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1. Introduction

The purpose of this article is to investigate the distinctive characteristics of the academic spin-offs among the innovative new ventures. Even though the support of innovative new ventures is considered by policy makers as a driver of job creation and regional development (Acs and Armington 2006; Birch 1979; Anyadike-Danes et al. 2015), this link is not obvious. The ability of youngest firms at growing depends on the type of innovativeness among start-ups, and are context-dependent (Hyytinen et al. 2015; Clarysse et al. 2011; and Wright and Stigliani 2013). In the same vein as Mathisen and Rasmussen (2019), we do not considered young innovative companies (YICs) as a homogenous whole, but make the distinction between those with an innovation coming from technology transfer -academic spin-offs- with the other YICs. We provide evidence that academic spin-offs outperform thanks to their identity and the legitimacy provided by this identity at their early stages. We provide evidence of the greater ability of academic spin-offs at capturing resources, especially funding. Academic spin-offs are characterized by more patents and are more related to scientific activities. These characteristics are associated with higher growth in employment than the other supported YICs at the very first stage of their development (3 years old, on average) and higher survival probability in longer run (7 years old, on average).

We focus on YICs which receive support from public or semi-public institutions at the early stage of their development as a reward for their innovative business ideas. Consistently with the European Commission[1], these YICs are less than 6 years old, have fewer than 250 employees, and are highly Research and Development intensive (R&D intensity >15%). We compare two groups: one is comprised of academic spin-offs where innovativeness comes from academic technology transfer, and one is composed of other YICs where innovation cannot be classified in the previous category. The study is

[1] Article 35 of the General Block Exemption Regulation

performed in two steps. First, we estimate the growth of the academic spin-offs within a set of YICs supported for fewer than 5 years. This estimation is based on data gathered in 2014. Second, we investigate the survival of these supported YICs with the Cox proportional hazards model, 5 years later, at the end of 2019.

The article is organized as follows. First, the literature review details the elements that explain the growth and survival of YICs. The review shows the role of innovativeness, especially in the case of academic spin-offs. Second, after describing the regional context and the sample, we investigate the performance of academic spin-offs compared to other YICs in terms of growth in job creation and survival rates with two alternative models. Third, we present the results in two ways: the descriptive results and the regression results. Fourth, we discuss the results and their implications for regional public policies and discuss the limitations of this study.

2. Literature review

2.1. Performance of young innovative companies

Whereas the growth of established firms is about sustaining viability, new venture growth is about obtaining viability (Gilbert et al. 2006), this is the reason why YICs survival and growth are so closely intertwined. Regarding growth, literature underlines that growth of new ventures is a multidimensional rather than unidimensional phenomenon (Delmar et al. 2003), an extensive literature has made considerable progress in identifying why some new ventures experience more growth than others. The most important predictors of new venture growth include the entrepreneur characteristics, resources, innovation strategy, industry, and organizational structure and systems (Gilbert et al. 2006). Note that the financial capital a firm has is also considered as a key factor influencing the sales and employment growth performance of new firms (Lee et al. 2001). Focusing on YICs, innovativeness is of major interest for our research. We know that the technology strategies the ventures implement to maintain their level of internal innovation is important for new venture growth (Dowling and McGee, 1994). Research also suggests that the radical nature of new products, frequency of product upgrades, use of external technology sources, patents, and copyrights (Zahra and Bogner, 1999), and use of advanced technologies (Siegel et al., 1993) or technologically advanced partners (Stuart, 2000) make important contributions to new venture growth.

Regarding survival, Stinchombe (1965) suggests that an entrant organization suffers from liability of newness, which manifests itself in lower survival probability

compared with a similar incumbent organization. Among the most frequent reasons given to explain this phenomenon, we find the age of the firm (Agarwal, 1997; Agarwal and Audrecht, 2001), the size measure by the number of employees (Audrecht, 1991), the level of competitiveness and innovation intensity in their sector (Audrecht, 1991 ; Audrecht and Mamood, 1995) and financial factors (Altman, 1989). For Aldrich and Auster (1986) and Vankataraman et al. (1990), the failure of young firms can be found in the relation between the firm and its environment because they find their resources in this environment.

