Queiroz, 2018).

What is really the nature and significance of AE and how to define and study this phenomenon, are still open questions. There is no doubt that this emerging field of studies is inspiring and could lead as to the better understanding of the connections between knowledge generation at the universities, its practical market application and its impact on the society and economic growth and development (Hayter, Nelson, Zayed, & O'Connor, 2018; Meek & Wood, 2016). There are also many factors affecting AE that can promote or constraint its development. Indeed, some contextual factors can be of the great importance for supporting the emergence of AE at universities in different countries. These include cultural norms, public policy at national and regional levels, as well as organisational conditions (e.g. university strategy and infrastructure) and the whole ecosystem supporting AE (Davey et al., 2016). There are also substantial differences in the stages of development of AE between US, Asia and Europe (Audretsch et al., 2015).

The aim of the chapter is to present the current stage of advancement in AE conceptualisation on the basis of international literature review, with special reference placed upon the theoretical concepts of entrepreneurship. Moreover, a comparison is made between traditional and new perspectives on AE research, as well as between the narrow and broader understanding of the concept.

In the following sections of the chapter, research method is described and AE as a subject of study in international research journals is presented, as well as definitions and theoretical perspectives taken by international scientists. In the next section, the evolving scope of AE concept is highlighted, followed by methodological issues and selected examples of findings from AE studies. The chapter ends with a summary and conclusions.

1.1. Research method

The main emphasis was placed on the concept of AE, its scope and evolution in international research. In order to present the current state of advancement of research on this issue, a traditional literature review was undertaken in terms

of both conceptual (definitions and theories) and empirical aspects (used methods and research results) (Li & Wang, 2018).

To achieve the aim of the study, the following specific questions, referring to AE as a subject of study, were focused: How is AE defined in international studies? What theoretical backgrounds and perspectives are taken? What research methods are used? What aspects of AE are studied and how are the results formulated?

Articles that referred directly to the AE term, definition or research framework were identified by searching the EBSCOhost databases and then the list was supplemented with public reports or other open access articles. Ultimately, 30 references were analysed in the chapter.

The research interests of AE as a socio-economic phenomenon, and the way the authors define and research this concept, are obviously related to the level and conditions of AE development in different countries and regions. However, these aspects were discussed to a limited extent in the chapter, as an auxiliary element in achieving the research goal.

1.2. Academic entrepreneurship as a subject of study

Academic entrepreneurship can be treated as a specific kind of entrepreneurship phenomenon with 'distinctive features' in comparison to "more traditional forms of entrepreneurship" (Siegel & Wright, 2015). However, the concept of AE is not taking first place as the most popular topic or subject in this research field. In some entrepreneurship handbooks, AE is only mentioned as one of several possible forms of entrepreneurial activities. Hayter and others (2018), for example, concluded that AE is a 'niche topic' within the fields of entrepreneurship and management. In their study, only 11 from a sample number of 53 journals, mostly included in the *Financial Times* ranking (May 2016) of the top 50 research journals (FT 50), had published articles on AE (see Table 1.1).

The findings of Hayter and others (2018) are in line with the results of the survey by Siegel and Wright (2015) that revealed that the concept of AE in the last years is mainly studied from the perspective of technology transfer from university to industry. The stage of AE development is thus related in different countries to their systems of higher education. This last depends on three different models of political and economic systems: that of Anglo-Saxon countries, Continental Europe and Asia (Audretsch et al., 2015). So far, a lot was said in the literature about the organisational changes in the higher education and science, as well as about challenges for universities and the new, third mission of that institutions, which is related to the entrepreneurial university model (Audretsch et al., 2015; Wadhwani et al. 2017). Some characteristics and differences between USA, Europe and Asia are presented in Table 1.2.

Table 1.1. Publication of articles on AE in the FT 50* journals from 2000 to 2017

Leading journals and frequency of publication (n = 209)	*Journal of Technology Transfer* (80); *Research Policy* (57); *Technovation* (19); *Small Business Economics* (13); *Journal of Business Venturing* (10); *Management Science* (9); *Entrepreneurship Theory and Practice* (6); *Organization Science* (5); *Journal of Management Studies* (4); *Strategic Management Journal* (3); *Strategic Entrepreneurship Journal* (3)
Author affiliation (n = 194)	USA (66); UK (26); Germany (17); Italy (15); Spain (10); Sweden (9); Norway (6); Ireland (6); Canada (6); Belgium (6); Netherlands (5); France (3); Israel (2); Singapore (2); Switzerland (2); Australia (1), Austria (1), Chile (1), China (1), Cyprus (1), Denmark (1), Greece (1), Hong Kong (1), Mexico (1), New Zealand (1), Portugal (1), Russia (1), Slovenia (1)
Country of study (n = 286)	US (80); UK (35); Germany (21); Italy (17); Sweden (16); Belgium (14); Spain (13); Canada (9); Netherlands (8); Ireland (8); Norway (7); France (6); Finland (5); China (4); Switzerland (3); Slovenia (3), Portugal (3); Austria (2), Croatia (2), Denmark (2), Georgia (2), Greece (2), Hungary (2), Luxembourg (2); Albania (1), Argentina (1), Bulgaria (1), Chile (1), Czech Republic (1), Estonia (1), Iceland (1), Israel (1), Japan (1), Latvia (1), Lithuania (1), Malta (1), New Zealand (1), Romania (1), Russia (1), Slovakia (1), Turkey (1), Venezuela (1)

Source: (Hayter et al., 2018; * FT 50 list supplemented by the *Journal of Technology Transfer, Technovation, and Small Business Economics*).

Table 1.2. Conditions and strategies for AE development based on different political and economic systems

	Anglo-Saxon countries	**Continental Europe**	**Asia**
Models of political and economic systems	market-based system	Greco-Christian model of democracy and egality; the welfare state model in some countries	centralized and governed system in most Asian countries
Important characteristics	• Bayh-Dole act (1980): the right to use the inventions developed with public funding at universities • strategic orientation on AE since the 1990s • fostering entrepreneurial spirit, seeking opportunities for ideas generation and commercialisation • a great number of academic spin-offs and new ventures created by universities • patent-revenue generation by universities	• efforts in building a knowledge-based economy (the Bologna Process (since 1999) in the higher education system; the Lisbon Strategy (2000)) • lower culture of entrepreneurship • the lower capacity for market absorption of new technologies • diversity of experiences between the EU countries • barriers and the EU programs for supporting spin-offs creation • problems of intellectual property rights management and potential benefits sharing	• the process of building an effective infrastructure to support academic entrepreneurship, innovations and technology transfer; intensive development of business incubators since 1997
Examples of pioneering countries	USA	Finland, Sweden	Japan, South Korea, Singapore

Source: Based on (Audretsch et al., 2015; Guliński & Zasiadły, 2005).

The level of AE in Europe is regarded as relatively low, although growing (Davey et al., 2016). Both the countries of author affiliation and the studied countries in Hayter and others (2018) show that scientific interests in AE can be found mainly in the US and UK. With regard to Continental Europe, the results reveal that studies regarding AE appear mainly in the west part of the continent. The contribution from CEE countries to the conceptualisation and studies of the AE phenomenon in the journals reviewed by Hayter and others (2018) is almost invisible. However, the number of publications on AE in international journals does not reflect the actual stage of development of this phenomenon in many countries. In case of Poland, as the example of CEE countries, two aspects should be highlighted when describing the situation regarding AE development. On the one hand, the authors interested in the phenomenon point to the lack of a tradition of strong scientific and economic ties in the Polish reality after World War II, as well as the lack of native mechanisms of technological progress (Matusiak & Zasiadły, 2005) and indicate that the changes in the higher education are still insufficient although in some cases they are characterized by increasing dynamics (Matusiak & Guliński, 2010). The Polish economy is rather on the initial stage of the implementation of AE model with still existing barriers for spin-offs creation (Poznańska, 2014). On the other hand, many positive changes in public policy and institutional environment are noticed. Step-by-step measures were taken to create a favourable climate for the development of AE, including the legal environment (Poznańska, 2014). The legal basis was created with the introduction in 2005 of the new act on higher education, which introduced the possibility of implementing new tools for technology transfer: academic business incubators and Technology Transfer Centres (Guliński & Zasiadły, 2005). In addition, along with the creation of institutional infrastructure, academic entities began to become more and more interested in the practical and legal aspects of the functioning of spin-off companies or the protection of intellectual property (Matusiak & Guliński, 2010). It is also worth mentioning that some forms of links between the sectors of science and economy in Poland already existed before the implementation of legal regulations regarding this phenomenon (Guliński & Zasiadły, 2005).

1.3. Definitions and theory embeddedness

The understanding of AE in international studies is not always related to the different concepts of entrepreneurship theory, however the nature of the phenomenon, as well as the research problems are similar as compared to other forms of entrepreneurship. Research in entrepreneurship has grown significantly since entrepreneurship emerged as a research field in 1970s and 1980s, but it is still regarded as being fragmented, with little knowledge accumulation and great theory building

difficulties (Lohrke & Landström, 2010). Similar to the entire entrepreneurship phenomenon, there is no one commonly used definition of AE, and according to Cantaragiu (2012), "the subject of academic entrepreneurship looks chaotic and the studies are hardly linked in order to provide a powerful theoretical framework, which would foster new researches" (s. 683). Pioneering definitions of AE in literature can be dated back to the late 1980s, but interest as reflected in the number of publications in the field has been mostly observed since 2011 (Kobylińska, 2020).

In the literature, both, narrow and broader definitions of AE are presented (Davey et al., 2016), but in the last years, some new tendencies regarding AE studies have appeared. First of all, some attempts have been made in order to shape the framework for AE studies, and certain authors stress the need for re-thinking the concept of AE (Crow, Whitman, & Anderson, 2019), as well as for "embracing greater variety in the extent and nature of AE" (Siegel & Wright, 2015). Over all, AE is an atypical example of commercial activity, because it is related to the area of science, education and universities, and it cannot be simply regarded as "the commercialisation of academic research" (Wadhwani et al., 2017). Cantaragiu (2012) classifies AE definitions into three categories:

- commercial definitions (for-profit business creation, spin-offs),
- knowledge transfer definitions (hard activities: patenting, licensing, spin-off formation and soft activities: academic publishing, grant seeking and contract research),
- value creation definitions (creation of societal value).

Siegel and Wright (2015) present the changing perspective on AE as a comparison between traditional and emerging views of the phenomenon. Within the traditional perspective, AE is considered as: "academic spin-offs, licensing and patents" of "academic faculty and post-docs", whereas in the emerging perspective, the scope of AE is broader and embraces "student and alumni start-ups; entrepreneurially equipped students and job creation in the local region or state". According to the first approach, the motivation for AE development is "to generate direct financial returns", while in the second perspective—"to provide wider social and economic benefit to the university ecosystem". Taking the categories of Cantaragiu (2012) into consideration, the traditional perspective covers commercial and knowledge transfer definitions, while the emerging perspective focuses on the value creation approach in broader social and economic contexts.

Table 1.3 presents the diverse definitions and perspectives put forward by authors of publications regarding AE concept.

From the above it can be concluded that scientists interested in AE phenomenon borrow theoretical backgrounds from many different disciplines and domains (e.g. resource-based theory, process theories, social cognition theory), what is also typical for the whole field of entrepreneurship research. However, direct

Table 1.3. AE definitions, theoretical assumptions and perspectives in international studies

Definitions, theoretical assumptions and perspectives	Author(s)/source
• process theories applied to understand the university spin-off venture formation (the stage model or life-cycle theory); from commercial opportunity recognition to the operation of a new venture • university spin-off defined as a new venture created inside the university with the use of technology developed at a university, which can then operates independently or with the university as operating partner	Rasmussen, 2011
"Academic entrepreneurship is a practice performed with the intention to transfer knowledge between the university and the external environment in order to produce economic and social value both for external actors and for members of the academia, and in which at least a member of academia maintains a primary role"	Cantaragiu, 2012
• a multi-level framework for re-thinking academic entrepreneurship research • four dimensions: reasons for adopting AE strategies (why), new, emerging forms of AE (what), actors involved in AE (who), new forms of support for AE (how)	Siegel and Wright, 2015
• the analysis of barriers and drivers of AE development taking the narrow definition of AE interpreted as university spin-off creation and academic start-ups • contribution to the literature of resource-based theory	Davey and others, 2016
"commercial application of academic research, type of entrepreneurial activity undertaken: patenting, licensing, spinouts and consultancy work"	Abreu and Grinevich, 2017
• university-industry collaboration as a source of AE • academic knowledge intensive entrepreneurship; grants obtained by academic personnel (faculty and researchers) and temporary staff (students and post-docs), used as a proxy for KIE activity	Fischer and others, 2018
• AE as the creation of spin-offs companies on the basis of university technology by faculty, postdocs, students or affiliated personnel • AE as a vehicle for economic and social development • "the importance of context to entrepreneurial innovation" • "potential of ecosystems to understand entrepreneurial performance" • "the role of networks and their ability to provide firms with resources and information"	Hayter and others, 2018
• the research draws on organizational behaviour literature to study micro processes, which can help explain the involvement of scientists in AE (e.g. identity, motivation, leadership, education or work-life balance) • AE is understood as commercialisation of university-based research (an invention or discovery) in forms of patenting, licensing and start-up creation • 'faculty member' term embraces "all of the scientists and engineers, including post-docs, who engage in university research"	Balven and others, 2018
• Knight's view of entrepreneurship, which is closely related to uncertainty • entrepreneurs are individuals (past university employees involved in commercialisation of their invention), whose own business is a principal employment (it does not contain a part-time employer, paid or pro-bono consultant, if he or she continues to work in academia)	Åstebro, Braguinsky, Braunerhjelm and Broström, 2019
• the gap identified in the study refers to "the variety of ventures generated by different academic stakeholders" (academic spin-offs and graduate start-ups) • entrepreneurial opportunities generated not only by academic staff (importance of research), but also by students and alumni, as the impact of teaching (role of education in start-ups formation)	Marzocchi, Kitagawa and Sánchez-Barriolengo, 2019

Table 1.3 – cont.

Definitions, theoretical assumptions and perspectives	Author(s)/source
• the role of AE in business education for the creation of "more entrepreneurial minded students (academic entrepreneurs)" • AE "as the process of creating and/or engaging in new academic opportunities, endeavors, and possibilities while assuming the risks of those opportunities and possibilities"	Powell and Rey, 2019
• AE "as the process of setting up technology companies and as a business activity of persons professionally affiliated with a university (academics) as well as (…) students or doctoral students. It also includes the promotion of entrepreneurship, entrepreneurship-related education, and the activation of entrepreneurship" • AE as "a specific type of entrepreneurship, focusing on the creative attitudes of the scientific community and the use of their effects in economic practice"	Kobylińska, 2020
• the research draws on social cognition theory, in order to explore the impact of individual and organisational determinants (such as: commercialisation experiences, organisational scientific reputation and entrepreneurial support policies) on AE intentions, involving spin-offs intention, patenting and licensing intention and contract research and consulting intention (theory of planned behaviour modelling)	Wang, Cai and Munir, 2021
• knowledge spillovers in universities influence the process of knowledge commercialisation through entrepreneurship (knowledge spillover theory of entrepreneurship)	Goethner and Wyrwich, 2020

Source: Own compilation based on literature review.

references to the entrepreneurship theoretical concepts, such as entrepreneurial intentions (Wang et al., 2021) opportunity recognition (Rasmussen, 2011), risk-taking (Knight's view of entrepreneurship) (Åstebro et al., 2019) or creation of innovations (Schumpeterian perspective) (Korpysa, 2014) can also be identified.

1.4. Evolving scope of academic entrepreneurship concept

The findings from the literature review suggest the evolutionary character of the AE concept, and we can see that there are calls for taking the broader perspective of AE in order to embrace the heterogeneity of the phenomenon (Marzocchi et al., 2019). Table 1.4 contains a compilation of different aspects of the AE concept, with a comparison being made between narrow and broader views as found in international literature. This presents a more traditional vs. emerging understanding of the engaged actors and resources, as well as the different forms and outcomes of AE activities.

From the traditional perspective, AE can be described as a phenomenon related strictly to university research commercialisation that is reflected through entrepreneurial activities (such as (especially) spin-off creation) undertaken by academic staff or postdocs with the use of academic knowledge, technology and infrastructure that is implemented in order to provide revenues for the academic community. This type of conceptualisation shows rather a narrow view of the

Table 1.4. Evolving scope of academic entrepreneurship

Aspects of AE concept	Narrow view/traditional perspective	Broader view/new perspective (additional aspects)
Contribution of the university to the development of AE according to the university mission	university research—intellectual property commercialisation (invention or discovery); knowledge or technology transfer into its commercial application	university education (methods of teaching and creation of students entrepreneurial mindset, cooperation with alumni, promotion of entrepreneurship, education for entrepreneurship and initiatives promoting start-ups creation)
Actors of AE who create and discover entrepreneurial opportunities and undertake entrepreneurial activities	academic staff and postdocs	students and alumni
Entrepreneurial activities of academic staff	patenting, licensing, spin-off creation	grants, projects, consultancy activities, publications
Outcomes of AE	financial revenues from product or service innovation	social impact, economic development, economy innovativeness
Resources engaged in the AE	mainly knowledge and technology and university infrastructure (e.g. technology transfer offices TTO)	access to broader resources through collaboration with different university stakeholders; university-industry collaboration, role of networks, potential of ecosystem, importance of context
Main approach in AE studies	process of academic employees spin-off creation (economic and technology perspective)	other forms of AE, which create value for wider society, e.g. formation of other university stakeholder start-ups—job creation, innovations (value creation perspective)
Level of analysis in AE studies	rather macro or mezo levels of analysis	studies on the micro level of analysis (e.g. intentions or motivation of academic staff towards entrepreneurial activities, academic staff identity, work-life balance)

Source: Based on (Siegel & Wright, 2015; Marzocchi et al., 2019; Davey et al., 2016; Abreu & Grinevich, 2017; Fischer et al., 2018; Balven et al., 2018; Hayter et al., 2018; Powell & Rey, 2019; Kobylińska, 2020; Wang et al., 2021).

AE phenomenon. Newly appearing challenges in the university socio-economic environment have provoked an evolution of the understanding of the AE concept. Indeed, its scope tends to be seen wider in AE studies regarding the role of universities as actors who discover entrepreneurial opportunities, as well as in research regarding type of entrepreneurial activities, resources engaged in the AE process and the outcomes of the phenomenon.

The emerging perspective embraces additional aspects in AE conceptualisation and studies. Now, not only is the view of actors and stakeholders broader (as we now take into account entrepreneurial activities undertaken by students and alumni), but also the type of activities in the scope of AE is extended to consultancy activities, grants or projects. Special attention is now given to the educational role of universities in the students' mindset creation through specific programs and

initiatives for entrepreneurship promotion, cooperation with external institutions and the creation of an ecosystem for supporting AE development. The understanding of the effects of AE, therefore, goes beyond the academic community advantages and are seen as a value for the society and the whole economy.

1.5. Methodological issues

Balven and others (2018) pointed out that studies on AE are characterized by methodological diversity, as the authors use qualitative, as well as quantitative methods, and the research samples originate from different national environments. In AE studies, we can find both theoretical/conceptual publications and empirical studies. For example, some authors followed a systematic literature review process, searching Scopus or Web of Science, Google Scholar and EBSCOhost databases (e.g. Neves & Brito, 2020; Sandström, Wennberg, Wallin, & Zherlygina, 2018; Terán-Pérez, Valdez-Lafarga, & Félix, 2020). Moreover, some authors of empirical studies who employ qualitative methods chose case study or multiple-case studies. Lundqvist and Williams Middleton (2013), for instance, used a qualitative study of two venture creation cases: one from a US university, and one from Sweden. The data was gathered through interviews, documentation, participant observation and archival material and was triangulated. In addition, Schaeffer and Matt (2016) took a qualitative case study approach in order to explore the role of the University of Strasbourg and its TTO in supporting academic start-up creation. What is more, Rasmussen (2011) chose a narrative approach and multiple-case studies to research the process of creation of four university spin-offs ventures. Beyond the aforementioned, Balven and others (2018) conducted semi-structured interviews with 30 faculty members, department chairs and TTO employees at two universities in the United States, with the aim "to explore why faculty members engage in technology transfer, especially informal practices".

In contrast, quantitative methods with large samples were applied to study AE in the international context. For example, Goethner and Wyrwich (2020) used the data on business start-up grants received by faculty members between 2007 and 2014 in German universities to examine spatial proximity between faculties as an AE driver. For this purpose, OLS and instrumental variables regressions were applied. In contrast, the study of Abreu and Grinevich (2017) was based on a survey that provided microdata on over 22,000 academics in UK. The intent was to look for the determinants of the AE gender gap. Furthermore, Davey and others (2016) carried out an online survey in 33 countries in Europe and European Economic Area that provided a sample of 2925 responses. The aim of the study was to understand the barriers and drivers of AE in different regional and national context.

1.6. Findings from academic entrepreneurship studies

As typical for entrepreneurship research with different methodological approaches and theoretical perspectives applied, results of AE studies do not bring about an entire phenomenon description. What is more, the findings from the domain are rather fragmented. Still, Terán-Pérez and others (2020) conclude that the number of AE studies is growing, with more quantitative methods applied, but more holistic approaches are still required.

The findings of Goethner and Wyrwich (2020) suggest the presence of knowledge spillovers in universities, between natural science and business schools that has impact upon the process of knowledge commercialisation through entrepreneurship. Their study contributes to the knowledge spillover theory of entrepreneurship, social networks and university context literature (Goethner & Wyrwich, 2020).

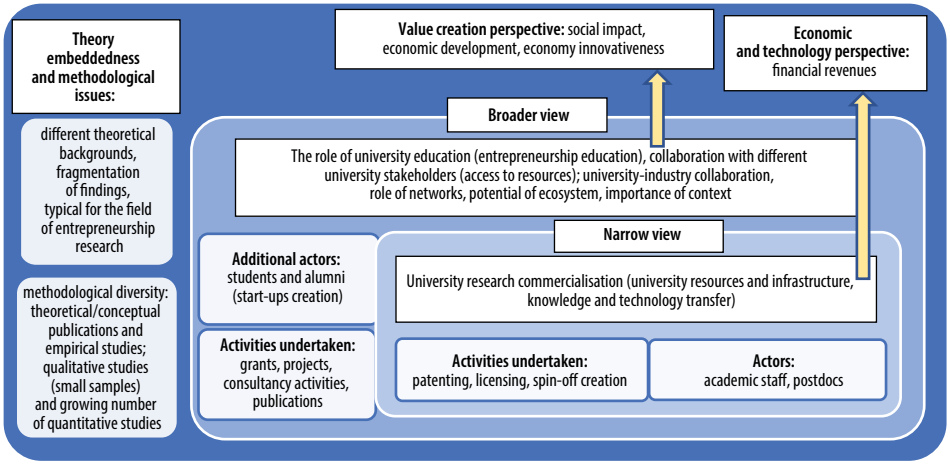
The line of AE study at the individual level brings interesting results regarding cognitions and intentions of academics towards entrepreneurial activities. The work of Neves and Brito (2020) reveals multiple, context-dependent and hierarchy-dependent push factors behind the entrepreneurial intentions of academics. Abreu and Grinevich (2017) found important differences between male and female academics in their attitudes to entrepreneurship that help to explain the gender gap in AE observed through lower rates of female academic venture creation activities.

Schaeffer and Matt (2016) confirmed the entrepreneurial contribution of the university, using the case-study of the University of Strasbourg's efforts towards enhancing the development of entrepreneurial ecosystem through building a network with different stakeholders within the local system of innovation. Herein, a special role in supporting AE was attributed to the TTO switching from revenue perspectives to the social and economic regional development model. However, according to Schaeffer and Matt (2016), the university collaboration with stakeholders depends on specific environmental conditions. Davey and others (2016), in exploring this, found a diversity of factors, barriers and drivers that condition university-business cooperation in European countries. These include: awareness barriers, funding barriers, cultural barrier, barriers relating to the usability of results; relationship drivers, access drivers, research drivers and university mission drivers. Moreover, according to Fischer and others (2018), the quality of university-industry collaboration is a stronger predictor of AE than the quantity of connections between them. Finally, the role of teaching and the contribution of education to AE development should be highlighted. In Siegel and Wright's (2015) opinion, there is too little scientific interest in "teaching/education—third mission nexus".

Conclusions

The AE concept is evolving and there is a tendency to broaden its scope in international studies. Scientific interest in the AE phenomenon is growing, however, AE is not a principal topic of research in management and entrepreneurship journals. In addition, while authors of AE studies borrow concepts and theoretical backgrounds from different disciplines, the domain is still closely related to the theme of technology transfer and commercialisation of academic knowledge. From the entrepreneurship research perspective, however, there are a growing number of publications that relate AE studies to specific entrepreneurship research aspects, such as entrepreneurial opportunity recognition, entrepreneurial intentions or motivations that are reflected in studies at micro level of analysis. It is also worth highlighting that some methodological problems and fragmentation of findings from AE domain are the same as compared to the whole entrepreneurship field.

Taking into account the above presented insights drawn from international studies, scheme 1.1 presents a summary of the important issues related to AE conceptualisation and studies.



Scheme 1.1. The scope of AE concept in international studies
Source: Own elaboration.

The AE phenomenon is still mainly described from the perspective of US and UK contexts. In European studies, there is a lack of greater contribution from CEE countries (or publications from that region do not have enough international publicity). In addition, insights from other emerging economies should be more frequently presented to the international scientific audience.

The problem of AE development is complex and contextual, thus a diversity of study from different environments should help to better understand the whole phenomenon. Moreover, AE should be analysed not only from the perspective of advantages at individual or organisational levels, but also through taking a more general social and economic perspective of the evaluation of AE importance and outcomes.

Among the emerging lines of research on AE phenomenon, two aspects should be especially highlighted. Firstly, the importance of entrepreneurship education and the role of university education in the creation of student entrepreneurial mind-sets in cooperation with different university stakeholders are important issues related to the AE development. Secondly, the changing technological conditions which impact socio-economic development should also lead us to better understanding of digital academic entrepreneurship, as well as digital academic innovations and their contribution to the emerging digital economy. Digital academic entrepreneurship is supposed to be one of the important lines in AE studies regarding the changing technological and socio-economic environments. Rules governing entrepreneurship in the digital world are changing, and these should be taken in consideration in the academic context (Arlott, Henike, & Hölzle, 2019).

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2. ACADEMIC ENTREPRENEURSHIP AS A PROCESS

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Abstract

Academic entrepreneurship is the process by which knowledge spills over from universities and other research institutions in order to be commercialised. Because the development of this process model requires a holistic and integrative perspective, the main objective of this chapter was to develop a process model of academic entrepreneurship. Based on a systematic review of academic literature data, 68 articles were selected, out of which 10 papers were further synthesized for the development of a process model so as to understand academic entrepreneurship. It was assumed that this entrepreneurial process consists of opportunities identification coming from university innovation that is perceived as a mechanism for knowledge spillover with regards to knowledge spillover theory of entrepreneurship. These opportunities are leveraged by the entrepreneurial resources and reconfigured to develop entrepreneurial competences according to the theory of entrepreneurship that consequently lead to knowledge and technology commercialisation. In this way, the proposed process model of academic entrepreneurship presents innovation as created in the university environment and driven by entrepreneurship to create value for knowledge-based economies.

Keywords: model of academic entrepreneurship, knowledge spillover theory of entrepreneurship, theory of entrepreneurship.

Introduction

In most of the literature studies, academic entrepreneurship (AE) covers a broad spectrum of different activities, mainly research and technology commercialisation via patenting, licensing, spin-offs and start-ups creations and university with industry and other stakeholders cooperation (Grimaldi, Kenney, Siegel, & Wright, 2011; Nicolau & Souitaris, 2016). In some scholarly studies, this scope is extended by contract research and consulting, as well as ad-hoc advice (D'Este & Patel,

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2007; Perkmann & Walsh, 2008; Wright, Clarysse, Lockett, & Knockert, 2008), teaching, joint publications with industry, staff exchange or joint student supervision (Schartinger, Rammer, Fischer, & Fröhlich, 2002). Abreu and Grinevich (2013) also recognize financial rewards from research or grant awards as forms of AE. Therefore, Klofsten and Jones-Evans (2000) define AE as any activity besides teaching and basic research (except for collaborative research with industry) that the authors classed as having equal status with those two.

Moreover, this term also refers to the efforts that universities undertake to generate revenues from a range of scientific research, or in other words, efforts to promote commercialisation within the university and in its surroundings hence, acting as a catalyst for their entrepreneurial activities (Siegel & Wright, 2015). Since the introduction of the Bayh-Dole Act in the United Sates and the Lisbon Strategy of the European Council, universities have experienced a shift from their traditional role in undertaking pure research and teaching, into being entrepreneurial. The idea that knowledge spawned via university research can be used for commercial applications led Etzkowitz (1983) to coin the term "entrepreneurial university" for describing the role that universities play in knowledge-based economies, and with time, entrepreneurial activities have become an integral part of university strategies (Rasmussen & Wright, 2015; Guerrero, Urbano, & Fayolle, 2016). At the same time, the discussion about interactions between academia, industry and government stressed the role of the triple helix paradigm in which the university plays an enhanced role in industrial innovation.

