Survival of High-Tech University Spin-off Firms in Sustainable Energy

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Abstract

High-tech startups play an important role in energy transition, and in strengthening interaction within entrepreneurial ecosystems. Such firms focus on development of innovative solutions for sustainable energy, introduce the innovations into the market, and eventually scale up. While the advantage of startups over incumbent firms in making technological changes has been popularized in recent studies, their actual contribution to change is still questioned. The aims in Europe to strengthen innovation and accelerate market introduction today tend to be contradictory to the relatively low survival rate (66 percent). This chapter investigates the survival of startups in the sustainable energy sector, in particular, the time required for market introduction and the longevity of the startups. Drawing on 106 university spin-offs in Northwest Europe, the chapter tracks events retrospectively over the past 20 years. Cox regression analysis is used with the result of importance of the following influences: early market introduction, small team size, strategic diversification, and benefits from a supportive National Innovation System. The chapter closes with potential contribution to new EU industrial policy in strengthening EU technology and innovation, with planning suggestions.

Keywords: Survival, exit, commercialization, academic entrepreneurship, sustainable energy, acceleration policy.

1. Introduction

In the era of increased global competition for European technology and innovation, attention is focussing on incumbents, startups and innovation ecosystems. In particular, the DG for Research and Innovation (2025) considers that public policy should encourage entrepreneurship and remove barriers to new business initiatives. In a targeted approach, emphasis is put on skills improvement, financing start-ups, and utilization of spatial context (clustering). Such industrial policy is relatively new. This chapter is a broad scanning study of a set of influences impacting on startups' growth and survival. The technology area involved encompasses renewable energy and energy efficiency.

In literature, startup firms in general are perceived as facing significant challenges and as failing within the first few years, imposing a burden not only on the founders but also on their investors and the economy (Headd, 2003; Wiklund et al., 2010). High-tech startups face even greater challenges in market introduction, while operating in a complex socio-technical system, such as the energy system, characterized by the interactions of several powerful agents. To navigate the complexity of changes in the energy system and activity of large firms, supportive policies and governmental assistance are often implemented to safeguard and stimulate startup firms active in this domain. Consequently, failure of high-tech startups in sustainable energy, after investing considerable efforts, creates significant damage and is not a desired outcome. The aim of this chapter is to understand the factors that can prevent firm failure and contribute to the survival of high-tech startups in sustainable energy, the more given emerging EU policy to strengthen technology and innovation capabilities.

Josefy et al. (2017) provide an overview of the significant hurdles that startups in general face compared to established firms in terms of survival. Startups typically struggle with the absence of an established reputation, customer base, and resources that established firms enjoy. In addition, the dynamic nature of the sustainable energy market poses unique hurdles for innovative startups. These startups face dual challenges stemming from introducing new technologies, or products, that align with sustainability goals, while also navigating evolving consumer preferences, changing market demands, and a shifting institutional environment. Furthermore, the existing path dependency and lock-in of consumers and investors in the traditional energy system complicate market entry and, consequently, endanger the survival of such innovative startups (Schöpper et al., 2024). However, startups can also mitigate negative challenges by selecting adequate innovation strategies, like small diversification with services and timely accessing external resources and competences, and benefit from supportive environmental conditions set by local policy actors (e.g. Meijer et al., 2019; Dutta & Khurana 2025). Accordingly, this chapter aims to analyse survival among startups in sustainable energy by focusing on firm resources, capabilities, and the role of entrepreneurial ecosystems (EES).

The chapter makes three contributions to the existing literature on firm survival. First, it focuses on the sustainable energy sector, encompassing renewable energy and energy efficiency technologies. The approach enables a thorough *scan* and exploration of the distinctive challenges and opportunities that startup firms in the sustainable energy sector may face. Second, while the conventional view regards firm closure as a negative and undesirable outcome, it is crucial to recognize that firms may opt for a merger or acquisition to facilitate resource and market expansion through integration with a larger firm**.** However, the new EU policy context favours to avoid acquisition of EU-based start-ups on a global scale, and 'keep' growth and upscaling within the EU. Some preliminary insights are presented in this chapter. Third, this study also considers the impact of intermediate events throughout a firm's lifecycle on its survival prospects. Analysing specific intermediate events, such as first market introduction, initial formal collaborations, and initial financial investment, the study aims to elucidate how these events shape the trajectory of firm survival in the sustainable energy sector. Understanding the implications can offer important insights supporting the design of competitive EU innovation policies.

Through analysing a sample of 106 university spin-off firms in sustainable energy technology, this study addresses the following research question: What are the dynamics of firms' survival among the sample of university spin-off firms with regard to time of survival, and influencing factors? To what extent does the scan of influencing factors contribute to understanding of realism in improving depth and speed of innovation?