More specifically on how innovativeness influences the survival rate of start-ups, Hyytinen et al. (2015) remind that the literature is not unanimous. Numerous studies report a positive link between innovativeness and firm survival. Younger firms may benefit more from innovativeness, because they have less rigid routines (Brüderl and Schüssler 1990), can adapt more quickly to changes in their operating environment (Klepper and Simons 1997), and are more likely to be entrepreneurially alert and oriented (Lumpkin and Dess 1996). Based on these arguments, Rosenbusch et al. (2011) hypothesize that the positive association between innovativeness and small business performance is stronger for younger firms. This finding, however, is not universal. The link may also be negative. Thus, pursuing innovations in the start-up phase involves greater uncertainty and complexity, both of which point toward a lower probability of survival. Pursuing innovations leads to riskier, more complicated, and less linear start-up processes (Samuelsson and Davidsson 2009) and potentially, to more skewed returns (Scherer and Harhoff 2000). An innovative start-up may face a greater liability of novelty than its non-innovative counterparts (Amason et al. 2006). Therefore, innovative start-ups have more limited access to external financing, which leads to a greater likelihood of failure (Berger and Udell 2006). Moreover, Hyytinnen et al. (2015) emphasizes that the question of different types of innovativeness among start-ups is differently associated with subsequent survival and is context-dependent.

As existing literature highlights, researches on YICs is inconclusive or contradictory about who they are and what explains their growth or survival. Much of the confusion seems to be related to the heterogeneity of this population, because measuring innovativeness is difficult in general (Buddelmayer et al. 2010). To tackle this heterogeneity problem, we follow previous research focusing on a particular subpopulation of YICs: academic spin-offs (Clarysse and Moray; 2004; Mathisen and Rasmussen, 2019).

2.2. Characteristics of YICs: the case of academic spin-offs

Comparative studies of academic spin-offs and other YICs are a traditional stream of literature (see Mathisen and Rasmussen 2019 for a systematic review). Many terms are used for academic spin-offs, such as research-based spin-off, university spin-off, or university spin-out. A common definition of academic spin-offs is a new company 1) formed by a faculty member, staff member, or student who left the university to found the company or started the company while still affiliated with the university and/or 2) a core technology or idea that is transferred from the parent organization (Smilor et al. 1990). Clarysse et al. (2011) broaden this definition to new companies set up by a host institutions (university, technical school, or public or private R&D department).

Linked by nature to research institutions (e.g., universities) and receiving public funding directly or indirectly, academic spin-offs are considered of major interest for public policies. However, their performance does not meet unanimity. Mathisen and Rasmussen (2019) show the divergent views and the incomplete understanding of the development processes, growth trajectories, and ultimate performance of university spin-offs. Academic spin-offs, similar to other high-tech companies, often show a low rate of growth in terms of sales, cash flows, and employees (Mustar et al. 2006; Van Geenhuizen and Soetanto 2009; Zhang 2009). Several researchers have found explanations for this situation. For example, academic spin-offs show a low growth rate because managers concentrate more on technological aspects than on the marketing aspect of their product or service (Abbate and Cesaroni 2016). Hesse and Steinberg (2017) show that the majority of academic spin-offs either lack entrepreneurial growth intentions or are impeded by reasons caused by personal characteristics of the academic entrepreneur. Ayoub et al. (2017) find that public-funded academic spin-offs (in the German support program "EXIT business start-up grant") underperform in comparison to start-ups without public funding support in terms of employment growth and financial performance, but they have a higher probability of receiving venture capital. However, academic spin-offs have greater capabilities for developing wealth-creating business models than is the case for other new technology-based firms (Ortín-Ángel and Vendrell-Herrero 2013). Thus, YICs should not be treated as a single entity but differently according to the context in which they are created and developed.

The aim of this article is to provide insight into the question of the performance of YICs supported by regional public policies. First, we raise the problem of

heterogeneity of YICs and the necessity to focus on the identity of the firm based on its innovative characteristics. To achieve this goal, we compare special new ventures (supported young innovative companies), based on the origin of their innovativeness, that is, whether it comes from technology transfer or not. Second, we consider the YICs' performance with two non-financial performance measures (Walter et al. 2006), the survival rate and employment, because the two indicators are crucial for measuring performance from the government perspective. Anyadike-Danes et al. (2015) suggest that the growth of new ventures in terms of job creation needs greater understanding to develop a robust set of policy interventions. Whether different types of innovativeness among YICs are differentially associated with subsequent survival and how those effects are context dependent remain open questions. The present research fills this gap by comparing the survival of academic spin-offs relative to other supported YICs.

