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Key Factors of AS Performance in Emerging Central and Eastern European Countries: Evidence from Romania

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Abstract: The concept of academic spin-off (AS) has witnessed an increase in attention due to its effectiveness in solving industry problems using core technology and knowledge from academia. Most studies based on US and western Europe experiences have presented the main key factors for academic spin-offs. The present study aims to address a literature gap regarding AS survival factor identification for central and eastern European countries, to relate resource groups with these key factors from a literature perspective, and to statistically investigate the long-term performance of academic spin-offs in Romania, an eastern European country that has only recently understood the opportunity academic spin-offs offer for national and regional development. Since EU programs are setting the scene for AS development, this research brings new insights for university strategic management to achieve sustainable regional growth by proposing a novelty spin-off key factor specific to central and eastern European countries: team competency in accessing government funds. Since these emerging economies face similar challenges regarding AS formation and development, statistical evidence from Romania is insightful and valuable. Data were collected on Romanian AS companies founded from 2006–2010, and eleven survival factors were investigated within a quantitative survey to understand which had a significant impact on AS performance. By using Pearson's correlation matrix and a Cobb–Douglas nonlinear regression model, this study validated two research hypotheses that, in Romania, the quality of scientific support received from a university or research center during the development of a product and the competency of a team in accessing government funds were the most important factors having nonlinear influences on AS performance. Their positive and negative influences were furthermore discussed, and managerial implications were outlined.

Keywords: sales growth; spin-off–university relationship; European funding; team competencies; sustainable regional development

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1. Introduction

Based on resource-based views, firms are acquiring capabilities and resources that are both unique and valuable. Universities play a decisive role in the development of skilled human capital [1], knowledge, and technology. Technology transfer can be undertaken through spin-offs, licensing processes, publications, and industry research and development agreements. The present paper focuses on the concept of an academic spin-off (AS), one of the most important technology transfer mechanisms in today's changing society. The reason for this focus resides in the fact that AS companies, or university spin-offs, are one of the best ways to achieve sustainable development at a regional level and to have a real social impact [2]. Their main advantages in this line of reasoning are job creation, the diversification of businesses in a regional context, technological development, the creation of new sectors, and so on [3].

The literature discusses a variety of definitions for academic spin-offs, primarily with findings based upon case studies from the US and the UK [4,5]. Criteria used to distinguish other categories of science-based start-ups from academic spin-offs refer to the origin of the technology used, the affiliation of the founding personnel with a research institute or university, and the funding sources used that are linked to a university [6].

Smilor et al. [7] saw an academic spin-off from two perspectives: the technology transfer had to originate at a university, and at least one faculty member (active or retired) of the university had to be engaged in the establishment of the company. Following [8]'s rationale, Di Gregorio and Shane [9] explained the concept of academic spin-offs as independent companies established with the purpose of exploiting commercially patented inventions or some sort of intellectual property generated from university research.

Mathisen and Rasmussen [10] provided a more complex vision of the academic spin-off process, which saw them as active, new ventures with technology developed at public research institutions or universities [11] whose founding members were affiliated as employees of a research institution [12]. Thus, an academic spin-off (AS) can be defined as an atypical venture established by a researcher or a group (professors, scientific researchers, students, etc.) from a university or research institute that transfers a scientific result (patent application, patent, doctoral thesis, bachelor thesis, master thesis, result of a research project from a public program) to a new company in order to commercialize an innovative product or service [13].

Due to their inherent advantages for innovative commercial results, academic spin-offs are found in the literature under the following names: university spin-offs, research-based spin-offs, and spin-outs. Rogers et al. [14] showed that the highest commercialization values regarding technology transfer mechanisms were technology licensing and venture spin-out. In the same line of reasoning, Shane [5] concluded that university inventions could be successfully exploited through the formation of spin-off companies. Bray and Lee [15] demonstrated that, out of two technology transfer mechanisms, namely licensing and spin-out, the second generated ten times more income. Licensing was chosen as a process when technology was not suitable for a spin-off company. Various studies have demonstrated the clear impact of academic research on US industry [16], where academic spin-offs had better results than other start-ups [17].

According to a study from the OECD [18], between 2004 and 2010, Europe registered a higher rate of spin-off formation (2.1) than the United States and Canada (1.1), as well as Australia (0.7). However, despite their outstanding advantages and high formation rate, many spin-offs in Europe remain small, with 80% employing under ten people after six years of operation [19–21].

By recognizing the value of university research and AS potential for regional development, governments and policy makers have understood the need to increase the formation of new AS companies and to extend their survival rate. Thus, AS creation and their survival process has become a strategic and vital matter for national strategy. This action has caused policy makers to provide programs for spin-offs to stimulate the commercial exploitation of public research [22].

In Elpida's [23] opinion, the supportive structures at the beginning of the academic spin-off development stage are market requirements, suitable policies and legislative conditions, and skilled human resources. In addition, it is known that urban regions develop stronger small business landscapes in comparison to other regions [24]. Thus, university cities have the potential to start AS companies in an entrepreneurial-aware marketplace.

Therefore, appropriate policies for the commercialization of the final product are necessary, together with government programs. The government must encourage universities to increase the rate of spin-offs. Achieving the right policy mix can help governments shape and strengthen the contributions that innovations provide to economic performance and social welfare [25]. In addition, the role of EU funding programs in promoting collaboration between research institutions and companies has been stressed in a variety of programs. Many of these programs have not had a solid organizational structure or clearly identified activities. Different models of academic spin-off support programs have been proposed [26].

They have provided a high level of research knowledge using public funding, but they have not managed to commercialize it for wealth creation and regional development [27].

Using data from two German regions, Sternberg [28] showed that the regional conditions in which a spin-off was formed had a bigger influence on the survival rate in contrast with the government support received from the European funds. It seems that a funding scheme did not create the same results in a different regional context [29]. Therefore, EU funding and all government programs need to adapt to the specificity of regional context. In this way, the objectives of increased AS formation and survival rate can be adequately achieved.

Vincett [30] showed in a longitudinal study on Canadian spin-off companies (1960–1998) that, in contrast with government investments, an AS had an impact on an economic level between three to four times higher. The added value an academic spin-off provides to regional development makes it an ideal candidate for future government funding programs. However, the specific survival factors for academic spin-off regional success are not fully understood. Although scholars have investigated the number of AS companies created in specific countries [31,32] and have analyzed the formation of academic spin-offs [29], few studies have looked to assess what ensures their development and survival [33,34].

Furthermore, Mathisen and Rasmussen [10] outlined the fact that studies from western Europe (most in the UK) and North America (with an emphasis in the US) are prominent in the literature. Another aspect pointed out was the problem encountered in obtaining dynamic data on AS development in eastern European countries, hindering scholars from understanding the broader European regional development context.

The present study aims to classify the main AS survival factors for central and eastern European countries from a resource-based perspective and to statistically test their influences on AS performance, investigating which factors are key for AS long-term performance development in Romania.

From a resource-based perspective and based on the classification of the literature review, two research questions were addressed:

RQ1: What are the most important resources that influence the survival of AS companies in terms of background functioning?

RQ2: What are the main factors influencing the performance of AS companies from a resource-based perspective?

The present paper investigates survival factors because they are more prominent in the literature, and they represent the starting elements for future performance. However, after a correlation assessment with a chosen performance indicator, they are called key factors for AS performance.

The article is structured as follows: Section 2 gives an overview of the main survival factors and performance indicators delimited from the literature with an emphasis on particularities from central and eastern European countries; Section 3 presents the method used for data collection, sampling, and variable definition, as well as the statistical regressions employed; Section 4 encompasses the results; Section 5 presents the implications of the research for theory and practice, with the study limitations; and Section 6 delineates the final conclusions.

