The effect of entrepreneurial origin on firms' performance: The case of Portuguese academic spinoffs

Abstract

We investigate the role of entrepreneurial origin on firms' performance by comparing academic spinoff firms with their non-academic counterparts. Academic spinoffs grow through resources accumulation and internationalization; yet they do not translate these advantages into productivity gains. The access to upstream complementary resources appears to play a chief role in explaining the academic spinoffs' superior performance. Academic spinoffs are contributing to economic development by creating new jobs, but their relevance as a source of sustained economic value is limited so far.

Keywords: Academic Spinoff, firm growth, dynamic estimators.

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1. Introduction

Significant scholarly attention has recently been devoted to understanding the formation and evolution of academic spinoffs (see Rothearmel et al., 2007, Djokovic and Souitaris, 2008; Markman et al., 2008 and Colombo et al., 2010b for literature reviews). Academic spinoffs (also referred to as university spinoffs or academic spinouts) are defined as new venture formation by faculty, staff or students who innovate in an academic or non-profit research context, and subsequently found a firm, while still affiliated with the university, that directly exploits this knowledge, core technology or idea (Shane, 2004; Siegel et al., 2007). Although technology transfer and university-firm relationships can be traced back to late 19th century (see Nelson, 1959; Stokes, 1997), the phenomenon became more pervasive after the mid 1990s as a shift in legislation took place both in the United States (US) and the United Kingdom (UK) toward intellectual property (e.g. Mowery, 2005; Siegel et al., 2007).

The study of academic spinoffs is relevant for a number of reasons. First, these start-ups are a key vehicle of knowledge transfer (from research institutions to the market), innovation diffusion and knowledge spillovers, which are seen as important drivers of economic growth and social progress (Baumol, 2002; Aghion et al. 2009). Second, academic spinoffs may also contribute to economic development by creating new and highly skilled jobs (Audretsch and Feldman, 2004). Third, academic spinoffs have been described as distinct from other innovative new ventures in that they exhibit

peculiar "genetic characteristics". These characteristics could leave an enduring imprint on firm development (Colombo and Piva, 2012) as well as on industries´ knowledge and capabilities (Agarwal and Shah, 2014; Colombo and Piva, 2012; Wright et al., 2012). Therefore, assessing the relative effectiveness of that entrepreneurial origin is crucial to understand the economic value of those peculiar "genetic characteristics" and could provide important implications for public policy related to the support of academic entrepreneurship.

The potential benefits of academic spinoffs have led a growing number of European countries to allocate public revenues in promoting this university-based entrepreneurship over the last decade (Wright et al., 2008). Yet, this view is not unanimously shared among scholars who see academic spinoffs more like technology lifestyle businesses than dynamic start-ups with high-growth potential, thereby casting doubts on their economic impact (Carroll et al., 2001; Harrison and Leicht, 2010). Although the formation of academic spinoffs is already well established in the US, in Europe it remains quite diverse across countries, suggesting that institutional differences at national level may play an important role in the diffusion and performance of these new ventures (Fini et al., 2017).

In this regard, existing evidence on academic spinoffs' performance is inconclusive so far. On one hand, it has been documented that in Europe academic spinoffs remain relatively small (Rothearmel et al., 2007; Djokovic and Souitaris, 2008)

and grow less than counterparts (Wennberg et al. 2011). On the other hand, some studies found that academic spinoffs outperform firms from different origins regarding employment and/or sales growth (Colombo et al., 2010a; Rodríguez-Gulías et al., 2017).

A possible explanation for these contradictory results could be a methodological one. Specifically, despite the growing evidence on performance differences between academic start-ups and independent new ventures (Ensley and Hmieleski, 2005; Zahra et al., 2007; Colombo et al., 2010a; Clarysse et al., 2011; Siegel and Wessner, 2012; Festel, 2013), only a few studies focus on their growth process (Colombo et al., 2010a; Wennberg et al., 2011; Rodríguez-Gulías et al., 2017).

Most of these studies take a static approach as they are based on a rather limited sampling frame in that the data refers to a small number of universities or spinoff firms, a single sector, or a short span of years. This sampling frame does not allow precise estimations of the relative performance of academic spinoffs, and does not allow a higher degree of generalizability to the overall economy. In order to evaluate firm´s growth, one needs to take into account its dynamic nature. From a methodological point of view this can only be dealt with rather long-time span data and dynamic estimators.

Therefore, the objective of this paper is twofold. First, we take a broader perspective and look at the whole population of academic spinoffs from 1979 to 2010 in order to map it and disclose the particular features of the Portuguese case. Portugal

seems to be a case of relatively high level of academic entrepreneurship vis-a-vis other European countries such as Italy (Fini et al., 2017). Since the early 2000s the Portuguese government has been actively supporting academic entrepreneurship through various public programs in collaboration with US universities such as the University Technology Enterprise Network (UTEN) program with Austen University, Texas, the MIT Portugal Program with the Massachusetts Institute of Technology, and the Cohitec Program with The North Caroline University. Furthermore, it has been reported that some of Portuguese academic spinoffs have grown into quite large firms operating in the international market (Mendes, 2010).

Second, academic spinoffs' performance is compared with its counterpart of firms with different entrepreneurial origins, using a variety of indicators and a comprehensive database either in terms of spinoffs coverage or time span. Specifically, our dataset tracks the population of Portuguese academic spinoffs since 1979, i.e., the year in which the first Portuguese academic spinoff was born, until 2010 and merge it with data collected from a database that covers almost the population of Portuguese firms that are set up during the same period. By taking advantage of the rather long observation period and sampling frame, we employ a dynamic panel-data estimation technique, which permits a more robust control of endogeneity problems associated with the firm growth process than regular panel data estimators.

Here, we diverge from previous studies on academic spinoffs´ performance differentials (e.g. Ensley and Hmieleski, 2005; Zahra et al., 2007; Colombo et al., 2010a; Wennberg et al., 2011, Claryssee et al., 2011). First, besides the long-time span, our sample is not restricted to high-tech sectors (e.g., Zahra et al., 2007; Wennberg et al., 2011) or new technology-based firms (e.g., Colombo et al., 2010a). We analyse the population of Portuguese academic spinoffs, irrespectively sector or type of firm. Second, as opposed to previous studies (e.g., Wennberg et al., 2011) and for comparison purposes, there is no restriction on the baseline type of entrepreneurial origin. The economic value of the academic entrepreneurial origin is comparatively assessed to any other type of entrepreneurship. Those differences from previous studies allow a higher degree of generalizability to the overall economy and better approximation to the overall economic value of academic spinoffs.

Based on this novel approach, the paper makes several contributions to the literature. First, we add to the literature that aims to assess the impact of university research commercialization by giving evidence on performance differentials of academic spinoffs, and, thereby, we inform the current policy debate. Second, we contribute to the literature on entrepreneurship that investigates the role of different knowledge context at firms' origin in shaping their evolution and performance (Agarwal et al., 2007; Agarwal and Shah, 2014; Bruneel et al., 2013) and to the broader area of firm growth by providing evidence on what extent the reasons leading to growth

and the outcome of growth may diverge among firms of different entrepreneurial origins (Delmar et al., 2003; McKelvie et al., 2017). In particular, this study adds to previous contributions (e.g. Colombo et al. (2010a) and Rodríguez-Gulías et al. (2017) by employing alternative measures of firm growth namely firm efficiency (e.g. productivity) and successful market post-entry (e.g. export intensity), in addition to employment (as in Colombo et al. 2010a) or employment and sales (as in Rodríguez-Gulías et al., 2017). By doing so we contribute to the study of firm growth by assessing whether firms grow in different ways as proposed by Delmar et al. (2003). Third, by analysing academic spinoffs' performance differentials using different sub-samples, this study attempts to empirically disclose possible mechanisms and conditions that would favour academic spinoffs superior performance.