The subsequent sections are structured as follows: Section 2 outlines the theoretical background of the study. Section 3 explains the methodology employed with regard to dynamics of survival/closure over time. Moving forward, Section 4 analyses firm survival through Cox regression analysis. Finally, Section 5 concludes the chapter y summarizing key findings and drawing conclusions, and suggesting potential future research, in particular, serving new EU policies.

2. Start-up Survival

This study is grounded in the main theories of Entrepreneurial Orientation (EO) and the Resource-Based View (RBV) of the firm, while also integrating the concept of the Entrepreneurial Ecosystem (EES).

2.1 Entrepreneurial Orientation

The firm's strategy to manage sustainable energy innovations and leverage them for benefits, is a crucial determinant of the firm's success. Building on Schumpeter's theory of innovation (1934), which underscores the economic value created by innovation, several studies have explored firms' innovation strategies as potential sources of competitive advantage (Chandy & Tellis 2000; Zhou et al., 2005; Hana, 2013; Anning-Dorson, 2018; Nosella et al. 2025). This perspective echoes Wiklund and Shepherd's view (2003) highlighting that a firm's entrepreneurial strategy regarding innovation is a crucial knowledge source for generating competitive advantage and enhancing a longer firm survival (Wiklund and Shepherd, 2003). Below, we discuss innovation radicalness, newness of markets, and diversification with additional products/markets.

Innovation radicalness

Previous empirical studies, that examine the effect of radical innovation on firm success, show diverse outcomes (Evanschitzky et al., 2012). Some studies argue that a firm may enjoy a competitive advantage and experience longer survival if it exploits radical innovation with a broad scope of patents. It can prevent other firms from imitating them in a short period (Zhou et al., 2005). Alternatively, other studies suggest that if firms combine radical innovations with strategies to reduce risks and uncertainties involved, they may survive longer. For instance, Nerkar and Shane (2003) examined the influence of product radicalness on the survival of university spin-offs and discovered that this correlation depends on the risk levels within the industry. Consequently, they argue that risk-averse or risk-mitigating strategies should be carefully considered, especially among small high-tech startups.

In general, risk-taking is substantially stronger and comprehensive in radical innovation compared to incremental innovation. Radical innovations as novel technologies that offer substantially new core technology compared to existing technologies, contrast with incremental innovation as minor changes or line extensions of the existing technology in order to improve its performance or efficiency (Zhou et al., 2005; Bessant et al., 2014).

Newness of markets

With regard to newness of markets, some innovation studies distinguish between product-based innovation and market-based innovation, proposing that the latter gives access to new customer segments and, subsequently, new markets. Conversely, product-based innovations, even if they entail radical innovation, may not necessarily lead to the creation of new markets (Zhou et al., 2005; Sainio et al., 2012). The creation of a new market or the development of a new customer segment offers a notable competitive edge, particularly providing advantage for startups, over established firms (e.g., King and Tucci, 2002). However, despite the potential benefits it offers to startups, the process of establishing new customer segments or markets is characterised by inherent complexity, stemming from the challenge of evaluating customer reactions and acceptance, and risk of not passing the "Valley of Death" (Markham et al., 2010; Mohr et al., 2013). In the present study, the young high-tech university spin-off firms, are categorized based on the type of market: those that create or enter a new/emerging market, and those that enter an existing market.

Diversification in product or market

Diversification in product or market is a recognized strategy aimed at enhancing a firm's performance by mitigating risks through expanding its market and sales, increasing cash flow, and enabling self-investment in R&D (Mohr et al. 2013). However, when applied to innovative startups, the literature approaches this topic from different perspectives. In one meta study, the results of past studies are summarized, showing the disagreements on the relationship between diversification strategy and firm performance (Palich et al., 2000). Accordingly, while some studies suggest that diversification strategy can potentially yield superior performance in comparison to a focused strategy, certain other studies highlight the adverse effects associated with diversification strategy, citing hurdles that top managers may encounter in managing diversified products or markets. For startup firms, diversification means spreading resources and focus across multiple areas, rather than concentrating all efforts and resources into a single area where success would depend solely on it. Dependent on timing, the diversification then helps to increase the chances of success (Khurana & Farhat, 2021).

2.2 Firms' Owned Resources and Capabilities

Following the resource-based theory (Barney, 1991), this section next links the resource-based view to firm survival, considering that firms' ownership of and access to resources and capabilities, can help to adapt to changing competitive environments (Esteve-Pérez & Mañez-Castillejo, 2006). In our analysis specific attention is given to the founding team and its competences. These encompass team size, educational degrees, and pre-start business experience, as potential sources of firms' advantages or disadvantages in survival.