3. Methodology

3.1 Sample

The investigation involves the regional population census provided by Nord de France Innovation Développement (NFID). NFID is a structure founded in 2009 by the Nord-Pas de Calais Regional Council (France) to implement regional innovation policy, and its means and powers have been reinforced in recent years. In the Innovation Regional Strategy project for 2014–2020 (Stratégie Régionale d'Innovation 2014-2020[2], SRI), the Nord-Pas de Calais Regional Council set the target of catching up with the national average by doubling the number of innovative new ventures. Thus, to achieve this target, NFID was founded to "enhance the coordination of entrepreneurs and the development of networks involving entrepreneurship and innovation stakeholders (SRI, p.54)." The development of innovative new ventures is one of the main drivers of the region's economic policy, and the development of entrepreneurial networks is considered one of the main conditions for the policy's success. In 2014, NFID conducted a census of 325 monitored firms created between 2008 and 2013. These firms received support (e.g., incubation, and/or mentoring) from public or semi-public regional institutions at the early stage of their development as a reward for their innovative business idea. Based on this

[2] *https://www.nordpasdecalais.fr/upload/docs/application/pdf/2014.../sri-si_cmv1.pdf*

census, the sample was collected through a questionnaire administered to 104 founder-owners during the second half of 2014 by phone (52), face to face (49), or by email (3), with a response rate of 32%. The second part of the study has been carried out in January 2020 to collect information on survival of the 104 firms based on Bodacc[3].

3.2. Variables

3.2.1 Dependent variables: performance

As we investigate the performance of academic spin-offs with respect to a set of comparable YICs, we focus on two metrics: the growth and survival rates of the firms at two different time periods. The literature suggests that the most important measures of new venture growth are sales, employment, and market share (Gilbert et al. 2006). Thus, a more relevant indicator of growth performance for such ventures, particularly in high-technology industries, may be their growth in employment, because some industries (e.g., biotechnology) may spend years developing their products for the market. Growth in job creation is relevant because assets and employment of high-tech ventures may grow before any sales occur (Kogut and Zander 1992). We evaluate growth by job creation scaled by the age of the firm in 2014, which corresponds to the first data collection based on the questionnaire. Consistent with Davidsson and Wiklund (2001), we take the firm's status in terms of job creation (full-time jobs) into account at two given intervals: t_0 corresponds to the moment the firm is launched, and t_1 corresponds to the time of the study.

The second variable is the survival in 2019, 5 years after the census was performed in 2014. We draw a continuous variable of relative risk of death based on a semi-parametric Cox proportional hazards model. We assess this hazard through the combination of the age of the firm in months and a dummy variable that takes a value of 0 if the firm is a going concern or 1 if the firm went bankrupt. We checked the status of each firm based on the Bodacc[4] historical releases collected in January 2019.

3.2.2. Independent variables

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[3] Bulletin officiel des annonces civiles et commerciales : https://www.bodacc.fr/

[4] The Bodacc (Bulletin Officiel des Annonces Civiles et Commerciales) registers and discloses the minutes associated with the creation, the failure (the U.S. equivalent is Chapter 7), the *sauvegarde* (the U.S. equivalent is Chapter 11), and the official releases of financial and accounting statements. For further details, see https://www.bodacc.fr/

The key independent variable, *academic spin-off*, is a dummy that takes the value of 1 (and 0 otherwise), if any of the following conditions are true about the firm at the time of market entry: (i) One of the founders is an academic, has a PhD, or is an engineering student; (ii) an academic researcher or PhD student has been recruited; and/or (iii) the firm has a contract or is supported by a public research center. Cronbach's alpha is 0.727, which indicates that this set captures an underlying one-dimensional latent construct well.

3.2.3. Control variables

We estimate the relation between the YICs' characteristics (academic spin-offs *versus* YICs) and the growth in tandem with the log of the total external funding raised and the sector of activity. The financial capital a firm holds is known to influence the sales and employment growth performance of new firms (Cooper et al. 1994; Lee et al. 2001). We deepen the characterization of the YICs by controlling for the ownership of patents. Patents are generally considered a measure of success regarding innovativeness (Artz et al. 2010). We refer to a dummy variable which equals 1 if the firm has at least one patent, and 0 otherwise. Based on the French industry classification (Nomenclature d'Activités Françaises, NAF code), we pooled the firms into four activity sectors: (1) industry, (2) service, (3) information and communication, and (4) specialized scientific and technical activities. We complete this categorization with a dummy variable that measures the innovativeness of the sector. The variable indicates the relative importance of the innovativeness of the firm with respect to the intensity of the competition in the sector. This dummy variable equals 1 if the respondent considered that the sector is characterized by a high level of innovations.

3.3. Estimation models

3.3.1 Growth of academic spin-offs

We estimate whether the growth of the firm scaled by its age in 2014 is enhanced in the case of academic spin-offs with an ordinary least squares (OLS) regression. We estimate the growth while taking into account the total external funding, patents, sector, and sector innovativeness.

3.3.2 Survival of academic spin-offs

We estimate the same specification on the survival of the firms observed in 2019 with the semi-parametric Cox proportional hazards model. This model estimates hazards, the probability that a firm goes bankrupt at a given time. In contrast to binomial regression

models, survival models provide unbiased estimation by taking into account censored observations. The semi-parametric Cox proportional hazards model is compared with the parametric survival model to avoid strong assumptions about the distribution of the survival time.

