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BARRIERS TO THE DEVELOPMENT OF SPIN-OFFS. A FUZZY-SET THEORETIC APPROACH

University spin-offs have idiosyncratic strengths in comparison to other new firms. However, evidence also shows that Polish university spin-offs have a low survival rate, and only a small percent of them grow into sustainable businesses. The purpose of this paper is to carry out an empirical study to determine the nature of barriers to the growth of Polish university spin-offs, in order to address the two major research questions considered by this paper: what are the major barriers to growth, and which combinations of these barriers have the greatest impact on the performance of the university spin-offs under study? Firstly, this paper attempts to explore these research questions through a literature review and pilot interviews, based on which a questionnaire was developed. Secondly, this study attempts to address the research questions through a fuzzy-set-theoretic approach by using a software package, such as fs/QCA- fuzzy set Qualitative Comparative Analysis. This paper identifies six key groups of barriers to the growth of university spin-offs in Poland, namely financial, competence, psychological, organizational, informational and formal barriers. Moreover, four alternative configurations of key groups of barriers to the growth of spin-offs that lead to low performance among the organizations examined are distinguished using fs/QCA. This problem is interesting not only from a scientific, but also a practical, point of view, pointing out the need for increased attention, not only from academic entrepreneurs themselves, but also for greater effort from universities and the government to cultivate university spin-offs. Most importantly, simultaneous action in all of these directions is necessary. The continuation of such research is also important, which will consider, on the one hand, a larger sample of firms, and, on the other hand, the results achieved so far and their re-conceptualization.

Keywords: *academic entrepreneurship, university spin-off, barriers to growth, fuzzy-set-theoretic approach, fuzzy set qualitative comparative analysis*

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1. Introduction

Enterprises referred to as university spin-offs came to being in the Polish economy along with the economic transformations in the early 90s. The period of more than twenty years that has passed since that time has not been marked, however, by their luxuriant growth. Nevertheless, recent years have seen increased interest in this subject from researchers. Precise estimation of the size of the spin-off sector in Poland is difficult due to the lack of reliable statistical data. It is estimated, however, that there are at least several dozen of them. According to the Association of the Organizers of Innovation and Entrepreneurship Centres in Poland, about 90 university spin-offs were active countrywide in 2015. The data collected show that, in terms of their economic characteristics, these firms do not diverge from the standards of European spin-offs. Usually, these are small-sized firms employing fewer than 10 workers and often using outsourcing. The incomes of spin-off firms are normally between 250 and 500 thousand EUR per year. The creators of these firms are chiefly people with higher technical education, who often also have an academic degree and were or are still employed in academia. Links with academic centres constitute an important source of innovation and information to these entrepreneurs. Many of them have retained their university positions and participate in academic research. These enterprises fill gaps in high-tech production and services. They also provide high quality, specialized consultancy services, comparable to those offered by similar centres in other countries.

The dynamics of the growth of university spin-offs is still low in Poland, where it is generally accepted that, on average, two or three such entities are established countrywide per year. Academic entrepreneurs have faced, especially during the global economic crisis, numerous barriers, both procedural and mental, which have impeded the growth of university spin-offs in Poland. What is more, from the perspective of the growth of such firms, some studies have analysed the factors that impede or facilitate the creation and development of university spin-offs [7, 12, 15]. However, there is little research that has examined barriers to the growth of university spin-offs specifically in Poland. Furthermore, even less research has carried out empirical investigation of the “potential” barriers using a large sample, rather than examining unique, but limited, cases. This reflects a research gap which requires further inquiry.

This research is based on an empirical study aimed at determining the nature of barriers to the growth of Polish university spin-offs. The research questions posed in this paper are: What are the major barriers to growth? What configurations of barriers are most likely to lead to low performance amongst the organizations under study? This paper attempts to explore these questions by examining Polish university spin-offs via a fuzzy-set-theoretic approach by using fuzzy set qualitative comparative analysis (fs/QCA), a technique developed by Ragin [17, 20].

The remainder of this paper is structured as follows. First, a brief literature review is provided, followed by a description of the research method. Empirical evidence is then analysed from the point of view of barriers to growth. In turn, the major barriers to growth are analysed using fuzzy set qualitative comparative analysis, which enables one to determine which combinations of the barriers identified are most often associated with low performance among the firms examined. Finally, this paper concludes with a short summary that describes the conclusions of the research, its contributions to theory, and relevant implications.

2. Theoretical background

The literature on this subject shows a lack of a consistent systematization of spin-off processes accepted by individual institutions and researchers. This situation is emphasized by, e.g., Callan [4], who in an OECD report highlights a number of differences in the approaches presented by various members of this organization [4]. Analyses of the definitions of a spin-off are similarly presented by, e.g., Pirnay, Surlemont and Nlemvo [16].