2. Literature Review and Hypotheses

2.1. Survival Factors for AS and Performance Measurement

2.1.1. Main Factors Influencing the Survival of an Academic Spin-Off

There are different factors that affect the survival of a spin-off, such as entrepreneurial skills [5,11,35], characteristics of the core technology [36], industry characteristics [37,38], career experience [39], research knowledge [40], and market requirements [41].

Academic spin-offs in their early stages are influenced by the available skills from the university departments or research centers in which they are formed [42].

Following Djokovic and Souitaris's [43] rationale, Venturini and Verbano [36] explained that an academic spin-off could achieve a bigger advantage by combining four types of resources: financial, social, technological, and human [44].

After the extensive literature review in Table 1, the connections between the four types of resources and the most important influencing factors are synthesized in Table 2.

Table 1. Summary of the factors that influence AS performance.

Study	Country	Sample Period	Methodology	Relevant Variables	Results
Sinell et al. [11]	60 qualitative interviews in the UK	6-month period	Case study approach	Design and resource acquisition competence	"Successfully initiate an academic spin-off, academic founding teams must develop a specific set of entrepreneurial competencies"
Schillo [12]	7 spin-offs in 5 European countries	1995–2000	Case study approach; regression	Organizational resources, human resources, technological resources, physical resources, financial resources, networking resources	"Case of survival through merger or acquisition, the presence of venture capital"
Buenstorf [20]	143 producers of lasers in Germany	1964–2003	Company longevity: over 7 years of survival; proportional Gompertz model	Years of entry and exit from the laser industry, type(s) of lasers produced initially, mergers and acquisitions, founders' names and backgrounds, prior employment periods, firm background prior to entry into laser industry (for diversifying firms)	Technological capabilities are determinants of firm success
Clarysse et al. [26]	43 companies employed by European research institutions	1995–2002	Qualitative approach	Networking resources, technological resources, financial resources	Because the origin of each spin-out company lies within the lab, internal office space is offered for free, and infrastructure is available

Table 1. *Cont.*

Study	Country	Sample Period	Methodology	Relevant Variables	Results
Venturi and Verbano [36]	2009–2012	India	Case study approach using four stages of development by Vohora et al. (2004)	Techn. Resources: degree of innovativeness, stage of development of technology, ability to patent and protect the technology, scope of technology; Human resources: type of parent organization (PO), founders' positions in PO, formal team size, PhD experience or scientific background in active founding team, sector experience of at least one of the founders, management experience, previous entrepreneurial experience of team, variety of backgrounds and work experience in the team, joint working experience and cognitive similarity of the team; Financial resources: type of funding, amount of funding, social resources, relationship with PO, supporting strategy, mechanisms and financial incentives toward spin-off, tangible resources (i.e., laboratory facilities and access to research equipment), intangible resources (e.g., access to human capital, and scientific and business knowledge), scientific quality and perceived image of PO, quality and support of technology transfer office, contacts with industrial, financial, and research organizations (no. of entities), venture capital investors, financial institutions, commercial partners, competitors, customers, suppliers, or other research centers	" . . . the success of RBSOs is based on technological resources, even if social resources appear to be equally important . . . "
Shane and Stuart [37]	134 spin-offs in the USA	1980–1994	Event history method; regression	Endowments: social capital (venture capital investitor); endowments: human capital (founders' industry experience); endowments: technical assets (patents); endowments: industry attractiveness (industry conditions)	"social capital endowments have a positive effect on the performance ", capacity to attract venture capital financing and the experience of initial public offerings influence the performance of a spin-off
Aspelund et al. [44]	80 Norwegian and Swedish technology-based start-ups	1995–2000	Cox regression model	Team size, entrepreneurial experience, team heterogeneity, radicalness of the technology	Team heterogeneity and radicalness of the technology increase the probability of survival
Soetanto and Geenhuizen [45]	100 spin-offs in Netherlands and Norway	2006–2008	Curvilinear model regression	Firm age, firm size, university-employed founder, level of innovativeness, university network density (contacts within a network connected to each other)	"spin-off's ability to attract external funding for innovation is influenced positively by the density of its university network"
Treibich et al. [46]	France and Switzerland	Too long-term periods (4–15 years); 25 case studies of spin-off		Sharing of research equipment (parent unit: department or team)	Biotech firms need the technical support of the parent because the cost of equipment is very high

Table 1. *Cont.*

Study	Country	Sample Period	Methodology	Relevant Variables	Results
Gurdon and Samsom [47]	USA	22 spin-offs; 1999–2000	Longitudinal study	Number of employees, technological knowledge, access to capital	"Scientific expertise is essential for the long-term survival of USOs"
Miranda et al. [48]	Spain	500 spin-offs; 2014	Squares (PLS) regression	Creativity (CREA), entrepreneurial intention of the manager, entrepreneurial attitude of the manager, perceived utility, business experience	Academic business experience positively influences academic perceived utility, entrepreneurial attitude of the manager is the most relevant indicator for AS performance
De Cleyn et al. [49]	8300 ASOs in 24 European countries	1985–2009	Logistic regression	Management team and director characteristics (education, work experience, heterogeneity, and participation), prior entrepreneurial experience	"strong and positive effect of the level of legal expertise of the manager or the different effect of the previous entrepreneurial experience of the manager foster ASO survival"
Bolzani et al. [50]	Italy; 551 universities	2000–2008	GMM estimator	Parent ownership, geographical proximity, technological ties, parent board membership, entrepreneurial team, commercial experience, regional financial support, market performance, innovation skills	Geographical proximity does not have an impact on market performance; technological ties negatively influence the market performance; parent ownership has a positive effect on market performance
Rasmussen et al. [42]	Norway	12–15 months	Case study using the stages of development credibility threshold (Vohora et al., 2004)	Company founders' entrepreneurial team member competencies, opportunity identification and development, championing resource acquisition	University department reputation positively influences the competencies in university spin-offs
Bigliardi et al. [38]	Italy	20 spin-offs	Delphi Technic	Characteristics of the university: involvement of the university by financial contribution in the company and allowing access for acquiring entrepreneurial knowledge; Characteristics of the founders: the desire to be autonomous, the motivation of the founders, and reorientation in the career; Characteristics of the external environment: characteristics of the industry, existing regional infrastructure, geographical location, and existing capital; Technological characteristics: the degree of innovation, the development stage of the product, technology or service, the ability to patent and maintain the intellectual property rights	The performance is measured with the 4 financial factors previously identified: growth in sales, employment growth, net cash flow, and revenue growth

Table 2. Main factors proposed that influence AS performance.