It has been recognized that academic institutional enhanced entrepreneurship can generate many benefits to universities, among others, access to industry laboratories and facilities, as well as know-how (Grimaldi & von Tunzelmann, 2002), opportunities for sponsored research, flow of funds from licensing and consulting, and donations from successful academic entrepreneurs (Quintas and Guy, 1995). Being entrepreneurial may also offer some advantages to academic scientists—such as increases in resources and reputational and societal benefits or greater satisfaction (Lam, 2010).

Since university research output is considered as a knowledge spillover source (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009) that can be commercialised, Audretsch and Keilbach (2007) describe knowledge spillovers between parties of "incomplete commercialisation", as a source of entrepreneurship. Consequently, building on the notion of knowledge spillovers, the theory of entrepreneurship and the endogenous growth theory, the knowledge spillover theory of entrepreneurship (KSTE) has been introduced. What distinguishes KSTE from other theories of entrepreneurship is that "the source of the entrepreneurial opportunities involves knowledge spillovers" (Shane, 2000). As argued by Acs and Sanders (2013), KSTE advances the microeconomic foundation of the endogenous growth theory by providing a new framework clarifying the unobserved heterogeneity of growth

rates between regions and nations. Romer (1990) assumed in the endogenous growth theory, that knowledge spills over automatically, while Audretsch, Keilbach and Lehmann (2006) and Acs and Sanders (2012) suggest that instead, the automatic spillover of knowledge is impeded by a knowledge filter, meaning all barriers that inhibit the conversion of knowledge produced in R&D laboratories into commercialised knowledge (e.g. legal restrictions and regulations). KSTE is also concentrated on variables that shape entrepreneurship, namely, research organizations and incumbent firms (i.e. knowledge incubators) that create knowledge but are not fully commercialised, a variables shaping knowledge spillover to other economic agents—entrepreneurs.

According to Friedman and Silberman (2003), AE is not a single event, but rather a continuous process comprised of a series of events that leads to sustainable and ongoing revenue generation for universities, research institutions and their industry partners. Therefore, consistent with this statement and KSTE, in this chapter, academic entrepreneurship is defined as a process, during which knowledge spills over from universities and other research institutions in order to be commercialised through mechanisms such as academic start-ups, spin-offs, university patents, licensing, sold technologies and other forms of university-industry collaborations—including consulting and contract research (Lockett & Wright, 2005; Phan & Siegel, 2006; Siegel, Veugelers, & Wright, 2007; Fini, Lacetera, & Shane, 2010; Grimaldi et al., 2011). Because the development of a multi-stage process model that recognizes the key actors, activities and successful drivers requires a holistic and integrative perspective and the literature on AE is rather fragmented (Wood, 2011), the main objective of this chapter was to develop a process model of academic entrepreneurship based on systematic literature studies. This process model is embedded in the theory of entrepreneurship and KSTE and, accordingly, explains entrepreneurial value creation through "entrepreneurial intention and the discovery of entrepreneurial opportunities", to develop "entrepreneurial competences and the appropriation of the entrepreneurial reward" (Mishra & Zachary, 2014).

Building upon this assumption, this chapter was organized as follows. In section 2, a conceptual framework was laid out that is followed by a description of the applied method. In section 3, "the discovery of entrepreneurial opportunities" was discussed, taking into account motivations and intentions of academic community to AE, as well as university innovations as a source of entrepreneurial opportunities. Section 4 provides an overview of the entrepreneurial competences and different forms of knowledge and technology transfer and research commercialisation. Section 5 summarizes all the other sections and presents a process model of academic entrepreneurship as well as conclusions.

2.1. Conceptual framework

Academic entrepreneurship is seen as a mechanism by which faculty members and (in some literature sources) also students, technicians and alumni (Chrisman, Hynes, & Fraser, 1995) convert scientific information into products and services. As it was described before, this corresponds with the commercialisation process. Throughout this chapter, only faculty members are considered as the key unit of observation. According to Balven, Fenters, Siegel and Waldman (2018), this term refers to all academic scientists and engineers who are engage in university research. The role of other individuals, including the staff of knowledge transfer intermediary organizations, is also taken into consideration, as faculty member relationships with such individuals represent the most basic level at which decisions to engage in AE are made. Moreover, only formal technology transfer is discussed wherein faculty members officially disclose their inventions to the university, e.g. via technology transfer offices. Since, the definitions of entrepreneurship often comprise individuals, opportunities, context and the process over time (Rasmussen, 2009), academic entrepreneurship can also be seen as a process. In this process, research-based idea or opportunity leads academics to create the necessary properties for direct or indirect commercialisation.

Among various forms of academic entrepreneurship, that which often is directly related to the process approach, is the establishment of academic spin-offs and start-ups. Firms that use university derived innovations, started or co-founded by faculty members, also have the greatest impact on economic growth. Based on Lockett, Siegel, Wright and Ensley (2005), in such ventures, knowledge understood as intellectual property (scientific and technical knowledge), as well as organizational knowledge, have become key resources. Therefore, most of the attention applied in this process model of academic entrepreneurship development is directed towards the process of spin-off formation. Still, better understanding of the AE process requires holistic perspectives in which other form of AE are taken into account, so as to develop a multi-stage process model that identifies the key actors and activities (Wood, 2011). As such, the proposed process model of academic entrepreneurship presents university generated innovations (as driven by entrepreneurship) becoming crucial engines in driving change processes in the society, while at the same time this entrepreneurship is becoming a mechanism "through which temporal and spatial inefficiencies in an economy are discovered and mitigated" (Shane & Venkataraman, 2000).

2.2. Research method

To explore the process model of AE conceptually, a systematic review of academic literature was undertaken in the manner put forward by Petticrew and

Roberts (2006). In the first step, a scientific literature repository search using keywords was carried out and subsequently expanded from the resulting articles, conference proceedings and book chapters, to their reference lists and citations to identify further articles. The focus was on those articles that explicitly used the terms: "academic entrepreneurship", "technology transfer", "entrepreneurial university", "university spin-offs", "academic spin-offs", "knowledge transfer", "commercialisation". In step 2, the resulting 718 articles from the Scopus database were scrutinized using the following inclusion criteria: the publication had to be a peer-reviewed academic paper in the field of business, management and accounting; social sciences and economics, econometrics and finance studies, as well as thematically oriented to academic entrepreneurship. Abstract reading resulted in an initial selection of 178 papers, of which 52 articles were included into step 3 that involved "forward and backward citation snowballing". Thus, 68 articles formed the material for systematic review, out of which 10 papers were synthesized for the development of the process model of AE (Table 2.1).

Table 2.1. Papers selected for the development of the process model of academic entrepreneurship

Author	Model type	Stages included in the model	Reference to the theory
Ndonzuau, Pirnay, & Surlemont, (2002)	graphical, descriptive, spin-off formation model	generation of business ideas from research—finalization of new venture projects out of ideas—launch of spin-off firms from projects—the creation of economic value by spin-off firms	did not mentioned
Rasmussen (2009)	graphical, descriptive, spin-off formation model	development of a technology or business opportunity from being an idea to becoming an independent new venture—individual entrepreneur in the business development process—institutional context (university)—university spin-offs	process theories
Rasmussen (2011)	graphical, descriptive, spin-off formation model	research—opportunity framing—proof of viability—post start-up	process theories
Wood (2011)	descriptive, AE as a commerciaisation process model	innovation disclosure and intellectual property protection stage—awareness and securing industry partnerships stage—commercialisation mechanism selection stage—commercialisation stage	theory of the growth of the firm
Secundo and Elia (2014)	graphical, descriptive, input-output model	design and implementation of research based, innovation oriented and entrepreneurial capital initiatives—opportunity recognition and elaboration of inventive concept—early stage technology development—product and service development and commercialisation—profit and harvesting	did not mentioned

Table 2.1 – cont.

Author	Model type	Stages included in the model	Reference to the theory
Simmons and Hornsby (2014)	graphical, descriptive, stage based model	motivation—governance—mode selection—competition—performance	agency theory, transaction costs theory, network theory
Backs, Günther and Stummer (2019)	descriptive, agent-based model of spin-off out of patent formation	invention—patenting—spin-off companies	did not mentioned
Del Bosco, Chierici and Mazzucchelli (2019)	descriptive, spin-off formation model	innovation development, including intangible intellectual properties transformation into patents, prototypes, or tangible properties—venture creation and development, including selection of the new startup entrepreneurial team members, access to additional financial resources and business development support by technology transfer intermediary organization	did not mentioned
Shepherd and Gruber (2020)	graphical, descriptive, lean start-up formation model	finding and prioritizing opportunities—designing business models—validated learning—building minimum viable products—preserve or pivot	social theory
Thomas, Bliemel, Shippam and Maine (2020)	graphical, descriptive, spin-off formation model	invention—entrepreneurial capabilities pre-formation: technology-market matching, claiming and protecting the invention, attracting and mentoring the founding team, strategic timing—science commercialisation—science-based spin-off formation	dynamic capabilities theory

Source: Own work.

2.3. The discovery of entrepreneurial opportunities

The traditional role of universities was attributed to education, basic research and knowledge promotion. Although these are still central parts of the university mission, but in recent years, there has been increasing pressure on universities, to shift from mainly teaching and performing research, to add and equivocal Third Mission (TM) meaning contributing to society (Wissema, 2009). From a general point of view, it consists of wide-ranging concepts such as "entrepreneurial university", "technology transfer" and "Triple Helix Model (THM) partnerships" (Trencher, Yarime, McCormick, Doll, & Kraines, 2014). On the other, the Third Mission refers to an extensive array of Higher Education Institutions (HEI) activities which seek to transfer knowledge to society in general, as well as to promote entrepreneurial skills, innovation and social welfare (Compagnucci & Spigarelli, 2020).

Because of the universities' third mission, academics are facing a new phenomenon of linking their work more closely to economic needs and to becoming important engines for development and economic growth. Therefore, some academic scientists commit to spin-off and start-up creation, some chose less entrepreneurial paths like licensing or patenting and some tend to remain in their traditional occupational choices as full-time scientists (Bercovitz & Feldman, 2008). It was therefore recognized that only some faculty members driven by entrepreneurial intention or/and aspiration for entrepreneurial reward, are actively interested in commercialisation.

D'Este and Perkmann (2011) found four motivations for researchers to engage in AE activities: commercial exploitation of science; gaining new insights and receiving feedback on research through engagement with industry; access to private funding; and access to external resources such as industry-provided equipment, materials and data. Thus, academics involved in AE may not be motivated primarily by an entrepreneurial vision to maximise profits. Fini, Grimaldi and Sobrero (2009) argue that the most important incentive for AE is the enhancement of academic status, but, Guerrero and Urbano (2014) suggest that there are other relevant motivational factors, namely, attitude towards entrepreneurship and perceived behavioral control (ease or difficulty of becoming an entrepreneur), that acts as knowledge filters from the individual perspective of the KSTE. Similarly, Lam (2011) emphasized the importance of the scientist's intrinsic motivation for AE, as some might become "barriers inhibiting the conversion of knowledge produced in R&D laboratories of incumbent firms and in universities into commercialised knowledge" (Ghio, Guerini, Lehmann, & Rossi-Lamastra, 2015, pp. 9–10).

Clarysse, Tartari and Salter (2011) argue that the key predictors of academic scientists' entrepreneurial engagement are the individual-level attributes and prior experience. Other studies highlighted the importance of demographic factors, like age (ambiguous effect on collaboration with business partners), gender (male academics are significantly more likely to engage with industry) and seniority (positively related to collaboration) (Perkmann et al., 2013). Hence, deeper understanding of these individual characteristics determines different AE approaches. Würmseher (2017) assumes that some scientists prefer to become entrepreneurs and refers it to "the inventor entrepreneur model", while some prefer to let go of their inventions to others interested in their commercialisation ("the surrogate entrepreneur model"). There is also an intermediate model, which the author calls "founding angel model", where inventors cooperate with other co-founders who provide finance, new venture experience, networking or technological knowledge (Festel, Breitenmoser, Würmseher, & Kratzer, 2015). According to Shane (2004), "the inventor entrepreneur model" is the most common in practice, which in fact assumes that the inventor becomes an entrepreneur (O'Shea, Chugh, & Allen,

2008; Kenney & Patton, 2009). Based on Jensen and Thursby (2001), an academic entrepreneur is someone engaged in formal commercialisation activities that often lead to patent creation, license sales or the derivation of new venture. However, Meyer (2003) and Bicknell, Francis-Smythe and Arthur (2010) assume that some faculty members participate in a wider range of engagements, such as collaboration with industry e.g. by consulting, and so recognize them as entrepreneurial academics that are often driven by the research related motivations described above, but who are not primarily motivated by an entrepreneurial vision to maximize profits.

All motivational factors are captured by entrepreneurial intentions that influence behaviour. Miranda, Chamorro-Mera and Rubio (2017), based on studies in Spanish universities and relying on the theories of planned behaviour, found entrepreneurial intentions as the key to understanding the first step in the AE process. As indicated by Bird (1988), entrepreneurial intentions are the most proximal predictors of the decision to become an entrepreneur, and as Krueger, Reilly and Carsrud (2000) add, even if someone may have potential, he or she will refrain from making the transition into entrepreneurship when he or she lacks the intentions. As antecedents of the AE construct, Miranda and others (2017) consider creativity, perceived utility (e.g. the income anticipated, the amount of work effort anticipated to achieve this income, the risk involved), self-confidence, previous business experience, entrepreneurship training and the perception of an enabling environment for entrepreneurship. Prodan and Drnovsek (2010) found that entrepreneurial self-efficacy, type of research, perceived role models, number of years spent at an academic institution and the number of patents generated are significantly related to the formation of academic entrepreneurial intentions.

For knowledge or technology-based AE, the opportunity for any kind of AE activities is usually recognized in knowledge or technology that potentially can be developed into highly innovative products or services. D'Este, Mahdi, Neely and Rentocchini (2012) suggest that the creation of such opportunity is driven by scientific excellence. Hence, according to Wood (2009, p. 930), university research can lead to new innovations defined as "any invention, new technology, idea, product, or process that has been discovered through university research that has the potential to be put to commercial use", and in his subsequent paper (Wood, 2011), argues that the AE process just starts with university derived innovations and scientific discoveries. Therefore, university-origin innovation as entrepreneurial opportunity is assumed as the first step in the presented process model of academic entrepreneurship, and, referring to Acs et al. (2009), the use of university-produced innovation is a mechanism for knowledge spillover with regards to KSTE, in which, as described above, some academics motivations act as knowledge filters (Figure 2.1).

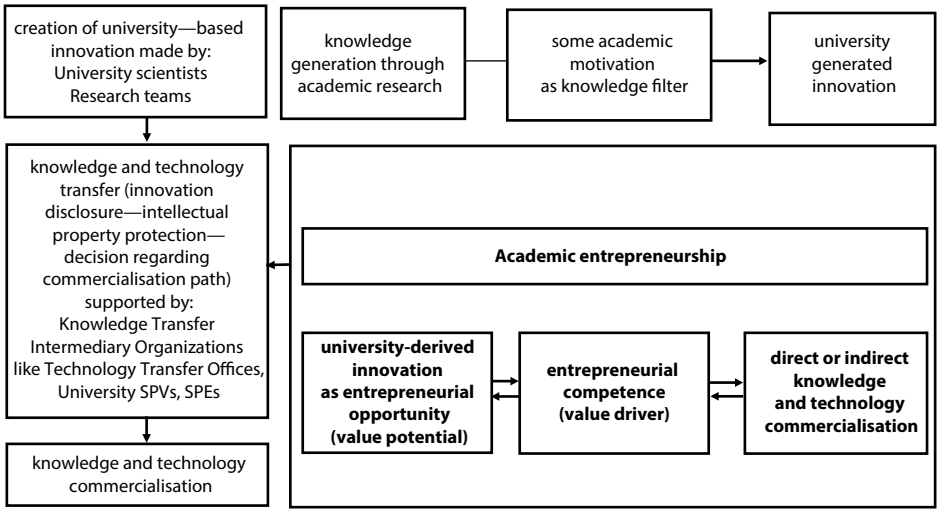

Figure 2.1. The process model of academic entrepreneurship during which knowledge spills over from universities in order to be commercialised
Source: Own work.

2.4. The entrepreneurial competences as value drivers

Relying on the theory of entrepreneurship, the entrepreneur discovers an opportunity that is leveraged by the entrepreneurial resources and reconfigured to develop entrepreneurial competences (Mishra & Zachary, 2015). Rasmussen and others (2015) described three competences required to succeed in new academic venture creation. First—identification and development of an opportunity (opportunity development competency). Second—the need for championing individuals that provide business, managerial expertise and energy to the entrepreneurial process (championing competency). Third—the need to access the resources for commercial exploitation of the opportunity (resource acquisition competency). Other prior studies have focused on scientists commitment to AE and their entrepreneurs' attributes such as risk-taking, opportunity recognition, the ability to identify market potential of their research output, creativity, perseverance, expertise knowledge, team building skills, ability to organize financial resources and technical facilities, ability of customer needs analysis, networks building and self-confidence of the members of the scientific team (Clarysse et al., 2011; Morris, Webb, Fu, & Singhal, 2013; Soetanto & Jack, 2016; Wang, Soetanto, Cai, & Munir, 2021).

At this point, however, it should be noted that a vast number of literature studies emphasize that the entrepreneurial opportunity recognition is not only attributed

to the scientist himself, but, very often is dependent on commercial expertise, networking between science and industry or management of the university intellectual property provided by different knowledge transfer intermediary organizations such as technology transfer offices (TTO), special purpose vehicles (SPVs) or special purpose entities (SPEs), science and technology parks or university business incubators (Agrawal, 2006; Shane, 2004; Rasmussen, Mosey, & Wright, 2011). In addition, other competences can be supplemented by knowledge transfer intermediary organizations, especially complementary resources needed for commercial exploitation of opportunity like laboratory equipment, office space, information technology infrastructure or access to financial resources. Szulczewska-Remi and Nowak-Mizgalska (2021), in the aforementioned work, based on Polish and Czech studies, showed that other entrepreneurial competences are provided by these intuitions, mainly evaluation of an invention's commercialisation potential, team building and business model development.

2.5. Knowledge and science commercialisation

Commercialisation of research results is a derivative of university-based innovation and a multidimensional process that enables the innovator (the creator of innovation) to achieve economic benefits from the implementation of scientific research results into business practice. In-depth recognition of the inventions' advantages and assessment of its market potential are indispensable elements of the commercialisation process. Therefore, commercialisation is a process where innovation flow form the basic research to commercial entities and then to public use (Van Norman & Eisenkot, 2017). Moreover, commercialisation occurs via academic entrepreneurship with the objective to commercially exploit an invention, or in some cases, a body of expertise (Shane, 2004).

To support commercialisation, higher education institutions have established two ways of commercialisation through direct (setting up Technology Transfer Offices that, for example, assist in gaining a patent and/or license for the developed solution or arrange different forms of university-industry collaborations like consulting) or indirect commercialisation (creating a company that was founded by inventors coming from the same scientific institution in a form of spin-off or start-up through the support of Special Purpose Vehicles (SPVs) or Special Purpose Entities (SPEs)) (Szulczewska-Remi, 2016). As noted earlier, universities establish Technology Transfer Offices, SPVs or SPEs to manage the commercialisation of intellectual property arising from the faculty research. Academics, who wish to patent, licence, or form a new company formally disclosure their inventions in order to start the process of intellectual property protection (e.g. patent application), while technology transfer organizations very often advise on the selection of the

commercialisation path (selling the outcome of research, grant licensing of R&D outcomes or making contributions of research to the firms). The entrepreneurial impact of university sourced innovations is further measured as a result of commercialisation process in terms of number of patents and/or corresponding licensing agreements, contracts with industry or spin-off/start-up companies (Figure 2.1).

The World Bank's report on the prospects for the development of the knowledge-based economy in Poland indicates that also in our country it has become important to establish universities' units dedicated to the commercialisation of technologies (Goldberg, 2004). As noted, the role of intermediary organizations is systematically growing, and their importance is emphasized by all the most important strategic documents in the country (Bąkowski & Mażewska, 2015; Byczko & Trzmielak, 2013).

2.6. The process model of academic entrepreneurship

Applying the AE definition proposed in this study, AE is seen as a process that may serve to moderate the impact of university derived innovation (input) on knowledge and technology commercialisation outputs consistent with Secundo and Elia (2014) input-output model for AE. With regards to KSTE, the university-introduced innovation is a mechanism for knowledge spillover and some academic motivations act as knowledge filters in the creation of university-born innovation, while some are captured by entrepreneurial intentions. Although Simmons and Hornsby (2014) have introduced a stage based model of AE, in which individual faculty members, university, industry and government motivations are seen as the first stage in this process, according to most references found when researching for this model development (Ndonzuau et al., 2002; Rasmussen, 2009; Rasmussen, 2011; Wood, 2011; Secundo & Elia, 2014; Thomas et al., 2020), university-sourced innovation alone initiates the process of AE.

As was stated before, this entrepreneurial process involves the identification of opportunities from university initiated innovation (step 1) and matching the entrepreneurial resources at hand with the opportunity to effectuate an entrepreneurial competence (step 2); acquiring external resources, if necessary; creating sustained value through the commercialisation and as was suggested by Ndonzuau and others (2002) in their four-stages spin-off process, strengthening the economic value. In this manner, AE is recognized as a process of value creation explaining the transformation of academic research into value creation. The process is driven by the entrepreneurial intentions and entrepreneurial capabilities described by Thomas and others (2020). In turn, entrepreneurial capital resources include knowledge capital, social capital or tangible capital (financial and physical assets)

(Mishra & Zachary, 2015), very often provided by a technology transfer intermediary organization.

Del Bosco et al. (2019) in their spin-off model based on Italian case-studies, described the role of technology transfer intermediary organization. Similarly, Backs et al. (2019) introduces two agents: researcher and technology transfer office, which are involved in the spin-off of the patenting process. Moreover, Shepherd and Gruber (2020) propose a lean start-up formation model, in which business model and minimum viable product formation were included, besides opportunity recognition and entrepreneurial search. Therefore, the proposed process model of academic entrepreneurship covers the discovery of opportunities from university-derived innovation that has potential value wherein in the second stage, entrepreneurial competences drive the value creation and lead to knowledge and technology commercialisation. This model presents academic entrepreneurship as a process that enables (Padilla-Meléndez, Del Aguila-Obra, & Locket, 2012) knowledge spillover through knowledge creation, knowledge transfer and knowledge commercialisation (Guereo & Urbano, 2014) (Table 2.1 and Figure 2.1). Moreover, academic entrepreneurship refers to the efforts and activities that universities undertake in the hope of commercialising the outcomes of HEI research (Wood, 2011). Accordingly, it relates to the transition from the known "ivory tower" to the entrepreneurial university (Etzkowitz, Webster, Gebhardt, & Terra, 2000).

Conclusions

Innovations stemming from university research are a growing source for the ideas and new technologies that drive entrepreneurial endeavors through academic entrepreneurship. For the purpose of this chapter, academic entrepreneurship was defined as a process during which knowledge spills over from universities and other research institutions in order to be commercialised through mechanisms such as academic start-ups, spin-offs, university patents, licensing, sold technologies and other forms of university-industry collaborations, including consulting and contract research. Still, the process of AE has not been well articulated, thus, based on selected academic papers, the process model of AE was developed and presented graphically.

This entrepreneurial process creates sustained value through the identification of opportunities from university-based innovation that is perceived as a mechanism for knowledge spillover with regards to KSTE. Building on the theory of entrepreneurship, these opportunities are leveraged by the entrepreneurial resources and reconfigured to develop entrepreneurial competences that drive value creation and lead to knowledge and technology commercialisation.

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PART II
ACADEMIC ENTREPRENEURSHIP AT PUEB

3. DEVELOPMENT AND COMMERCIALISATION OF AN INVENTION IN THE FIELD OF ACTIVE PACKAGING

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Abstract

The aim of the work is to present the case study of commercialisation process by using the example of an invention (active packaging) developed at a university (PUEB) and intended for employment in the packaging industry to preserve the quality of goods and prolong its shelf-life. The stages from basic research, further development of the solution, through the process of fundraising, obtaining intellectual property protection, prototyping and attempts at proper commercialisation including its final results are presented.

Keywords: commercialisation, technology transfer, active packaging, oxygen scavenger.

Introduction

The quality of products is a guarantee of customer satisfaction (Defeo, 2016). Taking into account the product life cycle and the specifics of the sales process, it should be remembered that not only the quality created at the production stage is important, but also maintaining this quality in all further stages of the product life cycle (Pyzdek & Keller, 2012). This is especially important in the case of food products, which, by their nature, are particularly susceptible to external factors and the quality changes caused by them, unfortunately, for the worse. This leads to losses amounting to millions or even billions of dollars a year, and in addition, they are nothing more than the food waste that we grapple with all over the world (Wadman, 2015). Therefore, apart from quality management at the production stage, it is extremely important to introduce solutions that allow the maximum maintenance of the original product quality as unchanged as possible (Taormina & Hardin, 2021). In the case of food products, this is achieved by appropriate

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development and carrying out of the production process and, which is crucial, by appropriate packaging of the produced food (Galanakis, 2019).

Packaging of food products is based on the selection of suitable packaging materials and optimal packaging technology for a given product (Grumezescu & Holban, 2018). The main aim of the packaging materials is to adequately protect the product from the outside world—in the case of food, this is ensured by materials with high barrier properties. Barrier properties determine the speed or the possibility of chemical, physical and biological factors penetrating the inside of the package. Examples include, among others: water vapor, oxygen, UV light and microorganisms (Singh, Wani, & Langowski, 2017). When it comes to packaging technologies, the best results are achieved by modified atmosphere packaging (MAP) (Lee, 2021). In this case, the air originally contained in the package is replaced with a gas or a mixture of gases optimally selected from the point of view of maintaining the quality of the product. The most commonly used gases are nitrogen, carbon dioxide and (less often) argon.

It turns out, however, that in the case of products that are particularly sensitive to external factors, as well as due to the physical and biochemical processes taking place in them, even the aforementioned modern packaging methods turn out to be insufficient. The solution to this problem may be the so-called 'active packaging' (Arvanitoyannis, 2012), an example of which is the invention presented in this case study, developed by research workers of one of Poland's universities (PUEB).

3.1. Basics of commercialisation and technology transfer

As in the case of any invention, and, in particular, one covered by patent protection, the aim of the inventor or owner should be to transfer new technology to the market or, in other words, to commercialise it, which will contribute to the dissemination of the new technology, its implementation in practice and will provide financial benefits to inventors or organizations and institutions they work for. There are many definitions of commercialisation and technology transfer in the literature. Commercialisation may also include activities aimed at creating a business model of a given technology, shaping the process of its sale, production, sharing, sale or use so that it brings profit or constitutes a specific capital, and may also aim at obtaining added value of a given technology (Jordan, 2014). It can also be treated simply as all activities aimed at transforming knowledge into inventions, technologies, innovative products and organizational solutions serving this process (Liou, 2011).

Knowledge itself or even a specific invention is worthless until we find practical application for them, and what is most important from an economic point of view,

until we find people willing to buy them. The latter is particularly difficult due to the multitude of ideas and new inventions emerging all over the world and the price pressure associated with the desire to minimize costs and maximize profits. Only truly innovative, unique and at the same time, cheap technologies are able to break into the market and be successful. There are several different commercialisation strategies that are applicable. The most common are the sale of property rights, licensing, join venture or strategic alliance, implementation on your own, creation of spin-out or spin-off companies (Rafinejad, 2007; Butler & Gibson, 2011, Trzmielak, 2013).

The commercialisation process begins with determining the market potential, and thus, first of all, determining the advantages and possible limitations of a given solution, idea or technology. This is done with reference to existing, similar or alternative solutions available on the market. The size of the market is then determined, the necessary expenditures related to the development and potential introduction to the market, production costs, possible distribution channels, and existing market niches that could be filled by the solution intended for commercialisation (Szopa, 2015) are investigated.

Very often, the authors of a given idea are not able to make such an assessment on their own. Thus, additional people or entities specialized in the aforementioned activities are involved in the commercialisation process. Most often, innovation brokers or technology transfer centres are used for help (Mian, Klofsten, & Lamine, 2021). Regardless of this, the commercialisation process and the related technology transfer are accompanied by activities that allow the environment to be effectively and widely acquainted with the offered technological solution.

The first of these is the presentation of an idea or solution, e.g. at scientific conferences, symposia, as part of published works. As it happens in science, ideas are usually not fully crystallized, new ones appear, and therefore the solution is constantly developing, and at the same time, as many applications as possible are sought for it, which will increase market opportunities.

When the research is more advanced, the first prototypes are created and presented to the public (of course, provided that the intellectual property has been secured in advance). At the same time, literature research, patent analyzes and technological audits are carried out in order to be sure that so far there has not been any similar solution to the one on which the efforts are being focused upon (Gibert, Bobadilla, Gastaldi, Le Boulaire, & Lelebina, 2018). This guarantees originality and real innovation.