The paper is as organized as follows. Next section reviews the explanations for why and when academic spinoff firms should have better performance than counterparts and summarizes empirical findings. Section 3 describes the data, empirical variables and econometric strategy. Section 4 presents and discusses the empirical results and lastly, section 5 presents the conclusions, provides policy recommendations and proposes future research.

2. Why and when should academic spinoff firms have better performance than counterparts?

Various hypotheses have been advanced to explain why and when academic spinoffs

should perform better than their counterparts. These explanations arise from different theoretical backgrounds and include both internal (technology and knowledge) external (parent and industry) conditions as determinants of spinoffs performance.

Regarding internal conditions, seminal contributions have pointed out the technology upon which the firm is based as the key determinant of its performance or survival. Specifically, new firms founded to exploit university inventions should be more likely to survive if they exploit radical technologies with broad scope patents (Nerkar and Shane, 2003; Shane, 2001). This is because new technology firms are likely to survive if they exploit radical technologies that cannot be imitated in the founding period when a firm's marketing and manufacturing assets are being established, thereby allowing the new firm to undermine the advantages that established firms have in pursuing incremental technologies (Lerner, 1994; Teece, 1986). Given this, some studies have suggested that academic spinoffs are more likely to survive in the early stage of industry's life-cycle (Nerkar and Shane, 2003; Shane, 2001).

However, this advantage may not be present all the time, particularly so, if the new firm needs assets that are controlled by a few large incumbents, thereby increasing the difficulty of establishing an agreement with one of them to obtain needed assets (Williamson, 1975). The importance of these factors is evidenced by the fact the survival of new technology-based firms possessing a radical technology with broad scope patents appears to be quite industry-specific (Gans and Stern, 2000; Romanelli, 1989). Nerkar and Shane (2003) found that university-spinoff firms are less likely to survive in more concentrated industries.

Recently, scholars have focused on resources and competencies embedded in both the technology and the entrepreneurial team arguments to explain academic spinoffs' performance (Siegel and Wesser, 2012). Although they depart from different

theoretical frameworks, namely institutional isomorphism (Clarysse et al., 2011; Ensley and Hmieleski, 2005), resourced-based theory of the firm (e.g. Zahra et al., 2007) and entrepreneurship theory of the firm (Wennberg et al., 2011) they share the underlying idea that firms gain competitive advantages through effective resource accumulation (especially knowledge) and deployment. The access to upstream or downstream complementary resources would shape firm's knowledge endowments and capabilities that have to be explored to yield differences in performance. In particular, academic spinoffs tend to possess substantial human capital and advanced technologies and innovations that could foster the potential of creating performance differentials and economic value (Wennberg et al., 2011). Moreover, the knowledge being converted in these new technologies is more complex and difficult than those of incumbents, providing start-ups an enduring advantage relative to other firms (Clarysse et al., 2011; Zahra et al., 2007).

These contributions also developed a series of hypotheses addressing how knowledge endowments would differentially influence academic spinoffs and independent new ventures. Zahra et al. (2007) and Wennberg et al. (2011) argue that new ventures arising from a corporate parent should outperform academic spinoffs. According to Zahra et al. (2007) this is because being closer to basic research academic spinoffs may limit their chances of gaining higher short-term performance, since basic research usually takes years before generating revenues. Furthermore, corporate

spinoffs managers are also likely to better understand where their technologies can meet immediate customer needs and to better exploit marketing expertise because of their work histories. Likewise, these managers may be better connected to other companies' networks than other managers and thereby they can draw upon colleagues' market expertise or even hire consultants or other professionals to lead or manage these activities.

In a similar vein, Wennberg et al. (2011) focused on the characteristics of the founding team and argued that the average performance of independent new ventures will be higher than comparable academic spinoffs because commercial knowledge gained by industry experience is potentially more valuable for entrepreneurial performance compared to the academic knowledge gained by additional research experience at a university. Overall, these theoretical arguments support the idea that academic spinoffs are expected to have a lower growth outcome than independent counterparts. Therefore, the inferior performance of academic spinoffs could be explained by their comparatively fragile access to downstream resources such as market capabilities.

However, some studies have argued that academics may enjoy benefits associated with their parent. These relate to the access to key resources, namely research labs and highly qualified human capital, as well as reputation, which in turn would facilitate access to government funding and venture capital (e.g. Colombo et al.

2010a; Colombo and Piva, 2012; Soetano and Geenhuizen, 2015; Yague-Perales and March-Cordà, 2012; Rodríguez-Gulías et al., 2017). A key idea is that academic spinoffs are in a better position to enjoy these benefits due to their social ties and their scientific knowledge, which enhances the absorption of university knowledge (Colombo et al., 2010a). Corroborating these arguments, Siegel and Wessner (2012) found that start-ups with closer ties with universities exhibit better performance. Also, Festel (2013) found that academic spinoffs are more likely to succeed than corporate counterparts, if there is the need for additional funding to further develop the technology, and Bock et al. (2018) found that venture capital-backed academic spinoffs outperformed non-supported academic spinoffs. Hence, the mechanism explained why academic spinoffs would outperform other firms based on the access to upstream resources supported by university ties.

Table 1 presents studies with empirical evidence on academic spinoffs' performance. In reviewing this evidence our criteria were twofold. First, we excluded evidence based on case studies due to the small number of spinoff firms under analysis. Second, we only considered studies with an explicit focus on performance comparison between academic spinoffs and counterparts.

The following observations can be pointed out. Regarding the sampling frame and the methodological approach most studies are very limited in terms of both the number of spinoff firms and the time period covered. Only three studies employ a larger

sample (Zhang, 2008; Wennberg et al., 2011; Rodríguez-Gulías et al., 2017), but Zhang (2008) is restricted to ventured backed-up firms. With respect to the methodological approach, it is noticeable that only two papers employ dynamic panel data techniques (Colombo et al., 2010a and Rodríguez-Gulías et al., 2017), Wennberg et al. (2011) employ panel data but not dynamic.

Table 1: Empirical studies on academic spinoff firms' performance.