Resource Dimensions	Factors for Spin-Off Survival	Authors
Social resources	networking, material resources available in the incubation stage	Aspelund et al. [44] Clarysse et al. [51]
	quality of scientific support regarding the development of the product	Soetanto and Geenhuizen [45]
	the sharing of research equipment for spin-off long-term development	Treibich et al. [46])
Human resources	manager research skills	Gurdon and Samsom [47]
	the entrepreneurial competency of the manager	Miranda et al. [48] De Cleyn et al. [49]
	previous entrepreneurial experience of the team	Rasmussen et al. [42] Hesse and Sternberg [52] Sinell et al. [11]
	the individual-level attitude towards commercialization of the research results	Würmseher [53] Hesse and Sternberg [52]
Technological resources	the stage level of the research product	Aspelund et al. [44] Bigliardi et al. [38] Venturi and Verbano [36]
Financial resources	venture capital during the growth of the firm	Schillo [12] Shane and Stuart [37] Park et al. [54]
	consortia of public research institutes and firms	Bolzani et al. [50] Kroll and Liefner [55]

The *social resources group* represent social ties to academia in both the incubation stage and the future development stage. It is composed of the following survival factors:

- Networking and material resources available in the incubation stage: Spin-out from research experiments where an AS receives internal office space and infrastructure for free [26]. According to Aspelund et al. [44], the initial resources in the incubation stage (human, social, and access to material equipment) were significant predictors of AS survival. From this point, the aim is to have a strong collaboration with the parent research institution [52].
- Sharing of Research Equipment for Spin-Off Long-Term Development: The knowledge infrastructure is of the greatest significance because industrial production is based on knowledge: industrial technology is knowledge related to material transformation, which is the center of the national innovation system [56]. Steffensen et al. [57] underlined that the most relevant factor influencing the success of spin-offs was the degree of support received in the growth stages.
- Quality of scientific support for the development of the product: AS companies in later stages of life focus on maintaining strong relationships with universities, aiming to increase the chance of obtaining research funding [45].

The *human resources group* is very complex because it envisaged the human capital necessary for AS success. Thus, it referred to the particularities of the manager, but also to team skills in different domains. The survival factors that composed this group were as follows:

- The manager's research skills: A higher probability of survival for an AS is given by the degree of heterogeneity of the founding team [44]. Successful scientist-entrepreneurs mentioned that the quality of the management team's research knowledge was key for accomplishing their goals [48].
- The manager's entrepreneurial competency: The available evidence on university spin-offs [58] demonstrates that, often in the initial years of functioning, the founders of the company are the managers of the AS. Since scientist-entrepreneurs do not possess commercial managerial skills [33], prior business experience has been considered an advantage for the survival of the company [42,50]. Landry et al. [59] explained how consulting experience helped in the creation of a university spin-off.

- Previous entrepreneurial experience of the AS team: Business expertise in the team helps an academic spin-off to grow [35]. Moreover, the team's ability to identify market opportunities for technical innovations is of great importance for AS survival [11,41].
- The individual-level attitude towards commercialization of the research result: The initial strategic actions taken by the employees of an AS are crucial but largely unexplored [60]. Würmseher's [53] three entrepreneurial models explained the main challenges academic researchers face when commercializing their innovations. Inevitably, inventors who become entrepreneurs are strongly committed to technology, which is particularly useful for overcoming problems arising during the commercialization process [61].

The *technological resources group* take into consideration one very important survival factor, namely:

- The stage level of the research product: The level of product innovation was used as an assessment method for spin-off survival in the UK [62]. Schillo [12] considered patent protection and technological uncertainty for spin-off success. Aspelund et al. [44] showed that a higher degree of technological radicalness increased the probability of survival.

The *financial resources group* expressed the origin of capital and its influence on practical AS companies. The possible survival factors could be as follows:

- Consortia of public research institutes with firms: Public authorities offer grants in most cases only for the first stages of research. Thus, academic spin-offs are not able to adequately finance the next commercial development stage because they do not generate sufficient revenue to cover the needed investment costs. In this situation, scholars have outlined that parent university equity ownership is vital to the success of a spin-off [50,55].
- Venture capital during the growth of the firm: Having an idea or invention is not enough, and finance becomes critical for a spin-off company. For external source financing, we found venture capital and business angel financing. Due to the fact that an AS is a high-risk project, it loses attractiveness to banks and has to direct its efforts towards venture capitalists [63]. The performance of an AS is influenced by its capacity to attract venture capital [37].

Since there are numerous opinions in the literature and several classifications, factors determined from a resource perspective need to be statistically evaluated in terms of their influences on AS survival. Additionally, specific survival factors must be discussed for relevant results. Their importance must be compared with an appropriate performance indicator.

2.1.2. Measuring Academic Spin-Off Performance

Concerning the performance of an academic spin-off, scholars have different opinions. Most existing studies have presented data from successful AS companies that have overpassed the initial development phases. According to Egeln et al. [64], growth in sales, employment growth, and credit ranking were indicators for measuring AS success. Schmelter [65] expressed spin-off performance in terms of sales growth and employment growth. On the other hand, Ensley and Hmieleski [58] argued that net cash flow and revenue growth were useful indicators to measure the success of a firm.

Bigliardi et al. [38] stated that the performance of a spin-off could be measured with the help of the following indicators: growth in sales, employment growth, revenue growth, and net cash flow.

Hesse and Sternberg [51] used the number of employees to measure the growth of spin-offs. In their study, they used data from more than 10 years, demonstrating the importance of the period used to observe the development path of an AS. Schillo [12] measured spin-off performance using a multitude of indicators, such as sales growth and return, short-term and long-term profit, market share, new market outreach, and corporate liquidity.

As shown above, academic spin-off performance can be measured in several ways. The most-employed in such studies have been employment or sales growth, credit rating, and productivity indicators. Since AS companies are atypical, sales growth appears to be the best indicator for long-term survival.

2.1.3. Team Competency in Accessing Government Funds: A Specific Factor for Central and Eastern European Countries

Eroglu and Rashid [66] emphasized that, even if a government launches several support programs for start-up or spin-off creation, there are still several barriers that hinder their appropriate development. The support services for such entrepreneurial opportunities include innovation policies, training programs, and public funding.

Antoln-López et al. [67], in a study on 5328 firms from 29 European countries, showed how different innovation policy instruments helped new ventures overcome the liability of newness when developing new products, as well as how existing types of public instruments affected product innovation development differently. Central and eastern European countries faced similar challenges due to their cultures and emerging economies.

According to the OECD glossary [68], the following countries are part of the group of central and eastern European countries (CEECs): Albania, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, and the three Baltic states of Estonia, Latvia, and Lithuania. A report from the European Commission [68] mentioned the lack of collaboration between research institutions and industry in creating innovative spin-offs and start-ups in many of these countries. In most cases, the study proved that the cooperation was developed in the context of EU funding projects (e.g., the European Structural and Investment Funds).

The authors adapted the data from the 2019 Global Competitiveness Report [69] by taking into consideration three main pillars that directly addressed AS formation and development: the 9th pillar of the Financial System, with its subdomains of financing SMEs and venture capital availability; the 11th pillar of Business Dynamism, with its subdomain of attitudes towards entrepreneurial risk; and the 12th pillar of Research and Development, with its subdomains of multi-stakeholder collaboration, patent applications per million population, and research and development expenditures.

The main three pillars and their selected subdomains were compared for the majority of the central and eastern European countries. In the end, Figure 1 presents the comparative ratings (ranging from 1 to 141 possible ranking places, with 1 being the best and 140 the last place in the respective domains) of these countries. It is easy to observe that they faced similar ratings and problems in the three chosen pillars. The most unsatisfactory ratings were noticed to arise in subdomains such as attitudes towards entrepreneurial risk and multi-stakeholder collaboration. It was somewhat contradictory for the good rating of the patent domain. In essence, it showed a specific cultural factor for emerging countries that was not encountered in the experiences of western societies, namely the problem in accessing EU or government funding. The problem originates from a lack of skills and experience in translating the funding program into simple rules for practical application.

According to Figure 1, in 2019, as an impact of European funding, Lithuania was ranked 33rd out of 141 countries in the multi-stakeholder collaboration subdomain of the 12th pillar, followed by Estonia (37th), Czech Republic (43rd), and Latvia (56th). On the opposite side, Poland ranked 116th out of 141 countries in university–industry collaboration, followed by Hungary at 108 out of 141 countries [70], Romania (98th), and Bulgaria (62nd).