In the later period, when the invention takes almost its final shape, market research is carried out, and potential marketing strategies are developed. Finally, when an investor is found, production is being prepared. The culmination of the commercialisation process is launching the product on the market and selling it (Touhill, Touhill, & O'Riordan, 2008).

Various concepts, approaches and models of commercialisation can be found in the literature. Regardless of that, in each of them, commercialisation is a process of successive stages, from the idea, through its development, to the proper commercialisation (e.g. sale or licensing). One of the frequently used measures of product development and readiness for commercialisation is the technology readiness level (TRL) (Schramm, 2018). TRL method was originally developed by NASA during 1970s and was used to support technology maturity assessments and compare the maturity level of different technologies. TRL describes increasing technological maturity levels as a concept progress from an initial idea to a fully tested and proven device. Readiness levels are presented on conventional scale ranging from 1 to 9.

In this case, a given technology is assigned one of the nine levels, with the lowest, TRL 1 being the commencement of research, and the highest TRL 9 being the situation when the technology is ready for implementation. As a result TRL is a very useful tool for assessing the technology development process. TRL allows determining the level of development of a given technology, identifying missing elements (e.g. analyzes) and taking further steps (e.g. modifications, improvements) to make it fully ready for commercialisation.

Current TRL model bases on definitions presented by John Mankins, the former Director of the Advanced Concepts Office at NASA Headquarters (Mankins, 1995). Particular TRLs are shown and described in Figure 3.1.

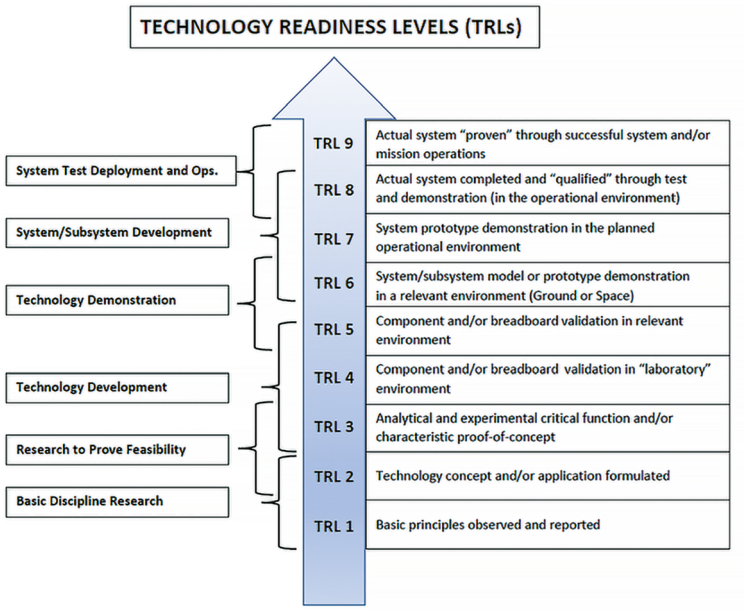

Figure 3.1. Overview of Technology Readiness Level scale
Source: (Mankins, 2009).

An inherent process accompanying commercialisation is technology transfer. Basically, it is an exchange of technological knowledge and the accompanying organizational knowledge between two entities (Hockaday, 2020). One of them is someone with this knowledge (technology donor), and the other is someone who needs this knowledge (technology buyer) (Mietzner & Schultz, 2021). Said exchange may take place between entities from different spheres of research and industrial activity. Most often, technology is transferred from the science sector to the business world. It also happens that the exchange takes place between two enterprises. Sometimes it happens that the technology provider for the industry is an individual inventor, not necessarily related to science.

When it comes to the sphere of science, the subjects of technology transfer in this case may be, inter alia, universities, research institutes, research and development centres (Audretsch, Hayter, & Link, 2015). In turn, the buyers are most often enterprises (small, medium, large), but sometimes they are also public institutions. It also happens that private persons are party to the technology transfer process.

In practice, technology transfer can take many forms. Most often it is trading in patents, licenses and broadly understood know-how. It can also be direct investments, modernization of the machine park, cooperation of companies, e.g. as part of joint-venture and mergers of companies (Hoekman & Smarzynska Javorcik, 2006). In the public domain, it may be also contracts for research and development that are commissioned by the state under government programs or other entities, e.g. companies, agencies (Marshall & Piper, 2005). In the case of scientific and research units, and, in particular, universities, technology transfer also includes publications, reports, conference reports, seminars, and classes (Link, Siegel, & Wright, 2015).

Unfortunately, commercialisation and the accompanying technology transfer is often a complicated, multi-stage, expensive and long-lasting process, which is particularly unfavourable in the conditions of high technological competition in the world (Becker & Niebuhr, 2010). On the one hand, there is a need to offer a product that is refined in every respect and tailored to the client's or investor's requirements, and on the other, there is time pressure—in the era of constant development of new technologies, products are technologically aging faster and faster.

3.2. Investigation methodology

Presented work bases on case study, which is one of the qualitative research methods and its main goal is to best visualize a certain case. It is an in-depth analysis of a specific phenomenon. The main purpose of this method is to best depict particular "case". It may contain a detailed analysis of the case, goals, assumptions, motives and actions (Fulford, 2012; Yin, 2009, 2012)

In this particular case an invention in packaging field developed on Poznań University of Economics and Business was analysed. The study covered the commercialization process from the idea, basic research, further development of the solution, through obtaining intellectual property protection, prototyping to attempts to implement and sell the solution. The analysis was based on the author's own experiences and the experiences of other team members who developed the invention. The aim was to define the advancement of the commercialization process. The basis for the assessment was the reference to the previously described TRL method and, as a result, indication of the technological maturity level of the presented invention.

3.3. Background of the invention

The first attempts to develop an oxygen absorber were made in 1998. Then, various basic studies were carried out. The resulting solution was a "by-product" of master thesis research carried out at the PUEB. It is based on copper compounds and showed satisfactory efficiency in removing oxygen from the packaging, therefore, it was decided to submit it to the patent office of the Republic of Poland as a new invention. While awaiting the decision of the patent office to grant the patent, further work was carried out to develop an equally effective, but cheaper solution. Therefore, a query of existing solutions on the packaging market was made. It turned out that most of the oxygen absorbers sold on the market are based on iron and its derivatives. However, the existing solutions were usually in the form of a sachet with a mixture of powdered iron compounds.

This form of oxygen absorber is simple to manufacture, but has a significant drawback, namely, that the sachet (mostly made of paper) containing the said active substances can be easily damaged, and its content can come into direct contact with the protected food product and be accidentally consumed with it. This, in turn, may endanger the health safety of the potential consumer.

Taking into account the above, an attempt was made to develop an oxygen absorber, the active ingredient of which would also be iron, but closed in some polymer matrix, becoming a kind of composite, which would also be a safe form of the absorber without the risk of contamination of the food protected by it. The work focused on the development of a method of obtaining iron with the highest possible oxygen absorption capacity, and then the selection of the optimal polymer matrix from the point of view of the oxygen absorber, which on the one hand, will enable oxygen penetration, and on the other hand, will constitute an effective barrier between the iron incorporated into it and packaged food product.

After many trials and studies of absorption capacity, the most effective method of obtaining iron was selected and optimized (Foltynowicz, Kozak, & Fiedorow, 2002). Herein, silicone was chosen as the matrix due to its unique feature—oxygen permeability, which was considered once by manufacturers of contact lenses as a material ensuring oxygen access to the eyeball (Efron, Morgan, Maldonado-Codina, & Brennan, 2010). The obtained material was also checked for possible migration of iron from the polymer matrix and emission of undesirable odors. For this purpose, studies on specific migration and use of an electronic nose were carried out. These attempts were successful, the material turned out to be neutral and therefore usable in packaging.

Meanwhile, in 2007, after 8 years of patent procedure, a patent was granted for the previously described copper-based solution (Patent 193082, 2007). Following this success, the patenting of said iron-silicone composite was also considered. However, in order to gain a competitive advantage, by proposing an original solution that had no counterparts on the market, an attempt was made to develop an oxygen absorber that uses nano-iron as an active oxygen absorbing agent. At the same time, it was found that the previously used silicone matrix will also work perfectly in the newly proposed solution. Intensive research and modifications to the new solution were carried out, as well as tedious tests of its effectiveness as an oxygen absorber.

In the end, promising results were obtained. Among other benefits, we discovered that the obtained nano-iron did not require water for oxidation, which was a unique feature compared to the available iron-based oxygen absorbers. The potential oxygen absorber could therefore be used to protect the quality of dry products susceptible to oxygen. Therefore, it was concluded that this invention should be protected by a patent and its inventors should be protected as much as possible with regard to intellectual property rights. The only problem was that patent protection for inventions, and, notably, international patent protection, was a huge cost that neither the inventors nor the institution they worked for (a public university) would be able to provide. Thus, an attempt was made to obtain funds from an external source.

It turned out that under the development projects of the European Union, under the innovative economy operational program (POIG), there are funds in the form of grants for the protection and commercialisation of inventions. After reviewing the requirements, an application was prepared and submitted to the institution dealing with the distribution of the aforementioned funds in Poland (OPI). To the delight of the inventors, in 2010, the project was granted and it was possible to start the patent procedure—first at home, and later abroad.

The patent procedure was thus started, and, in the end, 3 patent applications were prepared for two methods of obtaining an active substance absorbing oxygen

and one method for obtaining an appropriate oxygen absorber composite. After the filing of the patent applications, the inventions were henceforth entitled to priority rights, so it was possible to start talks with potentially interested parties in the patented solution without fear of losing intellectual property or to lose out to simple piracy.

As a natural consequence of the steps taken, attempts were made to commercialise the invention.

3.4. Commercialisation process

Before the official presentation, the invention was thoroughly researched and tested (e.g. for compatibility with food products susceptible to oxygen spoilage) (Kwiatkowska-Sienkiewicz, Foltynowicz, & Kozak, 2015) and then presented to the public for the first time in 2014, at a packaging conference in Melbourne, Australia (Foltynowicz & Kozak, 2104). It aroused the interest of one of the participants, as it turned out, an employee of a Danish Technological Institute. Several meetings were held at the invitation of the Danish side, during which contact was made with another eminent research centre dealing with packaging, namely, the Fraunhofer Institute. The invention was jointly tested for its properties and compared with commercially available solutions.

The results of the joint research were published in 2017 (Foltynowicz, Bardenshtein, Sägerlaub, Antvorskov, & Kozak, 2017). They showed that the solution has (in some respects) advantages over analogous products available on the market. The Danish and German sides proposed a joint application for a grant under the Horizon 2020 program. Additionally, Scandinavian and German companies from the food and packaging industry, as well as a professional consulting company specializing in EU grant applications, were invited to the consortium. Working meetings were held, and then in 2016, an application was prepared and submitted to the European Union for a project that would lead to the implementation of the described solution for production on an industrial scale.

Unfortunately, despite the very good assessments of experts, funding was not granted. Therefore, it was decided to slightly change the application form, taking into account expert comments, and apply again for the next call for applications. This time it was a haircut from obtaining financing, and as proof of the commercialisation potential of the proposed project, the project team was awarded the Seal of Excellence certificate, opening up the possibility of obtaining funds for the implementation of the project from other sources. This was also done and an attempt was made, together with a partner from the chemical industry, to obtain funds from the Polish enterprise development agency (PARP) to test the possibility of producing an invention on an industrial scale.

In 2017, the first three patents—one in Japan and two in Poland were granted (of the aforementioned POIG project) (Patent 6093713, 2017; Patent 227585, 2017; Patent 227096, 2017).

In the meantime, a unit specializing in the valuation of modern technologies intended for commercialisation was commissioned for the assessment of the solution. With the help of the PUEB Knowledge Transfer Company, cooperation was established with a company from the food industry that was interested in a solution extending the durability of its products. Joint research on the compatibility of the oxygen absorber with the edible product began. In the course of the research, the absorber was given a special form adapted to the packaging used by the food manufacturer. The test results turned out to be interesting, the absorber gave better quality protection effects than other packaging methods used so far by the company, e.g. MAP, but the cooperation ended without a favourable outcome.

One of the problems was most likely the potential costs of adapting the packaging line to the possibility of using an oxygen absorber—it would be necessary to ensure an oxygen-free atmosphere, which would be a significant investment. Another issue was that the company interested in the invention wanted to obtain the rights to produce it exclusively, while the owner of the invention, in this case a public university, was more interested in selling the license. In connection with this turn of events, further attempts were made to establish cooperation with the food industry in order to commercialise the invention, so far without a happy ending. In 2018, two further patents were granted (1 in Israel and 1 in European Union) (Patent, 227146, 2018; Patent EP2658666, 2018) and the project submitted to the Polish industrial development agency was included in the list of projects to be financed.

There was a possibility of developing the invention and transferring its production from laboratory to industrial scale. Unfortunately, the obstacle was the fact that, as it turned out later, the second participant of the project would first have to put up in advance a large own contribution (almost 1/3 of the entire project budget foreseen), which taking into account the prototype character of the invention would be too much of a risk for the company. Ultimately, the company's authorities did not agree to advance the funds and the project was unfortunately not implemented. Nevertheless, it can be stated that the invention has reached the 6th technological readiness level (TRL), and thus it has become a prototype that has been tested in conditions similar to real ones (Schramm, 2018).

In its current form, it is waiting for interest from business and funds for development. It is the limited resources that most likely limit the ability to offer potential customers a ready-to-use solution. The whole commercialisation process of the presented invention is shown in Table 3.1.

Table 3.1. Commercialisation process of oxygen scavengers

No.	Time period	Development stage	Development phase	Technical readiness level (TRL)	Remarks
1.	1998–1999	Idea of new type of oxygen scavenger. Initial work on an oxygen scavenger based on copper	**Research**	**1 BASIC PRINCIPLES OBSERVED**	Works were a subject of a master thesis. Patent application has been submitted to the Patent Office of the Republic of Poland
2.	1999–2005	Formulation and tests of composite oxygen scavenger based on iron powder built into silicone matrix	**Research**	**2 TECHNOLOGY CONCEPT FORMULATED**	Works were a subject of PhD thesis
3.	2005–2010	Nano-iron synthesis and formulation of composite oxygen scavenger based on it	**Research**	**2 TECHNOLOGY CONCEPT FORMULATED**	Works were a subject of several master theses. In 2007, first patent was granted
4.	2010–2014	Improving of the invention. Shelf life test with packed products protected by developed solution. Official presentation of the invention to the public	**Development**	**3 EXPERIMENTAL PROOF OF CONCEPT**	Shelf test were realized in cooperation with Gdynia Maritime University. Presentation of the invention took place in Melbourne (Australia) during an international packaging conference
5.	2014–2016	Comparative tests with commercial alternatives	**Development**	**4 TECHNOLOGY VALIDATED IN LAB**	Tests were performed in cooperation with the Danish Technological Institute (Taastrup) and the Fraunhofer IVV Institute (Freising)
6.	2017–2018	Performance test in real conditions with packed product. Adaptation to the requirements of a potential buyer. Efforts undertaking to obtain financing for the production of the invention on an industrial scale	**Development**	**5 TECHNOLOGY VALIDATED IN RELEVANT ENVIRONMENT**	Cooperation with food producers. Application for Horizon 2020 and PARP grants. The first was awarded with "Seal of Excellence" certificate, and the latter was granted. In 2017 and 2018, five patents (in Japan, Poland, Israel and EU) were granted
7.	2019	Further development and test. Presentation of the invention to potential buyers	**Development**	**6 TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT**	A producer of packaging materials showed interest in the invention and expressed a desire to purchase it. Unfortunately, the invention was not sold on so far
8.	2019–2020	New idea to use the presented invention as antimicrobial packaging. Initial shelf life test with food products were conducted	**Research**	**1 BASIC PRINCIPLES OBSERVED**	Three patent applications have been submitted to the Patent Office of the Republic of Poland
9.	2021-	To be continued…			

Source: Own work.

The experiences described in the work lead to the conclusion that companies in Poland potentially interested in a solution are not willing to invest in the development of prototypes in order to adapt it to their needs, they are more interested in an almost ready-to-use product. This is an insurmountable barrier for most public universities, as they have limited resources for development and commercialisation of inventions created under their auspices. The observations made are consistent with the observations of other researchers in this area (Trzmielak, Grzegorczyk, & Gregor, 2016).

3.5. New life of the invention

Regardless of what has been presented above, further attempts have been made to commercialise the invention. Recently, a light at the end of a tunnel has appeared, namely, in the course of new research conducted at the PUEB, it turned out that iron, which was the active factor of the described oxygen absorber, has very good bacteriostatic properties. Hence, the idea of creating a packaging material based on said iron that could potentially be used as so-called "anti-microbial packaging" (Barros-Velazquez, 2016). This idea has become the subject of another patent application that is awaiting the decision of the Polish patent office (Patent application P.432267, 2019).

The new solution has aroused the interest of a company operating in the field of plastics. Negotiations are, hence, underway to sell the technology for the production of an active agent that was originally designed as an active element of an oxygen absorber. Perhaps, ultimately, the original invention will be commercialised as a completely different solution in terms of its function, but will still support traditional packaging. Ultimately, this would be commercialisation by finding a new application for a non-commercialised (so-far) invention.

Conclusions

This paper presents the use of case studies to analyse and determine the advancement of the commercialization process. In this particular case, the subject of the analysis was the process of the emergence and development of an invention in the field of packaging at one of the Polish universities. The study covered the period from the first ideas, initial tests, concept changes, modifications, further development and attempts to implement the invention in a form that takes into account and is adapted to the specific requirements of a potential buyer. In addition to the process of developing the invention, the process of obtaining intellectual property protection for it, including obtaining national and international patents,

is also presented. An additional element was the presentation of financing sources for the development of the invention, as well as the method of cooperation with potentially interested industry representatives.

The analysis of the advancement stage of the invention was carried out on the basis of the TRL model commonly used for this purpose. The effect of the work is, firstly, the identification of breakthrough moments in the product development process, and then relating them to the TRL model. As a result, the technological maturity of the analysed solution was determined as TRL 6. Thus the invention was formally placed in the context of the widely understood commercialization process. The study also partially answers what else should be done to achieve full technological maturity, so as to enable the completion of the commercialization process, understood as a sale or granting a license.

The conducted case study can also be a practical guide for potential inventors and help them, first of all, to identify all elements related to planning, development, financing, as well as legal protection of new technical solutions. It will also allow to avoid problems and stumbles that the authors of the presented invention had to deal with. They did not have similar studies at their disposal and in many moments they based their decisions on intuition, which was burdened with a considerable risk and certainly contributed to the extension of the product development process and its commercialization. An additional advantage of the analysis presented in the paper is that it takes into account the specificity of the operation of Polish universities in the field of commercialization, which is a derivative of a relatively small commercialization experience and specific principles of financing and implementing the commercialization process by universities.

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4. ACADEMIC ENTREPRENEURIAL ATTITUDES IN THE ASSESSMENT OF ECONOMIC FACULTIES STUDENTS

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Abstract

The aim of the research is to analyse selected attitudes related to entrepreneurship and to present their significance assessment according to students of economic faculties. The empirical basis is built upon the results of the research conducted in March 2021 on a group of 270 students of the Poznań University of Economics and Business. As part of the questionnaire and using the 5-point Likert scale, the respondents assessed various features, skills and abilities that, according to the respondents, are key in the context of an entrepreneurial attitude. In addition to the general statistical analysis of the response, a factor analysis was also carried out that aims to reduce the number of variables to a few, the most important ones that highly describe the analysed problem. Based on the research conducted, it can be concluded that from the students' perspective, the entrepreneurial attitude profile consists of a combination of personality types such as precursor, creator, rival, individualist, risk-taker. The research was limited because it was based on one academic centre (Poznań University of Economics and Business). Extending the research to other areas of higher education (e.g. law, medicine, psychology, computer science, mechanics) would allow the conclusion to be drawn on a wider scale and provide more insight into the nature of the phenomenon. The value of this study lies in the fact that it presents a coherent framework to explain the diverse characteristics of entrepreneurial attitudes in the business school environment.

Keywords: entrepreneurial attitudes, economic activity, entrepreneurship, economic education.

Introduction

The time of university is full of milestones and challenges for young people. It is often associated with living away from home, taking their first paid job, planning a budget on their own, determining a professional career and choosing an educational

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path. At this time, students develop entrepreneurial attitudes that will determine their future and success in the demanding and dynamically changing market.

Entrepreneurial attitudes are an important aspect that is the subject of interest of many different scientific areas such as economics, sociology, anthropology, psychology, political science and organization theory, etc. The growing emphasis on the development of a knowledge-based economy makes the creation and development of appropriate attitudes a key problem from the point of view of future entrepreneurs, academic circles and the business world.

The aim of the research is to analyse selected attitudes related to entrepreneurship and to present their significance assessment according to students of economics. The empirical basis is constructed upon the results of research conducted in March 2021 on a group of 270 students of Poznań University of Economics. The research had the form of a diagnostic survey using the CAWI (Computer-Assisted Web Interview) method. The results were analysed using descriptive statistics and factor analysis.

Due to the fact that there are many definitions of the entrepreneurial attitude and they are interpreted in different ways, and this issue is analysed in the light of different scientific disciplines, the theoretical part of the study outlines its essence from the perspective of the conducted research. In the empirical part, the most important results from the point of view of the aim of this publication are presented.

4.1. The essence of academic entrepreneurship—theoretical approach

A detailed discussion of the theoretical underpinnings of the entrepreneurial attitudes is provided in the chapter titled "Advancements in conceptualisation and studies on Academic Entrepreneurship phenomenon". However, it should be emphasized that from the point of view of the empirical research presented in this chapter, some clarification of the theoretical background was necessary.

Entrepreneurship is a commonly used term; however, it is difficult to identify a single definition in the literature that captures its essence fully. Moreover, one can feel that it should be seen as a multidimensional concept that plays an important role in the socio-economic processes (Czyżewska & Kozioł, 2020, p. 47). According to Drucker (1992, p. 8), the science of entrepreneurship is a means to an end, and the object of this science is mainly determined by the purpose by which such activities are carried out, i.e. by practice.

Entrepreneurship can be considered from different perspectives, such as economic phenomenon or social phenomenon, but also in the context of business activities (Glinka & Gudkova, 2011). On the other hand, the definitions of entrepreneurship themselves centre around four of its dimensions (Wach, 2015, pp. 26–28):

1) market—as a search for the effects of entrepreneurship, where it is reduced to a function of the micro, small and medium enterprise sector;
2) personality—research focuses on the characteristics of human action, and most often concerns the entrepreneur or, less often, the team of employees;
3) managerial actions—the research focuses on the analysis of the entrepreneurial process;
4) individual entrepreneur—where the role of the entrepreneur is analysed.

Due to the subject matter of this chapter, the authors focused on entrepreneurship considered in the context of personality. Entrepreneurship (as a personality element) as discerned within the management sciences is an important conceptual category related to the sub-discipline of management of human resources (human capital) (Matejun, 2016, p. 132).

An analysis of the concept of entrepreneurship should begin with a rather narrow definition presented by Rachwał (2004). This author perceives entrepreneurship as a set of human personality traits, such as creativity, enthusiasm for work, divided attention, initiative, self-discipline, self-confidence and a tendency to take risks.

In contrast, a broader definition is presented by Bojewska (2002), according to which entrepreneurship includes knowledge, skills and attitudes necessary for the effectiveness and efficiency of these activities that are related to the undertaking and implementation of projects that enable the achievement of specific values in conditions of uncertainty and risk.

An interesting approach was presented by Noworol (2006, p. 41), who assumed that entrepreneurship is the human activity of creating economic well-being through the creation of additional values, including jobs, based on the risk of capital, time and personnel, on the basis of own commitment and energy to achieve self-interest, contributing to the construction of wealth of the whole society.

Worth mentioning, the European Union sees entrepreneurship as a key competence within the European education system (European Union, 2006). According to the "Entrepreneurship Roadmap 2020: Fostering Entrepreneurial Mindsets in Europe", entrepreneurship is considered a competence that can be learned and should be promoted at all levels of education. Consequently, the European Union—for the purposes of its education policy—defines entrepreneurial competence as the ability of an individual to turn ideas into action (European Union, 2007). This competence includes creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives.

Entrepreneurship should also be explored in the course of academic studies, in particular in the field of economics or management. The appropriate development of career choice represents an attempt by pupils/students to take the initiative to participate in social competition (Misiak-Kwit & Zhang, 2022, p. 119). Starting

a business can be a good alternative for young people facing employment pressures, but also an expression of their creativity, which can be a key factor in creating the right entrepreneurial mindset (Hirschmann, Hartley, & Roth, 2020, p. 116). Shaping an entrepreneurial mindset is supposed to help young people who benefit from entrepreneurial learning to develop their business knowledge and basic skills and attitudes (including creativity, initiative, perseverance, teamwork, understanding of risk, and sense of responsibility), and on the other hand, it supports putting ideas into action and notably improves employment opportunities (Urbaniec, 2016, p. 77). Therefore, creating students' awareness of different types and forms of behaviour considered entrepreneurial together with the development of soft skills such as e.g. leadership, risk taking and risk tolerance or teamwork management should be the goal of the academic entrepreneurial attitude that young people acquire during their studies (Jando, 2018, pp. 195–197).

Continuing the educational theme, it should be emphasized that entrepreneurship significantly exceeds the space of decisions and actions related to the professional functioning of the individual. According to Liao, Liu and Li (2022, p. 3), strictly academic entrepreneurship is an innovative combination of two elements: resources and risk. Shane (2003) adds that this is related to the fact that:

- project results are not guaranteed (risk element),
- organisational effort is required as a new way of exploiting opportunities is created (resource element),
- the venture must be innovative, i.e. it cannot duplicate what is already available on the market (innovative background).

As a result, entrepreneurship should be treated as a cardinal trait necessary for flexible, prolific and creative functioning in almost any sphere of human activity, regardless of the type of profession (Nowak, 2011, pp. 45–62; Nowak & Wściubiak, 2020, pp. 160–172; Strojny, 2010, p. 178). If entrepreneurship is accepted as a cardinal trait, then it should be considered a component of the canon of competencies necessary for positive transgression from education to work (Klimkowska, 2019, pp. 252–253). Therefore, one can expect its possession (or at least theoretical knowledge) by students of economic studies, i.e. young people standing on the threshold of entering the labour market or starting their own business.

4.2. Methodology of research

The aim of the research is to analyse selected attitudes related to entrepreneurship and to present their significance assessment according to students of economics. The research problem has taken the form of a research question: what combinations

of personality traits and competencies compose the profile of an entrepreneurial person from the perspective of an economics student?

The research population consisted of all students of Poznań University of Economics and Business, the research sample was selected using the method of purposive selection of typical units. The study involved 270 people and was conducted in March 2021. The main measurement instrument was a survey questionnaire and the study had the form of a diagnostic survey using the CAWI method (Computer-Assisted Web Interview). Respondents filled in questionnaires using Google Forms application. The adopted methodology was conditioned, on the one hand, by the necessity to adapt to the prevailing epidemiological conditions, and on the other hand, by the intention to achieve the intended research goal and to answer the research question.

At the research design stage, great importance was attached to the selection of an appropriate data analysis method. At this point it should be emphasized that the issue of entrepreneurship is extremely complex and multifaceted. Due to a large number of factors influencing the creation of entrepreneurial attitudes, it was necessary to apply multidimensional data analysis in the research. It was considered that the use of factor analysis as the primary research method would be the best choice, allowing the greatest degree of recognition of the scientific problems under study (Kim & Mueller, 1978, pp. 9–11; Mulaik, 2009, pp. 1–12; Stevens, 2012, pp. 271–285; Thurstone, 1931, pp. 406–427). Moreover, it is worth noting that factor analysis is the main, but not the only research method used in the process of developing the results. In addition, basic methods of descriptive statistics were also applied in the research.

4.3. Characteristics of the research sample

The empirical research involved 270 students of Poznań University of Economics and Business. At this point, it is important to emphasize the breadth of the research sample—the respondents were diverse in terms of gender, age, year, grade and mode of study. Looking at Figure 4.1, we can see that a larger group of respondents were women (63%) in relation to men (37%). The majority of the respondents were between the ages of 20–25, making up a total of 93.3%. This state of affairs is due to the structure of students of Poznań University of Economics and Business.

Analysing the structure of respondents by mode, degree and year of study (shown in Figure 4.2), it can be observed that full-time students (70% of respondents) outnumbered part-time students (30% of respondents). In the three year program, second-year students were the predominant group (87%), and in the two year program, first-year students were the predominant group (76%).

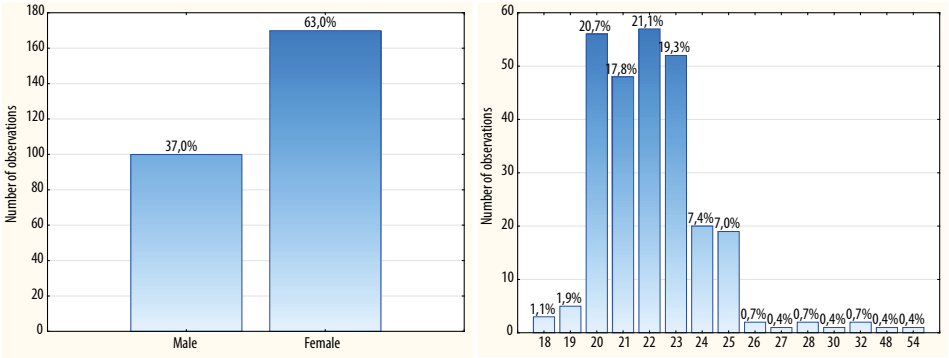

Figure 4.1. Structure of respondents by gender and age
Source: Own elaboration based on empirical results.