Study	Sampling Frame	Industry	Methodological Approach	Theoretical background	Focus	Performance
Ensley and Hmieleski (2005)	102 USOs, 154 independent new venture, 2001, USA	Not specified	Discriminant analysis, cross-sectional	Institutional isomorphism	Top management team characteristics	USOs lower performance in terms of net cash flow and revenue growth than independent firms
Zahra, Velde, Larraneta (2007)	78 USOs, 91 CSOs, 5 USA States; time period not specified	Five high-tech industries	Cross-sectional over 3 year average	Knowledge-based theory	"Knowledge conversion capability" hypotheses	CSOs outperformed USOs in ROA and productivity; USOs reported significantly higher revenue growth rates than CSOs.
Zhang (2008)	Venture capital backed firms of which 704 USO, 6555 non-spinoffs; USA; 1992-2001.	Multi-industry (services and manufacturing high tech)	Cross-sectional, OLS regression, probit on survival	Not discussed.	Comparative empirical analysis.	USOs have a higher survival rate but are not significantly different from other start-ups in terms of the amount of venture capital raised, the probability of completing an initial public offering (IPO), the probability of making a profit, or the size of employment.
Colombo, D'Adda, Piva (2010a)	48 USOs, 449 NTB, Italy; 1994-2003	Multi-industry (services and manufacturing high tech)	Dynamic panel	Resource- and competence-based theories of the firm	How universities located in a geographical area contribute to firm growth (measured by employees)	Spinoff dummy not significant on the growth of employment; academic spinoff has positive effect only when interacted with local University characteristics.
Wennberg, Wicklund, Wright (2011)	528 USOs, 8663 COs, Sweden, 1994-2002	Multi-industry (Knowledge intensive services and high tech manufacturing)	Panel data	Knowledge-based entrepreneurship theory	Founders experience	CSOs grow more than USOs in terms of sales and the survival probability is higher for CSOs than for USOs. No statistically significant difference in growth in employees between CSOs and USOs.
Clarysse, Velde, Wright (2011)	73 USOs, 43 COs, 1991-2002; Flanders region in Belgium	Biotechnology, Software, Electronics	Cross-sectional	Resource based theory	How different characteristics in the technological knowledge base at	Differences in growth not discussed. COs and USOs benefit from different types of technological bases.

Study	Sampling Frame	Industry	Methodological Approach	Theoretical background	Focus	Performance
					start-up influence spin-off performance.	
Siegel, Wessner (2012)	1108 start-ups, USA	Multi-industry	Cross-sectional	Human capital, founders and top management characteristics.	Role of universities on and public funding on start-ups success.	Start-ups with closer ties to universities achieve higher levels of performance and public funding more important than venture capitalists´ funding.
Festel (2013)	15 USOs, 12 COs, Germany, Switzerland	Chemicals and pharmaceutics	Case studies	Discussion of advantages and disadvantages of each spinoff origin.	How effective are different spinoffs at technology transfer.	University spinoffs are better technology transfer mechanism than corporate spinoffs if there is the need to additional funding to further develop the technology.
Rodríguez-Gulías, Rodeiro-Pazos, Fernández-López (2017)	469 USOs, 469 non-USOs, Spain, 2001-2010,	Multi-industry	Dynamic panel	Resource based theory	How firm´s characteristics, and venture capital contribute to growth (measured by on employees and sales)	USOs perform better than non-USOs both in terms of employees and sales

Focusing now on performance outcomes, we identify the following results. First, and foremost, empirical evidence is mixed. For instance, in Sweden academic spinoffs underperform corporate spinoffs (Wennberg et al., 2011) whereas in Italy (Colombo et al., 2010a) and Spain (Rodríguez-Gulías et al., 2017) academic spinoffs grow more than counterparts. Therefore, it does not support the overall prediction that academic spinoffs should have lower performance than counterparts. Second, performance outcomes vary across growth measures. This is true within studies as well as across studies. That is, within a given study when employing more than one outcome measure it is found that academic spinoffs outperform counterparts in some measures, reinforcing the idea that different measures represent different underlying phenomenon and growth processes (Gilbert et al., 2006).

Likewise, across studies the performance outcome is not consistent. For instance, Ensley and Hmieleski (2005) found that academic spinoffs have lower performance in revenue growth than counterparts, but Zahra et al. (2007) found the opposite. Zhang (2008) found higher survival rates among academic start-ups, whereas Wennberg et al. (2011) found the opposite. Naturally, these comparisons are somehow limited by both differences in the sample, and in the methodological approach. In this regard, the evidence provided by panel data techniques (Colombo et al., 2010a; Wennberg et al., 2011; Rodríguez-Gulías et al., 2017) is far more robust than that provided by cross-sectional data analysis. Further, these studies suggest that academic spinoffs have a similar (Wennberg et al., 2011) or even better (Colombo et al., 2010a; Rodríguez-Gulías et al., 2017) performance when taking employment growth as the outcome measure.

Finally, an interesting result is that academic spinoffs benefit from different types of technological bases, hence knowledge, as predicted by Clarysse et al. (2011)

and Colombo et al. (2010a). For instance, Colombo et al. (2010a) found that academic spinoffs have more benefits from knowledge produced by local universities than counterparts.

3. Data, empirical variables and econometric strategy

3.1. The data

In this paper we use two sources of data. First, we use a unique self-collected database for the population of Portuguese academic spinoffs that were established between 1979 - the year in which the first Portuguese academic spinoff was born - and 2010. This database has been used in Conceição et al. (2017), where a detailed description of its collection is provided. The definition of academic spinoffs follows the one that has been proposed by Siegel et al. (2007) and Wright et al. (2008) and it refers to firms created by universities' faculty members or graduate students, who developed a technology as part of their activity in that institution. During this period there was a total of 580 academic spinoffs. Previous accounts on the formation of Portuguese can be found in Fontes (1997) and Fontes and Combs (2001).

We then merged this unique database with data collected from a database that covers almost the population of Portuguese firms that are set up during the same period; the SABI (System Analysis of Iberian Balance Sheets) database, supplied by Bureau van Dijk. From the SABI, economic data on academic spinoffs and non-academic spinoffs firms were collected. More specifically, we collected information for all firms that were founded in Portugal since 1979 until 2010, that is, the year in which the first academic spinoff was founded (1979) and the last year for which we collected data for the population of academic spinoffs (2010). For these firms, we have data regarding the foundation year, the industry in which they operate according to the NACE

classification (Classification of Economic Activities in the European Union), their location according the NUTS III classification (Nomenclature of Territorial Units for Statistics, level 3), and economic data regarding the number of employees, sales, exports, value added, expenses in R&D. With respect to economic data the SABI database only has data available for the period 2006 and 2015. The merging procedure yields a perfect identification of 549 academic spinoffs in the SABI database.

Given that our aim is to study the possible difference in performance between academic spinoffs and non-academic spinoffs, we restrict the sample to the same founding years and to the same industries in which we observe academic spinoffs formation in order to guarantee greater homogeneity of the sample. By doing this, we ended up with a total of 98,649 firms, of which 549 are academic spinoffs. Table 2 presents the sample composition by founding date, industry and geographic area.

Overall, the distribution of academic spinoffs does not follow the distribution of new firms with different entrepreneurial origin, even when the sample is restricted to sectors when there is at least one academic spinoff. There is a clear concentration (77,1%) of academic spinoffs in knowledge intensive sector, namely software (28.1%), research and scientific activities (34,8%), and health, education and business supporting services (14,2%), which is far away from the distribution of firms with other entrepreneurial origin. Other firms are mainly concentrated on non-tech manufacturing and services.

Table 2: Distribution of sample firms.