By analysing the definitions of a university spin-off used in the literature, three components can be indicated as being decisive to the possibility of classifying a given entity to the group of enterprises under discussion. These are: (i) the creation of a new enterprise, (ii) the transfer of knowledge from the parent institution – a university and (iii) personal connections with the parent institution.

With regards to the first area – the creation of a new enterprise – a spin-off should include the process of creating a new enterprise in the form of a new entity, separate from the parent institution, as an independent being in the eyes of the law. In relation to university spin-offs in Poland, this factor does not raise any objections, as business activity, in principle, should be separate from the basic activity of academic institutions.

Within the second area – the transfer of knowledge from the parent institution – one of the key elements defining a spin-off is the use of various forms of knowledge generated in the institution, in order to create a new enterprise. It should be assumed, however, that this knowledge should play an important, or even key, role in the new entity achieving a competitive advantage. In some situations, whether this condition is satisfied could be questioned. In such cases, an enterprise could be considered as being independent.

As regards the third area – personal connection with the university – an important role in the creation of a university spin-off is played by persons that have been so far employed in the parent institution, which can be generally defined as an academic institution. Most often, these persons play the key roles in the transfer of knowledge to the new entity, especially as far as know-how and unique knowledge related to specific solutions are concerned. Such knowledge is very hard to transfer in a formal form

– documentation, drawings, etc. Hence, their participation in the technical sphere of the undertaking reduces, in principle, the risk and the venture costs.

In Poland, as elsewhere, university spin-offs develop in those branches of industry that are regarded as prospective and having potential for growth. These includes sectors, such as biotechnology, chemistry, informatics, microbiology and electronics. According to both studies on academic entrepreneurship and European Commission reports, the success of a firm is primarily determined by factors, such as financial security and a developed, friendly business environment. Moreover, certain skills are important, such as creativity or the ability to gain partners, who could support an enterprise's activity in the spheres of both substantive and financial potential. The skills and knowledge of the main originators of an undertaking are also important [11]. In spite of the absence of reliable quantitative data on the establishment of spin-offs in Poland, the relatively low interest of academics in economic processes in a macro- or microeconomic context is noticeable. Moreover, reluctance to make changes is visible in Poland, together with the opinion that science is a value in itself and thus there is no need for it to enter into any deeper interactions with the world of business, since this might be to the prejudice of the nature of science itself or the research conducted. Moreover, a source of the low level of entrepreneurship amongst the representatives of Polish academia should also be sought in the number of economic or formal barriers that are faced by individuals who seek to introduce inventions or innovative solutions onto the market [2]. In the case of Poland, it is therefore necessary to intensify activities leading to the promotion of and support for the commercialization of knowledge and technology transfer processes, at national, regional and local levels.

There have been a number of spectacular successes of university spin-offs on the global market that are well-known and described in the literature (e.g., Google Inc., Hewlett-Packard), including some in Poland (e.g., Pharmena established by a research team who worked at Lodz University of Technology on the application of research results to the prevention and treatment of skin diseases, Cynel Unipress Sp. z o.o. based on high-pressure filler metal forming technology developed in the Polish Academy of Sciences), despite there being many barriers that impede the growth of such firms.

BVCA attempted to incorporate the aspect of technology into the set of barriers to the growth of university spin-offs in greater detail. However, the problems that they summarized were investor-orientated and not comprehensive, and thus missed some entrepreneurship-orientated problems, such as funding gaps or industrial knowledge. In addition, this summary failed to consider the heterogeneity of university spin-offs [25].

In summary, university spin-offs and technology transfer from universities have been duly emphasized in the USA and the UK. By contrast, there is still little research on university spin-offs in Poland. Consequently, the present research will address an important research gap that will contribute to the existing literature by adding sound evidence, helping to enrich the robustness of the existing models, in order to extend the boundaries of knowledge.

In the creation of spin-offs, there are several difficulties related to their heterogeneity and the context in which they occur. Spin-offs face difficulties in establishing a market presence and achieving sustainable returns. However, spin-offs also face two fundamentally different problems [24]. First, because they emanate from what is historically a non-commercial environment, spin-offs encounter specific obstacles and challenges, since the environment of universities and research institutes typically lacks commercial resources. One key concern is whether universities and research institutes have academic entrepreneurs with the commercial skills necessary to create viable ventures. Second, a venture's ability to develop commercially may be adversely impacted by the conflicting objectives of key stakeholders, such as the parent university, academic entrepreneurs, the venture's management team and its investors. For example, Clarysse et al. [7] highlight the problem of conflicts between the objectives of stakeholders with regard to the type of ventures they wish to create and the resources they are willing to commit. Spin-offs are thus faced with major challenges if they are to realize their potential to meet the objectives of their founders and the parent research organizations from which they emerge. Wright [26] suggests a third option involving the university working with existing outside firms/industrial partners to create joint venture spinout companies. Academics involved in such enterprises are commonly given an equity stake in such companies as a reward for developing a new technology, and as an incentive to participate in the development of the technology into marketable products and services. Limited and inadequate resources may constrain the development of a spin-off, which may be exacerbated by an un-entrepreneurial university environment.