These countries have potential in the field of scientific results, as Figure 1 shows: Czech Republic was ranked 21st out of 141 countries in patent applications per million population, followed by Estonia (29th), Hungary (31st), Poland (34th), and Lithuania (35th). Romania was ranked 51st out of 141 countries in patent applications per million population.

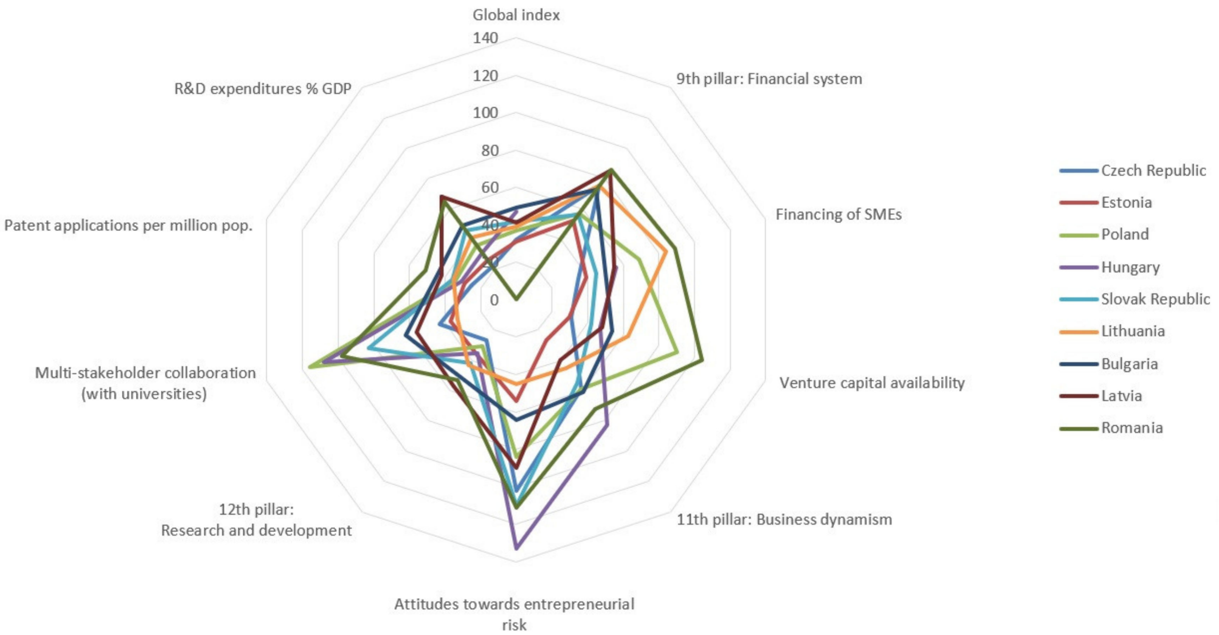

Figure 1. A comparative analysis of the main central and eastern European countries based upon three AS-oriented pillars of the 2019 Global Competitiveness Report.

There are national financial schemes from the European Union that target certain stages of the spin-off process. The accession of European funds for establishing academic spin-offs requires effort in elaborating complex budgetary proposals, meeting public economic needs, and respecting strict rules regarding costs. In this complex mechanism, new companies suffer from a lack of skilled and experienced labor force. Additionally, they are less likely to have acquired the suitable practices to succeed in the project requirements, to respect the conditions of submitting a project, and to know how to communicate with representatives of European funds, that are specifically developed in completing these actions. Because new ventures do not fully understand the conditions of submitting projects for grants, wrong decisions are made that can influence the longer survival of an AS.

In Hungary, the 2017 RIO Country Report [71] showed that university–industry collaboration centers and continued investment in research and development led to improvement in the 2017 Global Innovation Index.

In Lithuania, the 2017 RIO Country Report [72] mentioned that the period of 2014–2020 had a greater impact and influence on the development of technology transfer centers and the stimulation of AS formation compared to the period of 2000–2015, when structural funds (ESIF Research and Development and Innovation projects) did not encourage sustainable forms of collaboration between universities, industry, and business.

In the Czech Republic, a major weakness is represented by the collaboration between research and industry [69]. In the 2017 RIO Country Report [73], it was underlined that measures were taken to face the problem by the establishment of national centers of competence with the aim of strengthening the relationship between the public and private spheres. The result was objectively achieved because, in 2019, the Czech Republic ranked 108th out of 141 countries in the multi-stakeholder collaboration subdomain of the 12th pillar. The indicator of the National RIS3 Strategy 2021+ referred to spin-offs generated with a turnover of EUR 1 million after five years of operation. The Czech Republic Innovation Strategy 2019–2030 pointed out that the number of AS companies should increase by using EU funds and national resources.

In recent years, in Poland, the government has made efforts to establish the right conditions to encourage university entrepreneurs. Being a late entrant in the research and development competition, the number of academic spin-offs has increased in the context of public funding from the UE [74]. According to the 2019 Global Competitiveness

Report, Poland ranked 116th out of 141 countries in university–industry collaboration, even though the number of patents offered Poland the 29th position. Since 2014, it appears that public funding, such as NCBR's Bridge Alfa program and Biznest, designed to help develop AS companies and start-ups has had an impact at the regional and national levels [75]. In addition, Korpysa [76] showed in a study on Poland spin-offs that the codification of legislation for business opportunity, seen as an exogenous factor, influenced the development of these atypical companies. Even if in the national context there were available funds for the development of AS, entrepreneurs were sceptical.

A report from [69] noted that, in Slovakia, there was a lack of skilled labor force in universities. Since universities encounter problems because of bureaucracy, it is more likely that, in Slovakia more than elsewhere in Europe, research institutes do not have any knowledge about opportunities concerning the development of academic spin-offs. Although Slovakia registered good values regarding patents (36th position) and research and development expenditure percentage (46th position), when it came to university and industry collaboration it was ranked 83rd.

In Romania, academic spin-offs were seen as companies recently created or in their formation stage that emerged because of a university or research center research and development project. The national program for the "Development of Technological Transfer & Infrastructure—INFRATECH" (approved by GD no. 128/2004) provided financial and logistical support for the establishment and development of specialized technological transfer (TT) institutions, such as TT centers, technology incubators, and science parks, because the scientific support received from academia in the development of the product was considered very important.

The main objective of the Sectorial Growth of Economic Competitiveness Operational Program (POSCCE) for the period of 2007–2013 was the establishment of innovative spin-offs that created economic benefits. The absorption rate was EUR 2,179,933,761 (85.94%), and the number of patent applications submitted by research institutes increased six times more compared to 2001.

The Global Competitiveness Report for 2014–2015 showed that a problem in business was bureaucracy and access to funding. The new Competitiveness Operational Program of 2014–2020 allocated EUR 1582.77 million to stimulate start-up and spin-off innovation enterprises.

In the entrepreneurial finance literature, it has been pointed out that AS companies are very risky, and those with clear opportunities for growth encounter obstacles in obtaining funds for developing their innovative services or products [5,22,27]. Soetano and Geenhuizen [45] showed that sustainable businesses had labor forces with the ability to attract funding for innovation activities.

All the above-mentioned arguments point out that we need to consider team competency in accessing funding as a specific survival factor for AS companies formed in central and eastern European countries. In addition, all ten survival factors proposed in Table 2 should be investigated to see if they have influences on AS performance.