	Academic Spinoff		Non-Spinoff	
	N	%	N	%
Foundation date				
1979-1985	3	0.55	3,920	4.00
1985-1989	17	3.10	6,254	6.38
1990-1994	44	8.01	9,881	10.07
1995-1999	66	12.02	14,477	14.76
2000-2004	152	27.69	23,417	23.87
2005-2010	267	48.63	40,151	40.93
Total	549	100.00	98,100	100.00
Industry				
Biotechnology, pharmaceuticals	4	0.73	81	0.08
Computers and electronic equipment	18	3.28	3,630	0.37
Telecommunication services	30	5.46	1,839	1.87
Software	154	28.05	3,036	3.09
Research and Scientific activities	191	34.79	12,801	13.05
Health, education and business supporting services	78	14.21	30,592	31.18
Non-tech manufacturing and services [a]	74	13.48	49,388	50.34
Total	549	100.00	98,100	100.00
Geographic area				
Lisbon	148	26.96	35,656	36.35
Porto	112	20.40	17,807	18.15
Braga, Aveiro and Coimbra	208	37.89	13,795	14.06
Others [b]	81	14.75	30,842	31.44
Total	549	100.00	98,100	100.00

Notes: [a] Includes manufacturing of beverages, apparel, printing, chemicals, metal products, machinery, energy, construction activities, computers trade, accommodation and tourism; [b] includes 19 NUTSIII peripheral regions in which there are no main university. Lisbon, Porto, Braga, Aveiro and Coimbra are the regions in which the largest Portuguese universities are located.

Geographically, the dissimilar distribution of academic spinoffs is less noticeable, suggesting that the local presence of a largest university may not be a strong factor explaining the formation of academic spinoffs. This seems to be particularly valid on the largest cities – Lisbon and Porto, suggesting that there are other relevant locational factors explaining new firms´ foundation. One exception seems to be Braga, Aveiro and Coimbra, where the location of a largest university appears to greatly nurture academic spinoffs compared with other new firms with different entrepreneurial origin. Looking at the firm's founding date, there are no noticeable dissimilarities among firms with different entrepreneurial origin, even though the last period, 2005-2010, records a slight acceleration on academic spinoffs, in line with the European trend.

3.2. Empirical variables

In this study the dependent variable aims at measuring firm's performance for heterogeneous firms with heterogeneous growth process. As growth is a sign of success and performance, the dependent variable aims at measuring growth. In the context of new and young firms, a considerable debate has been yielded on the appropriate measure of growth and no consensus exists with regards to the ways of measuring growth.

Taking a more economics-oriented perspective on performance and growth, previous studies researching academic spinoffs commonly used employment or sales as alternative measures of firm growth. However, the choice of the growth indicator may condition empirical results, as they represent different types of growth that may or may not reflect growth in terms of other indicators. The variety of growth indicators does not necessarily correlate well, suggesting that firms grow in different ways

(Delmar et al., 2003) and that the process of growth may involve multiple, but not contemporaneously correlated, actions. Therefore, we analyze firm growth by using alternative measures of growth in order to disclose substantially qualitative differences in terms of how firms grow and its heterogeneous nature. In particular, *employees* and *productivity* are used to proxy growth through resources and knowledge accumulation and efficiency, while *sales* and *export intensity* are indicators of growth through successful market post-entry. The matrix of correlations (see Appendix A1) indicates that the alternative growth indicators are positively, but modestly, correlated, reinforcing the argument of heterogeneous processes of growth and the need to employ different indicators of growth.

The independent variable of interest is *academic spinoff*, which takes value 1 if a firm was created by universities' faculty members or graduate students, who developed a technology as part of their activity in that institution, and zero otherwise. As control variables, we include some of the most commonly used explanatory factors of firm growth such as resources available at the firm, proxied by *R&D intensity* and *firm age*, the geographic *location* of the firm, and its *industry context*. Table 3 shows the description and measurement of each empirical variable, while Table 4 present some descriptive statistics by type of firm.

Overall, academic spinoff firms are, on average, significantly larger firms than firms with other entrepreneurial origin, and they invest more in R&D. On the other hand, firms with other entrepreneurial origin are, on average, older than academic spinoff, suggesting that the foundation of academic spinoff firms in more recent years speed up comparatively to other firms. The distribution of firms' foundation date displayed in Table 2 endorses this finding. Nonetheless, the level of dispersion around the mean indicates that academic spinoff firms seems to be more heterogeneous than

firms with other entrepreneurial origin with respect to sales, suggesting that, for those firms, post-entry market success could be more uncertain.

In turn, non-academic spinoff firms seem to be less successful in external markets and with greater level of dispersion around the mean, indicating that a more dissimilar performance among them than that observed among academic spinoffs. These findings hint qualitative differences on growth among those types of firms.

Table 3: Variables description and measurement.

Variable	**Description and measurement**
Academic spinoff	Firm created by universities' faculty members or graduate students, who developed a technology as part of their activity in that institution.
Employees	The natural log of number of employees.
Sales	The natural log of total sales.
Productivity	Labor productivity measured as the ratio of the natural log of added value to the number of employees.
Exports	Exports intensity measured as ratio of the natural log of exports to total sales.
R&D	R&D intensity measured as the ratio of the natural log of the amount of R&D investment to total sales.
Firm Age	The natural log of a firm at a certain time, i.e., the number of years the firm has been in existence from its foundation up to a given moment.
Sector dummies	Sector dummies to control for common shocks at industrial level.
Regional dummies	Regional dummies to control for differences in location.
Year effects	Time dummies to control for common macroeconomic effects.

Note: Monetary variables in real terms; deflated by the Added Value deflator or manufacturing and services industries, respectively. Deflator data were collected from the European Commission AMECO database.

Table 4: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
			Academic spinoff firms		
Employees	2,888	1.681	1.278	0	6.845
Sales	2,933	5.066	2.054	-3.287	11.169
Productivity	2,573	2.985	0.994	-2.303	6.842
Exports	1,282	4.066	2.665	-4.770	10.138
R&D	751	-3.920	4.238	-19.098	-0.0142
Firm Age	4,879	1.927	0.794	0	3.584
			Non-spinoff firms		
Employees	496,195	1.133	1.056	0	9.128
Sales	524,945	4.813	1.724	-11.527	14.699
Productivity	433,987	2.703	1.078	-12.604	11.755
Exports	99,745	3.455	2.645	-11.512	14.639
R&D	20,805	-4.865	3.077	-20.095	-0.001
Firm Age	872,078	2.108	0.838	0	3.584

Note: Pairwise tests of differences in means are all statistically significant at $p<0.05$.

3.3. Econometric strategy

On the econometric side, a dynamic econometric specification of alternative growth models was adopted in order to account for the inherent endogenous structure of the model, allowing the identification of parameters of interest, even when the dynamics themselves are not the principal focus of attention. The possible endogenous nature of the relationship among dependent and explanatory variables requires the use of appropriate estimation techniques. Therefore, consistent estimates of the parameters of interest were obtained by using GMM methods in which lagged values of variables are valid instrumental variables in the first-differenced equations. As in first differences, predetermined variables become endogenous, they are instrumented with suitable lags

of their own levels. To increase efficiency, equations in levels were added to the estimation system (GMM-SYS) in which endogenous variables in levels are instrumented with suitable lags of their own first differences (cf. Arellano and Bover, 1995). Estimates can be considered consistent, and consequently suitable for interpretation, if the instruments are valid and there can be no second-order correlation. To test the validity of the instruments we resorted to the Hansen test and, for autocorrelation, we test for the existence of first and second-order. Further, we have followed Haskel et al. (2007) and added full sets of time, industry, and region-fixed effects to the differenced specification in the augmented estimator (GMM-SYS).

4. The impact of being an academic spinoff on firm performance

In order to examine whether academic spinoffs exhibit superior performance than counterparts from different entrepreneurial origins and whether there are qualitative differences in terms of how firms grow, several alternative growth models have been estimated. First, those models were estimated using all firms in our sample. Then they were re-estimated using several sub-samples in order to evaluate the robustness of the empirical findings, and as an attempt to disclose contextual conditions and mechanisms that explain why academic spinoffs perform better than firms with other entrepreneurial origins.