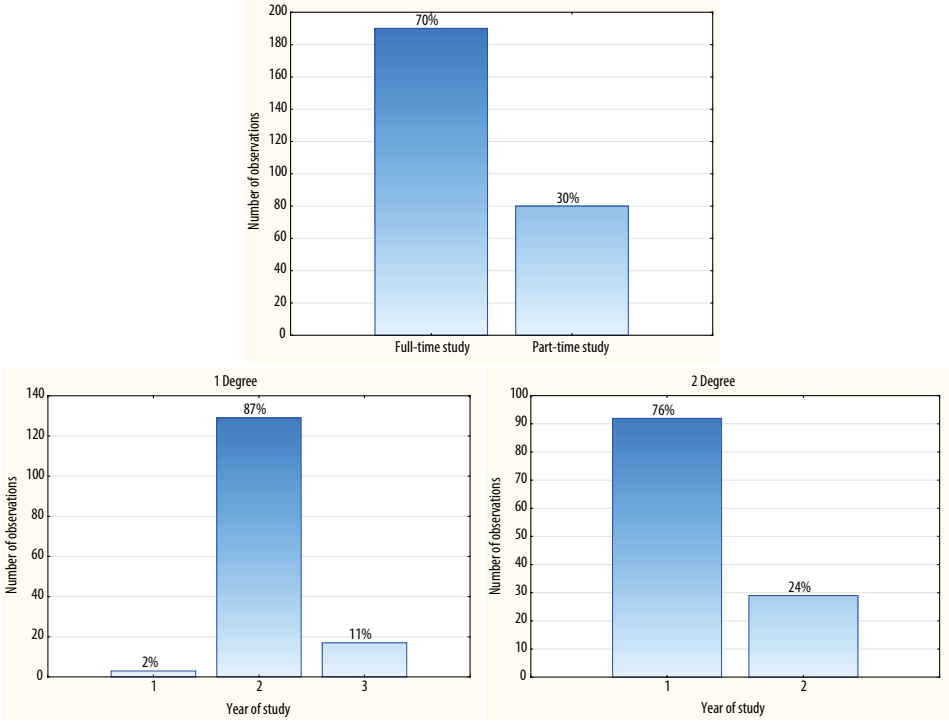

Figure 4.2. Structure of respondents by mode, degree, and year of study
Source: Own elaboration based on empirical results.

4.4. Findings

The aim of the study was to identify and analyse the key entrepreneurial attitudes in the opinion of students of Poznań University of Economics and Business. Entrepreneurial attitudes are largely related to characteristics and competencies that students may acquire during their studies. The respondents were therefore asked to assess the importance of 31 selected determinants using a five-point Likert scale (where 1 meant no importance, 5—very high importance). The studied determinants of entrepreneurship, determined on the basis of literature studies and the authors' own experience, included such factors as: creativity, ingenuity, creative thinking, ambition, ability to see opportunities in the environment, being aware of oneself and one's strengths and weaknesses, flexibility, ease of adjusting to changing conditions, taking initiative, self-confidence, courage, resistance to stress, responsibility—both for oneself and one's subordinates, ability to accept failures and draw constructive conclusions from them, ability to make conclusions, communicativeness, ability to act and make decisions in conditions of uncertainty, well-developed organizational skills, ability to think analytically, willingness for constant development and deepening of knowledge and improvement of skills, ability to set goals, ability to convince others to accept themselves and their ideas, goal orientation, willingness to take up new challenges, assertiveness, openness both to changes and to the surroundings and people, ability to work in a team, ability to manage material resources, independence, self-reliance, dynamism in action, highly developed leadership skills, willingness to take risks, attitude to achieve profit, success, optimism, willingness to compete and the spirit of rivalry. The above factors are listed in order from highest to lowest significance coefficient. Detailed data including mean score, median response and standard deviation are included in Table 4.1, while the exact distribution of responses is shown in Figure 4.3.

Table 4.1. Importance of selected characteristics and competencies, key to being an entrepreneur

Characteristics and competencies	R	M	SD
Creativity, resourcefulness, creative thinking	4,40	5,00	0,80
Ambition	4,40	5,00	0,72
Ability to see opportunities in the environment	4,35	4,00	0,78
Being aware of yourself, your strengths and weaknesses	4,34	4,00	0,73
Flexibility, ability to adapt to changing conditions	4,33	4,00	0,78
Taking initiative	4,31	4,00	0,79
Self-confidence, courage	4,31	5,00	0,82
Resistance to stress	4,30	4,00	0,85
Responsibility, both for yourself and your subordinates	4,23	4,00	0,81
Ability to accept failure and draw constructive conclusions from it	4,23	4,00	0,82
Ability to make conclusions	4,23	4,00	0,83

Table 4.1 – cont.

Characteristics and competencies	R	M	SD
Communicativeness	4,21	4,00	0,87
Ability to deal with uncertainty and make decisions	4,20	4,00	0,79
Well-developed organizational skills	4,20	4,00	0,77
Analytical thinking skills	4,17	4,00	0,85
Willingness to constantly develop, expand knowledge and improve skills	4,17	4,00	0,88
Ability to set goals for oneself	4,15	4,00	0,86
Ability to convince others to accept themselves and their ideas	4,13	4,00	0,79
Goal-oriented	4,12	4,00	0,89
Willingness to undertake new challenges	4,09	4,00	0,84
Assertiveness	4,07	4,00	0,89
Openness, both to changes and to the environment and people	4,06	4,00	0,83
Ability to work in a team	4,03	4,00	0,93
Ability to manage material resources	4,03	4,00	0,87
Independence, self-reliance	4,00	4,00	0,86
Dynamism in action	3,98	4,00	0,85
Highly developed leadership skills	3,97	4,00	0,89
Willingness to take risks	3,81	4,00	0,89
Orientation on achieving profit, success	3,80	4,00	0,96
Optimism	3,74	4,00	0,99
Willingness to compete, competitive spirit	3,38	3,00	1,09

Legend: R—significance coefficient determined as the mean of the scores, M—median of the scores, SD—standard deviation.
Source: Own elaboration based on empirical data.

An in-depth analysis of all variables in terms of their significance did not allow for an exhaustive evaluation and interpretation of those whose importance is prioritized. Many of them have similar cognitive load, moreover, they show high interdependence, which makes the presented picture unclear and chaotic. Therefore, it was justified to carry out further research, which allowed determining the general profile of the entrepreneurial attitude. It was decided to use factor analysis for this purpose. First, it was necessary to decide on the number of factors describing the phenomenon under study. To do this, a Cattell's scatter plot shown in Figure 4.4 was used, which graphically delineates the point of choice. Eigenvalues were then plotted on the graph, and the intent was to discern a point from which there is a gentle decrease in the eigenvalues. According to Cattell's idea (1966, pp. 245–276), to the right of this point a "factor dump" is formed, which contains factors that only residually explain the problem under study. After applying this criterion, 5 factors were worth being considered for further analysis.

The selection of the number of factors was verified using Kaiser's criterion (1960, pp. 141–151). Herein, the minimum eigenvalue of a factor should be greater than or equal to 1. It was noticed that each of the factors extracted using Cattell's

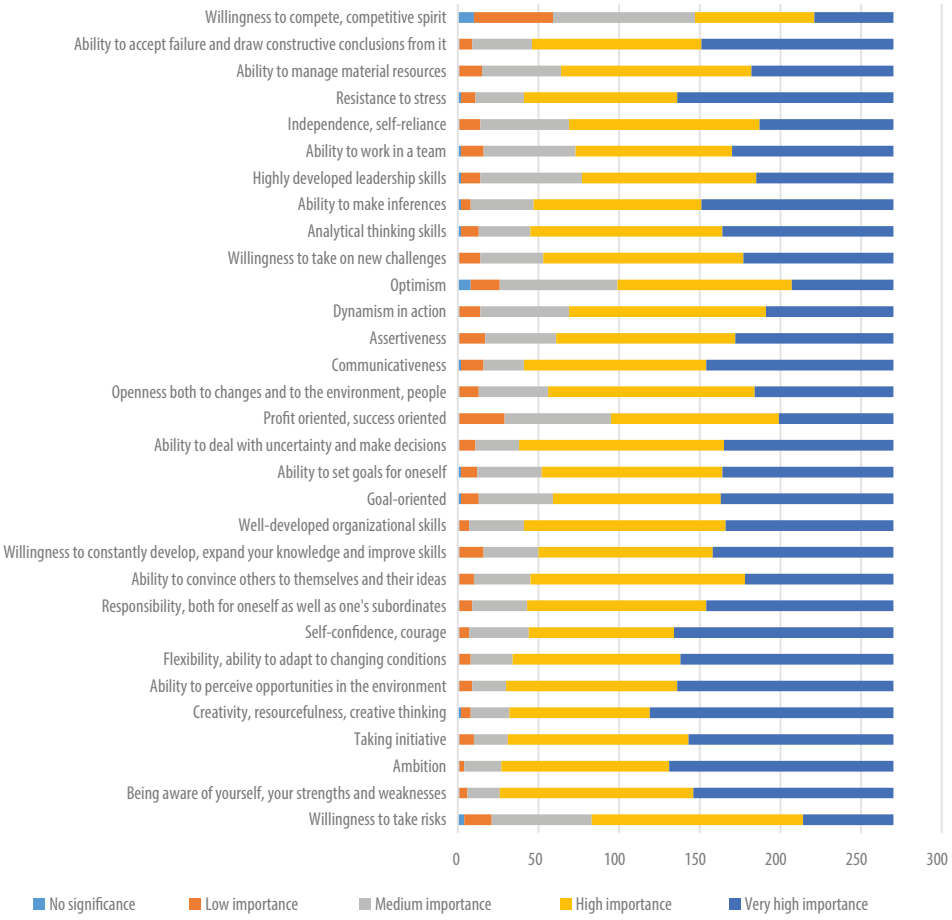

Figure 4.3. Distribution of responses concerning the evaluation of characteristics and competences, crucial for being entrepreneurial
Source: Own elaboration based on empirical data.

criterion is characterized by an eigenvalue greater than 1, which confirmed the validity of the selection. Moreover, it is worth noting that the first factor was characterized by a high eigenvalue, at the level of 13.19, and the cumulative eigenvalue of the selected factors was 18.20. Detailed data on the eigenvalues of the extracted factors for selected characteristics and competencies that are key to being entrepreneurial are presented in Table 4.2.

It is worth emphasizing that on the ground of the conducted analyses, 5 main factors were distinguished. These are presented in Table 4.3 and explain in total 59% of all variance of the examined problem. The first factor explaining 43% of all variance of the problem consisted of variables: goal orientation, ability to set

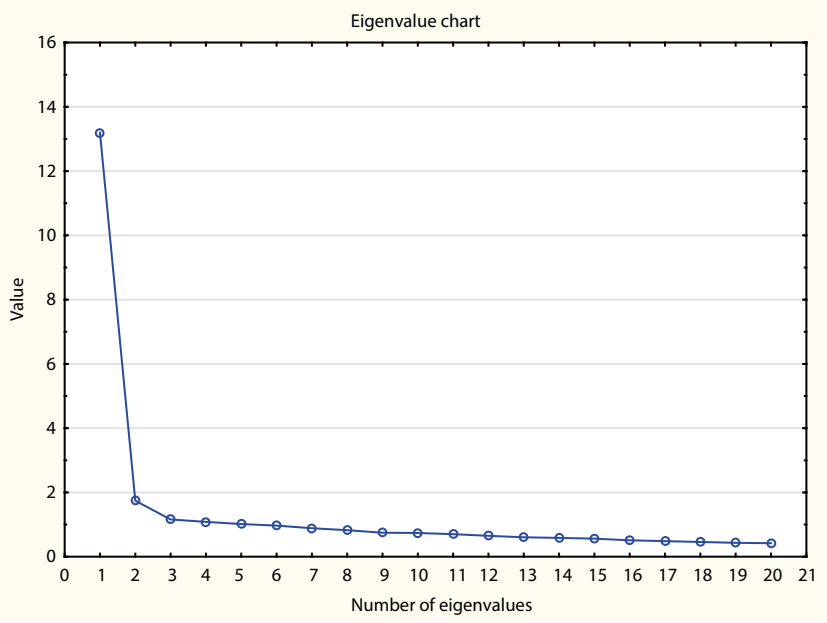

Figure 4.4. Cattell's scatter plot for selected characteristics and competencies, key to being entrepreneurial
Source: Own elaboration based on empirical data.

Table 4.2. Eigenvalues corresponding to successive factors for selected characteristics and competencies, key to being entrepreneurial

Factor	Eigenvalue	Cumulative eigenvalue
F1	13,19	13,19
F2	1,74	14,94
F3	1,16	16,09
F4	1,09	17,18
F5	1,02	18,20

Source: Own elaboration based on empirical data.

goals, communicativeness, assertiveness, dynamism in action, optimism and willingness to undertake new challenges. It can therefore be described as a *Precursor*. The second factor, which should be defined as a *Creator*, included the variables: being aware of oneself—one's strengths and weaknesses, ambition, taking initiative, creativity, ingenuity, creative thinking, ability to see opportunities in the environment, flexibility, ease of adapting to changing conditions, self-confidence and courage. It is worth noting that it explained 15% of all variance of the analysed phenomenon. The third factor identified as *Rival*, explained 16% of the variance and included such factor loads as: profit orientation, success and the desire to

Table 4.3. Factor loadings matrix after Varimax rotation for characteristics and competencies, key to being entrepreneurial

Motives	Factor 1 Precursor	Factor 2 Creator	Factor 3 Rival	Factor 4 Individualist	Factor 5 Risk-taker
Willingness to take risks	–0,10	0,20	0,54	0,36	0,13
Being aware of yourself, your strengths and weaknesses	0,13	**0,67**	0,16	0,13	0,21
Ambition	0,23	**0,67**	0,21	0,23	0,01
Taking initiative	0,17	**0,71**	0,11	0,21	0,26
Creativity, resourcefulness, creative thinking	0,04	**0,64**	–0,18	0,32	0,25
Ability to perceive opportunities in the environment	0,23	**0,62**	–0,12	0,23	0,21
Flexibility, ability to adapt to changing conditions	0,15	**0,60**	0,18	0,17	0,36
Self-confidence, courage	0,36	**0,60**	0,31	0,14	–0,09
Responsibility—both for oneself and one's subordinates	0,28	0,53	0,18	0,17	0,35
Ability to convince others to accept themselves and their ideas	0,32	0,44	0,25	0,28	0,08
Willingness to constantly develop, expand knowledge and improve skills	0,38	0,37	0,16	0,11	0,51
Well-developed organizational skills	0,45	0,39	0,08	0,12	0,50
Goal-oriented	**0,62**	0,11	0,08	0,15	0,39
Ability to set goals for oneself	**0,59**	0,24	0,07	0,23	0,44
Ability to deal with uncertainty and make decisions	0,23	0,31	0,35	0,20	**0,57**
Profit oriented, success oriented	0,31	0,14	**0,62**	0,02	0,33
Openness both to changes and to the environment and people	0,53	0,33	0,42	0,17	0,20
Communicativeness	**0,66**	0,29	0,11	0,19	0,17
Assertiveness	**0,61**	0,21	0,16	0,31	0,14
Dynamism in action	**0,60**	0,20	0,29	0,23	0,19
Optimism	**0,76**	0,07	0,10	0,16	0,11
Willingness to take on new challenges	**0,59**	0,29	0,19	0,36	0,09
Analytical thinking skills	0,27	0,23	–0,03	0,53	0,44
Ability to make inferences	0,37	0,30	–0,04	0,57	0,36
Highly developed leadership skills	0,15	0,12	0,27	0,42	0,55
Ability to work in a team	0,26	0,23	0,22	0,20	0,55
Independence, self-reliance	0,28	0,23	0,14	**0,61**	0,03
Resistance to stress	0,20	0,30	0,24	**0,62**	0,09
Ability to manage material resources	0,33	0,20	0,19	**0,62**	0,19
Ability to accept failure and draw constructive conclusions from it	0,25	0,32	0,23	0,54	0,27

Table 4.3 – cont.

Motives	Factor 1 Precursor	Factor 2 Creator	Factor 3 Rival	Factor 4 Individualist	Factor 5 Risk-taker
Willingness to compete, competitive spirit	0,35	0,03	**0,63**	0,19	0,11
Percentage share of explanation of variance	4,84	4,75	2,22	3,38	3,00
Cumulative percentage of explanation of variance	0,16	0,15	0,07	0,11	0,10

Legend: Charges of ≥ 0.57 are indicated.
Source: Own elaboration based on empirical data.

compete, competitive spirit. The next factor explaining 17% of the variance contained variables such as independence, self-reliance, and resistance to stress and therefore can be defined as *Individualist*. The last factor studied was defined as the *Risk-taker*. It explained 18% of the variance and contained one primary variable, which was the ability to deal and make decisions under uncertainty.

Conclusions

Creating entrepreneurial attitudes is an important aspect of educating students nowadays. In order to adjust the educational offer to the needs of the recipients and market requirements, it is necessary to develop young people taking into account pro-entrepreneurial features and skills. In this context, it was important to conduct research aimed at a detailed analysis of selected determinants of entrepreneurship particularly important from the student's point of view.

The results of the empirical research made it possible to answer the research question posed: what combinations of personality traits and competencies compose the profile of an entrepreneurial person from the perspective of an economics student? The research shows that, in the eyes of students, the profile of an entrepreneurial attitude is complex and multifaceted, and consists of such combinations of personality types as:

- precursor,
- creator,
- rival,
- individualist,
- risk-taker.

This means that nowadays an entrepreneurial person should be able to set and dynamically realise goals, both perceive and undertake new, often risky challenges, communicate well with people, be creative and flexible. Also extremely important

is self-confidence and courage combined with optimism allowing for the implementation of difficult tasks. Also important is the ability to act independently and resistance to frequent stressful situations. An attitude of competition and success is also crucial. Identifying and effectively developing the above attitudes should make it easier for future students to be successful in setting up and running a business.

Therefore, in case of continuing research in this area, it would be advisable to focus in particular on the question to what degree the above personality profiles prove themselves in business conditions, as well as to what extent, within the framework of study programmes, universities enable students to develop specific entrepreneurial attitudes.

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5. THE IMPACT OF THE COVID-19 PANDEMIC ON THE PROSPECT OF STARTING OWN BUSINESS AMONG STUDENTS OF ECONOMIC STUDIES

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Abstract

The research objective was to present the significance of the coronavirus pandemic in the context of starting a business, by business students. The empirical basis was fabricated upon the results of a survey conducted at the Poznań University of Economics and Business. The research was dynamic and conducted in two stages: in February 2020 (just before the first lockdown in Poland) wherein 243 students were surveyed and in March 2021 (a year after the first lockdown), in which 270 students were surveyed. The respondents were asked, among other issues, to describe their professional experience, as well as perspectives and plans concerning setting up and managing their own company. In addition, factor analysis was used to deepen the findings. The pandemic has significantly influenced students' professional plans, including, above all, an increased desire to start their own business. In addition, of particular importance for students at the beginning of their professional career is the flexibility and ease of adaptation to changing conditions in the business environment. The research was limited because it was based only on students of Poznań University of Economics and Business. Extending the research to other social groups such as students of other universities, the unemployed, graduates of technical / vocational schools, economically active people, elderly people, etc. would allow to explore the reasons and conditions for setting up a business. The article shows how students' perspectives and attitudes towards setting up their own businesses have changed. The results of the research may be of particular interest to entities such as public administration, local governments, labour offices and all institutions which are focused on education and career shaping.

Keywords: academic entrepreneurship, self-employment, the COVID-19 pandemic, economic activity.

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Introduction

Entrepreneurship in management terms is defined as a way of acting that involves taking up new, unconventional and risky ventures, while showing commitment in putting them into practice. In Poland, entrepreneurship or entrepreneurial attitudes are mainly associated with the desire to establish and run a business. However, it should be emphasized that this is a highly simplified concept (Borowiec, 2011, p. 40).

Academic entrepreneurship can also be seen in this context, which is not only identified with activity in the sphere of practical support for new companies created on the basis of know-how (Matusiak & Matusiak, 2007, p. 158), but also the involvement of various units (academic institutions, academics, doctoral students and students) in the establishment, development and management of economic activity that does not have to be based on intellectual property (Bąkowski, Zasiadły, & Guliński, 2005, p. 10). The increased importance of academic entrepreneurship stems from the fact that it contributes, among other things, to increased competitiveness, not only for the national economy, but also for the European and global economy (Poznańska, 2014, p. 164). However, the current rapidly spreading SARS-CoV-2 virus and the mutations created from it, as well as the multiple economic exacerbations accompanying this pandemic, have caused different reactions related to start-up planning, especially in the context of young, college-age individuals.

The main objective of the chapter is to present the results of research related to the impact of the coronavirus pandemic on the perspective of setting up their own business by students of economics at Poznań University of Economics and Business. The authors focused on the most important determinants associated with planning to open their own business. The research had the form of a diagnostic survey using the CAWI (Computer-Assisted Web Interview) method. The results were analysed using descriptive statistics and factor analysis.

The theoretical part focuses on explaining the concept of academic entrepreneurship from the perspective of the conducted research. The empirical part, on the other hand, presents the results of the study on the impact of pandemic on students' career prospects.

5.1. The essence of academic entrepreneurship

The term "academic entrepreneurship" was created in the American system of organizing scientific research (Budyldina, 2018; Meoli & Vismara, 2016). University teachers working in American universities behave like typical entrepreneurs, as they are not only involved in academic research, but also actively participate in

entrepreneurial activities. In essence, academic entrepreneurship manifests itself in the fact that an academic will set up a company in order to commercialise the results of their research, and the aspect of "academia" stems from the fact that innovations are the result of the research and work of the academic (Micozzi, 2020).

Academic entrepreneurship is discussed in detail in the chapter "Advancements in conceptualisation and studies on academic entrepreneurship phenomenon". However, as rightly noted, the concept is complex and variously interpreted. In the context of the conducted research, it is necessary to focus on a selected specific approach to the term in question, and this requires clarification and detailing of the theoretical basis for consideration.

In recent years, the term "academic entrepreneurship" is gaining more and more importance and is used both in the context of research and theoretical analysis, as well as in practical forms. The following sources can be distinguished to explain this increased interest in the scientific community (Kumański, 2016, p. 89; K. Matusiak, 2009, p. 30; Matusiak & Matusiak, 2007, p. 156; Nowak, 2011, pp. 45–62; Nowak & Wściubiak, 2020, pp. 160–172; Poznańska, 2014, p. 165):

- the need to make the educational offer addressed to students more attractive, where the emphasis is placed on the practical use of the acquired knowledge in their own companies,
- increased importance of knowledge as a factor of economic development,
- possibility of financing research from public and private institutions,
- increasing the prestige of universities,
- the need for universities and scientific institutions to look for new forms of additional income (by creating channels of communication and cooperation with business),
- the significant influence of the development of academic entrepreneurship on the process of building competitiveness and innovation of enterprises,
- possibility of commercialization of new ideas and transfer of ideas "from science to practice",
- growing market requirements creating barriers for ambitious university graduates that are difficult to overcome, hence self-employment becomes a relatively simple solution to this problem,
- shortening the time of the innovation process—"from idea to market application", which enforces the necessity of spatial alignment of scientific institutions or universities with entrepreneurs.

However, defining the notion of academic entrepreneurship is not easy and may be interpreted differently. It is worth noting, however, that initially this concept was limited to the creation of technological companies of spin-off and spin-out type by academic staff (this concerned mainly Anglo-Saxon countries) (Piech, 2010, p. 37). Currently, the term is understood much more broadly, as it covers all professional

activity of the university (including that of employees and students). According to Matusiak (2006, pp. 110–111), academic entrepreneurship is a programmed, Schumpeterian "creative destruction", and its implementation requires a "specific matrix" constructed of 3 elements:

- science, research and education sector (provides the results of scientific and research work, generates a qualified workforce and enables flexible possibilities of professional development, has potential entrepreneurs among students and academics);
- support systems (includes both programs and institutions supporting technology transfer and development of initial phases of company development);
- local innovation and entrepreneurship environment (composed of small and medium-sized enterprises, specialized business services, risk financing institutions and potential cooperators and buyers).

Through interdependence and permeation, the above-mentioned elements generate conditions for the development of modern business in the post-industrial economy. As a result, the following are created: innovative companies, revolutionary ideas and solutions and new products, services or technologies. Such networking of infrastructure and institutions has a strong environmental character, thanks to which clusters or technology parks are created (Matusiak & Matusiak, 2007, p. 161) (see Figure 5.1).

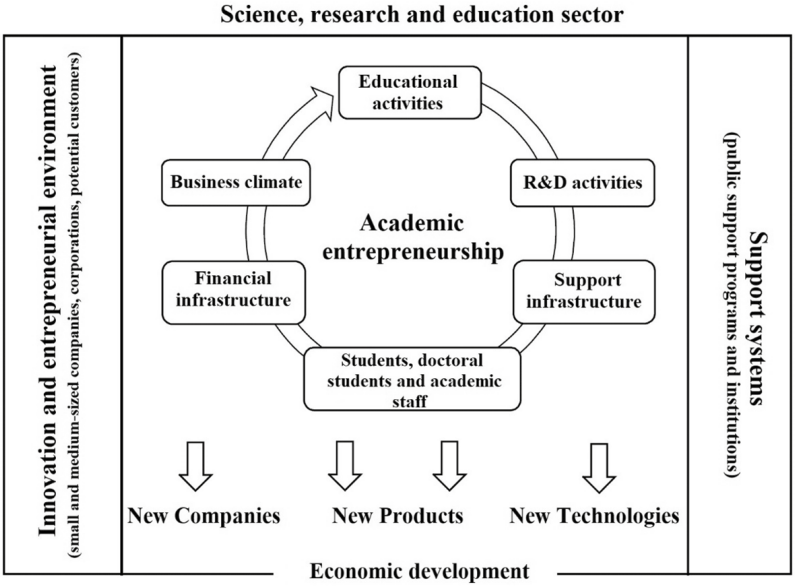

Figure 5.1. Academic entrepreneurship resources
Source: Based on (Matusiak, 2006, p. 111).

Academic entrepreneurship is an extremely complex phenomenon, as it concerns activities not only of an individual nature, but also activities within the whole organization (Klonowska-Matynia & Palinkiewicz, 2013, p. 34). Moreover, it is often treated as a specific type of entrepreneurship focusing on the creative attitude of the scientific community and the implementation of its effects in economic practice (Poznańska, 2014, p. 166).

The concept of academic entrepreneurship in Poland in the area of scientific community is so capacious and generally defined that sometimes there are problems with its interpretation and understanding (Stawasz, 2007, pp. 265–266). There should, therefore, be a holistic and comprehensive approach to the issue of academic entrepreneurship that would take into account its various manifestations (Komarnicka, 2020, p. 25).

Continuing to think in this direction, it can be concluded that academic entrepreneurship also means encouraging the creation of companies by all persons in any degree connected with the university, especially students. A similar view is taken by Szara and Pierścieniak (2011, p. 35), who see academic entrepreneurship as not only a form of combating graduate unemployment, but also a way of adapting to contemporary development trends.

Also, according to Prochorowicz (2009, pp. 65–66), academic entrepreneurship has become a fashionable concept in recent years, where it should be understood, among other notions, as supporting individual student ventures. Thus, it should be seen as a kind of incentive addressed directly by the academic community to students to take the risk of running a business.

The issue of academic entrepreneurship is not only the subject of theoretical considerations. Interesting research on this topic was conducted by Misiak-Kwit and Zhang (2022, pp. 122, 129), where a pilot study was conducted on young people's attitudes towards starting their own business. Polish and Chinese students were analysed. The choice of Poland and China resulted from several similarities, for example: similar political and economic systems before the economic transformation, similar Human Development Index (HDI). The results clearly indicate that in both countries there should be a particular focus on entrepreneurial competences. According to young people (both Polish and Chinese students), an entrepreneurial person should be characterised by readiness to take responsibility, diligence, enthusiasm, conscientiousness and resourcefulness. However, the authors underline that due to the size of the sample, the research results cannot be generalised.

Taking into account the above considerations, the next section of the paper focuses on the presentation of research results covering the aspect of setting up own business by students.

5.2. Methodology of research

The aim of the research was to present the significance of the coronavirus pandemic in the context of setting up a business by students of economics. The research problem has taken the form of a research question: how has the coronavirus pandemic affected students' career plans?