Research by Vohora et al. [24] into the development of spin-offs has suggested five phases that spinoffs must pass through if they are to develop. They concluded that the difficulties in moving from phase to phase create critical junctures, which are the key challenges a spin-off faces in its development. The four following critical junctures have been identified in the development of spin-offs: (1) recognizing an opportunity, (2) entrepreneurial commitment by a venture champion, (3) attaining credibility in the business environment, and (4) achieving sustainable returns within the appropriate markets.

In turn, Clarysse and Morey [6] distinguish issues at various stages of establishing a spin off. At the development stage, there are issues associated with planning and developing a preliminary proposal for a new venture, as well as problems related to the formation of a venture team and its appropriate motivation. At the product launching stage, there are issues related to strategic inertia, the management model and gatekeeping the technology. At the spin-off stage, there are issues related to team structuring. Similarly, Colombo and Piva [8] describe problems associated with the process of commercializing a technology, related to the proof of the concept or the principle of the technology, customer and market data for analysing applications of the technology, and assessing the potential (commercial value) of the technology or innovation. With regard to finance and the funding gap, they distinguish between issues associated with a) the ability to generate profits and positive cash flows, b) investment capital c) the problem

of exiting, d) managerial conflict, e) the problem of corporate governance, e) appropriability hazards (e.g., protecting investments via patenting) and f) R&D investment (for development). In addition, with regard to entrepreneurial management, they mention issues associated with dealing with uncertainties, dealing with knowledge gaps (industrial knowledge, market knowledge, cross-disciplinary knowledge, etc.), forming a management team (with the required skills, experience, and entrepreneurial commitment), as well as issues related to knowledge regarding the market and channels to the market, building customer (commercial) bases, infrastructure, proximity to the market, regulations and bureaucracy. However, Zhou et al. [25] argue that this list is not comprehensive, too technology-skewed, and misses some key concepts, including organizational concerns. In addition, these models fail to consider the specificity of Polish university spin-offs.

Based on data provided by the European Commission and the information contained in rather sparse Polish studies [2, 3, 10, 13, 23], it is possible to identify a number of barriers and problems of social, cultural and formal natures that are faced by people starting up spin-off activities.

With regard to factors that adversely affect the establishment and running of business activities associated with academia, the relatively low level of entrepreneurship and lack of appropriate training in this area are particularly visible in Poland, as well as the relatively low level (in European terms) of economic development and bureaucracy involved in setting up businesses. Academics have a limited knowledge of methods and tools for commercializing the results of research, and they are not familiar with the idea of university entrepreneurship. Also, academic researchers are not prepared for the formal and legal aspects of conducting business activities and do not show initiative due to a low level of motivation and reluctance to take risks. What is more, a lack of acceptance for, or even aversion to, activities undertaken to use academic knowledge or research for money-making purposes is particularly noticeable in academia. Moreover, academics often show no interest in financial issues, since they have a sense of satisfaction and security within the framework of their current job.

With regard to economic factors, a low level of activity and cooperation between the research sector and the world of business should be noted. There is also a shortage of direct forms of collaboration or mutual learning, e.g., in the form of training sessions, workshops, traineeships or study visits, from both entrepreneurs and researchers. Academics doubt that there would be demand for their solutions to be implemented in practice or products and services resulting from their innovations. If they do demonstrate pro-development and pro-market attitudes, they have no concept for setting up their own business or commercializing a specific product. If, however, such an activity ends in success or the establishment of a company, it is likely that there will be a lack of skilled or properly qualified managerial staff. There is also insufficient access to financial resources for setting up business activities or implementing the results of research and the risk involved in commercial activities and credit is relatively high. In addition, there is

a lack of adequate mechanisms to reduce the level of risk associated with establishing an academic enterprise.

Barriers of a formal nature are also worth identifying. In Poland, there are numerous legislation gaps in the area of processes of technology transfer. The regulations in the sphere of intellectual property rights are incomprehensive. A high level of bureaucracy involved with running a firm or protecting innovative solutions, by means of utility models, patents or trademarks, is still visible. These barriers to growth will be considered in the design of the questionnaire and definition of variables, described in the next section.

3. Research methods and data

In order to examine how university spin-offs operate in Poland and identify the barriers to their development, a multiple case study was conducted, in which several cases were studied simultaneously within a single research undertaking. One consequence of the research method selected was the non-random, intentional choice of a sample of university spin-offs.

On the basis of the literature review, including examples of university spin-offs in Poland reported in the literature, and a preliminary pilot survey carried out by the author on a group of thirteen firms of this type, a research tool – a questionnaire designed to gain specified information, was constructed. This questionnaire consisted of two parts: the first part concerning basic information about the university spin-off, such as its size, age, type of activity, the branch of industry, the number of employees and the founder(s). The second part was about the barriers to growth of university spin-offs.