Based on the observations outlined above, we formulated three hypotheses:

H1: The consortia of public research institutes with firms, resources in incubation, manager's research skills, manager's entrepreneurial competency, previous entrepreneurial experience of the team, research product stage, resources for long-term development, scientists' attitudes towards commercialization, venture capital during the growth of the firm, quality of scientific support concerning the development of the product, and team competency in accessing government funds all have influences on AS performance.

H2: The quality of scientific support concerning the development of the product and the team competency in accessing government funds both have significant linear influences on AS performance.

H3: The quality of scientific support concerning the development of the product and the team competency in accessing government funds both have a nonlinear influence on AS performance.

3. Method and Data Used

After identifying the main AS survival factors in the context of central and eastern European countries, the present study aimed to assess their impact on Romanian academic spin-offs. Such evidence has the potential to unravel the specificities of government funding needs to take into consideration for fruitful results in emerging economies.

The research took several steps to answer the proposed research questions. In Figure 2, the main methodological stages are outlined.

After a critical review of the literature, the main factors influencing the survival of academic spin-offs were identified and grouped according to the type of resource to which they were related. An additional survival factor specific only for emerging European countries was added to the list, and a suitable indicator for measuring the AS performance was considered.

In order to validate the three hypotheses stated above and to uncover the regional development particularities of central and eastern Europe, the Romanian context was chosen. For the data collection phase, Romanian academic spin-offs formed between 2006 and 2013 were identified using public data (http://www.poscce.research.gov.ro/ro/node/node/nid/1703; last accessed on 9 May 2022).

At a national level, AS companies were identified using data retrieved from research organization reports and internet statistics. Since information on the subject was scarce, data collection started with the first funding program (POSCCE), which had a main purpose of stimulating technology transfer from academic towards industrial environments for AS creation. After analysing the official POSCCE reports for each grant beneficiary, the number of spin-offs financed each year was outlined.

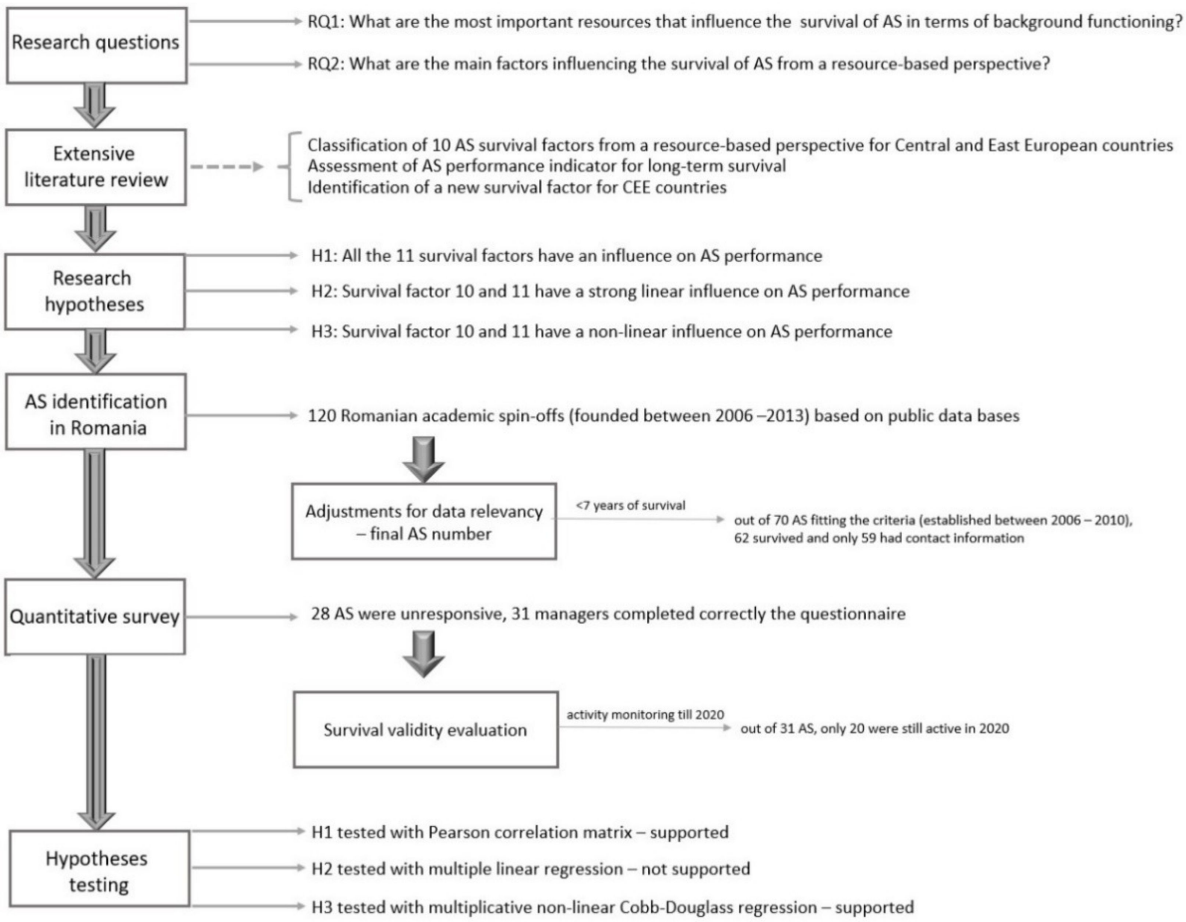

Figure 2. Methodological steps for the statistical analysis of survival factors in the Romanian context.

In November 2017, the authors created a database with the financial information of 120 academic spin-offs (established between 2006 and 2013 and financed by the POSCCE 2006–2013 in Romania), considering the number of employers, the turnover, and the domain. The information was collected using public data (https://www.romanian-companies.eu/search.asp, accessed on 19 November 2017; www.m.finante.ro, accessed on 19 November 2017) and the web page of each company.

As seen in Table 3, 47.5% of the firms were active in advanced services, 25% in materials, and 18% in electronics. During the research, it transpired that statistical data on the number of AS entities in Romania had not yet been collected and classified.

Table 3. Industry or field of activity for the 120 Romanian academic spin-offs.

Industry or Field of Activity	No.	Year							
		2006	2007	2008	2009	2010	2011	2012	2013
Materials	30		2	3	6	8	7	4	
Environment	3		1		1			1	
Electronics	18	2	1	1	2	5	5	2	
Advanced services	57	2		6	14	13	8	10	4
Biomedical	12				1	2	2	5	2
TOTAL	120	4	4	10	24	28	22	22	6

The industry categories were outlined based on classifications by Fini and Toschi [77] and Bolzani et al. [50]. Furthermore, to ensure that the companies were long-term survival examples, we used a survival rate of seven years, as argued by [12]. Thus, only academic spin-offs founded from 2006–2010 were considered, determining only 70 AS companies that fit this criterion. Since November 2017, from the 70 companies determined, eight failed, and the target population remained 62. Of these, only 59 companies had contact information.

In the design stage of the questionnaire, five general questions were constructed by the authors based on the literature, regarding the title and function of the respondent, the creation date of the AS, the research domain, and the region, followed by eleven specific questions (one for each survival factor, as seen in Appendix A) with possible answers of a closed-scale type. The questionnaire was first tested and validated on five spin-offs in April 2018, after which it was sent to the selected 59 academic spin-offs from June 2018 until August 2018. The managers who did not respond in that period were contacted by telephone to see if they had received the questionnaire and to remind them of the importance of their cooperation. A total of 28 academic spin-offs did not respond or agree to the survey, and only 31 managers correctly finalized the questionnaire. Of the 31 retained managers, approximately 72% were male, and 28% were female. Their average age was around 45 years.