The research population consisted of all students of Poznań University of Economics and Business, the research sample was selected using the method of purposive selection of typical units. The research was dynamic and conducted in two stages: in February 2020 (just before the introduction of the first lockdown in Poland) where 239 students were surveyed stationary and in March 2021 (a year after the introduction of the first lockdown) in which 270 students were surveyed using using the CAWI method (Computer-Assisted Web Interview). It is also worth mentioning that the selection of respondents (students of economic studies) was based on the fact that they should have knowledge and experience in the functioning of the market and the enterprise.

The research was conducted using a survey questionnaire that included questions about students' plans in terms of future careers and prospects for starting their own business. The processing of empirical data was controlled. The collected empirical material was verified, reduced and then processed into an alphanumeric form using specialized software. For this purpose, the statistical package Statsoft Statistica 12 and auxiliary spreadsheet Microsoft Excel were used. Descriptive statistics methods and factor analysis were used in the data analysis.

5.3. Characteristics of the research sample

Finally, the survey covered 509 students of Poznań University of Economics and Business. It is worth noting that the respondents were diverse in terms of gender, age, year, degree and mode of study. Looking at Figure 5.1, it can be seen that the majority of respondents were women (64.24%), while men made up 35.76% of the sample. The respondents were predominantly between the ages of 20–25 constituting a total of 93.3% of the respondents. This state of affairs is due to the structure of students of Poznań University of Economics and Business. Detailed data taking into account the time of the survey are presented in Figure 5.2.

Upon analysing the structure (shown in Figure 5.3) of the respondents by mode and degree of study, it can be observed that among the respondents both before and during the pandemic, full-time students (28.5% and 37.5%, respectively) predominated over part-time students (18.5% and 15.7%, respectively). However, it is worth noting that the predominant group of respondents before the pandemic

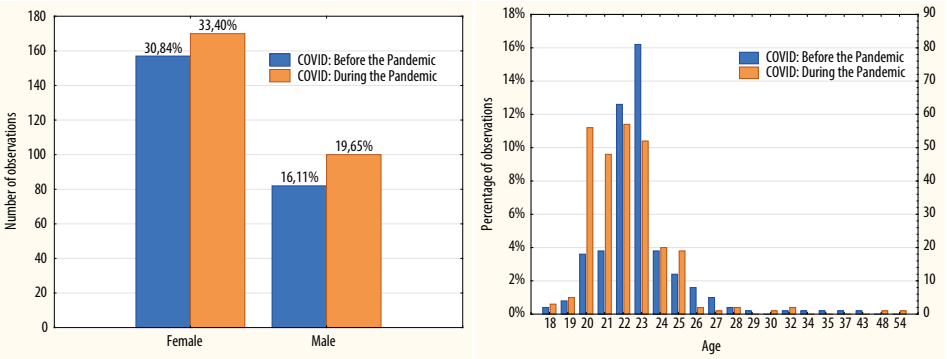

Figure 5.2. Structure of respondents by gender and age
Source: Own elaboration based on empirical results.

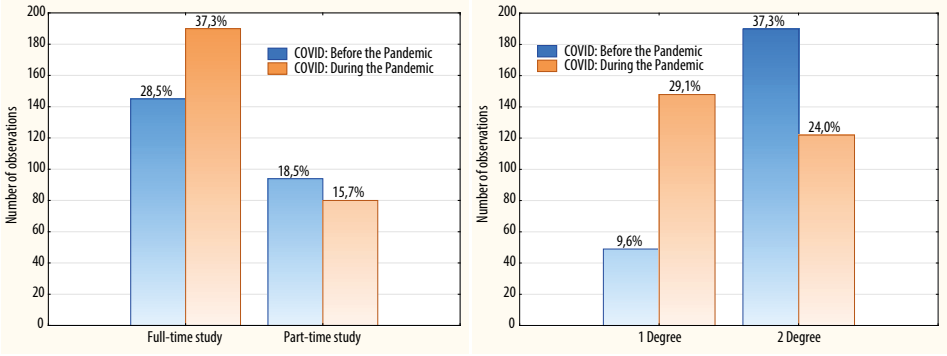

Figure 5.3. Structure of respondents by mode and degree of study
Source: own elaboration based on empirical results.

were second degree students (37.3%), while during the pandemic, these were first degree students (29.1%).

When examining the current occupational situation of the respondents, it should be noted that both before and during the pandemic, the respondents were economically active (36.9% and 35.2%, respectively). However, one can see a significant increase in the proportion of non-workers (by as much as 79%) due to the pandemic. The forms of employment based on a contract of mandate or a contract of employment were clearly dominant. In this case, no large differences were observed between the survey stages. Detailed data with the distribution of responses are shown in Figure 5.4.

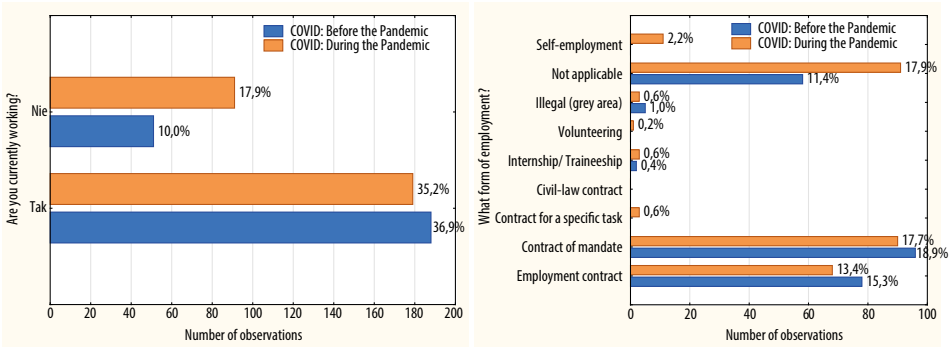

Figure 5.4. Respondents' current work situation
Source: Own elaboration based on empirical results.

5.4. Findings

During their studies, young people often encounter the job market for the first time, where there are many offers aimed specifically at students. Some industries and professions are almost entirely based on the employment of students. The Polish labour market offers many opportunities for young people, and finding a job, even a casual one, is not particularly difficult in large academic centres. At the same time, purely economic emigration is widely present in Polish society, which, in the case of students, is mainly limited to short trips during the summer holidays (up to 4 months), so that the money earned can be used for living during the academic year. We can also observe an increased interest in running a business, which manifests itself, for example, in the growing popularity of business incubators. This shows that students want to be active and develop in this direction, and undoubtedly they are a significant group with a huge economic and entrepreneurial potential (NZS, 2017, pp. 4–5). In recent years, students' behaviour and plans have also been strongly influenced by the pandemic situation, which has caused huge changes not only in local labour markets, but also in the global market.

Based on the above reflections, the purpose of the study was defined as presenting the significance of the coronavirus pandemic in the context of starting a business, by business students. At each stage of the research (before and during the pandemic), respondents were asked to answer a series of questions about their situation and work experience, as well as their plans for starting a business. This allowed conclusions to be drawn about the impact of the pandemic on young people's business prospects.

First, respondents were asked to identify how they envision their professional future. It can be observed that before the pandemic, the predominant desire was to work in private enterprise (24.4%). Own business was desired by 16.1% of the

respondents. Other career plans or lack thereof were marked by only less than 7% of the respondents. An interesting situation occurred during the second stage of the research, where the number of people planning to work in a private enterprise significantly decreased (by about 8 percentage points). The largest increase was noted among those planning to start their own business (by about 8 percentage points), but also increased the percentage of responses in other groups, i.e. among people planning to work in a public company, family business, abroad, as well as without any professional plans.

The desire to look for a more stable job, in the public sector or a family business, is understandable. Of particular interest, however, is the shift in optics from working for a private company, to running one's own business. Despite the fact that in theory those who run their own business bear the greatest risk, the pandemic situation has shown that private enterprises, flexibly adapting to changing economic conditions, as well as lack of demand and imposed legal restrictions, look primarily for opportunities to reduce operating costs, including personnel costs. Students noted that when running their own business, they often have more security than when working in a private enterprise—they have the opportunity to benefit from assistance of various nature. In addition, the pandemic has caused major changes in global markets, resulting, on the one hand, in the collapse of many companies or a change in their operating strategies, but, on the other hand, in the emergence of new gaps and lucrative sectors where there is a high demand for specialized products or services. Details of the respondents' career plans are shown in Figure 5.5.

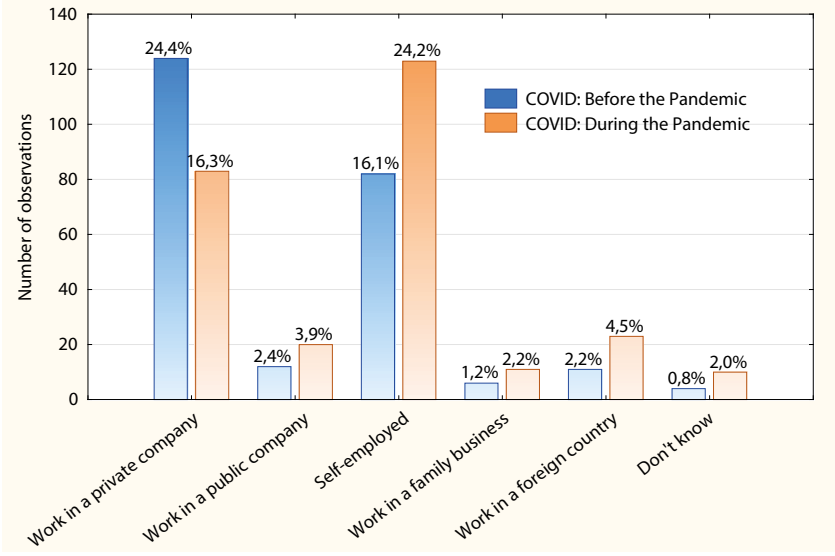

Figure 5.5. Distribution of responses regarding respondents' career plans
Source: Own elaboration based on empirical results.

Respondents were then asked to identify the profile of activities related to their future professional work. Both before and during the pandemic, services clearly dominated (28.9% and 27.5%, respectively). It is worth noting, however, that the pandemic resulted in a significant increase in the share of trade (by less than 7 percentage points), while the share of services and manufacturing decreased (by 1.4 and 1.1 percentage points, respectively). This probably has to do with the high flexibility of this type of activity, the relative ease of changing the sector of activity, and the fact that trade was relatively little affected by the regulatory tightening. Detailed data, including the structure of responses, are shown in Figure 5.6.

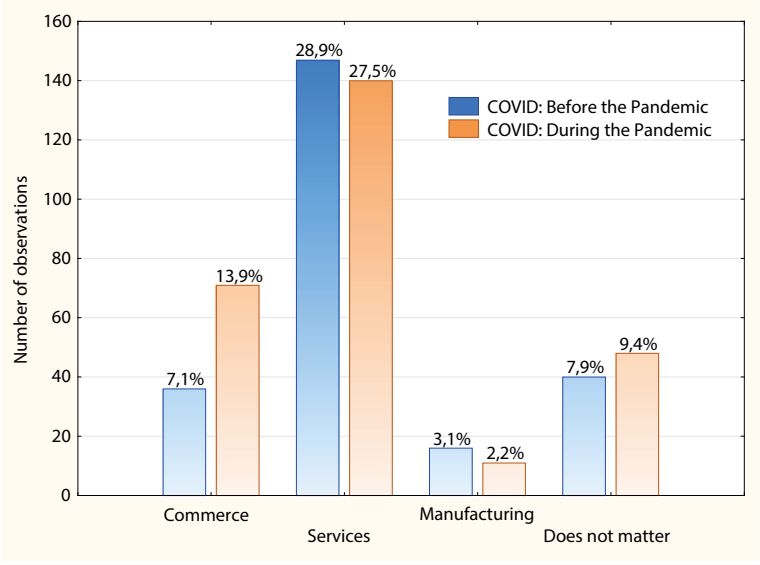

Figure 5.6. Distribution of responses regarding planned work-related activity profile

Source: Own elaboration based on empirical results.

The respondents were then given the opportunity to respond to a question about their plans for starting their own business. At this point it is also worth mentioning that out of more than 500 people participating in the survey, 30 already have experience in running a business. Both before and during the pandemic, responses indicating a desire to start their own business (definitely yes and rather yes) predominated. The pandemic significantly increased the proportion of "definitely yes" responses by 62% and "rather yes" by 23%, which is consistent with the results of previous questions. Detailed data are shown in Figure 5.7.

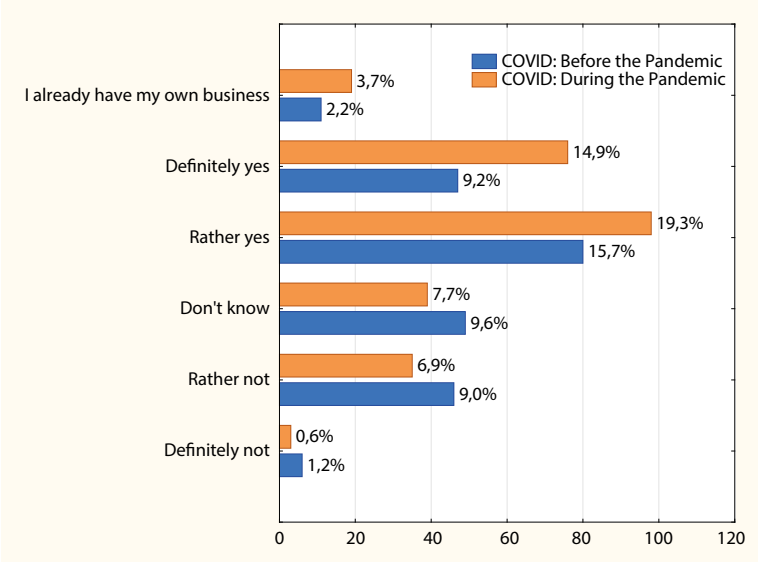

Figure 5.7. Distribution of responses regarding desire to start your own business

Source: Own elaboration based on empirical results.

The next question was designed to elaborate on the conclusions of the previous question—respondents could specify within what time frame they planned to start a business (if any). Both before and during the pandemic, the predominant intention was to open a business in more than two years, which was mainly due to the desire to complete the study first and acquire the necessary knowledge and experience. The differences in the shares of individual responses in this case were not due to the pandemic situation, but rather to the age of the respondents and the year and degree of study. Detailed data are shown in Figure 5.8.

Finally, respondents were asked to identify whether they already had an idea for their own business. Both before and during the pandemic, affirmative answers dominated (among those planning to start their own business). It is particularly interesting to note that in the surveys conducted during the pandemic, the percentage of "definitely yes" answers was 63% higher and "rather yes" 49% higher compared to the pre-pandemic stage. At the same time, it should be emphasized that the second stage of the research was dominated by younger people, in the earlier years of study, which only confirms that students take their future business seriously and its plans are well thought out. Detailed data on the structure of responses are shown in Figure 5.9.

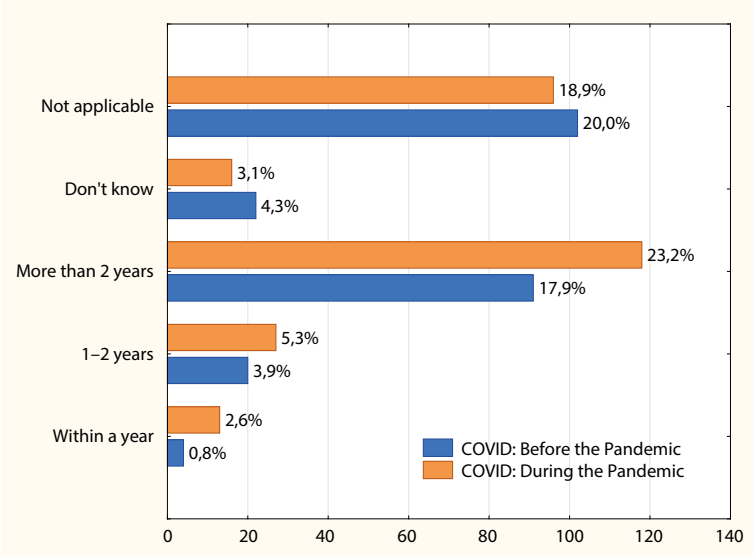

Figure 5.8. Distribution of responses regarding when to possibly start your own business

Source: Own elaboration based on empirical results.

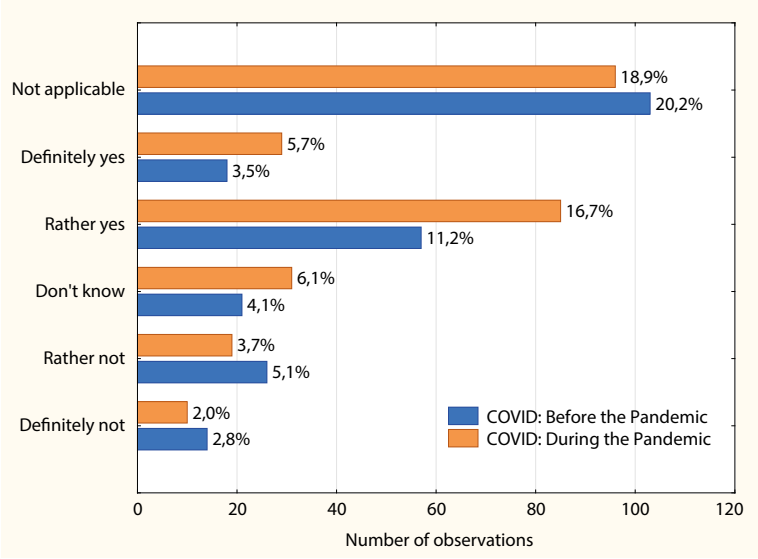

Figure 5.9. Distribution of responses regarding having an idea for a business

Source: Own elaboration based on empirical results.

As the research has shown, interest in setting up one's own business has increased over the years studied. Therefore, the research was deepened, where students were asked about the motives that lead them to set up their own business.

To this end, 14 factors encouraging self-employment were identified. Based on the analysis of literature and own experience, the following variables were identified:

- possibility of high earnings,
- good business idea,
- sense of independence,
- lack of other alternatives,
- social prestige,
- possibility of self-employment,
- possibility of obtaining financial support,
- flexible working hours,
- self-employment,
- the opportunity to realise your own goals and dreams,
- job security,
- results dependent on your efforts,
- freedom to choose your working conditions,
- no monotony of work.

The basic statistical analysis of all variables in terms of their significance did not allow a clear and exhaustive evaluation and interpretation. Many of the variables had a similar cognitive load and showed significant correlation. As a result, the resulting picture of the phenomenon was unclear and chaotic. It was therefore necessary to deepen the analysis. For this purpose, a factor analysis was used, the results of which are presented in Table 5.1.

Factor analysis made it possible to isolate 5 main factors explaining almost 55% of the variance of the studied problem. The first mega-factor, explaining less than 17% of the variance of the problem consisted of one variable, i.e. the possibility of obtaining funding. So it is related to external support and so it was also named. For the second factor three variables were assigned: self-employment the possibility of realizing your own goals and dreams and the effects depending on your work effort. The combination of these variables relates the direct translation of the time and effort involved to the results obtained, therefore it was called effort = results and explained more than 12% of the analyzed phenomenon. The third mega-factor was called financial independence, as it contained two variables (possibility of high earnings and sense of independence) and the degree of explained variance was more than 10%. Within the fourth mega-factor, which should be called business idea, only one variable was identified which explained

Table 5.1. Factor loadings matrix after Varimax rotation for motives to start a business

Motives	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
	External support	Effort = Effect	Financial independence	Business idea	Prestige
Possibility of high earnings	0,07	0,01	**0,73**	–0,07	–0,02
Good business idea	–0,01	0,01	0,07	**0,89**	0,03
Sense of independence	–0,04	0,05	**0,69**	0,26	0,05
Lack of other alternatives	0,52	–0,17	0,30	–0,02	0,37
Social prestige	0,30	–0,17	0,12	0,09	**0,68**
Possibility of self-employment	0,27	–0,01	–0,10	–0,09	0,63
Possibility of obtaining financial support	**0,68**	0,18	0,12	–0,19	0,02
Flexible working hours	0,58	0,18	–0,20	0,30	0,11
Self-employment	0,12	**0,76**	0,00	0,00	0,01
The opportunity to realise your own goals and dreams	0,18	**0,67**	–0,03	0,29	–0,12
Job security	0,46	0,28	–0,19	0,09	0,15
Results dependent on your efforts	–0,05	**0,67**	0,09	–0,20	0,08
Freedom to choose your working conditions	–0,22	0,35	0,31	–0,11	0,56
No monotony of work	–0,14	0,10	–0,26	0,19	0,60
Percentage share of explanation of variance	1,57	1,81	1,40	1,19	1,73
Cumulative percentage of explanation of variance	0,11	0,13	0,10	0,08	0,12
Eigenvalues	2,34	1,69	1,40	1,16	1,11

Legend: Charges of ≥ 0.65 are indicated.
Source: Own elaboration based on empirical data.

about 8%. Also, the last main factor accounted for less than 8% of the variance and was identified as prestige.

Conclusions

Student entrepreneurship is an important aspect as considered from academic, teaching and business perspectives. During their studies, young people gain their first work experience and form their skills and competencies for running their own business. However, it is worth noting that the coronavirus pandemic has significantly affected both the labour market and business prospects. In this context, it was important to conduct a study that answered the question of how the coronavirus pandemic affected students' career plans and whose purpose was to present

the importance of the coronavirus pandemic in the context of business start-ups among business students.

A number of interesting conclusions can be drawn from the research. First of all, the pandemic has significantly affected students' career plans. Although the desire to stabilize employment through employment in the public sector can be seen, above all, a significant increase in interest in starting their own business can be observed, while interest in working in the private sector has decreased. The pandemic has also affected the preferred profile of future professional activity—students think above all about flexibility and ease of adaptation to changing conditions in the environment. It can also be noted that plans to start a business have become more concrete. There has been a clear increase in the percentage of those who have an idea for their business. It is noteworthy that among the main motives that induce students to start a business were: external support, effort = effect, financial independence, business idea, prestige. This shows the high ambitions of young people, who see in their own business the possibility of becoming independent and achieving results proportional to the resources involved. Moreover, widely available external sources of financing help in taking the decision to start a business. Not without significance is also the social position, which is connected with running a business.

Therefore, if research in this area is to be continued, it would be appropriate to focus primarily on the question of what factors most influence young people's willingness to start businesses and how entrepreneurial attitudes can be shaped among students.

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PART III
UNIVERSITY–BUSINESS RELATIONS AND DATA SCIENTIST ANALYSIS

6. UTILISING SCIENCE–BUSINESS RELATIONS IN DISSERTATIONS DEVELOPED AT UNIVERSITIES

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Abstract

This article presents theoretical background based on research results that is related to the issue of creating applied diploma theses at universities in Poland. On the one hand, this issue is very important for improving the quality of higher education and broadly understood innovation of the economy, and on the other hand, it is still treated as a set of expectations and demands towards universities.

The aim of the paper is to identify and investigate the possibilities of increasing the applicability of dissertations developed in higher education institutions. The main research question was: "How to increase the applicability of diploma theses developed by its students?". The applicability of diploma theses developed by its students is positioned here as one of the tenets of the Third Mission (TM) in universities. The paper aims to make a contribution to the efforts aimed at explaining the engagement of universities in the TM implementation. The TM-driven approach to operating a university represents a radical (and often contested by academics) departure from their traditional 'ivory tower' stance in which teaching and research have always been treated as ends in themselves (Nakwa & Zawdie, 2016). The authors used the workshop method to achieve this aim. Workshops are becoming a popular research tool in qualitative research where researchers can gather a group of participants who under the instructions of a facilitator can discuss a specific subject. The authors participated as facilitators in a series of workshops at the University of Warsaw attended by the academic staff who were dissertations supervisors.

The study also presents suggestions and recommendations for thesis supervisors in the field of increasing the applicability of research results published in theses. The article contains the results of a survey conducted among participants of a training and consulting project carried out at the University of Warsaw. The project aimed to increase the applicability of diploma theses developed by its students.

Keywords: applicability of diploma theses, cooperation between science and business, cooperation with the socio-economic environment (OSG), commercialization of research.

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Introduction

The diploma thesis is the crowning achievement of several years of education at the university. In principle, it should be the culmination of the intellectual development of a student. In the parametric assessment of Polish universities, increasing the importance of university cooperation with the socio-economic environment challenges them with introducing elements combining academic education with business practice into the education process. The most evident way to comply with this postulate is to include issues familiarizing students with the practical aspects of the knowledge transferred at the university to the content of the curricula and taught subjects. However, there are also different complementary ways to fulfil the postulate of combining practical and theoretical knowledge in the course of academic education. One of them is promoting diploma theses that meet academic standards, as well as taking into account the postulates related to the application of scientific research results in the context of the needs of the socio-economic environment of the university.

The article aims to present the experiences and observations gathered during the implementation of a training and consulting project, which was carried out at the University of Warsaw by one of the authors. The purpose of the project was to increase the intensity of applied diploma theses. Moreover, the article contains the results of a survey carried out among project participants, who were academic teachers employed at the University of Warsaw. The survey investigated the opinions of academic teachers regarding the level of connections with industry. The study also presents suggestions and recommendations for thesis supervisors to increase the applicability of research results published in diploma theses. The suggestions and recommendations resulted from the qualitative research conducted among the project participants.

6.1. Application of research results as a challenge for the university

The idea of combining knowledge with the real world is associated with the Enlightenment Revolution that started at the end of the 17th century. The Age of Enlightenment overthrew stagnant religion and traditional authority and ended the period when religion was considered the main source of knowledge about the world. In the nineteenth century, the industrial revolution strengthened the interaction between business and science to intensify the cooperation between scientists and businesses. This alliance provided good practices regarding the application of scientific results for the benefit of economic growth and internationalisation of business (mainly by the great European powers), and continues to be strengthened with time.

The issue of cooperation between universities and business has been present for many years in the scholarly literature in the fields of innovation management, knowledge-based economy and knowledge management (Lundvall, 1992, p. 10; Dyer, Kale, & Singh, 2004, p. 115; Davey, Baaken, Galan Muros, & Meerman, 2011, p. 140). The relationship between academia and business is often referred to as "technology transfer" (Mansfield, 1991; Friedman & Silberman, 2003, pp. 17–30). Enterprises and universities are the main elements of the national innovation system (Lundvall, 1992, p. 10; Nelson, 1993, p. 56; Fazlagić, 2003). One of the differences between the organizational culture of universities and businesses is the attitude of both environments to uncertainty (Slaughter & Rhoades, 2004; Raper, 2017). Scientists, by their very nature, are accustomed to the ambiguity of the research findings and the lack of definitive conclusions and are aware that almost every theory may be undermined over time as a result of subsequent research. Meanwhile, business representatives have a much lower tolerance for ambiguity—they expect solutions and decisions based on binary data (Willis, 2013).

Despite many spectacular successes in the use of scientific achievements for the needs of the economy, there is a strong current in academic circles claiming that the separation of science from the economic sphere has many advantages for the scientific community—among others, in the form of freeing science from limits and restrictions (Perkmann et al., 2013). However, in recent years, this trend has been described as archaic and challenged. Another reason for a change in the university's functioning model is financial considerations. It is assumed that a stronger inclusion of universities in the transfer of knowledge to economic practice contributes to better use of the public funds that are allocated to financing higher education. Another argument in favour of increasing the intensity of industry-academia cooperation, which is much less frequently mentioned in the literature, is research discoveries in the field of creativity. In common understanding, imposing any restrictions or limitations on academics by the university would be associated with a decline in scientific productivity. Meanwhile, in the literature in the field of psychology of creativity, a positive relationship between the restraints faced by innovators and the quality of ideas generated in the creative process is noted. Previously, the opposite view dominated the literature. Creative people could be most effectively motivated by means of intrinsic motivation. For example, Csikszentmihalyi (1996) identified a phenomenon, which he called "Flow" describing the peak creative performance. Newest findings prove that it is not only intrinsic, but also extrinsic motivations that play positive roles (e.g. deadlines or rewards) in motivating people (Amabile & Pratt, 2016).