4.1. All firms

Table 5 shows the estimated results for alternative growth models using the GMM-SYS estimator and with the entire sample of firms. In all models the null hypothesis of no negative first-order serial correlation (AR(1) test) between differenced residuals is rejected, whereas the AR(2) test do not reject the null hypothesis of the absence of a second-order serial correlation. In turn, Hansen tests indicate the validity of the

specified orthogonally conditions and, hence, the instruments are valid instruments, as the test does not reject that they are uncorrelated with the error term.

The most interesting finding is that the effect of direct spillovers of university knowledge on firms' performance seems to depend on the way growth has been assessed, suggesting that academic spinoffs tend to pursue a specific growth process. Differences in the founding conditions of academic spinoffs, comparing with firms with other entrepreneurial origin, seem to influence how firms develop over time. In particular, academic spinoffs appear to perform better than other firms when growth is measured by the number of employees or by export intensity. However, no significant differences occur in terms of sales or labor productivity growth. This suggests that academic spinoffs are comparatively better in expanding size and in being successful in international markets but they fail to convert such better performance in productivity gains. Their linkages to universities endow them with higher status, which tend to facilitate the access to external resources (e.g. public funding or risk capital) and the attraction and accumulation of resources. Nonetheless, the effective resource accumulation (especially knowledge endowments) of academic spinoffs seems not to render competitive advantages based on productivity gains and sales.

One possible explanation could be, to some extent, deficient market capabilities to explore such knowledge endowments and to commercialize innovations ahead of the competition, as this type of firm emerges from a non-commercial context. The more fragile access to downstream complementary resources could undermine academic spinoffs' performance. As market knowledge is tacit in nature (Wennberg et al., 2011), the lack of commercial experience of academic entrepreneurs could narrow academic spinoffs' performance. Moreover, as Wright et al. (2006) argue universities are likely to be more bureaucratic, often involving quite strict decision-making processes, which

could generate a culture that is generally less inclined towards commercial activities than other organizations. If so, that context is likely to shape the organizational culture of academic entrepreneurs by rendering more difficulties to adjust to commercial demands, and to endorse a continuous search for efficiency.

Looking at growth as a process of resources accumulation, another possible explanation could be the size at start-up. If firms with other entrepreneurial origins tend to have a comparatively large pool of employees from the moment of their creation, then the need to search for additional resources based on employees could be smaller. This could imply that academic spinoffs need to make a greater effort to attain the pool of resources and knowledge they require by hiring additional employees. Therefore, the founding conditions, in particular the context that triggers firm formation, seems to affect the nature of subsequent firm growth. Bruneel et al. (2012) found a similar result in a context of corporate spin-off.

Table 5: The academic spinoff effect on firm growth.

	Employees	Sales	Productivity	Exports
Academic Spinoff	0.103***	0.036	0.002	0.272**
	(0.028)	(0.035)	(0.034)	(0.115)
Lagged dependent variable	0.653***	0.988***	0.880***	0.491***
	(0.049)	(0.061)	(0.156)	(0.101)
Control variables				
Firm size	0.295***	0.149*	0.085	0.884***
	(0.027)	(0.086)	(0.077)	(0.144)
Firm age	-0.059***	-0.046	-0.030	-0.432***
	(0.017)	(0.036)	(0.040)	(0.075)
$R\&D_{(t-1)}$	0.011	0.030**	0.052**	0.024
	(0.009)	(0.012)	(0.021)	(0.017)
Sector, region and time dummies	Yes	Yes	Yes	Yes
N	17562	16649	15966	4918
N groups	8314	8105	7809	2420
F Statistic	585.02***	815.03***	14946.54***	1434.26***
Hansen test	23.378[23]	24.28[25]	21.855[18]	49.174[40]
AR(1)	-11.453**	-8.20***	-5.484**	-4.207**
AR(2)	-1.379	0.28	2.319	0.319

Notes: *Lagged dependent variable* refers to $Employees_{(t-1)}$, $Sales_{(t-1)}$, $Productivity_{(t-1)}$, $Exports_{(t-1)}$. *Firm Size* is measured by past sales, except in the *Sales* regression where it is measured by past productivity. All estimates are GMM-System estimates based on a two-step model with robust standard errors and finite sample correction (Windmeijer, 2005). Estimates are based on a reduced set of instruments with moment conditions in the interval between t-3 and t-5 for equations in orthogonal deviations and between t-2 and t-5 for the equations in levels. F statistic is a test of overall significance of the coefficients. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator; in all regressions the null hypothesis of exogeneity of instruments is not rejected. AR(1) and AR(2) are tests of the null hypothesis of respectively no first- or second-order serial correlation. Standard deviations are in round brackets, degrees of freedom in square brackets. The p-value relating the coefficient of the lagged value of dependent variable refers to the null hypothesis that its coefficient equals unity. * p<0.09. ** p<0.05 *** p<0.001.

Nonetheless, it should be noted that entrepreneurial origin per se does not seem to induce comparatively positive sales variations and efficiency gains, but investments in R&D have a positive effect on sales and productivity growth. This suggests that R&D intensive firms, per se, grow faster than other firms, but the entrepreneurial origin of R&D intensive firms does not seem to be crucial to generate improvement in the process' efficiency and hence on sales. Another finding, which is transversal to all

firms, is that younger firms tend to grow faster. Although it is a stylized fact from the literature (see, e.g., Coad et al., 2013), our results show that it is valid irrespective of the nature of growth, echoing resource and knowledge accumulation or market success. Older firms are less likely to experience fast growth and they appear to be less capable to convert employment growth into growth of sales and productivity.

4.2. Founding contexts and performance mechanisms

Here, we explore the robustness of our findings and reveal detailed knowledge on the effect of entrepreneurial origin on firm's performance. In particular, we are looking for evidence on the role of founding contexts and alternative mechanisms in explaining performance differentials.

The importance of age in explaining firm performance has been widely recognized in the literature, even though there is no consensus whether firm performance deteriorates or improves with age (Coad et al., 2013; Czarnitzki and Delanote, 2013; Schneider and Veugelers, 2010). In order to assess whether the impact of the entrepreneurial origin on firm performance is moderated by age, the sample was broken into more homogenous groups of firms. In particular, Table 6, Panel A, presents estimates for firms founded after 1995 (the time when academic spinoffs began spreading out) and firms with less than five years old.

Overall, the estimates confirm a positive effect of direct spillovers of university knowledge on firm's employment growth and export intensity. Firm's age seems to shape the speed of growth but it does not seem to be a boundary condition, as academic spinoffs seem to perform better than firms from other entrepreneurial origin, regardless their founding date.

Nonetheless, academic spinoffs' ability to convert employment growth into sales' growth appears to take time. Older academic spinoffs are more successful into markets than firms in the same cohort of age but with different entrepreneurial origins. This seems to imply that the comparative advantage of academic spinoffs over their counterparts in terms of market success, measured by growth of sales, improves as firms survive in the market. The innovativeness of academic spinoffs renders market benefits only after several years in the market, and other firms are not able to catch up them over time. This finding suggests that the competitive relevance of accessing to upstream resources from universities increases as firms compete in the market, comparatively to the access to complementary downstream resources, such as market capabilities.