By analysing the 31 academic spin-off survival rates until 2020, we found that only 20 academic spin-offs remained active. The financial information was collected using public data (www.m.finante.ro, accessed on 9 May 2022).

Therefore, the sample used to check which factors influenced the performance of the spin-offs finally consisted of 20 active firms. The characteristics of these companies established from 2006–2010 are presented in Table 4.

The study revealed that the 20 academic spin-offs active today were established in regions where the numbers of research institutes and universities were high. In the same manner, other scholars have analysed such small amounts of case studies [12,46] due to the long-term period of survival.

To analyse the AS performance, the performance was calculated as sales growth in the period of 2010–2019. The 11 survival factors (dependent variables) received allocation numbers (X_1, X_2, etc.) to not influence the results. In the statistical analysis phase, Pearson's correlation matrix was chosen as the primary analysis step, followed by different types of regressions, until an optimal model was reached.

Table 4. The main characteristics of the Romanian academic spin-offs that survived until 2020.

Academic Spin-Off	Industry Affiliation	Year of Establishment	Region	Number of Research Institutes and Universities in the Region	Firm Age (from Formation Until 2020)
AS1	Manufacture of other electrical equipment	2009	Bucharest-Ilfov	67	11
AS2	Analyses for control problems in the pharmaceutical field	2009	Northwest	17	11
AS3	Wholesale of electronic and telecommunication components and equipment	2009	Northeast	17	11
AS4	Electrical works	2006	Northeast	17	14
AS5	Manufacture of pharmaceutical preparations	2010	Central	13	10
AS6	Custom software development activities (customer-oriented software)	2007	SW Oltenia	5	13
AS7	Nutrition and heath	2010	Bucharest-Ilfov	67	10
AS8	Business and management consulting activities	2009	Bucharest-Ilfov	67	11
AS9	Manufacture of other electrical equipment	2008	Bucharest-Ilfov	67	12
AS10	Engineering activities and technical consultancy related to them	2010	Bucharest-Ilfov	67	10
AS11	Manufacture of electric motors, generators, and transformers	2008	Bucharest-Ilfov	67	12
AS12	Manufacture of other chemical products	2007	Bucharest-Ilfov	67	13
AS13	Custom software development activities (customer-oriented software	2009	West	15	11
AS14	Technology for the manufacture of cast steel parts	2009	Northeast	17	11
AS15	Manufacture of other electronic components	2010	SW Oltenia	5	10
AS16	General mechanics operations	2010	West	15	10
AS17	Custom software development activities (customer-oriented software	2010	Northwest	17	10
AS18	Specialized medical assistance activities	2009	Bucharest-Ilfov	67	11
AS19	Specialized medical assistance activities	2010	Bucharest-Ilfov	67	10
AS20	Production of medical and laboratory devices, apparatus, and instruments	2010	Bucharest-Ilfov	67	10

4. Data Analysis

The regression analyses to validate the three hypotheses was performed with R software. Pearson's correlation matrix was chosen to test H1 because it envisages good or weak correlations between the dependent variables and the independent variable (Table 2). However, because Pearson's correlation matrix only provides a certain direction towards the best correlations possible and does not exclude the relevance of weaker ones, the next step was to employ a multiple linear regression method (classical additive model) with a backward selection procedure in order to test H2. The alpha significance level was equal to 0.1. Since we did not reach an optimal model (with all predictors having a *p*-value for the *t*-test above alpha, a *p*-value for the F-test higher than alpha, a determination coefficient <0.51, and an adjusted determination coefficient <0.2), we proceeded with the multiple linear regression model without an intercept. This method is useful when the independent variable is not worth computing when all the dependent variables (predictors) are 0, which was correct in our case.

The model in Equation (1) had the same optimization procedure and the same significance alpha level:

$$Y = b_1 \times X_1 + b_2 \times X_2 + b_3 \times X_3 + b_4 \times X_4 + b_5 \times X_5 + b_6 \times X_6 + b_7 \times X_7 + b_8 \times X_8 + b_9 \times X_9 + b_{10} \times X_{10} + b_{11} \times X_{11} + er \quad (1)$$

A relative optimal level model was reached (the *p*-value was slightly above alpha), but the determination coefficients were not high enough. Therefore, a logical statistical step was to take into consideration a nonlinear model (a multiplicative model with a nonlinear Cobb–Douglas function).

Multiplicative model (2) was considered:

$$Y = a0 \times X_1^{b1} \times X_2^{b2} \times X_3^{b3} \times X_4^{b4} \times X_5^{b5} \times X_6^{b6} \times X_7^{b7} \times X_8^{b8} \times X_9^{b9} \times X_{10}^{b10} \times X_{11}^{b11} + er \quad (2)$$

A log linearization with the relationship $X_1^{b1} = \exp(b_1 * \log(X_1))$ was used, as well as a backward selection procedure for alpha = 0.1. In this case, the determination and adjusted determination coefficient were better than those in the classical linear model. Nevertheless, a high number of iterations was needed for parameter estimation. The need for a Cobb–Douglas nonlinear model without an intercept was established.

The nonlinear model without an intercept can be seen in Function (3):

$$Y = X_1^{b1} \times X_2^{b2} \times X_3^{b3*} \times {}^*X_5^{b5} \times X_6^{b6} \times X_7^{b7} \times X_8^{b8} \times X_9^{b9} \times X_{10}^{b10} \times X_{11}^{b11} + er \quad (3)$$

5. Results

In Table 5, the correlation matrix is presented with Pearson's coefficient between the response variable Y and each predictor variable X_i, where I = 1,2, ... , 11. A greater (absolute) value (i.e., the absolute value lies above 1) of this coefficient correlation suggested a possible linear relation between Y and X_i. A small value did not mean that the relation was not possible, but that this relation was not sure linearly.

A good correlation was identified between the dependent variable Y of sales growth and X_{10}, the quality of scientific support concerning the development of the product), as well as X_{11}, the team competency in accessing government funds. Weak correlations between the independent variable and the dependent variables of X_2 (the incubation resources), X_3 (the research skills of the manager), X_4 (the previous entrepreneurial experience of the team), X_6 (the research product stage), and X_7 (the long-term development resources), as well as a very weak correlations with all the other variables, were also identified. Thus, the first hypotheses (H1) of the study was supported, with all eleven factors having an influence (strong or weak, not zero) on the performance.

Table 5. The correlation matrix for the 11 independent variables and the dependent variable.