Founding Team Size, Education, Experience

In entrepreneurship literature, the characteristics of the founding team are recognized as a critical factor for the success of a startup (Scholten, 2006; Hambrick, 2007; Criaco et al., 2013). This significance is even more pronounced in the context of university spin-offs, given their unique nature that requires a delicate balance between scientific orientation and business orientation (Visintin & Pittino, 2014). Furthermore, assuming that the diversity and amalgamation of different experiences within the founding team enhance team capabilities, it becomes conceivable that a larger founding team size translates into a more diverse composition of both tangible and intangible resources for the firm, and accordingly to (more) added value (Scholten, 2006; Huynh et al., 2017). However, various studies also point to potential dangers of large and more diverse founding teams, namely the rise of fault-lines between team-members that may delay effective decision-making (e.g. Aspelund et al., 2005; Yan et al., 2021).

A scientific orientation of university spin-off firms is crucial for innovative technology development and is considered a competitive advantage. However, the presence of business orientation, often poorly developed at firm start, is emphasized as necessary for effective product/service commercialization and the overall survival of the firm (Huynh et al., 2017). Some previous studies suggest that individuals holding a Master degree are often more practical and can run businesses more successfully than their counterparts holding a PhD degree (e.g., Clough and Vissa, 2022). Additionally, having pre-business experience among the founders may empower the business orientation of the firm from the beginning and count as an advantage, particularly when the firm suffers from lack of business orientation in their early years (De Cleyn et al., 2015).

2.3 Early-Stage Resource Acquisition

In a study focused on bankrupted firms, Thornhill and Amit (2003) explained the concept of a firm's liability of newness through the lens of the resource-based view. Accordingly, age itself does not stand as the primary cause of a firm's failure, instead, age acts as a proxy standing for insufficiencies in resources and capabilities. Accordingly, in contrast to older firms that have gradually accrued valuable resources and capabilities over time, the failure of young firms may stem from inadequacies in resources and capabilities. Following this line of thinking, the chapter contends that an early acquisition of resources and capabilities can mitigate the vulnerability associated with a firm's newness and enhance its chances of survival. Business studies have defined a wide array of both tangible and intangible resources and capabilities, each carrying varying degrees of importance. Missing capabilities in the first years tend to include skills on markets and marketing, capabilities in management and networking, and capabilities to access investment capital (Van Geenhuizen & Soetanto, 2009; Fackler et al., 2013). However, the situation becomes different when through market introduction and sales, cash flow is being generated enabling the firms to return previous loans and to do investment by themselves, e.g. to further improve the product and develop a sales organization. In this vein, *early market introduction* is also seen as a factor making survival easier through resource acquisition.

Seeking collaboration in networks is considered as vital for young high-tech firms in accessing external capabilities and resources (e.g. Lavie, 2006; Walter et al., 2006; Hayter, 2016; Engel et al., 2017; Eveleens et al., 2017; Wechtler et al., 2023). Being active in more diverse (larger) networks also prevents path-dependency by 'keeping horizons open' (e.g. Scholten et al., 2015; De Silva and Rossi, 2017). Since networks can be enriched over time, this is one of the areas in which startups remain behind compared with older firms, unless specific connections work highly effective. The sooner the startup can establish a collaboration with larger firms, customers, or governments, the more advantages they could gain.

Access to investment capital is crucial for innovative high-tech startups to improve the inventions and bring them to the market (Hall & Lerner, 2010; Nanda & Rhodes-Kropf, 2013; Bertoni et al., 2011). Although often initial investments can be afforded by startups through subsidies for starting a business or seed money, substantial amounts of capital may be needed later on, particularly if the invention is more radical and additional pilots or other testing are required.

Overall, based on literature it can be concluded that the liability of newness is triggered mainly by lack of firm resources and their disability in gaining them. Such development happens because the managing team needs time to develop and absorb the necessary knowledge about customers (segments), competitors, competing value propositions, market structure, etc. (Gaskill et al., 1993; Mohr et al., 2013).