The survey proper was conducted in the form of interviews with the founders or management representatives of thirty-five university spin-offs during the years 2014–2016. The information collected during interviews and from references such as internal documentation of the enterprises under examination, archival data, or websites, was used to identify the key groups of barriers to the growth of university spin-offs, to group and assess them, and then to carry out an analytical procedure using fuzzy set qualitative comparative analysis (fs/QCA).

Fs/QCA is an inductive analytic technique, grounded in set theory [20]. Fs/QCA facilitates the identification of multiple configurations of variables associated with the outcome of interest. It is an especially powerful approach, because it allows an analyst to derive configurations of key variables associated with the focal outcome(s) from case study evidence (including grounded interpretations of quantitative data). Recent advances in set theory have led researchers to developing a range of approaches to undertaking fs/QCA (see [17, 18]). Fuzzy set QCA is differentiated from traditional crisp set QCA by the nature of the variables under consideration [17].

While crisp-set QCA forces the dichotomization of inference, fs/QCA allocates a membership score between 0 and 1 to sets of independent and dependent variables [18]. In this way, fs/QCA allows researchers to take differences in the strength of organizational and social phenomena into account in their analyses.

In the present study, fs/QCA was used to provide an answer to the key research question, namely which configurations of barriers contribute to the low performance of the university spin-offs under study.

Variables

On the basis of the literature review, examples of university spin-offs in Poland described in the literature, and based on the examination of 35 case studies carried out by the authors, six key groups of barriers to the growth of university spin-offs in Poland were identified. The following categories were distinguished:

- financial barriers including: lack of initial capital, lack of creditworthiness, high investment costs, lack of profitability, expensive credit,
- competence barriers, including: lack of managerial skills or understanding of the rules of running a firm, lack of ideas for business activities, lack of marketing skills to present solutions, unfamiliarity with the rules for protecting intellectual and property rights,
- psychological barriers, including: low levels of motivation, reluctance to take risks, lack of acceptance for or aversion among academics to using knowledge or the results of research for economic gain, researchers' difficulty to adjust to market needs, low self-esteem,
- organizational barriers, including: low interest from national and local government authorities (insufficient policy support), the passiveness of research centres, the low level of collaboration between the research sector and the world of business, the insufficiently developed infrastructure for mediating between these structures,
- informational barriers, including: missing or insufficient sources of information regarding opportunities for commercial activity; missing or insufficient sources of information regarding opportunities for acquiring funds; and missing or insufficient sources of information regarding opportunities for conducting business activity,
- formal barriers, including: missing or insufficient legal regulations at national level, missing or insufficient legal regulations regarding higher education institutions, regulations restricting commercial activities by universities.

In order to assess these items, the author used the five-point Likert scale and asked respondents to rate these categories of barriers according to: 1 – the least important, 2 – of low importance, 3 – important, 4 – very important, and 5 – the most important.

To measure the output variables, assessments of the results of spin offs – organizational performance, subjective measures of effectiveness, a tool introduced by Antoncic and Hisrich, were used [1].

To explore the ways in which the key groups of barriers might lead to poor performance amongst the organizations examined, fs/QCA treats each possible configuration of key variables as a single case and identifies the necessary and sufficient causal conditions associated with each configuration. Via comparison, these cases are reduced to minimum combinations of causal factors (e.g., sets of barriers of various types) necessary for an outcome to occur (e.g., effectiveness).

Data coding

The condition and outcome variables differed in their underlying forms and were recoded for inclusion in the analysis using a continuous scale from 0 to 1 [18]. Subsequently, a direct method was utilized to code data points describing individual cases (as explained in [18]). This method focuses on three qualitative anchors that define the degree of membership to the focus set. These are: (1) a threshold for full non-membership, (2) a threshold for full membership and, (3) a cross-over point, where there is some ambiguity about membership. Table 1 presents an overview of the membership scores for all of the variables describing barriers (financial, competence, psychological, organizational, informational and formal) and outcome (performance) for the 35 university spin-offs considered in the analysis.

The next step in the analysis is to consider causal combinations/configurations relating the conditions to the outcome, here elucidated via truth tables. These truth tables represent logically possible combinations of conditions and are the key tool of the set-theoretic analysis [20], which describes the diversity of the cases. However, this is often “limited diversity”, such that not all of the theoretically possible configurations are represented in the empirical study, due to the tendency of “causal conditions” to fall into “coherent patterns” [14]. The resulting truth table shows logically possible combinations with strong associations to the outcome.

There are two issues with regard to the information in a truth table. Firstly, the identification of which cases are most strongly associated with a given configuration is determined by assigning 1 to degrees of membership > 0.5 , and 0 to those < 0.5 (hence, in terms of strong membership, each case can only be associated with one combination). Secondly, the decision regarding which configurations are considered to be strongly associated with organizational performance is based on the respective measures of raw consistency. The important point to reiterate here is that a row in the truth table does not represent an individual case, but the logical configuration which they are strongly associated with (since six conditions are considered, there are $2^6 = 64$ logical configurations).