The purpose of the estimation is to control whether academic spin-offs are characterized by different survival rates within a set of YICs and to identify to what extent early stage information, as well as funding and growth, are predictors of the failure of YIC. As in the growth model, we estimate the hazards while taking into account the total external funding, patents, sector, and sector innovativeness. In addition, we introduce in the regressors the growth in job creation in 2014 not scaled for its age because it appears as a strong performance indicator (Kogut and Zander 1992).

4. Results

4.1. Descriptive statistics and simple correlations matrix

In Table 1, we report detailed descriptive statistics of the full sample and of two subsets corresponding to the set of academic spin-offs and the set of supported YICs, which contain 45 and 59 firms, respectively. Information about the funding, growth, and sector was collected with a questionnaire in 2014, while information about the survival of the YICs was collected in January 2020. Intergroup comparisons provide evidence of important differences in terms of the growth of firms in full-time equivalent job creation. Academic spin-offs created +1.6 more jobs than the other YICs, whereas the age of the firms of each subset is homogeneous: 3 years and more than 3 months for the first group and almost 3 years for the second group. Between the launch date and the sample collection, the overall average growth in terms of jobs—as reported in the third column at the right side of Table 1—was +2.70 for a standard deviation of 5.74 employees. Three firms in both groups eliminated 1 to 2 jobs (6 for the overall sample); 26 YICs and 7 academic spin-offs had not created any. Four firms had created more than 10 jobs. Three of these firms are academic spin-offs. Nevertheless, the standard deviation of growth is highest in the case of academic spin-offs.

Furthermore, this performance seems achieved at the expense of greater capital expenditure. The total funding raised by the academic spin-offs is 2.925 times greater than that of the supported YICs. The main sources of funding of the academic spin-offs are public investments at 46.975% (19.53% from regional, 70.14% from national, and

10.33% from associations that are prolongations of the public administration) and venture capital at 24.45%. Public financial support is also the main source of funding for supported innovative new ventures, with 30.79% of the capital structure (25.74% from regional, 53.26% national, and 21% from associations that are prolongations of the public administration), but bank loans are the second source of funding at 29.12%. These firms also receive more funding from business angels and the entry of new associates.

The proportion of firms that have at least one patent is greater for academic spin-offs (40%; 18 firms) than other YICs (28.81%; 17 firms). Fifteen firms in the sample have more than one patent. Among them, 10 are academic spin-offs, including two with more than five patents.

In terms of sectors, IT & Communication activities are overrepresented, while the services sector, mainly composed of retail activities, is underrepresented in both groups. We observe that the proportion of firms in the retail sector is greater for YICs. Consistent with having patents, the proportion of entrepreneurs who considered their sector highly innovative is larger for academic spin-offs than for the other YICs.

The second key performance indicator is the survival rate measured by the ratio of the number of going concern firms in 2019 to the number of firms surveyed in 2014 is reported in Table 2. We observe that the two groups exhibit different survival rates, with a spread of 14.53% between the academic spin-offs (75.55%) and the YICs (61.02%). The overall survival rate is 67.31% corresponding to 35 dead firms. For purpose of comparison, Eurostat's Business Demography by Size Class statistics state that the EU-15 average percentage of enterprises that were established in 2005 and survived to 2008 is 63%, the same as in Finland (Hyytinen et al. 2015). Moreover, compared with the French national statistics[5], the present sample exhibits a better survival rate. The study of the French national statistics reports a survival rate of 71.8% of new ventures created in 2010 are still alive 3 years later, and 60% 5 years after, while we observe for the full sample a survival rate of 93.27% and 85.58%, respectively.

The middle part of Table 2 provides the cumulative percentage of the dead firms at four different ages: 3 years old, 5 years old, 7 years old, and 10 years old. We note that the spreads between the first three periods remain stable to the advantage of the academic spin-offs, but increase drastically between the seventh and 10th years. The proportion of

[5] https://www.insee.fr/fr/statistiques/2664148

bankrupt firms passed from 17.78% to 24.44% (+6.66%; +3 firms) for the academic spin-offs and from 20.34% to 38.98% (+19.64%; +11 firms) for the YICs. We note that five firms, still alive in 2019, were acquired after their 5th years. Three of them are academic spin-offs. In the end, it remains 70 YICs including 33 academic spin-offs.

The lowest part of Table 2 reports information about the number of employees of survival firms at the end of 2019. Employment is reported into classes as released by Infogreffe[6]. The comparison of the employment classes in 2019 with the number of employees at the launch of the business demonstrates that 5 YICs and 4 academic spin-offs have created more than 10 jobs, respectively. It suggests that the differences between the two groups tend to offset as the time goes by.