In turn, the difficulty of academic spinoffs to convert distinctively resources and knowledge accumulation and market success into productivity gains persists to not emerge. Again, academic spinoffs seem to fail to yield productivity gains, suggesting that there is not a distinct learning-by-doing effect among firms, regardless how long they compete in the market. The possibility of firms increasing their productivity as they compete in the market, and learn about more productive production techniques and incorporate them in their activities, does not seem to be a distinct feature of academic spinoffs. Although learning-by-doing effects can be expected to be particularly relevant for young firms (Coad et al., 2013; Czarnitzki and Delanote, 2013; Schneider and Veugelers, 2010), in the case of academic spinoffs it does not seem to be significantly different from other firms. The entrepreneurial origin per se does not appear to shape distinctively learning-by-doing effects.

Table 6: Robustness checks

	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
Panel A	**Founding date after 1995**				**Young Firms**			
Academic Spinoff	0.132***	0.065*	0.036	0.333**	0.166***	0.062	-0.051	0.530***
	(0.038)	(0.038)	(0.062)	(0.148)	(0.049)	(0.048)	(0.100)	(0.128)
N	12836	12090	11499	3209	8472	7945	7481	1896
N groups	5956	5781	5526	1566	4297	4152	3941	1056
F statistic	191.64***	53564.40***	22.71***	1089.71***	77.44***	166.06***	1339.55***	519.38***
Hansen test	22.04[22]	21.89[24]	20.29[5]	54.07[52]	26.11[22]	18.64[24]	9.67[13]	53.73[52]
AR(1)	-10.31***	-6.69***	-4.13***	-3.16**	-8.48***	-5.12***	-2.08**	-2.48**
AR(2)	-1.84*	0.37	1.54	0.53	-1.29	0.61	-1.54	1.39
Panel B	**High and Medium-High technology intensive sectors**				**Medium-Low and Low technology intensive sectors**			
Academic Spinoff	0.136***	0.076*	0.024	0.438**	0.038	-0.090	0.057	0.192
	(0.040)	(0.042)	(0.043)	(0.153)	(0.048)	(0.085)	(0.118)	(0.244)
N	6152	5889	5653	2052	10973	10346	9893	2688
N groups	2733	2685	2570	911	5373	5216	5030	1421
F statistic	4850.40***	367.45***	26.42***	669.36***	11813.77***	514.57***	8847.00***	11.19***
Hansen test	15.91[12]	14.62[17]	17.99[13]	79.49[77]	25.59[14]	20.09[21]	17.69[14]	83.97[75]
AR(1)	-6.80***	-5.63***	-3.54***	-2.47***	-10.22***	-7.62***	-3.79***	-3.42***
AR(2)	-0.64	0.59	1.75*	-1.69*	-1.17	-1.64	1.86*	0.85
Panel C	**Lisbon, Porto, Braga, Aveiro, Coimbra**				**Other regions**			
Academic Spinoff	0.119***	0.033	0.002	0.334***	0.0399	0.116	-0.016	0.104

	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
	(0.033)	(0.038)	(0.165)	(0.122)	(0.058)	(0.087)	(0.079)	(0.298)
N	10573	10015	9608	3526	6989	6634	6358	1392
N groups	4950	4819	4634	1705	3364	3286	3175	715
F statistic	8699.37***	69945.36***	42.32	35.27***	5284.50***	226.70***	6803.07***	63.97***
Hansen test	18.18[23]	31.55[25]	19.50[18]	43.76[40]	28.35[23]	31.21[25]	20.94[18]	49.07[39]
AR(1)	-9.27***	-6.80***	-4.69***	-3.97***	-6.61***	-4.97***	-4.03***	-2.71***
AR(2)	-0.39	0.09	1.32	0.60	-1.48	0.20	1.78*	-0.59
Panel D	**With subsidies**				**Without subsidies**			
Academic Spinoff	0.087**	0.062	0.203	0.464*	0.071	-0.093	-0.031	0.902
	(0.043)	(0.118)	(0.181)	(0.280)	(0.097)	(0.192)	(0.325)	(0.571)
N	5191	5022	4879	2182	4206	3926	3759	933
N groups	2209	2178	2124	956	2184	2113	2039	535
F statistic	241.97***	61.48***	755.07***	13.49***	55.97***	58.25***	484.50***	252.67***
Hansen test	22.26[20]	18.76[22]	10.80[14]	36.56[37]	15.23[20]	22.52[22]	18.60[14]	57.72[67]
AR(1)	-6.06***	-5.71***	-2.63***	-2.58**	-5.12***	-2.87***	-2.72***	-2.38**
AR(2)	-1.01	-1.09	0.37	0.88	-0.56	-0.44	1.73*	-0.87
Panel E	**Sole proprietorship and Private Limited Ownership**				**Public Limited Ownership**			
Academic Spinoff	0.013	0.171	-0.205	0.824	0.170**	-0.051	-0.065	0.490
	0.109	0.170	0.222	0.711	0.068	0.177	0.148	0.436
N	7850	7506	7196	2018	1884	1806	1758	1139
N groups	3797	3728	3577	1068	770	753	743	466
F statistic	3343.50***	7033.53***	6.74***	108.69***	3090.97***	4585.65***	1332.24***	187.54***
Hansen test	16.53[20]	22.27[22]	23.52[16]	27.89[37]	17.07[18]	19.14[20]	17.74[18]	33.77[30]
AR(1)	-7.18***	-5.31***	-2.33**	-1.92**	-2.86**	-3.43**	-1.85**	-1.80**
AR(2)	-0.79**	0.01	0.25*	-0.01	1.03**	0.09	0.93**	-0.25*

Notes: Each regression includes all regressors as in Table 5. All estimates are GMM-System estimates based on a two-step model with robust standard errors and finite sample correction (Windmeijer, 2005). Estimates are based on a reduced set of instruments with moment conditions in the interval between t-3 and t-5 for equations in

orthogonal deviations and between t-2 and t-5 for the equations in levels. F statistic is a test of overall significance of the coefficients. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator; in all regressions the null hypothesis of exogeneity of instruments is not rejected. AR(1) and AR(2) are tests of the null hypothesis of respectively no first- or second-order serial correlation; for simplicity AR(3) test of third-order serial correlation are not shown but they are all statistically non-significant and are available upon request. Standard deviations are in round brackets and degrees of freedom in square brackets. The p-value relating the coefficient of the lagged value of dependent variable refers to the null hypothesis that its coefficient equals unity. * p<0.09. ** p<0.05 *** p<0.001.

The heterogeneity of industries whose technological opportunities may be significantly different (Malerba and Orsenigo, 1997) is another potential boundary condition shaping performance differentials. Spinoff firms, either academic or opportunity spinoffs, using the Bruneel et al. (2013) concept, are more likely to introduce innovations in markets with high levels of market originality than in less innovative markets. Therefore, we may expect the type of industry in which the firm operates to moderate the effect of entrepreneurial origin on firm performance. Estimates using sub-samples of firms operating in industry-types based on the OECD taxonomy of technological intensity are reported in Table 6, Panel B.

Overall, academic spinoff superior performance comparatively to firms with other entrepreneurial origin depends on industry context. Technological opportunities and intensity at industry level seems to shape the effect of direct spillover of university knowledge on firm's performance. That effect seems to be confined to high and medium high technology intensive sectors, in which academic spinoffs appear to growth faster both in terms of resource and knowledge accumulation and in terms of market (local or international) success. In other sectors, there are no significant differences on firms' performance, indicating that, in that founding context, the access to upstream resources from university linkages is irrelevant to firm's performance.