In recent years, more and more attention has been paid to the so-called "third mission of the university", i.e. their involvement in cooperation with the socio-economic environment. Universities have become more entrepreneurial, and many reports have attempted to define and specify methods of measuring the relationship

between science and business. At the beginning of the 1980s, the concept of "academic capitalism" and the related research on the relationship between universities and business appeared. Traditionally, the mission of the university was to teach and educate staff for the economy and the state. On the one hand, this issue is very important for improving the quality of higher education and broadly understood innovation of the economy. On the other hand, it is still treated as a set of expectations and postulates—mainly towards the university. To a lesser extent, deficits or deficiencies in collaboration skills are observed in the industry. The cooperation of scientists with entrepreneurs encounters many cultural, legal, institutional and competence barriers (Benneworth, de Boer, & Jongbloed, 2015). Usually, divergent priorities of research units and commercial enterprises make the functioning of effective n-b relations still a little popular phenomenon. An additional barrier to the development of these relations is the specific context in different countries. Solutions developed in one country will not always be effective in another. Modern universities seem to be at a crossroads as far as their strategic goals are concerned (Bortagaray, 2009). The third strategic priority (aside from teaching and performing research) is usually called 'Third Mission' (TM) and is portrayed as "a contribution to society" (Compagnucci & Spigarelli, 2020). University's Third-Mission (TM) refers to those activities of Higher Education Institutions which go beyond their two traditional roles i.e. teaching and conducting (usually theoretical) research activities (Schuetze, 2010). Education (the 'first' mission) serves the purpose of developing human capital. 'The second' mission entails producing new knowledge. The Third Mission refers to a variety of goals which aim to deliver added value to the society in the form of applied research, solving societal and economic problems, improving the quality of life. The expression TM is rather nebulous (Compagnucci & Spigarelli, 2020) but by searching for some distinguishing factors of the TM as compared to the first two missions, one can come to the conclusion that the time frame of the outcomes may be one of those factors. The TM activities are usually aimed to solve a specific problem, which is observable and acute to some extent, which can be operationalised into a roadmap with an expected outcome in the short-run. University teaching activities usually develop general cognitive skills, general knowledge and develop human capital which will demonstrate its full value in the long term perspective. Many research activities also concentrate on solving scientific problems which may not be directly related to the current needs. Research activities involve experimentation and risk of failure. The TM may be therefore distinguished by a shortened time frame of activities. Another characteristic of the TM activities could be the source of inspiration. In the case of theoretical research, the process of scientific inquiry is often initiated by the state of the art as described in the scientific literature. The TM approach emphasises the importance of searching for the research questions in the external environment of universities, outside of the realm of science. The difference may be well explained

by studying the process of developing research questions during the process of B.A. and M.A. thesis development. Students may be encouraged by the supervisor to study literature in the field (which is the traditional approach) and identify the gap in knowledge, or to search for inspirations in the external environment, e.g. by contacting business practitioners asking and searching for inspirations). It is not to say that scientific rigour should be abandoned. The scientific method should still be used but the result of a BA/MA thesis driven by the TM is not just filling the gap in knowledge but also solving a pre-identified problem, finding a solution etc.

Here appears a conclusion that there is a visible need to create conceptual frameworks, measures and guidelines that will be adapted to the cultural and institutional contexts in each specific country, as:

- Cooperation with the socio-economic environment reflects the expertise of academic teachers—in a network society, the most innovative information may be situated outside the academia.
- Academic teachers, who will not create innovative knowledge as a result of participating in research projects serving the needs of the socio-economic environment still can gain benefits for the science and the welfare of the academia (e.g. by improving their analytical skills, through attending research workshops, by enhancing competences in the use of research equipment and infrastructure, through identifying inspirational topics of potential research and formulating new research hypotheses).
- Academic teachers do not have enough opportunities to confront their assumptions with the real laws of social and economic functions. This is the result of the (common in Poland) phenomenon of inbreeding, as well as the hiring of people who have graduated from university in the same year, yet who have not undertaken internship connected with any branch of industry before being assigned an assistant position. Numerous Polish academic teachers have never worked outside of the academic environment. Thus, they are not familiar with modern business practices and functioning. Moreover, the organizational structures of universities and businesses are not compatible, which hinders communication and the understanding of the cultural codes that characterize organizations within the socio-economic environment. Under such circumstances, it is imperative to upgrade the social skills that are not expanded in the organizational culture of the university.
- Group cooperation with the socio-economic environment gives academic teachers the possibility to improve their communication skills, which tend to rot as the academic teacher becomes immersed in the ivory tower of academia
- Cooperation with the socio-economic environment increases the sense of ownership and responsibility for their independent research, while creating

the opportunity to obtain feedback about the results. This is an important factor that helps to counter burnout and to increase motivation. The hermetic environments at universities do not provide many stimuli of this form.

- For candidates potentially being hired in Academia, cooperation with the socio-economic environment may be treated as one of the possible quality indicators. The field of medical and health-related sciences is especially predisposed to taking into account the opinion of socio-economic environment representatives in their researches.
- From the perspective of the development of knowledge and the quality of academic research, one of the unfavourable individual research strategies, which many scholars use, is an excessive attachment to a narrow area of specialization, which often tends to be detached from socio-economic environmental phenomenon and processes. For academic teachers, who tend to define their research mission too hermetically and exclusively, cooperation with the socio-economic environment may be a source of valuable inspiration, as well as a stimulus encouraging further consideration. Cooperation with the socio-economic environment may be treated as an additional source of (informal) reviews—feedback information in the process of scientific development.
- Cooperation with the socio-economic environment shapes the leadership skills that are crucial in managing scholarly teams. In the Polish system, academic achievements are often the main criteria to obtain promotion to executive positions, notwithstanding lack of leadership skills, not to mention lack of experience with industry. Participating with the socio-economic environment would also be an instrumental purpose, while raising leadership skills would be the ultimate purpose. Even if the reform of the Polish education system would not result in an instant, common increase in the cooperation intensity of socio-economic environmental scholars, there still should be an emphasis on candidates for measurement positions in the university structures to be the first to show their achievements in cooperating with the socio-economic environment. Currently, competencies in business/industry cooperation are not exposed in competition for executive positions in academia (heads of Departments, deans, etc.)
- Cooperation with OSG will increase the tolerance of failure in the social norms. Today, a failure in research is barely acceptable. One cannot defend a thesis in which the results are counter to the hypothesis—yet this is an aspect of reality. Due to the possibility of working on solutions for the needs of the socio-economic environment, academic teachers will have more opportunities to experience failure—which is more difficult to define (due to a higher tolerance for the verifiability of the results) in situation of basic research.

The mission of high education institutions concerning the character of the cooperation, especially in the range of leading researches and developmental work for business entities, is of paramount importance to the enhancement of science-industry relations. There are different forms of operation within such cooperation, such as creating a special purpose company or industrial/business-representative participation in developing education programmes and didactic processes. Cooperation with the socio-economic environment may also take different shapes such as the university of the third age or various types of professional training courses, addressed to either community or commissioned by external entities.

The realisation of the so-called "third mission," based on the cooperation of the university and the socio-economic environment, may occur particularly in the following fields:

- transferring technology and knowledge to the economy by, among others, granting licenses or commercializing researches in an environment permitted by law reforms;
- cooperating with employers in creating education programmes and developing the didactic process;
- sharing research infrastructure with the external entities to a given university (for instance, interested entrepreneurs or other universities);
- implementing Life-Long Learning by launching postgraduate programmes, professional training courses, and universities of the third age;
- engaging the university (represented by scholars and students), as well as representatives of the socio-economic environment into the process of creating and promoting diploma theses.

6.2. Research approach

The main part of this article is devoted to the last issue listed above. It contains conclusions from workshops, as well as from the survey conducted among academic teachers from the University of Warsaw in 2018. The research problem which the authors tried to solve was how implement the TM approach in one of several possible areas of university's operations, namely, preparing a dissertation. This area is unique because it combines elements of the 'first' and 'second' missions, i.e. it both involves elements of teaching and conducting research, which makes it especially interesting field of study. There is scarcity of literature sources discussing this element of university's life. Most papers covering the issue of the TM concentrate on the issues related to making the research results more applicable and broadening both the inputs to academic knowledge and its use in an economic and societal context through technology transfer (see e.g.: Gaisch, Noemeyer, & Aichinger,

2019; Compagnucci & Spigarelli, 2020; Ke Rong, Lin, Yu, Zhang, & Radziwon, 2021). We aimed to go one step further beyond defining different modes of the TM (see e.g.: Ke Rong et al., 2021) which limit the descriptive insights merely to the case studies of universities. In the case of our research we endeavoured to open 'the black box' of a university realising its TM and took a more detailed view on how the TM is implemented. Paradoxically, the added value of this research decreases if only the first and second mission perspectives are used. Our study reveals how the TM can be implemented in one very important fragment of university.

The results of the empirical research presented in this article were gathered among the participants of workshops for tutors organized at the University of Warsaw in November 2018 as a part of the project "Application Diploma Theses—Successful Professional Start." (Project "Application Diploma Theses—Successful Professional Start" realized as a part of Operational Program Knowledge Education Development). In total, 20 academic teachers participated in the workshops. They were mainly academic teachers hired at the following faculties of the University of Warsaw: Artes Liberales, Journalism, Information and Book Studies, Political Science and International Studies, Philosophy and Sociology, Polish Philology and Psychology, who are interested in competencies development required to supervise application diploma theses. Training workshops for tutors were created for academic teachers from the University of Warsaw, the intent being to improve the competencies that are vital in modern didactics and academic work. The workshops aimed to prepare participants to lead application diploma theses written by students from the University of Warsaw. The participants of the workshop were engaged in a moderated discussion, which was written down in the form of keywords and schemes (Picture 6.1). Moreover, participants filled the survey form, which contained open and multiple-choice questions. A discussion of the results of the survey can be found in the further part of the article.

Picture 6.1. An example of notes originating from one of the workshop sessions
Source: Authors' materials.

6.3. Research conclusions from the workshops

During the 16-hour workshops, participants of the research were involved in a moderated discussion on the challenges and issues related to the introduction of topics and matters corresponding to the needs and interests of socio-economic environment representatives to the subject of diploma theses. Academic teachers who supervise application diploma theses were defined as tutors. Conclusions from the workshop discussion were grouped according to the category of issues and displayed below:

1) *What should be the scope of duties of an academic teacher responsible for creating conditions for the preparation of diploma theses? What should you remember when assigning responsibilities?*

- The aim rooted in completing the task should be kept in mind (e.g., master thesis defence).
- Mutual expectations and the range of cooperation, such as details of the application diploma thesis, should be precisely defined. It is worth creating an assessment questionnaire that is known by a student in advance so he/she can meet the expectations of the application diploma thesis.
- The main focus should be "the work", not "the person" to emphasise the research-application purpose.
- Interactions between participants of the process should be enabled as it is essential to engage students in the dean's groups for horizontal communication and mutual exchange of experiences between them while writing their thesis.
- The engagement of previous participant experiences in application diploma theses should be treated as the university's long-term task. Therefore, experiences collected by younger age groups should be accumulated and promulgated. This postulate also considers the usage of previous diploma theses results as a base material for discovery and enhancement of innovative technologies, as well as social development.
- Not the academic rigour, but methodological frames should be looked after. Described knowledge should be segregated (universal knowledge, area knowledge and specific knowledge for certain research).
- The tutor's own experiences should be enlisted—workshop participants emphasized the importance of their personal professional experiences in cooperation with the socio-economic environment. Experiences may consist of both gathering knowledge and developing personal contacts, hence, enabling the student to gain an easier start of cooperation with an entity from the socio-economic environment.
- The publication acquis of the tutor should be used when writing a thesis. This postulate is universal and timeless, thus, should not be omitted in the case of application diploma theses.

- Collaborative publications involving students and tutors could be the outcome of the creation of an application diploma thesis. This kind of solution can be attractive for all participants in the process. The tutor will have the opportunity to enrich his acquis with a new publication, while the student will gain a distinguishing attribute at the beginning of his professional career. If the diploma thesis concerns a certain entity, the publication can contribute to the promotion and realization of CSR purposes.

Students in the group supervised by the tutor can be used as focus group participants for mutual evaluation and review of the partial effects written in the group of diploma theses. If several groups of students are supervised by one tutor, it is worth considering the possibility of mixing the group composition to increase their creativity.

The next issue discussed during workshops concerned the characteristics of a good tutor. The term "tutor" is related to the promoter of the diploma thesis—the academic teacher who supports the student in his/her research over the application diploma thesis. Ideas of the participants are displayed below.

2) What characterizes a good tutor?

A good tutor:

- has profound expertise related to the topic of the thesis,
- manages the research in such a way that the student independently performs tasks, which do not require the tutor's creative input,
- capitalizes on the synergies between topics of the research in creation in one seminar group,
- motivates students to systematic work,
- provides numerous interactions (frequent, regular, short feedback),
- is interested in the student's situation at the university,
- is interested in the motives of students,
- tries to employ the information gathered by older age groups and to pass this knowledge to the younger ones,
- defines the vision of the research, which should be innovative and original (emphasizing the significant role of personal research, regarding literature studies as a phase—not as an ultimate purpose),
- cooperates with other tutors by, for instance, participating as a guest in various seminars,
- has a broad group of potential reviewers (does not only participate in a "co-op," in which a couple of people notoriously swap roles of promoters and reviewers),
- uses researches from previous years as teaching material.

3) *What actions should the tutor undertake to build relations with students and stimulate their creativity?*

The tutor should:

- be present on the internet and provide more than just a laconic set of information,
- provide adequate availability by systematic email replies,
- use online course aps (Moodle) by uploading numerous auxiliary materials,
- send students materials related to their research topic, information about conferences, etc. on their own initiative,
- sharing personal contacts with students to give them access to research samples,
- learn about students' experiences (e.g., the topic of their bachelor's diploma thesis, secondary school background and achievements),
- be interested in students' plans after graduating from university,
- share knowledge about the alumni of the seminar with its present participants,
- competently manage teamwork,
- be a partner in a discussion,
- integrate and synthesize the previous experience of the student (recognize and bring out the potential that the student does not recognize in his/her experiences),
- provide contacts in the socio-economic environment,
- help acquire empirical data,
- serve as a creative process manager,
- serve as an advisor for university bureaucracy.

4) *What are the characteristics and attributes of the application diploma thesis?*

Application diploma thesis:

- is not just a compilation of existing theories,
- has a distinctive title,
- has distinctive research questions,
- is partly or fully based on the current socio-economic situation,
- contains the component of empirical research,
- attempts to solve a real issue,
- was created in collaboration with entities or/and people from the socio-economic environment,
- has attributes interesting for a potential employer,
- uses literature sources such as professional reports,
- at an early stage, its subject gained support/interest/approval,

- relates to existing researches concerning economic practice—it expands knowledge,
- uses foreign sources concerning economic practice wherever justified,
- can be used as a topic for the presentation at a professional conference.

5) What kind of motives should guide the idea of application diploma theses?

- utility—actions for the benefit of the society,
- reaching certain goals—its research gives satisfaction,
- the opportunity for increasing academic teacher's earnings,
- enhancing reputation in the environment,
- the willingness to help others,
- the sense of meaning,
- satisfying one's curiosity,
- active civic attitude.

The last issue discussed during the workshops was the organizational conditioning of universities connected to implementing the application diploma thesis programmes. Participants were asked to create a list of barriers.

6) What barriers to creating application diploma theses can you recognize?

1. Internal rivalry inside university organizational units.
2. Undefined range of duties of the university workers.
3. University motivational systems (including training availability)—unfavourable organization of thesis applicability.
4. Generation gap—the effect of the years 1989–2000, in other words the outflow of experienced staff or a stoppage in scientific development.
5. The lack of understanding towards the "third mission" of the university.
6. The lack of ability to fulfil numerous roles.
7. The lack of social skills among potential tutors.
8. The lack of intermediaries connecting the university with the business world.
9. The lack of community service tradition.
10. Ethical dilemmas: sacrificing ambitious academic goals for the sake of being less ambitious but having practical results.
11. Application diploma theses may have a smaller impact on publishing activity.
12. Problematic aspect of intellectual property protection of entrepreneurs.
13. Alleged bias to pursue commercial interests of the company involved in the thesis development.
14. Possible manipulation with research results by the client.
15. Thought patterns influencing the interpretation of research results (e.g., political connotations).
16. Access to public data.

6.4. Results of the survey research

The outcome of our study is new knowledge in the field of the TM implementation. By engaging a number of academics into a qualitative study we were able to demonstrate what opportunities and barriers to the TM implementation can be. Participants of the project were asked to fill in a questionnaire. Fifteen questionnaires were completed. Due to the small number of responses ($n = 15$), inference based on statistical analysis is unjustified. Nevertheless, the apportionment of answers to the individual questions is presented below. The measurement tool developed by the authors for the workshops may be used in future applications on a larger research sample:

I. The perception of APD in the academic community of the University of Warsaw

- The emphasis on creating APD violates the autonomy of the academic teacher: 1.30.
- APDs serve to improve the quality of research conducted at our university: 4.50.
- APDs only serve to satisfy the ambitions of politicians and decision-makers, not the university's academic mission: 2.10.
- APDs facilitates the start of the students' professional activity within the labour market: 4.30.
- APDs should become a standard at the University of Warsaw: 3.80.
- University teachers at the University of Warsaw have insufficient knowledge on how to supervise the development of APD: 3.00.
- Academic teachers should co-create APD only voluntarily—others should be able to promote non-application work without any negative consequences for their professional situation: 4.20.
- The emphasis on the creation of APD at the University of Warsaw will lower the scientific quality of diploma theses prepared at our university: 1.20.
- The time required to supervise the development of APD is usually higher than for non-application research: 4.00.
- The popularisation of APD among the works created at the University of Warsaw will improve its competitive position in the market of educational services in Poland: 4.00.

II. Competencies of the APD supervisor

Due to the small research sample and quasi-qualitative character of measurement, the results are displayed in the descriptive form. The dominant type of answer is presented in each box, where:

1. I presume I lack this competency.

2. I reckon I do not lack this competency.
3. I presume that the majority of academic teachers from the University of Warsaw lack this competency.
4. I reckon that the majority of academic teachers from the University of Warsaw do not lack this competency.

Competencies, skills, abilities and attributes of the APD promoter	(a) Self-assessment	(b) The assessment of academic teachers from my faculty at the University of Warsaw (generalized)
Having a net of contacts in the socio-economic environment, which allow students to contact with the economic practices	(1)	(3)
Attentiveness to the practitioners' needs	(2)	(4)
The ability to simplify verbal and written communication according to the practitioners' expectations	(2)	(4)
The ability to find deficiencies in knowledge / needs concerning problems with the socio-economic environment	(1)	(3)
Openness to contacts with practice (no defensive attitudes towards practitioners)	(2)	(3)
Experience in the project realization for the socio-economic environment	(1)	(3)
Work experience (full-time job, own business activity, etc.) aside from formal education	(1)	(3)
Experience in research projects executed abroad	(1)	(3)
Responsiveness (quick, specific responses to emails from a partner from the socio-economic environment)	(1)	(3)
Availability (the ability to adjust to time frames indicated by the project with the socio-economic environment—reconciliation of academic work with the work schedule of the client from the socio-economic environment, readiness to work during inter-semester breaks)	(2)	(3)

In the last question of the questionnaire, the respondents were asked to select from the list, the three most important (in their opinion) attributes of the application diploma thesis. Participants most frequently indicated the following, it:

- solves a problem formulated by a business partner,
- has the potential for commercialization of the research results,
- allows the author to find employment with the company that was covered in his/her thesis.

Furthermore, one of the participants of the research proposed another attribute: "It formulates and proposes solutions that can be interesting for the socio-economic environment". Further studies in the field of TM concerning dissertations may cover a variety of topics and try to answer such questions as: what is the added value to the society of dissertations developed within the framework of the TM?

To what extent the emphasis on the applicability of theses impacts goals related to the first and the second missions (is there a compromise made?).

Conclusions

This article displayed theoretical conditions backed up with research results that are connected with the issue of creating application diploma theses in universities in Poland. The process of creation of the application diploma theses is one of the possible practical realizations of the universities' TM postulate. Introducing regulations supporting the creation of application diploma theses to Polish universities may significantly contribute to the intensification of the cooperation with the socio-economic environment, because it gives potentially large synergy effects for all the partners—including university student-alumni. The presented research results are exploitative in their character and can serve as a basis for continued research on a bigger scale. The model of the questionnaire was created for the needs of the research. It was employed to survey the participants of the project. In the authors' opinion, the questionnaire can become foundation for continued research in this area involving a much bigger group of academic teachers and Polish universities so as to develop systemic solutions that would motivate the university and entrepreneurs to strengthen cooperation. One of the platforms of such cooperation between academic and socio-economic environments may be the emphasis on the practical exploitation of diploma theses.

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7. WHO REALLY IS A DATA SCIENTIST? ANALYSIS OF REQUIREMENTS FOR DATA CENTRED ROLES JOB MARKET AND THEIR FUTURE

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Abstract

Data analysis and processing skills are currently required by a multitude of job offers and cover a wide variety of applications. Although mostly shaped by the development of new technologies, programming languages and libraries, they are a necessity in the world of digital economy and entrepreneurship. A multitude of reports by large consulting companies such as Deloitte predict a sharp increase in demand for data science and AI roles in the future of not only the IT sector, but also the entire economy. The following questions arise: "What skillset do these innovators that use artificial intelligence and advanced analytical skills have?" and "What skills and requirements truly make a data scientist and are they are any different to that of data analysts, data engineers or software developers and programmers?", moreover, "What is the demand for these specialists and are the university programs educating future specialists in this field or are the skills too new and need to be taught solely by business practice?". To answer these questions, this article applies Natural Language Processing (NLP) techniques of machine learning to characterize and extract from the offers key skills important for data centred roles. The research was carried out on a preprocessed sample of 72 thousand job offers from the IT sector posted in 2019. A SVM linear classifier was applied to extract the most distinguishing technical skills and characterize the possibility of the automated classification of job postings, which resulted in about 85% precision and recall values for classifying data analyst, data scientist and data engineer roles and about 90% for classifying python developer roles.

Keywords: data scientist, data engineer, data analyst, job offers, job postings, big data, data analysis, job market, data mining, natural language processing, text mining, education.

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Introduction

It has been nine years since "data scientist" has been acclaimed as one of the most promising careers of the 21st century by the *Harvard Business Review* (Davenport & Patil, 2012). Despite the varying nature of the name: 'quants' (Miller & Hughes, 2017), 'data warehousing and ETL specialists', 'big data specialists', 'data scientists' or 'machine learning and AI experts', the need for people with a broad array of problem-solving and analytical skills centred around data processing and analysis has been rising steadily for the last 10 years. The McKinsey report from 2011 (Manyika et al., 2011) forecasted a need for hundreds of thousands of 'data centred' jobs in the next decade and their predictions were mostly met by the market. The value of the data analysis market, regardless of whether it is called 'AI', 'machine learning', 'big data' or 'data science' is rising and is currently facing significant skilled worker shortages all over the world (DuBois, 2021).

This may be fueled partly by the FAANG (Facebook, Amazon, Apple, Netflix, Google) tech giants' success in applying data skills and connected technologies. The largest companies in the world are now data science reliant enterprises that have built their position using large IT infrastructures and innovative analytics to achieve their position on the market. Their competition, on the other hand, needs to comply with the new market standard of using extensive data analytics.

The largest business social media platform—LinkedIn—has observed nearly a seven-fold increase in demand for "data science" roles and a ten-fold increase in machine learning jobs in 2017, compared to 2012. The growth in popularity and demand has also been present in 2020 (Seaman, 2021; Olsen, 2021) over multiple reports on most promising and rising jobs. The role of data scientist has been acclaimed "best job" by Glassdoor platform since 2016, and it fell to the third place only in 2020, due to the increase in demand for front and back end developers. This popularity, however, not only creates the need for multiple job openings in data centred areas, but also emphasizes these skills as a necessity for entrepreneurship and success in the startup and technology-oriented mindset of investors. Vision, creativity and management skills are and will remain key factors of success for rising entrepreneurs. However, in the world of AI, big data, mobile and wearable applications, fin-tech, med-tech and reg-tech, those companies need experts in applying these new technologies.

To build a knowledge-based economy, a large number of skilled specialists are needed. There is no denying that in the last few years, data processing, machine learning and AI took a large part in developing technical innovations. These skills are mostly connected with the traditional role of the data scientist—but do all companies need a data scientist or maybe do some need not one but a lot of them? To gain answers, we need to know who exactly is a data scientist and what skills he or she needs to possess. Moreover, we should also consider if there are any

emerging roles with similar skillsets that may be hidden under the popularity of the name and may be crucial for innovation. What is more, in the highly competitive employee oriented job market of IT, with the shortage of data science talents, it may be hard to convince these specialists to change their well-paid positions to take up an unsure future as a startup tech leader. Still, has the pandemic changed the demand situation? Furthermore, did the shortage of data scientists come about because universities are not addressing the demand and generating these experts or is it just the result of too high demand in a short term?

The goal of this chapter is to characterize the data centred roles job market, analysing both the demand side and the supply of skilled data professionals educated in Poland, compared to the flagship data science programs. In terms of those roles, the main goal is to ascertain the current skillset sought by the market for different data centred positions. This chapter is aimed at answering the following questions:

- Is the demand for data centred roles still high in 2020/2021, how has the pandemic affected it?—For those entering into the job market or higher education, it is important to recognize whether data science is still a growing trend or the recent events have decreased the demand for the skills and possibly ended its rising popularity.
- Which skills are the most prevalent and to what extent in the data centred roles?—The concept of data science is diverse, and there is no single definition as to what contributes to the skills of a data scientist. Measuring the diversity of required skills and similarities between the data centred positions will provide answers to what is actually needed. The results of the analysis could also point out to the dynamics and changes of the current market, highlighting the new skills gaining popularity in the recent year.
- Which skills are unique to the roles identified?—The analysis of skill importance and structure may point out to the different characteristics of data centred roles influencing the entry barrier, market demand and diversity of skills required. It is important to know what differentiates e.g. a data analyst from a data engineer and how that may influence the role that the given specialist should play in the company.

The approach applied to identify the key skills and differentiate between the said roles relies on a NLP classifier applied across the collected job postings, which based on a keyword detection are assigned to one of the data centred roles. A SVM machine learning classifier is further on employed to allow for the identification of the key skills that can differentiate between the roles and to automatically classify job postings based on its contents. Our approach is in line with other researchers' studies. This will be described in the subchapter "Comparison of results with other studies", which compares the results and methods applied by multiple authors focused on similar topic, mainly on the US job market. Our proposed method of

key skill extraction however adds an ontology database matching approach not used by other studies who have utilized similar NLP methods.

Additionally, we will check if key skills identified for these roles are taught in "data science" and similar academic programs in Poland and how they compare to some of the top US and UK programs. This will, of course, be a preliminary study and only the beginning to some more detailed analysis. Its aim is to confirm if today's academic programs are in line with meeting the market demand for data centred roles in terms of the curriculums and overall analytical skills taught. It will also help in identifying the skills the alumni will need to learn on their own from different code camps, micro degrees or from business practice.

This work has the following structure: first section is the introduction, describing the problem area and the main questions motivating the research. The next section describes the market of the "data centred" roles, along with the impact that the COVID pandemic had on it, thus aiming to answer the first research question. Further on, the second section describes the issue of analysing the key skills extracted from a large sample of job postings, along with the results answering to the second and the third research question. In this section both the problem, the dataset used, the NLP machine learning approach applied and the achieved results are described. The third part aims at comparing the key skills found out in the analysis with the curriculums of various "data science" and similar academic programs. Finally, the last section presents the conclusions of the article.

7.1. Data science—demand (market)

In 2018, the World Economic Forum (WEF) published its predictions for the future workforce through to 2022. In it, WEF predicts that by 2022, 85% of all business entities will have adopted big data and analytics technologies and 96% of all enterprises will be likely to hire new permanent positions to fill these roles (World Economic Forum, 2021).

According to Grand View Research, in 2019, the global data science platform market size was valued at $3.93 billion. Moreover, the role of data scientist has become one of the most in demand jobs in both the UK and the US. Indeed, the role appeared on LinkedIn's 2020 Emerging Job Report in both countries, featuring at number 3 in the US and number 7 in the UK, the first being AI specialist in both of the cases (LinkedIn, 2020a; LinkedIn, 2020b). In 2019 (Blake, 2021), in the UK, the demand for data scientists and data engineers tripled over the past five years, rising 231%. This is much faster than job postings overall in the UK. The annual number of job postings has more than doubled since 2014, reflecting strong growth in demand for these roles among employers.

According to the Quanthub, which started to measure the data scientist shortage in the market from 2019, there is still a 250,000 positions shortage for data scientists alone in 2020 (DuBois, 2021). In the US, in 2020, for the second time in four years, the number of jobs posted by tech companies for analysis skills, including machine learning, data science, data engineering, and visualization—surpassed traditional skills such as engineering, customer support, marketing and PR, and administration. Of note, demand for data scientists and ML and AI specialists began surging in 2016 (Ramachandran & Watson, 2021). Similarly, the Dice Tech Jobs report released in February 2020, showed that the demand for data engineers was up 50% and demand for data scientists was up 32% in 2019, compared to the prior year. "Demand for data-oriented occupations and skillsets skyrocketed in 2019," the company stated (Techhub.dice.com, 2021). In addition, these skills were needed not only in the IT sector, but also in healthcare, ecommerce and underlying logistics, the financial sector and in cyber security industries (Olsen, 2021; Motion Recruitment, 2021).

How has the pandemic affected the market? With COVID lockdowns enforced on shops and restaurants in multiple countries, online shopping and food deliveries has increased significantly. With the speed up of the digital transformation in companies caused by the increase in remote work, analytical and technical skills have become more valuable. On the other hand, companies were forced to undergo employment cuts and limit their spending on new endeavors during the pandemic. This negatively impacted the development for data analytics, but still placed more emphasis on IT infrastructure during the early stages of this crisis.