[6] Infogreffe is a service provided by the French Commercial Courts that releases legal information about firms: https://www.infogreffe.fr/

Insert table 1 here

Insert table 2 here

Table 3 reports the Pearson simple correlations matrix for quantitative variables and correlation ratios for categorical variables. The variable bankruptcy (*Bankrup*) is a dummy corresponding to 1 if the YIC went bankrupt and 0 otherwise. Only the age of the firm, sector innovativeness, and total funding are related to the firm's growth. The sector innovativeness, has at least one patent, and the characteristics of academic spin-offs are also positively related to external funding. However, these correlations are weak and do not bias the estimates.

Insert table 3 here

4.2. Regression results

4.2.1. *Growth of academic spin-offs*

Table 4 reports the OLS regression results for the relation between growth in employees scaled by the age of the firm and its situation in 2014. The estimated coefficient and significance levels are reported in the second columns of each table; the standard errors are reported within parentheses in the third columns. To compare the relative importance of each variable in the model, all data were standardized. As the purpose of this research is to test whether academic spin-offs outperform YICs, we account for the characteristics by introducing the dummy variable *academic spin-off*.

Results for the relation with growth in employees between the creation and 2014 in Table 4 indicate that the academic spin-offs exhibit higher growth than the YICs. We confirm that external funding is a core determinant of the growth of the firms. We observe that YICs that evolve in sectors in which the intensity in innovations is higher are characterized by higher growth. In contrast, firms that have at least one patent have less growth. The relations observed are weaker for the sector IT & Communication compared with the scientific activities sector. The model explains 29.2% of the variance of the dependent variable and is statistically significant ($p<0.0001$).

Insert table 4 here

4.2.2 Survival of academic spin-offs

The survival rate shown in Table 2 raises the issue of fundamental differences in survival curves between the academic spin-offs and the YIC. The heuristic Kaplan-Meier estimation of the survival curves and the non-parametric log-rank test of the differences, reported in Table 5, support that the academic spin-offs group differs significantly in survival from the other YICs. In particular, the test provides evidence with a probability of error of 2% that the academic spin-offs have a higher survival rate than the other YICs. Nevertheless, the multivariate Cox proportional hazards regression must be implemented to make sure that the treatment effect of academic spin-offs on risk of bankruptcy still holds when we account for other relevant covariates.

Insert table 5 here

Another practical implication of this result is that academic spin-offs may not be characterized by the same temporality in the early life stages compared with other YICs. In this case, the Cox proportional hazards models grounded on the hazard proportionality assumption may not be appropriate. This assumption states that the effect of the covariates, especially the treatment *academic spin-off*, must be independent from time. The effect of covariates on the hazards must be constant. Otherwise, the covariates may accelerate or decelerate the time to failure, and parametric accelerated failure time (AFT) models must be preferred. To test if the proportional hazards assumption holds, we implement a Schoenfeld residual test reported in Table 6. The global test and the result for each variable indicate that the condition for the implementation of the Cox proportional hazards regression holds.

Insert table 6 here

Table 7 reports the results for the Cox proportional hazards regression. The estimates include the coefficients, the hazard ratios obtained by the exponential of the coefficients, and the standard errors, within parentheses. We refer to the hazard ratios for interpretation. They are interpretable as multiplicative effects on the hazards, which measure the risk of bankruptcy at a given time. A hazard ratio less than one indicates that

the variable increases the survival probability, while a ratio greater than 1 decreases it. The bottom lines of Table 7 refer to the significance, the concordance ratio and the pseudo-R-squared which evaluate the explanatory power of the model. We note that the model predicts firm failure in 66.5% of cases. The p value for all three overall tests (likelihood, Wald, and score) is statistically significant, indicating that the model is statistically significant.

Results reveal that the treatment *academic spin-off* is associated with greater survival probability compared with YICs. Likewise, total external funding is a core determinant of the survival. Any euro invested decreases the risk of failure by 0.001% (1.000–0.999). The growth in employees between the creation of the firm and the survey in 2014 is also highly significantly associated positively with the survival of the YICs. We observe that firms characterized by job creation decrease the risk of failure by 13.1% (1.000–0.896). Regarding the sector, firms in the IT & Communication sector have a risk of failure 2.764 times greater than those in the industrial sector. Finally, sector innovativeness and patents are not statistically significant.