Nonetheless, the debility on productivity growth appears not to be vanished when one looks at more homogeneous sectors. In comparative terms, it could be argued that academic spinoffs possess higher resources and knowledge but no differential capabilities to shape competences to develop and exploit firm's activities in adapting

to a competitive environment and yielding productivity differential gains. Conversely to Ortín-Ángel and Vendrell-Herrero (2014), who have showed that Spanish academic spinoffs have higher productivity than new technology-based firms after 2 or 3 years of operation, the Portuguese academic spinoffs appear not attain such comparative economic value, even when one looks at technology intensive sectors.

Spinoffs´ prior knowledge should play a key role in facilitating the access to and the assimilation of the knowledge produced locally by universities or research labs, identifying interesting results and using them in their own activities. If so, academic spinoffs should be in a better position than other firms to benefit from this knowledge and to convert it into firm's growth as close ties with universities increases the probability of commercialization of research projects (Siegel and Wessner, 2012). Moreover, the pool of qualified and top-educated workforce at local level and the existence of localized knowledge spillovers (Colombo et al., 2010a) suggest that academic spinoffs located in regions where there are universities or research labs and a high share of qualified and top-educated workforce should perform better than firms with other entrepreneurial origins. The ease of accessing upstream complementary resources would play an important role in explaining performance differentials. Therefore, Table 6, Panel C, presents estimates for sub-samples of firms located in regions with and without relevant upstream resources related to research institutions and qualified and top-educated workforce.

Overall, the proximity to technological knowledge from universities and a pool of qualified and top-educated workforce seem to support growth of academic spinoffs. One possible interpretation is that geographic proximity eases the access to complementary upstream resources, which can be seen as the mechanism that explains the superior performance of academic spinoffs. Comparatively, firms with other

entrepreneurial origins appear to not benefit from that geographical proximity to relevant upstream resources. Moreover, academic spinoffs located in other regions, which are less endowed with knowledge and qualified and top-educated workforce, do not exhibit significant performance differentials, suggesting the existence of localized knowledge spillovers. Geographic distance from important sources of upstream resources seems to confine growth, even though firms have the ability to assimilate the knowledge produced by universities or research labs, as it is the case of academic spinoffs.

The access to external financial resources could also be an important factor in explaining performance differentials. For academic spinoffs, Siegel and Wessner (2012) have found that public funding is relatively more important to successful commercialization of research than additional developmental funding from venture capitalists. Moreover, Barbosa and Silva (2018) conclude that firm's involvement in innovation activities increase the probability of applying and being granted public funding, which can also be seen as a way to externalize investment risk. In the case of our sample of Portuguese firms, the proportion of academic spinoffs granted public funding is around 67%, while the proportion of other firms is less than 20%. If there were asymmetric access to public funding, then public grant-recipient firms could be in better conditions to grow. To evaluate whether academic spinoffs perform better than other firms due to their ability for searching, applying and using public funding, no matter its nature, firm's performance was estimated using sub-samples of public grant-recipient firms and with non-granted firms (see, Table 6, Panel D).

The ability to be a public grant-recipient firm appears to explain why academic spinoffs perform better than their counterparts. The asymmetric access to public funding seems to render performance differentials in terms of accumulation of resources, measured by employment growth, and external markets success. Since most of public funding programmes aims at reducing market failure, uncertainty and risks (Barbosa and Silva, 2018) and academic spinoffs tend to develop more risky and uncertain activities than their counterparts, they appear to use public funding to improve growth and competitiveness by potentially externalizing investment risk. Further, it is interesting to note that most of public funding programmes favour positive outcomes related to employment and internationalization, which are the growth dimensions in which academic spinoffs are comparatively more successful. However, the potential externalization of risk does not seem to help academic spinoffs to convert resources accumulation into efficiency gains. Moreover, without public funding, there are no significant performance differentials between academic spinoffs and firms with other entrepreneurial origins, reinforcing the role of accessing upstream complementary resources in shaping academic spinoffs' performance.

Studies arguing that firms with other entrepreneurial origins, in particular, new ventures arising from a corporate parent, should outperform academic spinoffs focus

mainly on the access to downstream resources such as market knowledge and commercialization capabilities. Although those resources are tacit in nature, they are not restricted to entrepreneur-specific capabilities. A superior ability to understand market changes and to match offerings to what the customer perceives as valuable could be brought to the firm by hiring a management team with prior non-technical experience in the market. Therefore, we explore this issue by estimating the model for sub-samples based on the firm's legal form. Comparing to sole proprietorships and private limited ownership, firms based on public limited ownership are less prone to rely on general human capital of founders, which would facilitate the integration and accumulation of market knowledge brought by hired top managers that are better connected to market. In the case of academic spinoffs, public limited ownership would favour different organizational contexts that facilitate the access to non-technical knowledge, which is a way to overcome founders' potential marketing weaknesses. Table 6, panel E presents estimates using two sub-samples based on the firm's legal form.

Although the legal form could be a fragile way to proxy the ease in accessing complementary downstream resources such as marketing capabilities, the results suggest that it is not a negligible explanatory factor. Academic spinoffs performance differentials appear to occur only when the legal form suggests a weak linkage between founders' human capital and firm's human capital, even though it seems to be significant only for resources and knowledge accumulation related to employees. Nonetheless, these findings do not support the argument that firms with other entrepreneurial origins should outperform academic spinoffs, as academic spinoffs' managers are less able to understand customers' needs and market changes. By hiring professionals with market expertise, the potential fragility related to complementary downstream resources could be overcome, leading to performance differentials.

5. Conclusions

Firm's entrepreneurial origin could have a long-lasting effect on firm performance. Utilizing a unique longitudinal database including the whole population of Portuguese university spinoff firms and 98,649 non-academic start-ups, we compared firm performance employing alternative measures of firm growth and exploring alternative

boundary contexts and explanatory mechanisms of firm's performance.

Clearly, Portuguese academic spinoffs are following a path of resources accumulation (especially knowledge) and internationalization. The knowledge accumulation path is consistent with arguments advanced by both resource-based (e.g. Clarysse et al., 2011; Zahra et al., 2007) and entrepreneurship theories (e.g. Agarwal et al., 2007; Wennberg et al. 2011), which state that firms gain competitive advantage especially through knowledge accumulation and deployment. Our findings support the view that, by exploring new and more radical technology, academic spinoffs may undermine the advantages of incumbents, particularly so in more high-tech sectors (Lerner, 1994; Shane, 2001; Teece, 1986). Yet, the finding that Portuguese academic spinoffs are pursuing growth through internationalization casts some doubts in the argument that they lack market capabilities

More importantly, our findings suggest that the access to upstream complementary resources such as technological knowledge produced by local universities and top-educated workforce is the main mechanism explaining why academic spinoffs outperform other firms. This mechanism is particularly important in technologically intensive industries and for academic spinoffs located in endowed regions in terms of knowledge and qualified and top-educated workforce. Also, the close ties to universities seems to favour them in accessing public funding, which can be seen as another important upstream complementary resource.

However, Portuguese academic spinoffs fail to convert this resource accumulation into productivity gains, thereby providing support to the argument that academic spinoffs may limit their chances of fully exploring or deploying their technological resources. Furthermore, the lack of access to important downstream resources appears to erode their competitive advantage compared to other firms with

different entrepreneurial origins. Nonetheless, academic spinoff's legal form based on public limited ownership seems to be a mechanism that offers more flexibility to attract and hire professionals with market expertise, who would overcome that potential weakness and yield superior performance.