3. Entrepreneurial Ecosystem

3.1 Introduction

In the mid-20th century, entrepreneurship expanded beyond individual and firm-level considerations to encompass regional, temporal, and social dimensions (Cavallo et al., 2019). This expansion led to the recognition of the relationships between entrepreneurs (small and large ones) and their local economic and social environments, adding a new dimension to previous considerations. Consequently, alongside the traditional focus on individual and firm-level, a systemic perspective on entrepreneurship emerged and developed in the 21st century, giving rise to the concept of the Entrepreneurial Ecosystem. While contextual and environmental factors and their influences were already explored in earlier entrepreneurial studies (e.g. Pennings, 1982; Ritsilä, 1999; Sorenson & Audia, 2000), the new concept of Entrepreneurial Ecosystems consolidated fragmented ideas, underlining the substantial impact that the community and cultural environment of a given area can exert on entrepreneurship (Isenberg, 2010; Zahra et al., 2014; Stam & Spigel, 2016; Audretsch et al., 2021). The entrepreneurial ecosystem underscores the role of social, political, and cultural elements embedded within a specific region or particular city, fostering growth of innovative startups (Spigel, 2017). Stam & Van der Ven (2021), and Leendertse et al. (2022) made attempts to quantify the quality of entrepreneurial ecosystems and defined them by elements required to sustain entrepreneurship in a particular area. Drawing upon the concept of entrepreneurial ecosystems, we explore the potential influence of national and regional factors on the viability of sustainable energy university spin-off firms, by incorporating the National Innovation System (NIS) scores from each country. Furthermore, distances and city-size in ecosystems, where these startups are established, will be considered given the potential advantages of proximity and density of information flows and networks, enabling face-to-face meetings and serendipity (McCann & Shefer, 2004). The scope of the entrepreneurial ecosystem narrows down further and considers the incubating university, ensuring a thorough assessment of regional advantages or disadvantages.

3.2 Selected EES dimensions

In this subsection, in a multilevel approach, attention will focus on the National Innovation Systems (NIS), metropolitan location and type of incubating university.

National Innovation System

A systemic approach to studying innovation actors and *country-level* specificities was initially pioneered by Freeman and Lundvall in the 1980s. These concepts and relationships gained traction and evolved into the notion of the National Innovation System as indicated by subsequent studies (e.g., Lundvall, 1992; Freeman, 1995). In this framework, innovation actors and institutions are seen as directly interacting and contributing to the generation, diffusion, and appropriation of technological innovation. Thus, it can be expected that countries with high ranks on NIS scores tend to foster strong collaboration between academia, industry, and government, creating a conducive environment for knowledge exchange and technology transfer, alongside financial incentives for firms involved (Acs et al., 2016). Moreover, the presence of a well-developed NIS indicates better innovation infrastructures, and better support for new startups to survive the first years and find an entry into the market. Better support, in turn, makes the country more attractive for entrepreneurs, and through quality of living environment, for attraction (retention) of highly skilled workforce.

Metropolitan area

It is widely acknowledged today that the accumulation of knowledge and knowledge networking within specific larger metropolitan areas foster innovation leading to a more pronounced increase in returns in these areas (Anselin et al., 1997; Fotopoulos & Louri, 2000; Acs et al., 2013; McCann and Ortega-Argilés, 2013). This situation is expected to also hold true for the presence of a more specialized labour market, supply of specialized services, and presence of cheap incubation sites in metropolitan areas. Consequently, the characteristics of metropolitan cities can significantly influence the performance of startup firms. In addition, cities are increasingly viewed as agglomerations of organizational and institutional entities with socio-technical, socio-economic, and socio-political goals (Simmie, 2003). If metropolitan policymakers have converging priorities and expectations, they can further enhance policies fostering entrepreneurship and innovation, like municipalities in acting as launching customer, and building (local) networks between important stakeholders (Van Geenhuizen & Nejabat, 2023).

Type of incubating university

There is a global trend towards reshaping academic institutions, including teaching colleges, research universities, and polytechnics, into entrepreneurial universities (Etzkowitz, 2003; Guerrero & Urbano, 2012; Miller & Acs, 2017). An entrepreneurial university is an extension of teaching and research activities, encompassing the internalization of technology transfer capabilities and the commercialization of knowledge. Such entrepreneurial universities are recognized as independent actors within the broader entrepreneurial ecosystem, working in conjunction with other stakeholders, like large firms and financial investors. As one of the first, Rasmussen and Sørheim (2006) have drawn attention to different types of university context that influence new entrepreneurial processes and knowledge commercialization by staff and students. Some universities prioritize teaching or fundamental research and may not actively engage in commercializing discoveries or participating in initiatives for societal improvement. In this vein, Guerrero and Urbano (2012) have differentiated between the entrepreneurial characteristics of technical universities and general universities, asserting that technical universities derive their main advantages from knowledge commercialization and strong industry relationships, whereas general universities leverage a multidisciplinary approach to exploit various areas, or they elaborate fundamental research. Moreover, technical universities have installed technology transfer offices that intend to commercialize the intellectual property (IP) that is generated at the university. When it comes to university spin-off firms, these technical universities use more often a support or incubator model (Clarysse et al., 2005) to safeguard that their IP, in the spin-off or in one of the owners, is used appropriately. However, such differences may have been reduced, more recently, derived from multiple collaboration between different types of universities.

4. Research Methodology

The focus of the chapter is on survival of sustainable energy university spin-offs (N=106) established between 1998 and 2018 in the Netherlands and four Nordic countries. The Nordic countries have been selected because of their relatively good NIS, enabling us to follow spin-offs located there over relatively long life-times. Data have been collected as representative as possible, using a multi-method approach of in-depth interviews, firm websites, energy organisations' website, and websites of financial consortia (press release). Given the nature of the data and the objectives of the study, Cox regression modelling is employed.