Insert table 7 here

5. Discussion

According to our results, we can lead the discussion on five points. First, literature differentiates academic spin-offs from other YICs from a conceptual point of view mainly based on academic technology transfer. Our results confirm that academic spin-offs must be viewed as a specific set of YICs. They contribute by considering the implications of their identity during their early life stages. Thus, results show that academic spin-offs' identity is associated with attributes of high intensity in innovation: they have more patents, they are more likely to be in scientific activities sectors, and in sectors that feature greater innovation intensity. They also have the greatest ability for accumulating resources, the highest growth in the early life stages, and the highest survival rates. Thanks to their links with academic institutions (universities, research centers), academic spin-offs obtain a strong identity among YICs. Their identity relying on human capital (competences of owner(s) and employees) and immaterial capital (the technology transfer from which the product or service comes) provides a unique legitimacy. This suggests that the team's academic reputation and the status of their affiliated institutions act as signals of quality during early stages (Stuart et al. 1999). It is of major interest because

YICs in emerging industry contexts tend to have few good signals upon which to rely. As a matter of fact, new ventures in the conception stage (Kazanjian 1988), lacking tangible performance metrics (e.g., financial revenues, cash flows, and market share), rely heavily on symbolic affiliations and adhere to processes that are familiar and understandable to resource providers (Fisher et al. 2016). According to Fisher et al. (2016), in the case of YICs, legitimacy is linked to an organization's identity mostly based on innovation and entrepreneurial team characteristics. Our results provide evidence on how the identity of academic spin-offs based on technology transfer act as a positive signal to obtain legitimacy. It is of particular interest for entrepreneurs who can rely on trust provided by their parent institution to engage in negotiations with different stakeholders.

Second, academic spin-offs obtain more financial resources. Because of their identity, academic spin-offs are also in line with investors' expectations, which may explain why these firms capture more financial resources, themselves determinants of growth. Referring to descriptive statistics and opposite to Ayoub et al. (2017), we observe that academic spin-offs are also characterized by much more external funding. They raised three times more funding than the other YICs, which may be considered as a signal about better allocation in R&D expenses (Guilhon and Montchaud 2003). Bollingtoft et al. (2003) find that for entrepreneurs with less innovative technologies, financial capital often comes from the entrepreneur's personal resources. In contrast, financial capital is often sourced from external funding for more innovative technologies. Vanacker and Manigard (2010) argue that more innovative companies, such as academic spin-offs, are less financed by retained earnings and debt, and more by business angels and venture capital. We provide consistent observations. The access to equity from venture capital and business angels remains marginal for YICs, but it is a major source for academic spin-offs. It represents 21.33% of the capital structure of YICs, but 31.2% for academic spin-offs. The greatest proportion of venture capital and business angels in the academic spin-offs capital structure is fostered by the certification effect provided by public grants (Meuleman and De Maeseniere 2012). Grants are viewed by investors as a positive signal about the quality of the YIC, which reduces the information asymmetry induced by innovative projects (Meuleman and De Maeseniere 2012; Minola et al. 2013). Academic spin-offs receive 4.46 (222 850€ for academic spin-offs/49 940€ for other YICs) times more public subsidies than other YICs. Private equity and banks benefit from investment risk reduction induced by public investment, which may also act as collateral. The identity

of academic spin-offs emphasizes the certification effect. Their links to academic institutions signal better-quality R&D and human capital.

Third, the present research also provides evidence that academic spin-offs have greater survival rates than other YICs. The theoretical implications of this result must nonetheless be appreciated in regards with the underlying assumptions of the model. It assumes that the temporality is the same for academic spin-offs and other YICs. Although robustness checks indicate that this assumption holds in the present estimates, many theoretical arguments advocate in favor of different temporalities at the early stages. Due to academic spin-offs' innovativeness, the development timeline of their product or service is likely to postpone their entry in the market (Samuelsson and Davidsson 2009; Van Geenhuizen and Soetanto 2009). Descriptive statistics support that academic spin-offs capture more resources needed to sustain the development timeline and have decelerated bankruptcy rates relative to other YICs. Similarly, the Kaplan-Meier non-parametric comparison between survival curves supports that the survival probability is greater for academic spin-offs. This consistent evidence suggests that fundamental differences in survival curves may exist between the two groups of YICs. This issue has important practical implications in the evaluation and the definition of public policies. Policy makers should keep in mind that academic spin-offs may have a different trajectory and need *ad hoc* supports. Unfortunately, this sample collected from a limited population of firms (325 supported YICs in a specific regional context) does not allow the comparison of survival analyses for alternative time windows. We have drawn hazards including firms older than 5 years, but it can be expected that many differences between the two groups of YICs are offset after a given time. As suggested by Hyytinen et al. (2015), survival models tested with alternative time windows (e.g., 2 years to 5 years) should be considered by future researchers. The implementation of AFT at different time windows to account for fundamental differences in survival curves or at least of strata models to exhibit differences between groups should be tested. The issues of non-constant covariates, especially to what extent academic spin-offs must still be viewed as a distinctive characteristic after a given time period, should also be considered.