The raw consistency measures the proportion of membership in the outcome explained by each logical configuration, and is computed for each logical configuration from the degree of membership data by dividing the sum of consistent membership in the logical configuration by the sum of membership in the outcome [18]. The choice of

a threshold value for this raw consistency variable used to define the configurations considered to be strongly associated with a respective outcome has an impact on the degree of evidence required to identify necessary and sufficient conditions [19].

Table 1. Membership scores for the association between conditions and the outcome (effectiveness)

University spin-offs	Barrier ^a						Effectiveness
	F	C	P	O	I	F	
Firm 1	0.83	0.05	0.95	0.83	0.05	0.54	0.57
Firm 2	0.83	0.05	0.83	0.95	0.05	0.54	0.96
Firm 3	0.83	0.05	0.95	0.95	0.54	0.54	0.7
Firm 4	0.54	0.05	0.83	0.83	0.05	0.54	0.98
Firm 5	0.99	0.54	0.95	0.83	0.83	0.83	0.05
Firm 6	0.54	0.05	0.83	0.95	0.05	0.05	0.81
Firm 7	0.83	0.05	0.83	0.83	0.05	0.54	1
Firm 8	0.83	0.05	0.95	0.95	0.05	0.54	0.7
Firm 9	0.99	0.54	0.95	0.95	0.54	0.54	0.15
Firm 10	0.54	0.05	0.83	0.83	0.54	0.54	0.98
Firm 11	0.99	0.54	0.95	0.95	0.05	0.05	0.05
Firm 12	0.99	0.54	0.83	0.95	0.83	0.54	0.01
Firm 13	0.99	0.54	0.95	0.95	0.05	0.54	0.05
Firm 14	0.54	0.05	0.99	0.83	0.05	0.83	0.98
Firm 15	0.54	0.05	0.99	0.95	0.05	0.83	0.98
Firm 16	0.99	0.54	0.95	0.95	0.54	0.54	0.07
Firm 17	0.83	0.05	0.95	0.95	0.54	0.54	0.76
Firm 18	0.54	0.05	0.99	0.54	0.05	0.83	0.99
Firm 19	0.54	0.05	0.99	0.95	0.05	0.95	0.98
Firm 20	0.05	0.05	0.95	0.54	0.05	0.99	0.98
Firm 21	0.05	0.05	0.99	0.54	0.54	0.83	0.98
Firm 22	0.83	0.54	0.99	0.83	0.05	0.54	0.97
Firm 23	0.54	0.54	0.95	0.95	0.05	0.54	0.98
Firm 24	0.54	0.54	0.95	0.99	0.05	0.54	0.97
Firm 25	0.99	0.54	0.95	0.54	0.05	0.54	0.99
Firm 26	0.99	0.54	0.95	0.95	0.54	0.54	0.98
Firm 27	0.99	0.54	0.95	0.83	0.05	0.05	0.97
Firm 28	0.99	0.54	0.95	0.54	0.54	0.54	0.99
Firm 29	0.83	0.54	0.83	0.95	0.05	0.54	0.98
Firm 30	0.99	0.05	0.05	0.95	0.95	0.54	0.97
Firm 31	0.99	0.54	0.95	0.83	0.54	0.54	0.98
Firm 32	0.99	0.54	0.95	0.95	0.05	0.54	0.98
Firm 33	0.99	0.54	0.95	0.99	0.54	0.54	0.98
Firm 34	0.99	0.54	0.99	0.95	0.83	0.54	0.97
Firm 35	0.83	0.54	0.83	0.83	0.99	0.95	0.96

^aBarriers: F – financial, C – competence, P – psychological, O – organizational, I – informational and F – formal.

Next, the causal conditions most strongly linked with the outcome are considered. This is based on seeing which combinations of causes define such configurations. Prior to this, consideration has to be given to those configurations that are not included in the corresponding truth table (the so called remainders). These are configurations that are theoretically plausible, but not empirically present. The inclusion or exclusion of remainders in set-theoretic analyses is a contentious issue. The inclusion of remainders in the analysis, by assuming their association with an absence of the outcome, leads to what is called the “complex” solution (for this particular reason, this solution is omitted in the further analysis). One alternative is to exclude remainders from the analysis. This is termed the parsimonious solution. Between these extremes, there is a solution “guided by theory”, which attempts to assign an outcome to the logical remainders, termed the intermediate solution [18, 22]. Importantly, these different treatments of the logical remainders lead to different logical formulas describing the solution [18]. However, all of these formulas are logically true, because they do not contradict the available empirical information contained in the truth table.