The age of a firm at closure is defined as the time between firm establishment and the official announcement of firm's exit from business operations. As previously indicated, the closing of a firm can be classified into two types: closure through bankruptcy, and through acquisition. During the observation period (1999-2018) 36 (34 percent) spin-off firms closed, either following acquisition (13 percent) or following bankruptcy (21 percent), whereas 66 percent survived (Table 1). The observed survival rate is consistent with the results of recent studies on firms' survival undertaken by Rannikko et al. (2019), which estimated 72 percent survival rate for high-tech startups founded in 2006 in Sweden in a time period of 8 years.

Table 1 Distribution of firms' age at Exit through Bankruptcy and Acquisition

Age of firms	Abs. No. of survived firms		Abs. No. of Bankruptcy	Abs. No. of Acquisition	Total Number of Exits
2	105		1	0	1
3	103		1	1	2
4	98		3	2	5
5	92		5	1	6
6	86		4	2	6
7	85		0	1	1
8	80		4	1	5
9	78		0	2	2
10	76		1	1	2
11	72		3	1	4
12	72		0	0	0
13	71		0	1	1
14	70		0	1	1
Total No. of firms	70		22	14	36

Table 1 illustrates the dynamics of the sample over time, specifically the number of firms exiting the business through bankruptcy and acquisition, alongside the firms' age. The highest frequency of exits occurs for firms in the range between age four and six, indicating this period as critical for high-tech startups.

5. What Matters in Survival?

5.1 Controls, Entrepreneurial Orientation, Resources and Capabilities

This section discusses the outcomes of Cox regression analysis (Table 2). Results of Cox Regression as a stepwise analysis are reported in Table 2. A hazard ratio less than 1 indicates a decrease in hazard, whereas a hazard ratio greater than 1 is associated with higher hazards.

We use a stepwise modelling, i.e. to enable dealing with a relatively small sample (106) and large number of explanatory variables (16), of which two serve as controls. The first model is the control model. It shows a relative weak outcome. In Models 1 to 4, the controlling variables are added with each set of variables, thereby constructing new one-dimensional models. Among the four models, only Model 1 which includes Entrepreneurial Orientation of firms, proves to be significant, with one influential factor (business diversification). Although Model 2 to 4 demonstrate some factors with relatively strong influence on survival, e.g. size of founding team, the models themselves are not significant. Concluding from this step, it is decided to eliminate the control model and keep the sets of variables related to Entrepreneurial Orientation (Table 2). Subsequently, the combinations of the remaining three sets of variables with Entrepreneurial Orientation factors are further explored.

Next, Model 5 to 7 present the models in which Entrepreneurial Orientation is consistently included. These sets of models *exhibit large improvements* in terms of both model significance ($p < .010$) and the number of significant variables. Building upon these significant variables, the next step involves adding the variables from the other categories while maintaining Entrepreneurial Orientation in all models. Model 8 to 10 provide the outcomes of these estimations. Accordingly, comparing the models based on their p-values, log-likelihood, and the AIC, Models 8, 9, and 10 exhibit almost identical improvements, with no substantial differences (p-values are in the same range, and the AIC differs by less than 2). Despite the attempt to avoid inclusion of all 13 explanatory variables due to the relatively small sample size-to-variables ratio, stepwise Cox regression modelling indicates *significant improvements* for three-dimensional models while assigning equal value to each set of variables (based on the results of Model 8, 9, and 10). Therefore, the decision was made to continue with Model 11 by incorporating all factors from Models 8, 9, and 10 into one model. Model 11 demonstrates a significant improvement in model features (the p-value of the model slightly improved, and the AIC number decreased by at least 4 and proved to fit the database the most. Thus, Model 11 in Table 2 has been selected for interpretation below.