Fourth, analysis of the growth of academic spin-offs in the early life stages (less than 5 years old) is of importance for two reasons. First, academic spin-offs have the greatest growth in employees. It suggests that the growth in employees is a proof of the firm's ability to capture resources devoted to the development of the organization. Second, given the intertwined relation between growth and survival (Delmar et al. 2003),

the growth in employees informs about the future success of the YICs. Considering that the number of employees may increase before any sales occur (Kogut and Zander 1992), we confirm that the growth in employees is a strong predictor of the survival of YICs. Our results are important for public decision makers which can use employment as a reliable indicator to assess the future of nascent firms.

Fifth, one of the interests of this research is the specificity of the sample of YICs directly and indirectly supported by regional public agencies. These firms have benefited from various types of public supports and are monitored by the policy maker who is interested in understanding their trajectories. The limit of this context-dependent analysis is nevertheless a modest sample despite a response rate of 32%. Nonetheless, these results provide important insights for designing, conducting, and monitoring policies that favor innovation. Moreover, it demonstrates to universities, research institutions and entrepreneurs engaged in technology transfer the economic and social usefulness of their approach.

6 Conclusions

This article investigates the distinctive characteristics and the performance of academic spin-offs within YICs. As the development of YICs is considered by policies makers as an important source of innovation and job creation, many programs are launched by national and local authorities to support those firms. Although YICs are frequently viewed as a homogenous group, this research focused on academic spin-offs in a set of supported YICs. First, academic spin-offs are differentiated by their identity which relies on the technical competences of the owner(s) and employees, and on the technology transfer from which the product or service comes. This identity provides academic spin-offs unique legitimacy, essential to obtain resources at the first stage of their development. We investigate the distinctive characteristics of 45 academic spin-offs within a sample of 104 French YICs strongly supported by national and local authorities in terms of subsidies and supports. We assess the growth and survival trajectories at two points in time. We first estimate the relation of the growth of YICs in 2014, when the average age was 3 years. Second, we estimate the survival of YICs at the end of 2019 with a Cox proportional hazards regression model. These results confirm that survival and growth are closely intertwined. We provide evidence that academic spin-offs are characterized by greater growth in employees at their early stages of life (less than 5 years) and greater survival after five years. We observe that within this group of strongly supported YICs,

academic spin-offs have more patents and are more likely to be in the scientific activities sector. They also have greater ability to obtain resources thanks to the public subsidies that foster the entry of venture capital and business angels. Even if academic spin-offs shape many public policies worldwide, the results they obtain locally in terms of growth and survival is of great interest for regional innovation policies.

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Table 1 Descriptive statistics*

	Academic spin-offs	YICs	Full sample
Employees t	1.29 (1.25)	0.91 (1.01)	1.08 (1.135)
Employees t+1	4.89 (6.575)	2.91 (5.6)	3.78 (6.09)
Growth in employees	3.6 (6.33)	2 (5.194)	2.699 (5.744)
Age of the firm in months in 2014	39.16 (19.85)	35.86 (17.88)	37.3 (18.74)
External funding in €	474 400 (773 889.2)	162 200 (313 348.1)	298 600 (580 898.4)
From new associates	7 689 (23 164.26)	20 090 (107 256.4)	14 670 (81 843.27)
From bank	50 600 (70 409.32)	47 240 (107 159.9)	48 710 (92 511.75)
From venture capital	116 000 (316 582.6)	9 707 (65 911.16)	56 150 (220 155.9)
From business angels	42 070 (85 725.09)	24 910 (133 424.8)	32 410 (114 854)
From public structures	222 850 (504 634)	49 940 (89 721.92)	125 480 (348 962.5)
From seed capital	20 000 (68 589.69)	7 155 (31 610.46)	12 770 (51 271.71)
From other companies	8 911 (43 098.1)	172.4 (1313.064)	3 990 (28 656.35)
From other sources	6 280 (14 304.575)	2 985.6 (12 252.73)	4 420 (13 157.35)
Firms that have patents	40%	28.81%	33.65%
Sector			
Industrial	22.22%	18.64%	20.19%
Service	11.11%	37.28%	25.96%
IT and Communication	40%	28.81%	33.65%
Scientific activities	26.67%	15.25%	20.19%
Sector innovativeness	55.55%	49.15%	51.92%
Number of firms	45	59	104