Overall, it seems that in spite of the COVID-19 pandemic and the overall decrease in job market demand, the data science job postings did not seem to be affected tremendously. Among the large companies, the demand for data centred roles still increased, as observed by interviewquery report in 2021 (Feng, 2021). The company carried out an analysis covering over 450+ tech companies, segmenting the data science roles into eight different types. Accordingly, there was an overall slight increase in the number of job offers between 2019 and 2020 in all of the roles, but also a 15% dip in interviews for the data scientist, compensated by the increase in business analyst, data analyst, and data engineering interviews. The demand among FAANG did not suffer much from the pandemic, but increased instead, which was also confirmed by Deloitte (Ramachandran & Watson, 2021). Some other reports such as from the hiring platform indeed.hiringlab.com showcased a large decrease in the demand for technical jobs during the pandemic (Konkel, 2021), although artificial intelligence and machine learning jobs have been hit the least.

Does this mean that the hype for data science has ended? It does not seem so. The opendatascience.com study confirmed a significant dip in job postings between

March and May of 2020, but also a sharp increase in July which may mean that pandemic had short lasting effects for this area of the job market (Opendatascience.com, 2020). The hiringlab results are hard to generalize, and according to other platforms, the overall data analysis area is still on rise. In Glassdoor's 50 Best Jobs in America for 2020, data scientist remains one of the top three positions in the U.S, and the recent LinkedIn study in 2021 (Seaman, 2021) emphasized that hiring in the data science domain increased 46% in 2020, compared to 2019, while the demand for AI Specialists increased 32% in the same period. In the UK, despite the challenges faced by employers in 2020 due to the COVID-19 pandemic, 2020 was the highest year to date for the number of online job vacancies related to AI and data science, with an increase of 16% from 2019 levels (Blake, 2020). Summarizing the effects the pandemic had on the data centred roles job market and answering the first research question:

- Even as the pandemic was worsening the business conditions in March 2020, job openings for roles such as: data analyst, data engineer and data architect continued to trend high for tech majors (Feng, 2021; Ramachandran & Watson, 2021) in all of 2020.
- The overall demand for data oriented jobs did not change much, but the structure of specific positions did (Opendatascience.com, 2020; Feng, 2021), emphasizing skills in the data engineering and machine learning fields and the need for more experienced data specialists.
- Small companies may be hiring less data specialists and more of the jobs seem to have bigger entry barriers for junior developers, with more specialized requirements posted. Companies are, therefore, looking for specialists who already possess extensive technical skills.
- The increase in remote work emphasized the need for analytical skills and showcased the issues of data management in companies. This was exemplified by the increased need for data engineers and the overall demand for IT specialists that surged in 2020. For now, the demand is expected to only increase, especially in cyber security, cloud computing and IoT areas (DuBois, 2021), with less emphasis on traditional engineering skills and more on data processing and analytics (Ramachandran & Watson, 2021).
- The demand for these specialists was not uniform thorough the sectors, for example, healthcare, e-commerce, logistics and financial industry increased their analytical significantly during this period. The companies which emphasized strong IT infrastructure survived better in the pandemic, where users switched more to online channels for accessing everyday services. This means more technology-savvy companies (e.g. providing e-commerce services) that might lead the transformation in the future.

7.2. Analysis of skills for data roles—online job postings study

The skillset of the new data centred roles differs significantly from traditional analysts, but that does not mean business reporting or databases are not required. It is just that nowadays the roles are more technology focused, and require programming and statistical skills, along with knowledge on how to extract, process and predict, based on diverse data sources.

We already have specialists that make analysis and inference on various data sources—statisticians. But how does this new trend of data science translate to the skills of this profession? Citing the statistics professor, Nancy Reid, in an article from 2018: "Data science may be to some point a different way of looking at data than statistics. Where statistics is cautious and deduces on data with underlying assumptions on the processes generating it, data science aims at classifying on varying and uncertain data formats, while largely emphasizing the speed and applicability in different domains. It is blend of statistical modeling and inference, data management, computing at scale, optimization, communication and visualization" (Reid, 2018).

Knowledge of statistics is important for the new data centred roles in enterprises, but so are visualization and prediction skills, including knowledge of machine learning methods and other algorithms originating from computer science. As emphasized by the paradigm of big data: the size of the data for analysis (volume) meets the requirement for real-time or short batch processing (velocity) of not only numerical, but also image and text data (variety) that may be burdened with high errors (veracity). In this environment, as stated by Davenport's article in 2012, when describing the role of a data scientist: "The traditional backgrounds of people you saw 10 to 15 years ago just don't cut it these days" (Davenport & Patil, 2012). In line with that, the focus of the data scientist it to produce a business actionable prototype using a programming language, with strong data management and analytical skills, supported by a strong foundation in math, statistics, probability and computer science (Cao, 2017).

To offer innovative services and derive insight directly from the raw sources available for the company, these experts require a variety of technical skills. The question is, which of them are absolutely necessary as of today, when the role is more mature than it was in 2012. Also, is the required skillset diverse or highly interchangeable between different roles? To answer this, the authors of this chapter have conducted an analysis of job offers in late 2020, that spanned over the whole previous year and aim to compare them with the results of similar studies.

The main goal of the study was to extract the skills that differentiate data scientist and similar roles from programmers and developers. As our dataset we have

extracted over 72 thousand job offers from one of the biggest online job advertisement services in Poland. We analysed only the technical offers[1], meaning the offer was included only if it classified the job offering as an IT job. The collected offers spanned from January to December 2019 and their geographical distribution, where the expected focus on large towns is clearly visible, is shown in Figure 7.1.

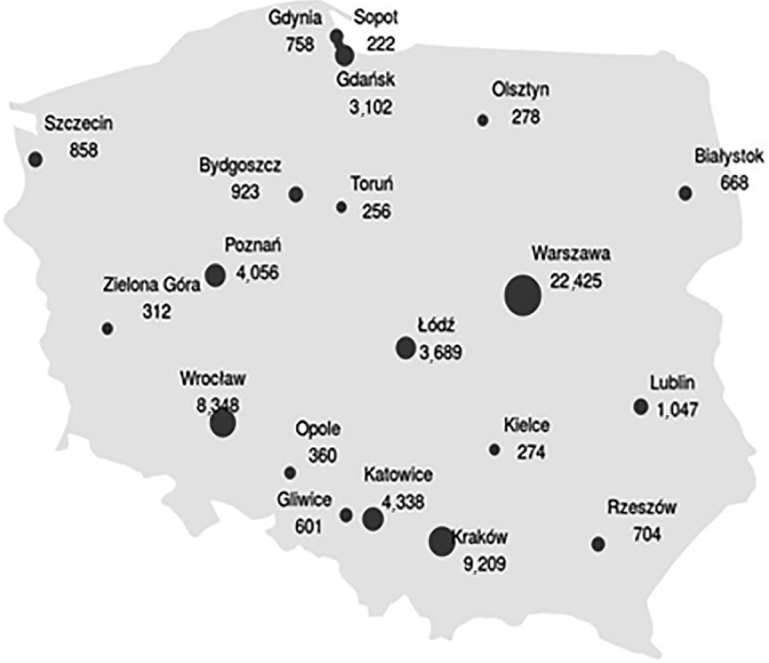


Figure 7.1. Distribution of all IT offers (duplicates removed) by city
Source: Own elaboration from authors' dataset.

We have cleaned the data to include only the offers written in Polish and English (we have used Python's "langdetect" library). The structure of extracted languages after the filtering procedure is shown in Figure 7.2. We have also excluded offers that were placed multiple times. All of the cleaning resulted in a preprocessed sample of 42,885 job offers.

Due to the size of the dataset, automatic keyword extraction and stemming and other similar natural language processing (NLP) techniques were applied as a part of our approach to the problem. The "soft skills" extraction for now was an issue, because of the complexity of Polish language, a lot of mixed-language words and potential translation errors when comparing Polish and English offers.

[1] From "IT—administration" and "IT—Software Development" categories, the only two directly connected with IT jobs.

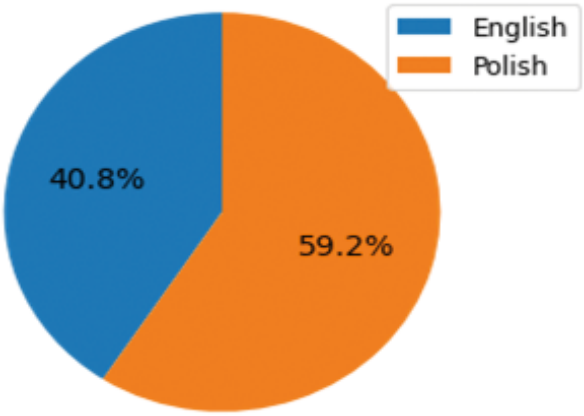


Figure 7.2. Distribution of languages in the prepared study
Source: Own elaboration from authors' dataset.

The technical skills, on the other hand, were mostly identified by a technology name: Python, SQL, Spark, Tensorflow etc., which are usually nouns, hence our approach for extracting technical skills was applicable for the offers in both languages. Due to that, and to compare the results with similar studies focused on the skillset identification, we decided to focus on technical skills. As an extension of our approach, however, extracting soft skills could be a valuable area of further work. An interesting approach for the English language has been explained in the work from 2017 (Papoutsoglou, Mittas, & Angelis, 2017). To extract the skills required by the data centred roles, the NLTK[2] and spaCy[3] Python libraries were used. Thus, the following approach was proposed:

- Part of Speech tagging was applied to extracting NNP (ang. propel nouns) as the skill names. Similarly, extracting ORG (original names) parts of speech by NLTK was tested, but it extracted significantly less names that were usable.
- Due to the fact that not all of the technical skills are single nouns, bi-gram detection was performed on the extracted nouns.
- The nouns and bi-grams representing technical skills were then compared with the Wikidata ontological database categories[4], which resulted in 24,580

[2] https://www.nltk.org/

[3] https://spacy.io/

[4] That included: programming language (Q9143), python library (Q29642950), free software (Q341), object-based language (Q899523), functional programming language (Q3839507), scripting language (Q187432), multi-paradigm programming language (Q12772052), imperative programming language (Q21562092), interpreted language (Q1993334), highlevel programming language

different technologies. **This is the main extension of this work over SOTA as it significantly increases the possibility of matching the extracted skill-set with its natural language descriptions without manual labelling work.**

- Some of the ambiguous phrases such as "nice" or "possess", which are rarely used terms in technologies, were parts of the "nice to have" and similar phrases. After careful examination, skills not matching the context were manually removed.

After the analysis of extracted skills, considering top 20 skills for all of the IT related jobs our results showcased, that:

- the most popular skill was SQL, connected with relational databases querying, and was included in 28% of all offers,
- Linux (15%) and Windows (13,5%) were commonly mentioned in posted offers,
- the most popular programming languages demanded besides SQL were: JavaScript (14%), Java (13,5%), HTML (11%), Python (9%) and C# (7,7%),
- knowledge of git versioning system was mentioned in 12% of all offers,
- analytical skills like "office" were present in 11% of the offers, and beyond this, "excel" was mentioned explicitly in 7% of the offers,
- Scrum (9%), Agile (11%) and Jira (9%) knowledge, corresponding to project management skills was also present in the job applications, and were used to identify the portion of jobs aligned with project manager roles among all of the IT offers,

(Q211496), statistical package (Q13199995), JVM language (Q56062429), procedural programming language (Q28922885), structured programming language (Q28920117), computing platform (Q241317), Web API (Q20202982), markup language (Q37045), academic discipline (Q11862829), numerical software (Q74086777), mathematical software (Q1639024), software library (Q188860), software framework (Q271680), computer science (Q21198), NoSQL database management system (Q82231), database management system (Q176165), document-oriented database (Q1235236), relational database management system (Q3932296), proprietary software (Q218616), open-source software (Q1130645), message-oriented middleware (Q1092177), programming paradigm (Q188267), artificial intelligence (Q11660), service oriented architecture (Q220644), communications protocol (Q132364), computer network protocol (Q15836568), continuous integration software (Q16947796), free and open-source software (Q506883), virtualization engine (Q7935198), web framework (Q1330336), virtual hosting (Q588365), agile software development (Q30232), computer science term (Q66747126), operating system (Q9135), software development methodology (Q1378470), protocol suite (Q67080166), Internet Standard (Q290378), distributed data store (Q339678), collaborative software (Q474157), application framework (Q756637), event-driven programming language (Q28920813), platform as a service (Q1153767), platform as a service (Q1153767), computer data processing (Q6661985), software design pattern (Q181156), architectural pattern (Q635346), search engine (Q19541), web server (Q11288), operating system shell (Q18109), certificating services provider (Q13460321), software (Q7397), modelling language (Q1941921), query language (Q845739) and generic top-level domain (Q29469).

- the most common coexisting pairs of skills were also analysed, but, mostly, the versioning systems and SQL were mentioned, along with their corresponding programming language. The only exceptions to this were the (Windows, Linux) pairing that was in 5,95% of all the offers and the (Agile, Scrum) pair. The meaning of this is twofold:
  - firstly, among the IT offers, only the knowledge of SQL and databases and the GIT versioning system can be considered basic and necessary knowledge,
  - there are no combinations of technical skills required that are strongly tied together.

This means that there is a wide array of independent skills necessary for the data analysis jobs.

7.3. Findings—data centred roles

Further on, only offers that contained the words "data" were included, creating a subsample of all IT offers. Additionally, for comparison with the standard programmer profile, developer job offers that contained the word "Python" were included and henceforward we will refer to them as the "Python developer" role. For each of these roles, the job offers were extracted based on the inclusion of the keyword name in the "data" subsample of offers. To characterize these roles in companies, an analysis of extracted skills was performed. The top skills for each of the roles are showcased in Figure 7.3.

To measure the stability of the job's profile, a classification experiment was performed. Its goal was to showcase how stable the skill profile is, based on a sample of skills extracted for a specific role. Relying on that, TFIDF vectorizer[5] was applied on the keywords extracted. After a few experiments, top 500 words were used to represent a single job offer in the data centred area. Further on, the SVM linear classifier with $C = 1$ parameter was used to train a machine learning model that can classify the job into: data scientist, data analyst, data engineer and Python developer categories. This was just a short experiment to showcase the potential accuracy and stability of data centred profiles—the low accuracy of the classifier would mean that potentially the identified positions do not differ much in terms of required skills and there are no distinctive technologies connected with a specific occupation. Fortunately, the classifier resulted in over 87,5% average accuracy and the results on a sample of job offers can be seen in Figure 7.4. Accordingly, there

[5] Term frequency—inverse document frequency statistic implemented in the scikit-learn Python library was used.

Data Scientist

	Skill	%
1	python	74.19
2	r	59.86
3	sql	46.59
4	machine_learning	37.28
5	spark	24.37
6	tensorflow	22.22
7	hadoop	21.86
8	big_data	17.20
9	data_science	16.85
10	hive	16.49
11	aws	14.34
12	java	14.34
13	linux	14.34
14	sas	13.98
15	git	13.26

Data Analyst

	Skill	%
1	sql	64.97
2	excel	46.12
3	python	25.50
4	r	22.17
5	power_bi	20.84
6	tableau	19.96
7	office	18.63
8	vba	17.52
9	sap	10.20
10	computer_science	9.76
11	sas	9.31
12	access	9.09
13	big_data	8.43
14	oracle	8.20
15	etl	5.76

Data Engineer

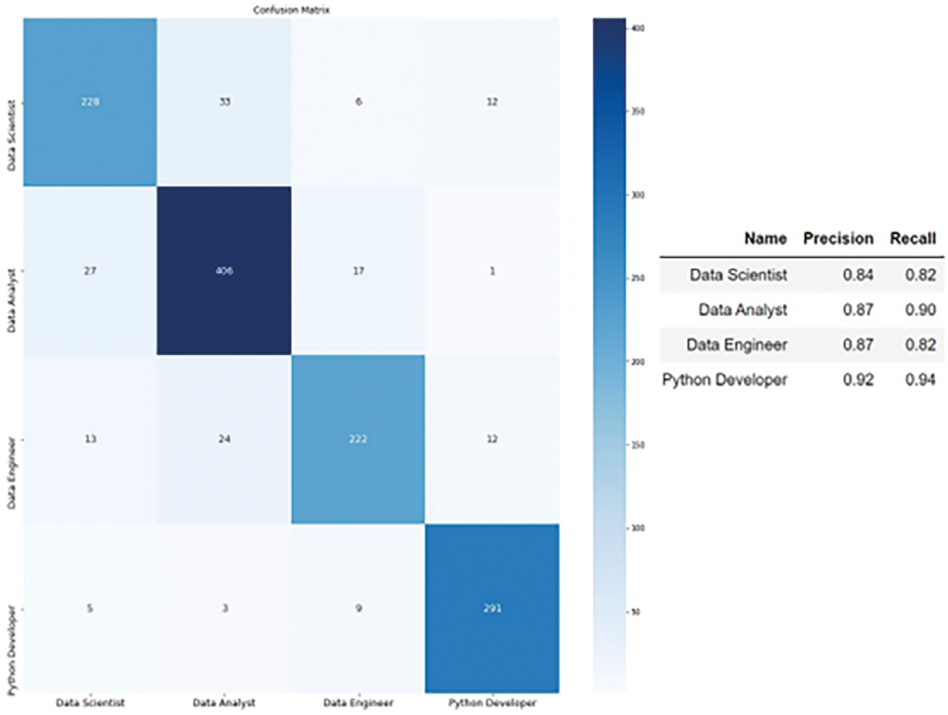
	Skill	%
1	sql	59.41
2	python	57.56
3	big_data	35.42
4	spark	35.42
5	java	35.06
6	hadoop	33.95
7	linux	30.63
8	etl	30.26
9	aws	22.14
10	agile	21.77
11	kafka	21.77
12	scala	19.19
13	oracle	18.08
14	nosql	17.71
15	hive	15.87

Python Developer

	Skill	%
1	python	88.31
2	linux	38.96
3	git	36.04
4	django	31.49
5	javascript	31.17
6	sql	29.55
7	postgresql	23.38
8	docker	21.75
9	rest	18.18
10	mysql	16.88
11	html	16.23
12	aws	14.61
13	flask	14.61
14	jenkins	12.66
15	css	12.66

Figure 7.3. Top skills extracted for data analyst, scientist, engineer and Python developer/programmer job postings

Source: Own elaboration from authors' dataset.



Name	Precision	Recall
Data Scientist	0.84	0.82
Data Analyst	0.87	0.90
Data Engineer	0.87	0.82
Python Developer	0.92	0.94

Figure 7.4. Classification experiment for job offers in data scientist, analyst, engineer and Python developer roles
Source: Own elaboration from authors' dataset.

were many more data analyst jobs than any other, and, actually, "data scientist" was the hardest to predict—which could mean that it required the widest variety of skills. Due to the use of a ML classifier, we could extract feature importance in terms of the unique skills that characterized each of the occupations. The resulting top 10 skills that are specific for each of the roles are presented in Figure 7.5.

As a summary of the results of both of these approaches (exemplified in Figures 7.3 and 7.5), it is easy to see that data scientist profiles include deep learning and machine learning knowledge. This state of reality partially implies that there is a strong connection of this occupation with AI and prediction. Secondly, data analysts were mostly connected with traditional analytics and office skills, but also required knowledge of python libraries and the statistics software used for data visualization, as well as other commercial analytical software. Data engineers, on the other hand, were mostly programming- and software-focused, and had the need for the knowledge of Scala, Haskell and NoSQL and big data databases, along with stream processing libraries. Python developers, in contrast, were more focused on

Data Scientist	Data Analyst	Data Engineer	Python Developer
tensorflow	excel	redshift	flask
keras	spss	orientdb	tcp
yarn	scipy	kibana	mongodb
deep_learning	office	scala	gerrit
nlp	sap	kafka	javascript
matplotlib	dbms	haskell	git
maths	mes	maven	bitbake
nltk	tableau	mdx	bamboo
machine_learning	matomo	vpc	redis
tfs	edi	etl	django

Figure 7.5. Top 10 unique skills specific for given data centred role based on feature importance of the classifier
Source: Own elaboration from authors' dataset.

providing web services with Flask and Django, along with front end and databases experience. Their skillset included a large quantity of software version management tools. Overall, the results are very interesting, but a confrontation of the results with other studies is required to build stable profiles for these roles. Summarizing, while some skills were prevalent among multiple data processing roles (SQL, and, of course, Python and R to some extent), the **analysed job profiles differ significantly** both in terms of their top skills, but also in terms of their distribution among offers, which answers both the **second** and **the third research questions**.

Data centered roles characteristics: an interesting outcome from the previous study is that some key skills for each data centred roles were identified and they do differ between the roles. This may confirm that the proposed division of the roles presented was justified. What remains to be answered, is to what extent the results correspond to similar studies and if there any dynamics which can be observed in these occupations that might have been missed. The approach proposed was unique in terms of an ontology-based approach to skill detection, which allowed a much broader keyword search for identifying the technologies used. On the other hand, the key skills identified should remain the same even in simple keyword-based approaches. Hence, to confirm the general nature of the results, before describing the role skillsets in detail, we will need to look at the results in a broader context of other analysis performed in the literature.

7.4. Comparison of results with other studies

According to the job interviews analysed by dataquery (Feng, 2021), data scientists required strong machine learning (and by the proxy of area, also AI) skills, with strong algorithmic knowledge, and ability to solve case studies, supported by statistics/AB testing and Python/SQL skills. This was also confirmed by our findings.

Similarly, the recent study by Jack Chih-Hsu Lin (Chih-Hsu Lin, 2020) on the dataset of 5,5 thousand data scientist jobs from 2020 in the US, identified similar key skills for all of the roles (as can be seen in Figure 7.6). He also pointed out that Python was more important for data scientists, while Excel and Tableau had pre-eminence for the Analysts. Spark, however, was more popular among the requirements for data engineers. What is interesting, is that some of the companies (hard to measure exactly, but about 5–10%) did seem to include skills clearly connected with other occupations—like the requirements for Tableau for data engineers or C/C++ knowledge for Analysts. This points to the fact that companies are sometimes looking for people who can actually fill multiple roles in one job offer, which may also influence the talent shortage on the market.

The last study, published in March 2021 (Shin, 2021) by Terence Shin, analysed over 15 thousand job postings from Indeed, Monster and SimplyHired platforms. Unfortunately, the approach was only limited to about 45 skills that were chosen

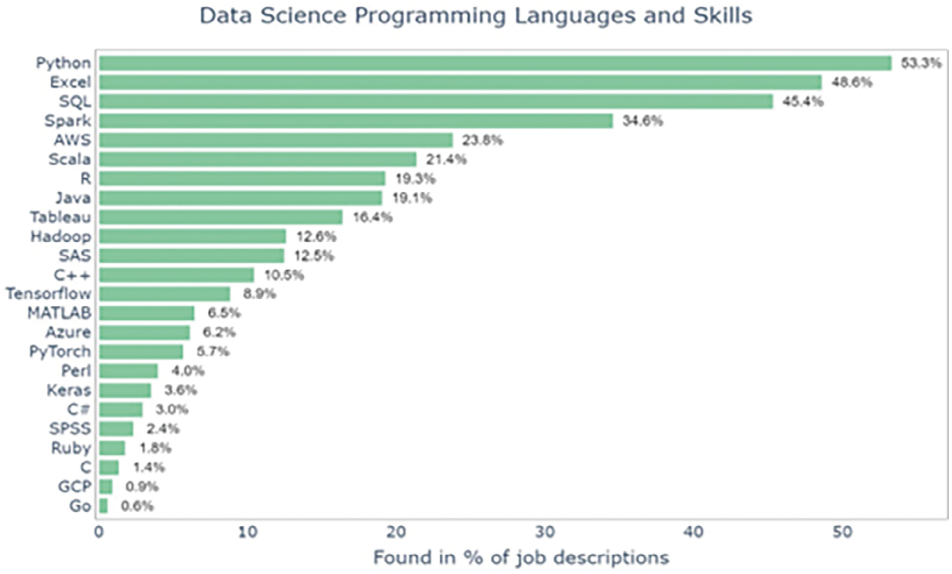


Figure 7.6. Percentage of 5,500 US job postings in 2020
Source: (Shin, 2021).

by the author. The results however, seem to be interesting due to the fact that they confirm the stable nature of the popularity of the most often mentioned technologies. The popularity of Python, SQL, R and other mentioned technologies seem to be in line with the results of our and Jack Chih-Hsu Lin's studies. Unfortunately, we are unable to confirm most of the data analyst skills, as Excel and other commercial technologies (with the exclusion of Tableau) were not included in the keywords for his experiment.

The role of data analyst has been recently mentioned in one of the largest IT studies in Poland, covering the Polish IT market in 2021 and carried out by bulldogjob.pl. It was classified as responsible for 6% of the overall demand for IT jobs and was divided into: Business Analyst, data analyst and System Analyst (bulldogjob.pl, 2021). The role was mostly connected with modelling IT software and its requirements, but the data centred role was mostly tied to business reporting, with Excel, SQL, Oracle and Python as main skills for the job. This also confirms the findings of our skills study that emphasize this job's role at providing business applicable analytical reports and its close ties to other more business oriented roles in the company—overlapping with more software and requirements analysis jobs.

As for the recent dynamics, based on the dataquery (Feng, 2021) research, data engineering specific interviews increased by 40% in 2020. The second fastest position growth within data science roles went to business and data analysts—which increased by 20%. In the data scientist role, a large emphasis on algorithms, machine learning and statistics was observed. The company profiles, however, differ between even the largest companies. For example, Amazon places a higher emphasis on machine learning and programming tasks, while Google mostly cares about statistical analysis. Moreover, a more broad classification of job offers was proposed by the authors of the research, showcasing that the demand for data scientists, data analysts, business analysts and data engineers make up about 90% of the offers for the data centred roles.[6] The overall distribution and changes in the popularity of the analysed roles can be seen in Figure 7.7. In terms of **the skills that increased in popularity in 2021**, based on the Terence Shin's (Shin, 2021) study: cloud computing technologies were more popular, especially AWS, along with deep learning libraries. What is interesting, is that the requirements for the most popular skills like SQL, Python and machine learning (scikit-learn) increased even more during this period. This may be due to the standardization of skillsets for those positions over the years, or just the fact that companies are more aware of the most popular technologies due to existing infrastructure. The most trending skills in 2021 can be seen in the bottom part of Figure 7.8.

[6] The inclusion of business analyst was an interesting choice, partially confirmed by our findings on the variety of skills for analytical roles and possible misunderstandings between data and business analysts responsibilities.

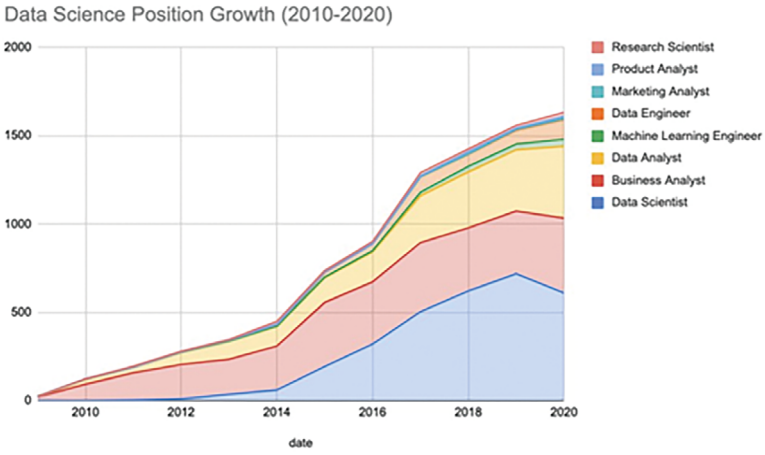


Figure 7.7. Growth of more detailed data centred roles
Source: (Feng, 2021).

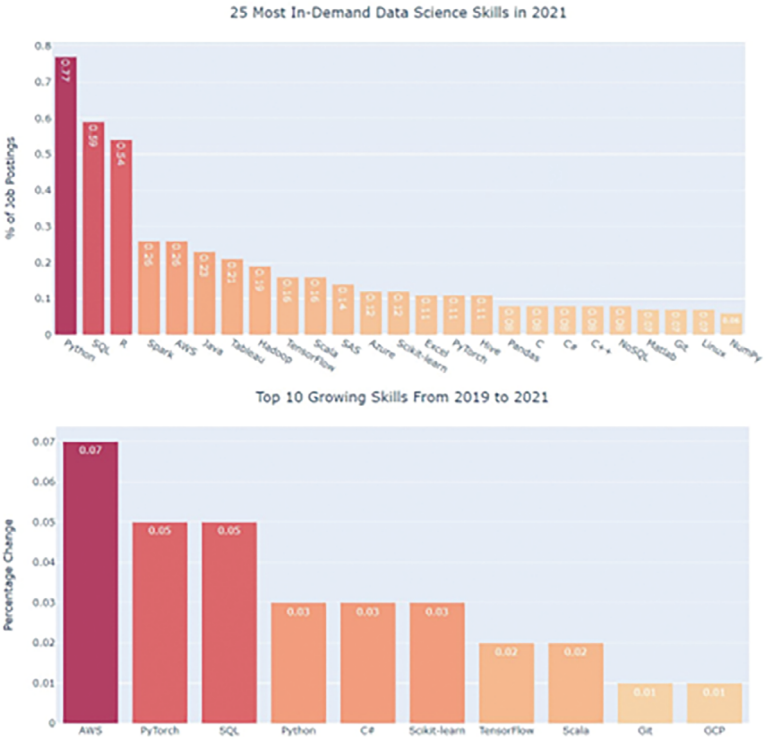


Figure 7.8. Percentage of 15,000 job postings from Indeed, Monster and SimplyHired that contained chosen skills (top) and trending skills between 2019 and 2021 (bottom)
Source: (Shin, 2021).