Insert Table 2 about here

5.2 Modelling results

Model 11 reveals five variables that significantly influence the closure of university spin-offs operating in sustainable energy. It should be remembered that interpretation of the results always needs to be done considering the reference category of each variable coded by 1. Business diversification demonstrates the strongest significance ($p < 0.01;\ HR = 0.19$). This indicates that employing a diversification strategy tends to diminish the hazard rate significantly compared to those with a focus strategy. Founding team size tends also to play a crucial role, with firms having one person in their founding team experiencing a significantly lower hazard rate of closure compared to those with more than two persons in founding team. This result confirms the effects of size of founding team on survival, however the result are in the *opposite* direction ($p < 0.01;\ HR = 0.49$). Additionally, the age at which a university spin-off firm enters with its product the market, tends to influence the likelihood of closure, indicating that for each year increase in the age of firm at first market introduction, the hazard rate of closure increases ($p < 0.01;\ HR = 1.05$). With regard to networking and environmental support, the quality of the National Innovation System (NIS) in a country is also a key influence, with university spin-offs operating in countries with a low-quality NIS facing higher likelihood of closure than those in countries with a high-quality NIS ($p < 0.1;\ HR = 1.89$). Furthermore, the type of university tends to be a significant factor, with spin-offs from general universities facing a lower hazard rate of closure compared to those from technical universities ($p < 0.05;\ HR = 0.34$). This result is in *opposite* direction than assumed. And finally, Model 11 is the full model, that by excluding non-significant control variables, emerged as the best fit for our data. With a p-value of .0002, this model demonstrates the influence of all variables and identifies five variables with a statistically significant influence on firm survival. The subsequent section discusses the obtained results.

Entrepreneurial orientation

Among the three factors related to the *entrepreneurial orientation* of the firms, i.e. innovation radicalness, newness of market, and business diversification, the business diversification strategy is shown to have a significant effect on firm survival. The result indicates that university spin-off firms adopting a focused strategy exhibit a significantly higher probability of closure compared to those that choose to have a diversified product or market. This finding suggests that small high-tech university spin-offs in sustainable energy need a certain flexibility to integrate the risks and uncertainties involved. Therefore, those with a high concentrated focus face increased vulnerability in terms of closure.

Resources/capabilities owned by team

Further, among the three factors representing the differences *in founding team competences*, i.e. size of founding team, education of founding team, and pre-business experience of founding team, the size of the founding team emerges to have a significant effect. Surprisingly, the observed direction *contradicts* assumptions. The results indicate that university spin-off firms with smaller founding teams possess a lower probability of closure, as compared to those with larger founding teams. This unexpected outcome challenges the study's premise, which posited that a larger founding team, with its potential for increased diversity in knowledge and capabilities, network, and resource access, would contribute to a lower probability of closure. One plausible explanation may lie in the unique characteristics of university spin-off firm’s founding team and the diverse backgrounds of their founders, like full professors aside from MSc graduates (Visintin & Pittino, 2014; Huynh et al., 2017), which could lead to more conflict. Founders of university spin-off firms often possess strong academic backgrounds but may lack familiarity with the business environment and team dynamics. It is also conceivable that larger founding teams experience heightened internal conflicts, potentially contributing to the observed higher probability of closure for firms with bigger founding teams. While the size of the founding team appears to influence a firm’s survival, its role in augmenting a firm’s resources and capabilities is not straightforward. Inspired by some previous studies in the same domain (Shane & Stuart, 2002; Scholten, 2006; Taheri, 2013), it could be concluded that to establish a more meaningful connection between team size and a firm’s resources and capabilities, other characteristics of the founding team, such as their diversity in knowledge and networks, and prior friendships or partnerships within the team, should be incorporated alongside the team size. The same holds for additional strategies following a small team size, like a Lean Model, e.g., by outsourcing various team activities to external advisors (Bocken & Snihur, 2020). ‘Balancing’ of weak starting teams, e.g. through adding competences or outsourcing of team activities, is receiving increased attention today (Van Geenhuizen & Taheri, 2024), but such later changes have remained unknown in the current study.

Accessed Resources/Capabilities

The influence of the timing of access to certain resources and capabilities, is also at stake, claiming that acquiring resources earlier would increase the probability of firms' longer survival. The primary focus is on timing, assuming that earlier access would increase the probability of firm survival. Based on the results, early market introduction seems to be a factor positively influencing the probability of firm survival. In the sample, the average age of market introduction is 4.4 in a min-max range of 1 to 14. In this context, we consider early market introduction as prior to five years of age as favourable for survival.

Early access to (other) resources, such as collaboration with large firms, financial investment, and hiring marketing staff, however, tends not to be influential regarding survival. The last results are not matching some previous studies that confirmed positive effects of access to the mentioned resources on the survival of the firm. For instance, Park et al. (2010) and Sungur (2015) in their studies found a significant relationship between firms' collaboration and their survival. Similarly, Musso & Schiavo (2008), and Bridges & Guariglia (2008), emphasized the role of access to substantial financial investment in the survival of the firms. However, the *timing* of access to the resources was not considered in any of the previous studies. The unexpected results might also be explained by specificities of the sample, namely university spin-off firms in sustainable energy sectors. Since the acceleration of energy transition towards sustainability aligns with global and national policies in recent decades (overlapping with the observation period of the study), it can be imagined that if the sustainable energy innovation introduced by the university spin-offs appears promising, missing access or missing early access to networks and financial investment wouldn’t be a major obstacle. Therefore, it is a doubtful step to compare the obtained results with previous studies beyond the energy sector and its’ changing policy context.