4. Results

In this study, parsimonious and intermediate solutions have been analysed. The results from these solutions can be summarized using a configuration chart (Table 2). Utilizing the notation from Ragin and Fiss [21], each column in Table 2 represents a configuration of conditions linked to the corresponding outcomes. Full circles (●) indicate the presence of a condition. Furthermore, core and complementary conditions are distinguished by a symbol’s size: larger circles indicate core conditions that are components of parsimonious solutions. Smaller circles indicate complementary conditions that only appear in intermediate solutions. Each panel represents alternative causal combinations or recipes for the outcome [18]. These are numbered consecutively S1, S2, S3 and S4.

In brief, consistency measures the degree to which the outcomes of cases satisfying a given condition are in correspondence. Raw coverage measures the overall coverage of a combination that may overlap with other combinations. Unique coverage refers to combinations that do not correspond to any other observed combination. Solution consistency measures the degree to which membership in the solution (here a set of types of barriers) corresponds to membership in the outcome. Lastly, solution coverage refers to the combined coverage of all the combinations inferred to lead to the outcome.

Fiss [9] argues that it is important to distinguish between the core and peripheral configurations of causal conditions in a set-theoretic analysis. According to him, core configurations are those *causal conditions for which the evidence indicates a strong causal relationship with the outcome of interest*.

Table 2. Configuration chart

Condition	Solutions			
	S1	S2	S3	S4
Financial barriers	●	●		
Competence barriers			●	
Psychological barriers		●	●	
Organizational barriers	●	●		●
Informational barriers			●	●
Formal barriers	●			●
Consistency	1.000000	0.951952	0.869940	0.909203
Raw coverage	0.279710	0.114855	0.622826	0.533333
Unique coverage	0.017754	0.032609	0.092029	0.017391
Solution coverage: 0.696377				
Solution consistency: 0.878829				

● – core causal condition present; ● – contributing causal condition present

By contrast, those causal conditions for which the causal relationship is weaker can be regarded as peripheral configurations. Table 2 indicates that there are three core conditions associated with low effectiveness, namely financial barriers, psychological barriers and organizational barriers. Importantly, in three of the four solutions (S1, S2, S4) organizational barriers occur, which are factors leading to low performance among the organizations examined. At the same time, in cases corresponding to the first solution (S1), in addition to organizational barriers, financial barriers and formal barriers also occurred, which are incorporated from the parsimonious solution. In the case of the second solution (S2), aside from organizational barriers, financial and psychological barriers also occurred. In turn, in the case of the fourth solution (S4), in addition to organizational barriers, there are also formal and informational barriers that are incorporated from the parsimonious solution. In the case of the third solution (S3), on the other hand, there also exist two conditions that are incorporated in the parsimonious solution. Aside from psychological barriers, informational and competence barriers exist.

5. Discussion and conclusions

Based on the investigation carried out, it can be stated that there exist four alternative configurations of the key groups of barriers to the growth of spin-offs that contribute to the low effectiveness of the organizations under study. In the first configuration, financial, organizational and formal barriers are combined; in the second, financial, psychological and organizational barriers; in the third, psychological, competence and in-

formational barriers; and in the fourth, organizational, informational and formal barriers. Three of these four configurations emphasize the role of organizational barriers as factors of low performance among the organizations examined. As indicated in interviews, these barriers are associated chiefly with the passiveness of research centres, the low level of cooperation between the research sector and the world of business, as well as the insufficiently developed intermediary infrastructure. Enterprises indicated a lack of assistance on the part of institutions supporting technology transfer in Poland, and to the absence of units in universities that could provide legal, financial and administrative-organizational support to researchers.

The university spin-offs examined strongly feel the low level of interest from institutions, whose mission should be to support the process of technology transfer. In some instances, one can meet the opinion that the actions of such institutions are fake. Poland has not yet managed to build a genuine bridge that would facilitate raising the effectiveness of the transfer of modern technologies from the research sphere to the economy. It is therefore necessary to enhance interest from units supporting technology transfer in innovative firms set up by academics – entrepreneurs, which stand a chance of achieving success on the international market. Moreover, the study has pointed out the need for increased marketing of research and development work and encouraging researchers to undertake entrepreneurial activities. Not detracting from the academic value of the statutory research carried out at Polish universities, it is necessary to ensure that the subject matter of research is connected to the economic needs of the country.

In the case of the first configuration, organizational barriers are additionally enhanced by the presence of financial and formal barriers. From an academic entrepreneur's point of view, the most important financial barriers include a lack of initial capital, greatly hindered access to financial resources, lack of creditworthiness, high investment costs, lack of profitability and expensive credit. So, contrary to the view prevailing in Polish studies that access to financing does not present one of the greatest obstacles to those wishing to start a business thanks to the resources available from employment offices and European Union structural funds, this study indicates that financial barriers significantly contribute to the effectiveness among the organizations examined. In turn, formal barriers generally encompass a lack of or inappropriate legal regulations at national level and within university structures, including regulations enabling universities to be competitive players on the market. Here, academic entrepreneurs chiefly face barriers associated with frequent changes to regulations, a lack of transparent rules for the functioning and growth of enterprises, and the instability of the tax system. According to respondent, other factors are also important, such as the ambiguity of legal regulations concerning the methods and possibilities of financing research for business purposes, a lack of unambiguous regulations in the domain of intellectual rights in Poland, and mutually contradictory regulations concerning the transfer of knowledge. There is, therefore, a need to improve legal solutions related to the process of commercializing knowledge, as well as regulating this process, especially solutions concerning intellectual property.