	X	1	2	3	4	5	6	7	8	9	10	11	Y
1	consortia of public research institutes and firms	1.000	0.567	0.109	−0.266	−0.098	0.258	0.015	0.111	0.426	−0.030	−0.402	0.012
2	resources in incubation	0.567	1.000	0.047	0.030	0.169	0.175	−0.047	0.234	0.216	−0.179	−0.400	0.176
3	manager's research skills	0.109	0.047	1.000	−0.111	0.154	0.233	0.646	0.181	0.368	0.563	0.146	0.115
4	manager's entrepreneurial competency	−0.266	0.030	−0.111	1.000	0.669	0.245	−0.334	0.275	0.315	−0.358	0.331	0.121
5	previous entrepreneurial experience of team	−0.098	0.169	0.154	0.669	1.000	0.367	−0.120	0.508	0.569	−0.018	−0.049	−0.049
6	research product stage	0.258	0.175	0.233	0.245	0.367	1.000	−0.147	0.314	0.417	0.025	−0.303	0.169
7	resources for long-term development	0.015	−0.047	0.646	−0.334	−0.120	−0.147	1.000	0.095	0.113	0.697	−0.024	−0.098

Table 5. *Cont.*

	X	1	2	3	4	5	6	7	8	9	10	11	Y
8	scientists' attitudes towards commercialization	0.111	0.234	0.181	0.275	0.508	0.314	0.095	1.000	0.339	0.225	−0.250	−0.026
9	venture capital during the growth of the firm	0.426	0.216	0.368	0.315	0.569	0.417	0.113	0.339	1.000	0.133	−0.116	−0.068
10	quality of scientific support concerning the development of the product	−0.03	−0.179	0.563	−0.358	0.018	0.025	0.697	0.225	0.133	1.000	−0.021	−0.343
11	team competency in accessing government funds	−0.402	−0.400	0.146	0.331	0.234	−0.303	−0.024	−0.250	−0.116	−0.021	1.000	0.243
	Y: sales growth	0.012	0.176	0.115	0.121	−0.049	0.169	−0.098	−0.026	−0.068	−0.343	0.243	1.000

For H2, as expressed in the data analysis method, a classical statistical model was considered to test the linearity of the data. Due to the fact that a multiple linear regression model with an intercept was not conclusive or statistically appropriate, the same model without an intercept (1) was employed.

A relative optimal model with two predictors was reached, namely X_{10} (quality of scientific support for product development) and X_{11} (team competency to access government funds), as can be seen in Table 6.

Table 6. Statistical parameters for the linear regression model (without intercept).

	Estimate	Std. Error	t-Value	Pr (>|t|)
b10	−1.3666	0.8257	−1.655	0.1152
b11	1.7173	0.7211	2.382	0.0285
Residual standard error: 4.163 on 18 degrees of freedom; multiple R-squared: 0.3347; adjusted R-squared: 0.2607; F-statistic: 4.527 on 2 and 18 degrees of freedom; *p*-value: 0.02555.				

Table 6 presents the estimation values of the parameters. Null values were not desirable due to the fact that this would mean that the predictor was not significant. In conclusion, a very small value was needed to accept the proposed model.

A factorial analysis (categorial type) was realized first on the two predictors, X_{10} and X_{11}, and second only on the X_{11} predictor. For the categorial values of X_{11}, better statistical results were obtained than for X_{10}. However, the linear relationship was acceptable only for high X_{11} values (values of 4 and 5). Furthermore, the values for the coefficients of determination were not high enough.

Due to the fact that the multiple R-squared (coefficient of determination) value of 0.3347 was slightly low, the hypothesis of H2 was nonvalidated (the relation was not significant linearly).

Furthermore, in order to test H3, the nonlinear model in Function (2) was computed. The linearized model was relatively optimal with the predictors of V_1, V_2, V_5, V_6, V_9, V_{10}, and V_{11} (where $Vi = \log(X_i)$), as can be seen in Table 7.

Table 7. Statistical parameters for the nonlinear regression model (with intercept).

	Estimate	Std. Error	t-Value	Pr (>|t|)
V1	−1.7865	0.7049	−2.534	0.2620
V2	1.6373	0.5537	2.957	0.01199
V5	−5.1852	1.8294	−2.834	0.01506
V6	3.1334	1.7014	1.842	0.09037
V9	0.9341	0.5556	1.681	0.11855
V10	−3.2461	0.9909	−3.276	0.00663
V11	4.5521	1.3113	3.471	0.00462
Residual standard error: 1.183 on 12 degrees of freedom; multiple R-squared: 0.6712; adjusted R-squared: 0.4794; F-statistic: 3.499 on 7 and 12 degrees of freedom; *p*-value: 0.02771.				

Due to the fact that V_9 had a slight overreach on the alpha level, it was the first to be eliminated. Through the optimization procedure, several predictors were eliminated, but the number of iterations was still too high. Thus, the same nonlinear model was considered without an intercept, as in Function (3). The same seven predictors were analyzed, as in Formula (4):

$$\begin{gathered} Y \sim \exp(b1 \times \log(X1)) \times \exp(b2 \times \log(X2)) \times \exp(b5 \times \log(X5)) \times \exp(b6 \times \log(X6)) \\ \times \exp(b9 \times \log(X9)) \times \exp(b10 \times \log(X10)) \times \log(X1)) \times \exp(b2 \times \log(X2)) \times \exp(b5 \times \log(X5)) \times \\ \exp(b6 \times \log(X6)) \times \exp(b9 \times \log(X9)) \times \exp(b10 \times \log(X10)) \times \exp(b11 \times \log(X11)) \end{gathered} \quad (4)$$

In Table 8 the seven predictors are presented based on an amount of 52 iterations to convergence. The convergence tolerance was achieved at 9.282×10^{-6}.

Table 8. Statistical parameters for the nonlinear regression model (without intercept).

	Estimate	Std. Error	t-Value	Pr (>|t|)
b1	−0.5488	1.6655	−0.330	0.747
b2	1.1235	1.5235	0.737	0.474
b5	−3.0281	5.2640	−0.575	0.575
b6	1.6698	2.6178	0.638	0.535
b9	0.8896	1.3362	0.666	0.517
b10	−2.0179	1.9846	−1.017	0.328
b11	2.8527	3.0331	0.941	0.364
Residual standard error: 4.094 on 13 degrees of freedom.				

After the backward selection procedure, five predictors were eliminated, and an optimal model with two predictors, X_{10} and X_{11}, was obtained. To further estimate the corresponding parameters of b10 and b11, a nonlinear regression procedure was employed. In Table 9, the statistical parameters for the model are presented.

Table 9. Statistical parameters for the nonlinear regression model.

	Estimate	Std. Error	t-Value	Pr (>|t|)
b10	−3.2431	1.4246	−2.277	0.03526
b11	3.1304	0.8765	3.571	0.00218
Residual standard error: 3.838 on 18 degrees of freedom; number of iterations to convergence: 7; achieved convergence tolerance: 4.219×10^{-6} (0.000004219).				

In conclusion, the developed statistical model had the following Function (5):

$$Y = X10^{\{-3.2431\}} \times X11^{\{3.1304\}} \quad (5)$$

The results in Table 10 show that hypotheses 1 and 3 were validated and that hypothesis 2 could not be sustained. The two factors, X10, which refers to the quality of scientific support of the university or research center in the development of the product, and X11, which refers to the competencies of specific team members in accessing government funds, had significant influences on AS survival in the Romanian context.

Table 10. Hypothesis summary.

	Hypothesis	Support
1	H1: The consortia of public research institutes with firms, resources in incubation, manager's research skills, manager's entrepreneurial competency, previous entrepreneurial experience of the team, research product stage, resources for longer-term development, scientists' attitudes towards commercialization, venture capital during the growth of the firm, quality of scientific support concerning the development of the product, and team competency in accessing government funds have influences on AS performance.	Supported ($p < 0.05$)
2	H2: The quality scientific of support concerning the development of the product and the team competency in accessing government funds both have significant linear influences on AS performance.	Not supported
3	H3: The quality of scientific support concerning the development of the product and the team competency in accessing government funds both have a nonlinear influence on AS performance.	Supported ($p < 0.05$)

6. Discussion and Findings

Our study on 20 Romanian academic spin-offs with survival rates of over 7 years showed that their performances were influenced by the consortia of public research institutes with firms, resources in incubation, manager's research skills, manager's entrepreneurial competency, previous entrepreneurial experience of the team, research product stage, resources for long-term development, scientists' attitudes towards commercialization, venture capital during the growth of the firm, quality of scientific support concerning the development of the product, and team competency in accessing government funds.