Overall, for university spin-off firms in sustainable energy, in many cases, the main uncertainty starts with the innovation and its technology readiness level. Access to investment capital or collaboration with large firms, is a necessary step to demonstrate or pilot a project, but it does not guarantee the survival of the firm. This might be the reason why the expected relationships do not appear in the results. In addition to that, it should be considered that some roles, such as marketing personnel advice or collaboration with other firms, are covered by the support of incubating universities for university spin-offs; thus, results for non-university spin-off firms might be different.

Entrepreneurial Ecosystem

The findings reveal that firms operating in countries with lower NIS rankings may face a considerably higher probability to fail, as compared to their counterparts in countries with higher NIS rankings. This result suggests that firms operating in countries with well-established innovation systems are more likely to benefit from a supportive entrepreneurial ecosystem that encourages research and development, collaboration, and the adoption of new technologies. In addition to that, such countries may strongly encourage activities related to energy transition, like financing national research programs, eventually also encouraging productive ecosystem development. Further, the type of university shows also to be a significant factor influencing firm closure, but these findings *contradict* our initial assumptions, which posited that technical universities might offer a more conducive environment for high-tech university spin-off firms due to their connections with industry and investors. And finally in contrast with assumptions, positive influence of a metropolitan eco-system location, is not supported by the results, suggesting that rural areas and smaller cities have developed compensation mechanism, e.g. within learning activities of university spin-off firms and most probably also incubators (Flåten et al., 2015). In addition, these areas and cities may benefit from technology specialization derived from nearby natural resources, like silicon sands (solar photovoltaic) and landscape ridges with excessive wind strength.

5. Conclusion, Future Policy and Future Research

5.1 Conclusion derived from modelling

Firm survival has become one of the most intensively researched events in the organizational literature. While few studies have specifically explored the survival of university spin-off firms

(Rodeiro-Pazos et al., 2021), the limited number of research endeavours and the diversity in the scope of analysis have prevented the establishment of a consensus on influencing factors leading to the survival of university spin-offs.

A major contribution of this study is the significance of the *diversification strategy*, which is identified as the most influential factor preventing firms from failure. By incorporating risk-avoidance strategies such as reducing the radicalness of innovation and entering established markets, alongside risk-mitigating strategies in the form of product or market diversification, the study explicitly pointed out the advantage of risk-mitigating strategies over risk-avoidance strategies for ensuring firm survival. Accordingly, the results suggest that in sustainable energy industry, risk-avoidance strategies such as choosing more incremental innovation or entering established market do not have a significant relationship with longer survival of small high-tech university spin-offs. Instead, the study highlights the impact of risk-mitigating strategies, such as securing early access to revenues, through limited diversification and early market introduction. In detail, among early access to all resources considered in this study, early market introduction proves pivotal for firm survival. This result confirms that, for small high-tech university spin-off firms, proof of product may open new doors and provide access to more resources and networks. In terms of the quality of the founding team, the results indicate that a smaller size of the founding team is more desirable for firm survival. This emphasizes the importance of agility and a faster decision-making process for the survival of university spin-off firms. Further, as one might imagine, a supportive environment plays a crucial role in the survival of high-tech university spin-off firms. The results suggest that university spin-off firms located in countries with a higher level of National Innovation System benefit more from their supportive ecosystems and experience a longer survival period. Furthermore, university spin-off firms originating from general universities tend to survive longer, a phenomenon that requires further exploration.

5.2 Policies in broader framework

This study served as a broad scanning instrument, encompassing spin-off entrepreneurial orientation and strategies along with different uncertainties on resources/capabilities needed and provided through networks, eventually in the local/regional ecosystem. Five factors appeared to be influential in survival, of which three clearly connect with firm strategic choice and two with the entrepreneurial ecosystem. This difference is important as policy-making is distinct in influencing specific strategic choice compared with entrepreneurial ecosystems.

We approach the question of acceleration and strengthening as follows. First, we focus directly on outcomes of the above regression analysis in order to identify circumstances that evidently foster acceleration through start-ups' early strategy and resources acquisition (networking). These include early market introduction, relatively small team size, business diversification, and using qualities of NIS. Taking the spin-offs, they should be advised to pursue market introduction earlier in time and follow a rational entrepreneurial business model (e.g. avoiding too much and too long consultancy/service development over time). Time to market in itself tends to be influenced by early first collaboration (with a large partner) and early access to first substantial investment (Nejabat, 2025). This development indicates that if such events do not happen early after start, risks of late market introduction and non-survival may increase. Accordingly, risk-mitigation should be offered at incubators and business hubs in the local/regional ecosystem. We may particularly think of venture studios and continuation in upscaling (scaling studios), through which the financial risks and market access and creation are taken collectively. According to JP Morgan (2025) a Venture Studio, also referred to as a startup studio, combines company building with venture funding to create, launch and grow startups. Most important is that risks for individual entrepreneurs are substantially reduced and networks being established and maintained. Though there is much variation, Venture Studios usually enter at the *idea stage* and generate, test and validate ideas. They also support in building startups' minimum viable product, recruit teams and manage operations. Venture Studios preferably stay closely involved in working as co-founders, guiding the startups' strategy and execution, and overall match with new dynamic approaches and needs for public support in acceleration and strengthening of innovation.