In the case of the second configuration, aside from financial and organizational barriers, psychological barriers also appear. Academic entrepreneurs primarily pointed out the low level of motivation, negative reactions on the part of academia, difficulties in research workers adapting to market needs and low self-esteem. Moreover, respondents indicated the large risk inherent in entrepreneurial activities, and thus a considerable fear of independently undertaking business activities, while perceiving their regular job as a more stable/advantageous option.

In the case of the third configuration, in addition to psychological barriers, competence and informational barriers are also included. As indicated in interviews, significant barriers that hinder the conducting of business activity lie in a lack of the following: ideas for setting up one's own firm, managerial skills, knowledge of the rules of running a firm, and marketing skills to present solutions. Moreover, a large number of respondents declared that competence barriers also include unfamiliarity with legal regulations, especially the rules covering the protection of commercial property, which entails the necessity of intensifying advisory and training services provided chiefly by institutions from the business environment. With regard to informational barriers, the respondents mentioned insufficient or even missing sources of information concerning the possibility of cooperating with commercial firms, acquiring funds, or conducting economic activity. These barriers also appear in the last, fourth, configuration, alongside organizational and formal barriers.

University spin-offs have received great attention from researchers and policy makers, and there is a strong need to investigate empirically the barriers to the growth of Polish university spin-offs. In Poland, university spin-offs are created by scientists who often do not have managerial experience. Therefore, difficulties arise, which are associated with legal conditions, or their absence, tax issues, bookkeeping, and the process of managing an enterprise. The products of such firms are very innovative, but niche, and for this reason they initially do not find a sufficient number of purchasers. The process of achieving positive financial outcomes by producing high-tech goods is often quite lengthy. At the same time, many Polish researchers-inventors still hold the view that their products or technologies are so good that they do not need marketing, as they are able to promote themselves. The above discussion leads directly to the question of how to support the establishment and then growth of university spin-offs. As far as the support for the process of setting up a spin-off is concerned, it is necessary to intensively promote this mechanism for commercializing knowledge, so as to encourage the most able and courageous individuals. Organizational and regulation changes are essential. Aside from promoting spin-off firms themselves, good ideas are needed on a larger scale. This, in turn, may result from intensifying research activity within the system of international research networks and providing a wider range of promotion paths to the young generation of academics.

In this empirical study, some specificities of university spin-offs in the context of Poland have been examined. Some barriers to growth have been identified through

a literature review, pilot interviews and a multiple case study, and have been tested using fs/QCA. In this way, six key groups of barriers to the growth of university spin-offs in Poland have been identified, namely: financial, competence, psychological, organizational, informational and formal barriers. It should be noted that the examination performed using fs/QCA indicates four alternative combinations of various groups of barriers leading to low performance among the organizations examined. This problem is interesting not only from a scientific, but also a practical point of view, pointing out the need for increasing attention, not only from academic entrepreneurs themselves (which is indicated in particular by the third configuration consisting of the combination of psychological, competence and informational barriers, which jointly lead to low effectiveness among the organizations examined), but also for more efforts from universities (the fourth combination containing organizational, informational and formal barriers) and the government (the first combination consisting of financial, organizational and formal barriers) to cultivate university spin-offs. Importantly, as indicated in particular by the combination of financial, psychological and organizational barriers in the second configuration, simultaneous action in all of these directions is necessary.

This paper also contributes to theory. First, it tests and validates some existing concepts about the barriers to the growth of university spin-offs. Second, it sheds light on the specificity of Polish university spin-offs, in the context of the growth of such firms, and identifies six groups of barriers. In addition, it distinguishes four alternative configurations of barriers that lead to low effectiveness among university spin-offs. One of the limitations of this study lies in the limited size of the research sample, due to difficulties in accessing relevant data. Hence, in order to obtain a full and more reliable picture of the entire functioning of university spin-offs in Poland, further research is necessary. Such research will consider, on the one hand, a larger sample of firms, and, on the other hand, the results obtained so far and their re-conceptualization. Moreover, in future research, the author will attempt to improve the validity and reliability of questionnaires by using more qualitative and quantitative tests. This paper will be the basis for further work to convert analysis into guidance for practitioners to address “barriers to growth” and to support the growth of Polish university spin-offs.