Although many studies have claimed to investigate the process of academic spin-off formation, few have looked at the survival of these companies, especially in central and eastern European countries [69,73,76]. AS firms are very different when considering their resource usage, business models, and institutional relationships and backgrounds. Regional context is particularly important and must be considered in future government funding strategies. The specific factors that influence the survival of Romanian academic spin-offs can change in other contexts.

Even though academic spin-offs have a special relationship with academia [45,50], who can recommend and intermediate AS company new offers to potential industrial partners or investors, the study revealed that the quality of scientific support concerning the development of the product measured by the number of employees in a spin-off coming from a university or research institute negatively influenced the AS performance. By focusing too much on research and the risks involved and less on market opportunities, researchers could hinder the natural development of a spin-off.

These spin-offs receive several resources from universities and research institutes or centers. In other words, public research institutes provide spin-offs with basic research and human capital creation. Therefore, from a human capital perspective, the research outlined that it was not recommended for AS companies to employ too many scientists from the academic field.

Our results are in accordance with [60], which pointed out that hiring employees for a spin-off from a university could trigger parental hostility and negatively influence AS performance.

By understanding how Romanian universities can influence AS formation and development, further studies should take into consideration other factors related to universities and AS companies.

In comparison to the quality of scientific support for the development of an AS product [32,45], the team competency in accessing government funds appeared to be a major advantage or a drawback if not acquired. The role of the AS team in accessing European or government funds was seen to sustain the company. Romania has a low European fund absorption rate, in most cases due to a lack of specialists in writing and managing government programs and projects.

From 2007 until now, Romania experienced two public financing programs that encouraged the development of spin-offs and start-ups in the creation phase. The UE allocated EUR 536.39 million for the priority Axis 2: Research, Technological Development, and Innovation for Competitiveness of the 2007–2013 POSSCCE Program and EUR 952.27 million for the priority Axis 1: Research, Technological Development, and Innovation in Support of Economic Competitiveness and Business Development of the 2014–2020 POC Program.

As our research suggested, the most important way to assure the sustainable development of AS companies is to establish in each university a department that offers researchers and staff special trainings for accessing European funds for technology transfer.

Most central and eastern European countries are dealing with this problem, unlike western countries [32], which have enough skilled training and personnel, as well as a culture focused on translating funding opportunities into practical projects. In addition, AS companies can operate better and for longer periods in areas with high economic and financial potentials.

Therefore, such competencies in an AS team can have a huge positive influence on its development and long-term survival. The existence of European or government funds does not guarantee their absorption, but the skills necessary for accessing them could provide the capital needed for the successful development of these special and innovative companies. Adequate training in universities and research centers on entrepreneurship and government project writing can enhance AS creation [35,42] and, moreover, AS long-term survival.

The limitations of this research are related to data collection. First, the time between the initial survey and the established AS survival status was taken as 2.5 years, but still, the most important factors were based on the experience in the moment of establishing the company.

Secondly, the number of analyzed academic spin-offs for the quantitative survey was low because AS companies are just starting to develop in Romania, as well as in most emerging economies. Additionally, few of them survive for long periods (more than seven years, as analyzed in the present article).

Thirdly, because the study related to the Romanian experience [2], it limited the generalization of the results. Nevertheless, due to the similarities between central and eastern European countries, the present conclusions could be meaningful for innovation-centered European program strategy designs. Future studies should be based on large-scale, officially collected datasets from other central and eastern European countries to avoid the limitations of single-country contexts and survey-based studies.

We believe that future work should seek to include additional factors of AS performance, taking into consideration the level of corruption in central and eastern European countries. If universities develop more spin-offs, economic growth can reduce the corruption and the average living standard in a country, which is represented by the GDP per capita [78].

7. Conclusions

Looking at the potential to generate performance, the description of the survival factors identified in the study highlighted that some of them were parts of AS companies since inception, such as networking, the material resources available in the incubation stage, the manager's research skills, the manager's entrepreneurial competency, the previous entrepreneurial experience of the team, and the attitude at the individual level towards the commercialization of the research result. Instead, other factors depended on specific choices made during the long-term development of the companies, such as venture capital during the growth of the firm, the sharing of research equipment for spin-off long-term development, the quality of scientific support concerning the development of the product, and the team competency in accessing government funds.

The present findings are relevant and valuable in the academic context of Romanian entrepreneurship because governments and universities are beginning to invest in and support academic spin-offs. The results obtained showed how developing the team competency in accessing government funds could play fundamental roles in creating and developing a successful AS, as well as how the quality of scientific support concerning the development of the product received from the research organization negatively influenced the AS performance. In the long term, the more employees that came from universities or research institutes, the more the AS performance decreased.

Regarding strategic managerial implications, the research had multiple inferences for management, policy makers, and research institutes in raising awareness to adopt adequate measures to support the entrepreneurial missions of AS companies. First, from the perspective of research organizations, they should organize specialized courses for AS teams to access funds and sustain the growth of AS companies, which are atypical companies with huge needs for research-related funding. In this way, sustainable regional development is possible. Second, the study explored the main important factors that influenced spin-off performance, and the findings are relevant for universities and research institutes to understand how to manage the linkage of the academic environment to AS companies, as well as for understanding how to increase the number of spin-offs. In this way the research showed that spin-off performance was influenced negatively by the number of employees from a research institute involved in the product development (quality of scientific support concerning the development of the product).

Third, the research outlined the need for design and institutional mechanisms in research institutes and universities aimed at addressing this gap.

Furthermore, these results highlighted the significance of path dependencies in AS performance and suggested a key competency for practitioners in helping academic entrepreneurs acquire the appropriate resources for the development of spin-offs.

The novelty of the research consisted of the database created from Romanian spin-off experiences. The added value of this research consisted or proposing a novelty spin-off key performance factor specific to central and eastern European countries: team competency in accessing government funds.

Out of 70 companies founded from 2007–2010, 62 survived up to 2018. This showed a good practice in sustainable development for universities and research institutes.

Another contribution that this study brought was the fact that, in Romania, even now there are many European call proposals open that encourage the creation of spin-offs, but scientists do not have the necessary information and training to understand the opportunities created and the insights for sustainable growth. Following the results of the study, we recommend that AS managers should not include too many scientists from universities in their teams because they can have a negative influence on AS performance.

The research can provide guidance for policy makers concerning the program indicators of European funding schemes, which should not include a high number of academic researcher employees in new ventures during the sustainability phase.

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Appendix A

X1. Consortia of public research institutes and firms: Among the shareholders of your company, are there public research institutes or firms?

X2. Resources in incubation: Did the AS start only with the founders' human, material, and financial resources?

X3. Manager's research skills: Did the manager have specific research experience in the field of the commercialized product?

X4. Manager's entrepreneurial competency: Did the manager have entrepreneurial experience when founding the firm?

X5. Previous entrepreneurial experience of the team: Did the managerial team have entrepreneurial experience when founding the firm?

X6. Research product stage: When founding the AS, at what level was the product research stage?

X7. Resources for long-term development: Did a university or research institute offer technical support or access to equipment over time?

X8. Scientists' attitudes towards commercialization: Did the capacity of risk-taking influence business success?

X9. Venture capital during the growth of the firm: Did other companies provide additional capital over time?

X10. Quality of scientific support concerning the development of the product: Did some of the AS employees also work at a university or research institute?

X11. Team competency in accessing government funds: Did the team competency of accessing government funding influence the success of the firm?

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