* *The standard deviation is reported within parentheses.*

Table 2 Descriptive statistics of survival*

	Academic spin-offs	YICs	Full sample
Number of ongoing firms in 2019	33	37	70
Survival rate in 2019	75.55%	61.02%	67.31%
Cumul. death 3 years	4.44%	8.475%	6.73%
Cumul. death 5 years	13.33%	15.25%	14.42%
Cumul. death 7 years	17.78%	20.34%	19.23%
Cumul. death 10 years	24.44%	38.98%	32.69%
Age of the firms in months at the end of 2019	91.91 (17.28)	86,64 (19,30)	89,16 (18,55)
Employees in 2019			
No employee	24.24%	21.62%	22.86%
[1; 5]	30.3%	29.72%	30%
]5; 10[	18.18%	13.51%	15.71%
[10; 20]	12.12%	5.4%	8,57%
Over 20	3%	8.11%	5.71%
NA	12.12%	21.62%	17.14%

* *The standard deviation is reported within parentheses.*

Table 3 Simple correlation matrix

	Growth	Age in months	External funding	Academic spin-off	Has one patent	Sector innov.	Sector	Bankrup
Growth	1***							
Age in months	0.32***	1***						
External funding	0.36***	0.10	1***					
Academic spin-off	0.14	0.09	0.24**	1***				
Owning one patent	0.01	0.00	0.24***	0.14	1***			
Sector innov.	0.19**	-0.05	0.18*	0.06	0.15	1***		
Sector	-0.03	0.1	-0.06	0.14	0.01	0.14	1***	
Bankrup	-0.07	-0.06	0.02	0.01	0.07	-0.01	0.07	1***

*Note: *, **, and *** indicate the level of significance at 0.1, 0.05, and <0.01, respectively.*

Table 4 Simple correlation matrix

	Growth	Age in months	External funding	Academic spin-off	Has one patent	Sector innov.	Sector	Bankrup
Growth	1***							
Age in months	0.32***	1***						
External funding	0.36***	0.10	1***					
Academic spin-off	0.14	0.09	0.24**	1***				
Owning one patent	0.01	0.00	0.24***	0.14	1***			
Sector innov.	0.19**	-0.05	0.18*	0.06	0.15	1***		
Sector	-0.03	0.1	-0.06	0.14	0.01	0.14	1***	
Bankrup	-0.07	-0.06	0.02	0.01	0.07	-0.01	0.07	1***

*Note: *, **, and *** indicate the level of significance at 0.1, 0.05, and <0.01, respectively.*

Table 5 Log-rank test of the differences in Kaplan-Meier survival probabilities between YICs and academic spin-offs

	N	Observed	Expected	Chi-test	Mantel-Haenzel test
YICs	59	18.1	13.0	2.02	5.08
Academic Spin-offs	45	8.5	13.6	1.93	5.08
Chi-square = 5.1 on 1 degrees of freedom, p= 0.02**					

*Note: *, **, and *** indicate the level of significance at 0.1, 0.05, and <0.01, respectively.*

Table 6 Schoenfeld residuals proportionality hazards test

	Rho	Chi-square	p value
Total external funding	-0.033	0.05	0.823
Academic spin-off *(ref : No)*	0.007	0.0025	0.960
Growth	0.086	0.272	0.602
Sector innovativeness *(ref : No)*	0.206	2.116	0.146
Has patents *(ref : No)*	-0.072	0.305	0.581
Sector *(ref: Industrial)*			
Service	0.061	0.227	0.634
IT and Communication	0.152	1.225	0.269
Scientific activities	0.122	0.684	0.408
GLOBAL		5.791	0.671

*Note: *, **, and *** indicate the level of significance at 0.1, 0.05, and <0.01, respectively.*

Table 7 Cox proportional hazards model (N = 104)

	Dependent variable Hazards - probability of failure at a given time		
	Coeff.	Hazard ratios	Standard errors (Coeff.)
Independent variables			
Total funding	-0.001***	0.999	(0.000)
Academic spin-off *(ref : No)*	-0.935**	0.393	(0.505)
Growth from creation to 2014	-0.140**	0.869	(0.079)
Sector innovativeness *(ref : No)*	0.498	1.645	(0.4325)
Has patents *(ref : No)*	-0.297	0.743	(0.5325)
Sector *(ref: Industrial)*			
Service	0.542	1.720	(0.6565)
IT and Communication	1.017*	2.764	(0.63)
Scientific activities	0.472	1.603	(0.658)
Log-likelihood test		16.22**	
Wald test		14.51*	
Log-rank test		16.29**	
Concordance		0.665	
Pseudo-R-squared		0.1667	

*Note: *, **, and *** indicate the level of significance at 0.1, 0.05, and <0.01, respectively.*