References

- [1] ANTOMCIC B., HISRICH R.D., *Intrapreneurship: construct refinement and cross-cultural validation*, J. Bus. Vent., 2001, 16, 495–528.
- [2] BANERSKI G., GRZYK A., MATUSIAK K.B., MAŻEWSKA M., STAWASZ E., *Academic entrepreneurship (the development of spin-off and spin-out firms). The need for training aimed at supporting its development*, Polska Agencja Rozwoju Przedsiębiorczości, Warsaw 2009 (in Polish).
- [3] BĄKOWSKI A., MAŻEWSKA M., *Centres of innovation and entrepreneurship in Poland*, Polska Agencja Rozwoju Przedsiębiorczości, Warsaw 2012, 1–192 (in Polish).
- [4] CALLAN B., *Generating Spin-offs: Evidence from Across the OECD*, [In:] STI Review, Special Issue on *Fostering High-Tech Spin-Offs*, A Public Strategy for Innovation, No. 26, 2000.

- [5] CAREN N., PANOFSKY A., *TQCA. A technique for adding temporality to qualitative comparative analysis*, Soc. Meth. Res., 2005, 34 (2) 147–172.
- [6] CLARYSSE B., MORAY N., *A process study of entrepreneurial team formation. The case of a research-based spin-off*, J. Bus. Vent., 2004, 19 (1), 55–79.
- [7] CLARYSSE B., WRIGHT M., LOCKETT A., VAN DE VELDE E., VOHORA A., *Spinning out new ventures: a typology of incubation strategies from European research institutions*, J. Bus. Vent., 2005, 20 (2), 183–216.
- [8] COLOMBO M.G., PIVA E., *Strengths and weaknesses of academic startups. A conceptual model*, IEEE Trans. Eng. Manage., 2006, 55 (1), 37–49.
- [9] FISS P., *Building better causal theories: A fuzzy set approach to typologies in organization research*, Acad. Manage. J., 2011, 54 (2), 393–420.
- [10] GRĘBOSZ M., MAKOWSKA A., KASIECZKA-BURNECKA M., *Report from a study aimed at identifying the internal and external barriers constraining academic entrepreneurship*, Polska Izba Gospodarcza Zaawansowanych Technologii, Warsaw 2010, 1–79 (in Polish).
- [11] KWOTKOWSKA A., *Organizational configurations of academic spin-offs*, Difin, Warsaw 2015 (in Polish).
- [12] LOCKETT A., WRIGHT M., *Resources, capabilities, risk capital and the creation of university spin-out companies*, Research Policy, 2005, 34 (7), 1043–1057.
- [13] *The system of technology transfer and commercialisation of knowledge in Poland. Driving forces and barriers*, K. Matusiak, J. Guliński (Eds.), Polska Agencja Rozwoju Przedsiębiorczości, Warsaw 2010, 1–56 (in Polish).
- [14] MEYER A., TSUI A., HININGS C.R., *Configurational approaches to organizational analysis*, Acad. Manage. J., 1993, 36, 1175–1195.
- [15] MUSTAR P., RENAULT M., COLOMBO M.G., PIVA E., FONTES M., LOCKETT A., WRIGHT M., CLARYSSE B., MORAY N., *Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy*, Res. Pol., 2006, 35 (2), 289–308.
- [16] PIRNAY F., SURLEMONT B., NLEMVO F., *Toward a typology of university spin-offs*, Small Bus. Econ., 2000, 21, 355–369.
- [17] RAGIN C.C., *Fuzzy-Set Social Science*, University of Chicago Press, Chicago 2000.
- [18] RAGIN C.C., *Redesigning Social Inquiry: Fuzzy Sets and Beyond*, University of Chicago Press, Chicago 2008.
- [19] RAGIN C.C., *Set relations in social research: evaluating their consistency and coverage*, Pol. Anal., 2006, 14, 291–310.
- [20] RAGIN C.C., *The Comparative Method. Moving Beyond Qualitative and Quantitative Strategies*, University of California Press, Berkeley 1987.
- [21] RAGIN C.C., FISS P., *Net effects versus configurations: an empirical demonstration*, [In:] C.C. Ragin (Ed.), *Redesigning Social Inquiry*, Vol. 1, University of Chicago Press, Chicago 2008, 190–212.
- [22] RAGIN C.C., SONNETT J., *Between complexity and parsimony. Limited diversity, counterfactual cases, and comparative analysis*, Working paper posted at <http://www.compass.org/WP.htm>, 2004.
- [23] TAMOWICZ P., *Academic entrepreneurship. Spin-off firms in Poland*, Polska Agencja Rozwoju Przedsiębiorczości, Warsaw 2006, 1–56.
- [24] VOHORA A., WRIGHT M., LOCKETT A., *Critical junctures in the development of university high-tech spinout companies*, Res. Policy, 2004, 33 (1), 147–175.
- [25] ZHOU Y., XU G., SU J., MINSHALL T., *Barriers to entrepreneurial growth. An empirical study on university spin-offs in China*, J. Sci. Techn. Policy China, 2011, 2 (3), 277–294.
- [26] WRIGHT M., BIRLEY S., *Entrepreneurship and university technology transfer*, J. Technol. Trans., 2004, 29 (3, 4), 235–246.

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