With regard to the other influences, relatively *small team size* and *the strategy of business diversification,* we forward that such understandings need to be standard communicated and elaborated in pre-start entrepreneurship advice and training (courses). They also need to be incorporated in monitoring and evaluation of early stage developments. In addition, *quality assets of the NIS*, as a multi-level and multi-sectoral dynamic interactive system, provide access to several resources and capabilities at a local level, of which financial investment and technology and market knowledge, eventually through large firms' networks, tend to be most important. Next, we move attention to the universities in potentially pivotal roles in improving conditions for acceleration and deepening of technology innovation. On the side of universities, we may observe more or less involvement in key conditions, which ought to be strengthened:

1) Crossing borders, increasing and deepening openness in knowledge flows. These may include cross-faculty learning, education and research, and cross-channel collaboration (collaborative commercialization projects, spin-off firms, joint future scanning networks), and appointment of joint staff at university with (large) firms.
2) Increase and deepen openness at university: role in investment consortia, technology platforms (incl. higher educational institutes), citizen science energy initiatives.
3) Optimize the role of incubators, Science Parks, living labs, field labs.
4) Optimize educating, attracting and maintaining of talents (increase brain gain and limit brain drain); collaborate with municipality in providing quality living near to the university.
5) Optimize using of process aims in planning, namely dealing with uncertainty (e.g. non-linearity), through using e.g. scenario-analysis, simulation, and monitoring and evaluation of change (ToC, as a theory of planning and evaluation of impact, this at different timelines) (Belcher et al. 2020).

No doubt, the mechanisms indicated above, are important but cannot be dealt with in a standard way. This is because a time dimension is involved, importantly concerning 'early' events – referring to time of market introduction, but also of first collaboration and first substantial investment. Planning outcomes may be subject to non-linearity of different kind (Mačiulytė-Šniukienė et al., 2023) requiring specific adaptive planning approaches. Such situation may also hold true for *spatial* variation in planning outcomes, as the planning situation at start of the planning efforts may be different e.g. sectoral composition of the ecosystem and distinct local/regional dynamics. There may be different planning responses to such situations ranging from conventional ´predict-then-act´ approaches to planning modes addressing uncertainty and partial planning failure, by using flexible and stepwise approaches (Malekpour & Newig 2020). The complexity following from these situations tends to be a substantial challenge in steering on local entrepreneurial ecosystems.

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Table 2 Cox regression analysis on firm survival

	Control model	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*	*Model 9*	*Model 10*	*Model 11*
Control variables												
Period (start year)	1.15	1.29	1.12	0.80	1.22							
Business model	1.76	1.46	1.81	1.07	1.96							
Entrepreneurial orientation		.80				0.74	.60	.91	.54	.80	.61	.63
Innovation radicalness		1.22				1.39	1.14	1.20	1.26	1.3	.96	.99
Newness of market		.33***					0.31***	.24***	.24***	.23***	.22	.19***
Business diversification						0.28***						
Resources/capabilities												
Team size			.63**			.55***			.49***	.56***		.49***
Team education			.95			.76			.51	1.02		.70
Team business experience			1.25			.81			1.01	1.11		.74
Age at first market introduction				1.00**			1.00**		1.00**		1.01***	1.05***
Age at first collaboration				.99			.99		.99		.99	.99
Age at first investment				1.00			.99		.99		1.00	.99
Age at joining first marketing staff				1.00			1.00		1.00		1.00	1.00
'Entrepreneurial Ecosystem												
Quality of NIS					1.46			1.90**		1.96*	.67	1.89*
Metropolitan Location					1.04			.83		.89	1.04	.85
Incubating University					.53*			.53		.55	.53*	.34**
LR Chi-square	1.85	13.02	8.52	7.72	6.27	19.15	18.34	19.5	28.34	26.73	27.84	39.06
Log likelihood	-147.58	-142.00	-144.25	-144.65	-145.37	-138.93	-139.34	-138.75	-134.34	-135.14	-134.59	-128.98
P value	.39	.023	.13	.25	.29	.0039	.010	.0028	.0016	.0015	.0019	.0002
AIC	299	294	298	301	300	289	292	289	288	287	289	283

N = 106 $*\, p < 0.1 \quad **\, p < 0.05 \quad ***\, p < 0.01$