7.5. Summary of profiles for data centred roles

Relying on all of the previously mentioned analytical studies, we can try to summarize the responsibilities and generalize the skillsets of the data centred roles. Although multiple technologies were found, they often correspond to similar tasks and general responsibilities which these jobs are expected to perform in enterprises. Summarizing these descriptions:

- Data analysts are the most connected with traditional analysts roles (business and system analysts), and they are mostly tasked with explaining current issues and presenting them to business representatives by the use of company's data. The quanthub interpretation of their responsibilities (duBois, 2020) seems to be fitting, as they provide processed information that enables companies to make business decisions primarily working on structured data from a single source and are strongly tied to a company division. Their professional needs emphasize statistics, communications and business oriented skills to not only perform historic analysis on organized data, but also to enable data-driven decision-making on a daily basis. These positions exhibit high demand for knowledge of SQL and commercial analytical software such as Excel, Power Bi, Tableau, VBA, SAP, SAS, SPSS, Access and Oracle. They use the infrastructure, software and databases that are already in the company to provide more insight.
- Data scientists, in fulfilling their most popular role, mostly emphasize machine learning and AI skills (machine learning, Spark, Tensorflow, data science), along with strong programming (Python, R) and data processing (SQL, Spark, Hadoop, big data, Hive, AWS, SAS) knowledge. The combination of broad keywords such as machine learning, data science and big data may however, emphasize that it is either hard to specify technologies or that employees assume data scientists will choose the right tools that are good for the job. The only libraries mentioned in the top skills are tied with data processing large quantities of varying data, which showcases that data scientists should be able to perform machine learning not only on megabytes of queried data, but also thousands of gigabytes or several petabytes of varying data stores. Where data analysts provide the foundation for decision-making, data scientists should be able to extract, process and infer on the data sources, while providing predictions and self-sustaining data products for mostly internal purposes. They seem to be expected to work throughout the entire process of developing a business prototype, and be able to resolve outstanding issues, which explains the higher variability of skills required for the role and the focus on prediction methods.
- Data engineer skills are much more focused on the deployment of the analytical software prototype in an effective way and providing data for the

analysts. The technologies required describe a skillset similar to traditional database and ETL specialists (SQL, ETL, Oracle, Java[7]), but highly extended with big data technologies for data processing and storage (big data, Spark, Hadoop, NoSQL, Hive, Kafka) and cloud computing knowledge (AWS, GCP). They lean more toward service management and providing the most effective ways of data processing company data by the use of dedicated programming languages (Java, Scala, Python). They are more in line with DevOps than machine learning or git skills as they can also work in deploying the data scientists' results.

- Python developers, effectively utilizing the same technologies as previously mentioned positions, are mostly characterized by very strong programming (Python) and SQL skills, along with the ability to manage self-sustained software (Linux, git, Docker, MySQL, Jenkins), supported by front-end frameworks (Javascript, CSS, HTML) and a database backend to create a full-stack web service (REST, Flask, Django). It can be clearly seen that the skillsets exemplified closely follow the DevOps approach for software creation, emphasizing continuous deployment, testing and release management roles with a skillset that is effectively a full-stack developer knowledge.

Overall, the analysis allowed us to generalize the responsibilities of analysed roles and compare them with developers, who use the same programming language as most of the data specialists. The number of data analysts is sure to increase and the basic "data literacy" skills connected with processing and visualization will continue to surge as companies will switch from excel to more analytical software or even data analysis libraries in languages like Python and R. The data scientist and engineer seem to be far more specialized roles. The first appears to have a very wide variety of skills, but significantly emphasized machine learning techniques (with deep learning and text mining knowledge), along with traditional data processing knowledge, supported by business and analytical skills in which the other two positions specialize in. This, in turn, means that some of data scientists may be responsible for analytical or data engineering tasks or are at least required to have basic knowledge in those areas. Data engineers, on the other hand, have a more focused skillset, emphasizing cloud and big data computing, along with technologies and libraries that allow fast and efficient processing of varying data sources in line with the big data paradigm. Their role is to bring an ETL and SQL company to the big data era and enable the processing of error-free, fast and high volume data sources that are built into various technologies.

[7] Exemplified by availability of ETL processing, JDBC drivers and ORM libraries.

7.6. Data science—supply (teaching)

An additional topic that was worth noting is the supply part of the market, exemplified mostly by the Universities' "data science" and analytical or computer science programs. As a lot of the skills described previously requires extensive mathematical, statistical and computer science knowledge, so it is reasonable to assume Universities are the first step in addressing the required skills shortage and the over-increasing gap of experts in this field. As an additional argument, most of the market studies showcased that over 90% of the currently employed data scientists and engineers have a master's degree, which only solidifies the previous assumption.

The goal of this analysis is not to showcase what technologies to teach, as it would break the general goal of a University degree. However, it should be an assumption that when a data science or data analyst program is offered by a University, it should teach at least general skills connected with the roles described earlier. As such, for example, there is no difference as to which library will be used, as long as data scientists will learn machine learning, deep learning or natural Language processing skills and possibly will be able to process large and varied datasets in line with the big data paradigm in any of the technologies that allow it. These are valid academic subjects often originating from computer science and are the core skillset of the data centred roles in the market—as confirmed by our study.

To confront the skills with the academic curricula, a preliminary study of subjects taught in the main path of English and Polish master's degree programs were examined. As a model example, two programs from UC Berkley (exemplifying more computer science skills) and University College of London (more in line with economic studies) were used. These two were then compared with a few selected Polish master's programs which seemed to be connected with the area. Excel analytical skills were not included, as they are assumed to be basic skills learned during bachelor's studies or high school. In most of the programs, statistics and data visualization classes were taught, while some of them focused on data storytelling—which points out that most of the alumni would have no problems in these tasks. Overall, from the characteristics which were summarized in Table 7.1, characterizing the programs more in depth[8]:

- UC Berkeley (University of California, Berkeley, 2021) was chosen as the main example, with very clear curriculums exemplifying technologies used, and a high focus on cloud development. No classes seemed to be directly

[8] The analysis of the study programs was carried out in September 2021, and all changes in favor of updating the syllabuses to meet the described skill requirements from this date should be interpreted as a high level of awareness of said programs and treated with the utmost respect to their program committees.

Table 7.1. Short description of skills covered by chosen Master's programs connected with the data centred roles

Name of studies	General skills	Programmer			Analyst			Data scientist					Data engineer				
	Project Management	Git	Web services rest	Programming	Data Visualization	Databases data wareh using	Statistics and statistical software	Big Data (general)	Machine Learning	Deep Learning	NLP	Big Data processing (Spark)	NoSQL and Big Databases Hadoop	Linux, Dev Ops	Cloud computing	Stream Processing	Java/ Scala
Master of Information and Data Science (UC Berkley)	X	X		X	X	X	X	X	X	X	X	X	X	X	X	partially	
Data Science (UCL)			X	X	X	X	X	X	X	elective	elective	X	X		X	X	
Data Science and Business Analytycs (UW)		X	X	X	X	X	X	X	X	X	S	X	X	X	X		
Data Science (Uwr)	X			X			X	X	X	elective	elective	elective*	elective*		elective*	elective*	elective*
Data Science (PW)	X			X	X	X	X	X	X	X	S	X		X	X	X	partially
Informatics and Economics (UEP): ISfBA track		X	elective	X	X	X	X	X	X	elective	S	X		X	elective	X	
Informatics and Economics (SGGW): "Big Data"	X		X	X		X	X	X	X	X		?					
DataAnalysis-BigData (SGH)				X	X	X	X	X	X	elective		X	X		X	X	

Source: Own elaboration.

tied to traditional REST web services, but the use of various API's were mentioned. Additionally, data visualization classes included not only Tableau, but also Javascript visualization libraries. One of the final subjects was a data science problem-solving project using real-world data and covering the issues of collaboration and project management skills.

- The data science program for UCL is more focused towards financial risk, stochastic methods and quantitative modelling (University College London, 2021). It, however, contains most of the key data analyst and data scientist skills and there are no general subject like management, economic theory or similar. All of the studies that correspond to the domain area of finance and economics are closely tied to analytics and the descriptions are phrased in a way that describes the usefulness of these subjects to analysts. UCL also has a more computer science-oriented program called "Data Science and Machine Learning".
- Comparatively in Poland, there seem to be a lot of programs tied to the economics departments (UW, UEP, SGH) compared to that of computer science or mathematics. The overall interest in this area for economics is the natural evolution of economic computer science courses (Korczak, Abramowicz, Gołuchowski, Kobyliński, & Owoc, 2014) that have a strong tradition of being connected with business information systems and data analytics. The changes are mostly due to the shift in the paradigm of data analysis services: dig data replaced data warehousing, cloud replaced web services and Tableau, along with visualization tools, took over ERP systems for enterprise analytics and business intelligence).
- Overall, UW (University of Warsaw, 2021a) seems to propose a very intriguing program fitting almost all of the criteria, with a very interesting course called "Reproducible Research", which covers a lot of the issues required by the business requirements [28], including: linux, git and cloud computing.
- The programs of UWr (University of Wrocław, 2021), SGGW (Warsaw University of Life Sciences, 2021a, 2021b) and PW (Warsaw University of Technology, 2021a) have the issue that most of the key skills concerning big data technologies, data processing etc. are stacked into very small, often elective courses or not offered at all. For example, in UWr, a lot of the skills (SQL, Scala, Hadoop, Spark, Cloud Computing, Stream processing) are taught in one course that is limited to 15 participants called "Tools and Methods in Big Data Processing". This includes all of the elective courses with an asterix (*) in the table, which the University can have graduates with no knowledge over the main skill areas of big data processing and software development. In case of PW, the same role (but fortunately in less areas) is carried out by the "Big Data Analytics" course (Warsaw University of Technology, 2021b).

- Other economic programs like SGH (SGH Warsaw School of Economics, 2021a, 2021b), UEP (Poznań University of Economics and Business, 2021) have a significant number of data centred skills taught (but slightly less than UW). It is also visible they have much more very general economics subjects than any of the other master programs. UEP did not label their studies as data science, so this is more understandable, however, overall, the subjects taught position it very close to a full data science program, as compared with other studies. The same issue of emphasis on general subjects applies for UWr and mathematics. It can be clearly seen that most of the subjects are very similar to the ones offered by other master's degree programs by the same faculty.
- The non-data analysis[9] skills take as low as 10% (UW), about 30% (SGGW, UW, UEP) to 50% (UWr) of the program, although in this case, the strong mathematical background may have been intended. The most focused program is "Data Science Masters" offered by PW. This has only two theoretical electronic courses: "Electronic Principles" and "Data Transmission", despite it being tied to the Information Science and Mathematics faculty, it does not offer that many theoretical subjects out of the scope for data centred roles, but it is still behind the Berkeley program in that regard.

Overall, in our analysis we did not include some studies offered, for example, by UAM (Adam Mickiewicz University, 2021) or PJATK (Polish-Japanese Academy of Information Technology, 2021), partially due to the fact, that to the best of authors' knowledge, there were no widely available descriptions of the syllabus content and so the list may be extended in future. The results are based only on a preliminary study of information found online, but some may argue that this might be the same source of information students will seek. Non-master postgraduate studies were also excluded from our study.

Interestingly, a lot of Polish programs analysed include a large number of general subjects that differ from University to University. Where PW includes, for example, "Principles of Electronics", clearly an aspect of computer engineering, UW, SGH and UEP propose courses in mathematical economics, marketing or finance (actuarial methods). UWr, on the other hand, offers a lot of courses focusing on the mathematical principles behind data science. The problem is not with these subjects, but that, sometimes, the hours they are assigned are disproportional to the number of courses exemplifying the key data science skills identified by us in the study. For example, the UWr program educates mathematicians and provides them with some analytical and data science skills. This showcases that Polish curriculums are significantly more tied to main scientific disciplines and less focused

[9] Meaning not teaching any of the skills identified in the analysis or general skills tied to responsibilities like data processing, visualization, data management etc.

on teaching classes aimed at developing analytical and data processing skills than are their top tier foreign counterparts.

While nearly all of the key skills were included in the study programs, sometimes a multitude of important skills are taught in 30 h of a single course. This creates an interesting conundrum, where more emphasis and time is spent on teaching the main discipline theoretical subjects than on data science in a data science master's course. This might happen partially due to adding data science (which is a very promising and popular area of education) to current programs and curriculums that are tied to the existing faculties that want to integrate subjects taught for multiple programs. This emphasis, however, is partially based on the requirement for Polish study programs to strictly follow the guidelines of assigning ECTS to underlying scientific fields of science (Economics, Computer Science, Computer Engineering etc.). Compared to the Polish programs, US and UK top data science programs are significantly more focused on analytics, and exclude many general subjects. For example, Berkeley's data science program offers more hours of training in key analytical skills and the same can be said for other programs from Carnegie Mellon University, Harvard or Colombia.

Overall, however, despite the fact that multiple the important issues in Polish curriculums are covered for some programs in only one subject, the coverage of the skills by the curricula seems to be good. However, the small number of subjects covering Hadoop and Spark, paired with the significant underrepresentation of Git, DevOps and Java or Scala skills seems to be an issue in teaching data engineering skills. Still, most of the programs teach both Python and R, with the use of R mostly for teaching statistical inference, regression and time series and panel data analysis—which is in line with global trends. The big data databases (Hadoop) and streaming environments seem to be lacking in some of the economics programs, and are sometimes overshadowed by SAS software, which is a significant over representation of commercial big data analysis software for these academic programs.

7.7. Recommendations for data science programs

As for the general remarks to the changes in data science programs compared to the other areas, based on the recommendations by (Hicks & Irizarry, 2018), the teaching needs to consider more training in computing (data management and processing), as well as in connecting—connecting the subject matter question with the appropriate dataset and analysis tools—which is not currently prioritized in statistics curricula (in terms of researching the dataset, data transformations, visualizations, cleaning and processing). In addition, emphasis should be placed on creating: in terms of searching for answers in the data, processing it by known methods and evaluating the results.

The courses should also emphasize real world problems, more projects and less memorization (which seems rarely useful in terms of the ever changing nature of the technologies and syntax used). Since, data science is more problem-solving oriented and less descriptory, this means that teaching data science emphasizes connection to solving business issues by employing the scientific method—and this emphasis should be visible in the nature of the studying process. It could include: more classes held by business professionals (Kross & Guo, 2019), or more group projects and data experiments. Overall, most of the Polish data science programs suffer from the very large number of general subjects, which significantly limits the key skills in big data, cloud computing and deep learning that they should provide. Summarizing the outcomes, a good data centred program should:

- In terms of bachelor's degrees, focus on teaching the basics of data analyst skills, which can include management of IT systems widely used in business, such as SAP, SAS, Office etc. Training in these should be expanded with developing skills in using PowerBI, Tableau or Web Analytics tools, as the work for IT professionals is more focused on analysis than on manual programming. This is supported by the requirements for skilled business professionals, in line with the findings of (Waller & Fawcett, 2013).For training in data analysis and other analytical roles, the inclusion of these skills, along with having strong statistical and mathematical backgrounds is crucial.
- The importance of teaching programming languages has not changed. Python has proven to be effective for teaching algorithms and data structures. It is not suited for studies which require low level embedded or network programming, such as computer engineering, automatics and robotics etc., but knowledge of it is very good for data centred roles, as Java and Scala programming are encouraged to be included or remain in the main-stream programs.
- Statistics, econometrics and similar courses should be accompanied by machine learning. What is more, the contents of the subjects should follow a coordinated approach for teaching the students how to solve different business problems while relying on a given source of data. Students should also learn multiple methods for analysing, classifying and predicting based on mining different types of data. Furthermore, training in NLP and graph analysis should be mandatory and non-elective to provide alumni with expert knowledge on the subject of data analysis.
- There should be significantly more focus on solving data-oriented problems and building services, and, later on, in using cloud computing or building API's, concept supported by other studies such as (Donoghue, Voytek, & Ellis, 2021). Theory should be accompanied by less textbook examples and more open datasets in which the limits of some methods should be learned. As noted by previous researchers, students must handle real, demanding data

to be prepared to be able to clarify situation wherein some assumptions of the statistical tests are not met.
- Computer networks, operating systems, databases and similar "hard" IT subjects should include how to prepare students in choosing the right IT architecture for the solution, and less on theoretical principles that are useful for engineers.
- As an addition, students should learn the development process, both from an analyst perspective (by being able to discern UML diagrams) and that of project manager (by understanding requirements analysis, task management in tools like JIRA and differences between approaches of Waterfall and Agile (including Scrum)—this is emphasized by the requirements of Agile knowledge and by the overall nature of the current IT management paradigm.
- The program should be highly focused on teaching all of the key skills, with a reasonable number of hours and ECTS assigned to develop key knowledge and data management expertise.

Conclusions

This article solidified the demand expectations for the role of data experts, identifying multiple diverse roles tied to this area (data analysts, data scientists and data engineers), along with a multitude of professions in great demand (research scientists and machine learning engineers). The need for those roles did not seem to be affected much by the pandemic: the slowing of the digital transformation of reluctant companies is countered by increases in demand for those experts among the leaders of the IT transformation. Automatic analysis of key skills relying on semantic databases and NLP knowledge, allowed building clear skill profiles for the major roles in this environment and showcased significant differences in skill-sets that correspond to the responsibilities held by different data experts within commercial, business and industrial enterprises.

The research provided interesting results in profiling the multiple data centred roles present in the job market. Our approach for machine learning has brought interesting results, but it could be extended further on as a possible tool to differentiate between the roles and possibly to help in classifying new job offers for companies which are unsure what occupation of data expert they are looking for. Some of the new occupations like machine learning engineer and research scientist were not included, as they had far too few offers in Poland as of the time of writing this article, but this might change in the near future.

As a limitation of our research, in our approach, not all of the skills were included, especially not soft skills, which could potentially create some new insights

into these roles—which is an interesting area of further work. However, based on the technical skills analysis, the Polish market of IT skill requirements for data centred roles do not seem to differ in any way from US and global trends, which means that the specialists are interchangeable in this global market. The demand for data centred roles seems to be similar, emphasizing that the talent shortage also appears in Poland.

Due to the diversity and changing nature of the skills, not all of the required technologies are taught broadly in the University programs, but according to the preliminary study of curriculums, most of the key skills are included in current offerings. Unfortunately, most of the Polish master programs lack focus on the main analytical skills found to be crucial in this study, and it seems that data science was just thrown into the already existing master programs, sometimes with a name change. Data specialists need to have a very wide portfolio of technical skills, which they must update every year—which means that the technologies are expected to be shifting. However, the big data paradigm of computing and connected technologies, cloud computing, machine learning, deep learning or stream processing have been present in the scientific literature and different study programs for years.

This may highlight the reason for the shortage of data scientists and engineers on the market—as the requirements of companies seem to require a multitude of different skills, which universities struggle to prepare their alumni for. Meeting the average skillset for data scientist or engineer requires extensive experience in dealing with technologies that are often hard to self-learn (e.g. cloud computing). As noticed by Song and Zhu (2016), "the biggest bottleneck in the big data era is the production of capable data scientists, and producing such capable people takes time". Due to this, the programs offered could specialize more, there is no possibility of graduating IT experts alone, as the area has broadened so much in the past 10 years that the notion is unrealistic. Similarly, as there is no single program to produce an engineer, with the profession's multitude of specialties and disciplines and unique key skills, there is no way to build an all-around IT expert.

On the other hand, these specialists should not be expected to be the 'one man army' that the current entrepreneurs are looking for. It is crucial to understand that average developers are not machine learning experts and run of the mill data scientists are not developers. While a data scientist is crucial to have in the team when collaborating on developing an innovative data-driven solution, they are mostly not equipped to scale the solution, which is what data engineers (or DevOps specialists) are for. This, of course, does not mean there are no experts that will meet these criteria, but if the focus is on minimizing the gap—narrowing the responsibilities for each of the roles may contribute to higher chances of educating future data experts and decreasing the talent shortage. The description of responsibilities contained within our study may also help future entrepreneurs in specifying

what experts do they need in their companies, narrowing the expectations may lead them to more effective processes of developing innovative products and services.

The profiles extracted for these roles allowed us to clearly differentiate between the responsibilities of data centred roles, but the skills demanded from a single company may still differ from the averaged profiles that we created. We may expect some unification in the future, as well as the appearance of roles which better emphasize some of the current roles, hence, narrowing the skillset (machine learning engineers or cloud architects), which may, in turn, influence the skills of the main-stream occupations.

Our analysis of the curriculums proved to be interesting in terms of assessing the supply of data skills. Still, our reasoning only provides conclusions that might help in meeting the shortage of experts in the data market. The results of this article may offer some interesting insights for some of the stakeholders in the job market:

- **For companies interested in data analytics:** With an increase in demand for data analysts, data scientists will play a more precise role as machine learning / AI specialists, applying their skills to develop prototypes of new data-driven solutions. The technologies they use may be influenced by existing company structure and market trends. Executives should take a selective approach to determining which analytics specialists are really needed and whether the goals can be accomplished with automated tools or available services (Ramachandran & Watson, 2021). The role played by a data scientist or any other data expert should be in line with the company strategy and their skills should be used to address specific needs (prediction, AI, new products) in which the company requires custom tools or wants to gain a competitive advantage. On the other hand, the majority of the daily analytical jobs are to be performed by data analysts whose held skillset must slowly evolve from PowerPoint and Excel, to the world of Python/R/SQL and Tableau dashboards or other visualizations utilizing the vast data sources transformed by data engineers.
- **For innovative entrepreneurs and startups:** The outcome of this article exemplifying key analytical skills should help in discovering bona fide data scientists among the students and alumni of University programs that meet their needs. The entrepreneurs should, however, be aware of the possibilities that big data, machine learning and connected technologies can offer. Data scientists will not be these magical experts that can solve all business, technological and organizational challenges in a startup. The skillset analysed describes them as experts with very precise knowledge on data processing and predictive analytics, with a much more goal- and product-oriented approach than that of data analysts.
- **For aspiring data scientists:** Investing time in learning either cloud computing or machine learning and deep learning technologies is the most promising

area for meeting the skill shortage in the near future. With hands-on experience with AWS/GCP/Azure, Spark/Hadoop and other big data processing and database knowledge engines, there might be a lot of data engineer jobs opening in the future, as the trend for this role is on the rise. On the other hand, it does not seem like the need for data-centred roles is going to decrease anywhere soon, but the emphasis on specialization may make it easier to find suitable and responsible job positions. Overall, the need for both specialized data experts and those who will perform daily business analytics will increase as companies are expected to build more and more complex analytical pipelines in the future.

- **General University programs remarks:** For now, Polish Universities offering "data science" and similar programs do not seem to have a clear skillset profile of the alumni for their Master programs or lack focus on key skills. Their approach seem to be more in line with teaching a good base of general skills tied to the main discipline of the studies that is only enriched by data science knowledge. However, due to the very broad nature of skills that are required by data expert roles, they might consider putting more focus on big data, cloud computing and similar key skills which are now a requirement for data scientists and engineers. This might help in addressing the shortage of skills in the global economy and teach a new generation of experts, who being equipped with the latest knowledge, might create much more opportunities in terms of innovation. Ensuring all of the 'hard skills' are covered by their curricula by adding in a reasonable number of ECTS might be a solution for the issues described—as the market does not require just some postgraduates, but it needs data scientists, engineers and analysts with a well-defined set of skills applicable in modern enterprises. In a world where big data, NLP, AI and machine learning are used widely even in academic studies, there is no reason to limit these subjects in master programs that are directly focused on data science, big data or business analytics. The possibility of undertaking this and achieving high success rates has been demonstrated by non-Polish top tier universities offering similar master studies with much more focused study programs in this domain.

The findings of this article are only the beginning for a full description of the responsibilities and skills evidenced in those occupying data-centred roles. The analysis of technical skills allowed showcasing key responsibilities and reveals that it is possible to differentiate between some of the data expert activities. However, with the appearance of more specialized roles in the upcoming years, the exact skillset may still change. Technical analysis of demand for particular skills over the years should, however, be the base for any governmental, university or private educational programs addressing the education of AI and data experts. The

stability of measured skills over the years demonstrates that some key responsibilities, e.g. data processing and prediction skills, remained stable over time despite the adoption of new tools. This might provide incentive to teach those key skills, which are we do not suspect to significantly change in the upcoming three or five years. Addressing them can decrease the data expert talent shortage that the world is currently facing.

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FINAL REMARKS

The book *Academic entrepreneurship in theory and practice* was designed to make contribution to the development of academic entrepreneurship studies. As this field has expended dramatically in recent years, the book provide forum for the discussion about academic entrepreneurship in CEE countries and show the diversity of issues, definitions and practices on the Polish example. Complex in its approach, it includes some theoretical and empirical works with references to fundamental principles, evaluation of existing concepts and theories.

The publication is the result of cooperation between Poznań University of Economics and Business and Santander Universidades within "Academic Initiative on Entrepreneurship and Innovation at PUEB" project.

SANTANDER UNIVERSIDADES

Santander Universidades is Santander Group programme supporting universities and colleges in Poland and abroad. It aligns with the Banks engagement in sustainable development. For over 25 years, Santander Group has been supporting educational initiatives through Santander Scholarships—so far, it has granted 630 thousand scholarships worth over EUR 2bn.

Santander Universidades supports students in developing skills of the future, such as:

- foreign languages;
- digital skills;
- soft skills;
- business and entrepreneurship knowledge.

The Bank offers free of charge training courses delivered in liaison with leading academic centres from all over the world. Thanks to that, students and academic staff have an opportunity to educate themselves and expand presence in international environment and gain international certificates.

Moreover, the Bank organises meetings with experts and business projects at which students can gain practical skills. Applications for skills-developing programmes can be filed at www.santander-grants.com/pl.

Santander Universidades in Poland

Santander Universidades launched its presence in Poland ten years ago, in December 2011. Since then, it has joined forces with 59 Polish universities and colleges thus helping thousands of students, graduates and academic staff spread their wings.

"Our mission is to support the academic community. We deliver this mission by promoting lifelong learning, which is indispensable in the dynamically evolving labour market. We help young people start their professional journey but also create opportunities for all those who want to expand their expertise", says Wojciech Leśniewski, Head of Santander Universidades in Poland.

Cooperation with Poznań University of Economics and Business

The first agreement between Poznań University of Economics and Business and Santander Bank Polska S.A. (the then Bank Zachodni WBK S.A.) was signed already in May 2012.

The oldest joint initiative is the annual Golden Mouse Contest. The contest consists in preparation of individual or group business projects using state-of-the-art IT and mobile technologies. The main awards and recognitions are given to students who design the most interesting solutions addressing the contemporary global issues.

”This contest is not a pure competition—it also encourages students to think creatively, to engage their knowledge and skills in order to create a business project that affects the functioning of a particular organization“, said Vice Chancellor for Education and Students at Poznań University of Economics and Business, Associate Professor Anna Gliszczyńska-Świgło, PhD, Eng. during the Final Gala of the 22nd edition of the contest in February 2021.

Moreover, Poznań University of Economics and Business hosted numerous other initiatives developed in liaison with Santander Universidades:

- Santander Universidades Awards—academic grant contest aimed to financially support the leading students, doctoral students and academic staff.

Students visit to Santander Global Head Office—a group of 20 students from the Business Finance and Accounting Faculty and Management Faculty had an opportunity to visit Santander Global Head Office in Boadilla del Monte.

- Dual degree for Management and Economics Faculty—an initiative involving many parallel activities, such as adding Spanish language classes for students and academic staff, and developing a joint academic degree programme for Poznań University of Economics and Business and IESIDE Business Institute in Vigo (Spain).
- Design of a new form of interaction with the user of Omnipresent Banking Applications—development of a universal description of interactions with the application user.
- uBankApps: omnipresent mobile banking applications—the goal of the project was to develop a method and tools enabling development of universal, multi-functional mobile banking application.
- Supporting conferences, such as: European International Business Academy (EIBA), International Conference on Finance and Economic Policy (ICOFEP) 2nd edition (Economics Faculty), INFINITI Conference,

International Conference on Theory and Applications in the Knowledge of Economy TAKE 2018.

- NeedApp—programming marathon.
- Santander Development Scholarship | From idea to own business—a series of sessions addressed to persons willing to start their own business. The sessions aimed to share practical skills and to enable consultation of business ideas.
- Development of the Academic Initiative on Entrepreneurship and Innovation at Poznań University of Economics and Business, which organizes various business-themed events and promotes programmes to develop skills of the future.

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With the increasing interest in academic entrepreneurship (AE), an interdisciplinary and multidimensional phenomenon, this book provides insights on the different aspects of the process, especially from the CEE countries. The topics cover include the theoretical issues related to defining and understanding AE as well as the empirical research featuring aspects of AE at the organizational levels of analysis that encourage the interchange of experiences from diverse institutional environments.

The audience for this book comprises researchers, policymakers and university students in the fields of management, strategy and entrepreneurship.

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