Although Portuguese academic spinoffs seem to contribute for economic development by creating new jobs and deepening firms' internationalization, further research might examine which factors prevent academic spinoffs to yield productivity gains when compared with firms based on other entrepreneurial origin. For that, future research should focus on what goes on within the firm and examine growth as a process that evolves through time. Without understanding the link (or the lack of link) between academic spinoffs' abnormal knowledge endowments and productivity and efficiency gains, the potential to creating substantial growth and economic value ascribed to academic spinoffs is at risk. As a consequence, public policies targeting that specific entrepreneurial origin could become ineffective in fostering competitive gains and become a waste of public funding. Further, on the public policy side, the usual focus on employment as a measure of entrepreneurial success and public policy effectiveness should be complemented with measures related to efficiency and productivity.

The long-time span and extent of the sample, which is very close to the population of firms, allows a high degree of generalizability to the Portuguese economy. However, as pointed out by Fini et al. (2017), institutional differences at national level could yield relevant differences in academic spinoffs' formation and performance. This implies that the institutional context could act as a boundary condition. If so, our findings could be challenged by evidence from other countries with significantly dissimilar institutional contexts. Therefore, an avenue for further research

would be to assess under which conditions the institutional context might act as a mediator factor in explaining academic spinoffs' performance differentials.

References

Agarwal, R., and Shah, S. (2014). Knowledge sources of entrepreneurship: Firm formation by academic,user and employee innovators. *Research Policy, 43*, 1109-1133.

Agarwal, R., Audretsch, D., and Sarkar, M. B. (2007). The process of creative construction: knowledge spillovers, entrepreneurship, and economic growth. *Strategic Entrepreneurship Journal , 1* (3-4), 263-286.

Aghion, P., Blundell, R., Griffth, R., and Howitt, P. (2009). The effects of entry on incumbent innovation and productivity. *The Review of Economics and Statistics, 91* (1), 20-32.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics, 68* (1), 29-51.

Audretsch, D., and Feldman, M. (2004). Knowledge spillovers and the geography of innovation. In V. Henderson, and J. Thiesse, *Handbook of regional and urban economics* (pp. 2713-2739). Amsterdam: North Holland Publishing.

Barbosa, N. and Silva, F. (2018) Public financial support and firm-specific characteristics: evidence from Portugal. *European Planning Studies*, 26(4): 670-686.

Baumol, W. (2002). The Free Market Innovation Machine: Analyzing the Growth Miracle of Capitalism. New Jersey: Princeton University Press.

Bock, C., Huber, A. and Jarchow, S. (2018). Growth factors of research-based spin-offs and the role of venture capital investing. *Journal of Technology Transfer, 43*, 1375-1409.

Bruneel, J., Van de Velde, E., and Clarysse, B. (2013). Impact of the type of corporate spin-off on growth. *Entrepreneurship Theory and Practice*, *37* (4), 943-959.

Carroll, R., Holtz-Eakin, D., Rider, M., and Rosen, H. (2001). Personal income taxes and the growth of small firms. *Tax policy and the economy*, 121-147.

Clarysse, B., Wright, M., and Van de Velde, E. (2011). Entrepreneurial Origin, Technological Knowledge, and the Growth of Spin-Off Companies. *Journal of Management Studies, 48* (6), 1420-1442.

Coad, A., Segarra, A., and Teruel, M. (2013). Like milk or wine: Does firm performance improve with age? *Structural Change and and Economic Dynamics, 24*, 173-189.

Colombo, M., and Piva, E. (2012). Firms' genetic characteristics and competence-enlarging strategies: A comparison between academic and non-academic high-tech start-ups. *Research Policy, 41*, 79-92.

Colombo, M., D´Adda, D. and Piva, E. (2010a). The contribution of university research to the growth of academic start-ups: an empirical analysis. *Journal of Technology Transfer, 35*, 113-140.

Colombo, M., Mustar, P., and Wright, M. (2010b). Dynamics of Science-based entrepreneurhsip. *Journal of Technology Transfer, 35*, 1-15.

Conceição, O., Faria, A., and Fontes, M. (2017). Regional variation of academic spinoffs formation. *Journal of Tehcnology Transfer, 42* (3), 654–675.

Corsino, M., Giuri, P. and Torrisi, S. (2018). Technology spin-offs: teamwork, autonomy, and the exploitation of business opportunities. *Journal of Technology Transfer*. https://doi.org/10.1007/s10961-018-9669-1.

Czarnitzki, D., and Delanote, J. (2013). Young innovative companies: the new high-growth firms? *Industrial and Corpotate Change, 22* (5), 1315-1340.

Delmar, F., Davidsson, P., and Gartner, W. (2003). Arriving at the high-growth firm. *Journal of Business Venturing , 18*, 189-216.

Djokovic, D., and Souitaris, V. (2008). Spinouts from academic institutions: a literature review with suggestions for further research. *Journal of Technology Transfer, 33*, 225-247.

Ensley, M., and Hmieleski, K. (2005). A comparative study of new venturetop management team composition, dynamics and performance between university-based and independent start-ups. *Research Policy , 34*, 1091-1105.

Festel, G. (2013). Academic spin-offs, corporate spin-outs and company internal start-ups as technology transfer approach. *Journal of Technology Transfer*, 38(4), 454-470.

Fini, R., Fu, K., Mathisen, M., Rasmussen, E. and Wright, M. (2017). Institutional determinants of university spin-off quantity and quality: longitudinal, multilevel evidence from Italy, Norway and the UK. *Small Business Economics, 48* (2), 361-391.

Fontes, M. (1997) "Creation and Development of New Technology Based Firms in Peripheral Economies" in M. Klofsten and D. Jones-Evans (eds.) Technology, Innovation and Enterprise - The European Experience, London: Macmillan.

Fontes, M. and Coombs, R. (2001). Contribution of New Technology-based Firms to the Strengthening of Technological Capabilities in Intermediate Economies, Research Policy, 30, 79-97.

Gans, J., and Stern, S. (2000). Incumbency and R&D incentives: licensing the gale of creative destruction. *Journal of Economics and Management Strategy, 9*, 485-511.

Gilbert, B. A., McDougall, P. and Audretsch, D. (2006). New venture growth: a review and extension. *Journal of Management*, *32*(6), 926-950.

Harrison, R., and Leicht, C. (2010). Voodoo Insitution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK. *Regional Studies, 44* (9), 1241-1262.

Haskel, J. E., Pereira, S. C., and Slaughter, M. J. (2007). Does inward foreign direct investment boost the productivity of domestic firms?. *Review of Economics and Statistics, 89,* 482–496.

Larrañeta, B. González, J. and Aguilar, R. (2017). Early efforts to develop absorptive capacity and their performance implications: differences among corporate and independent ventures. *Journal of Technology Transfer, 42*, 485-509.

Lerner, J. (1994). The importance of patent scope: an empirical analysis. *Rand Journal of Economics, 25* (2), 319-333.

Malerba, F., and Orsenigo, L. (1997). Technological Regimes and Sectoral Patterns of Innovative Activities. *Industrial and Corporate Change, 6* (1), 83-118.

Markman, G., Siegel, D., and Wright, M. (2008). Research and Technology Commercialization. *Journal of Management Studies, 45* (8), 1401-1423.

McKelvie, A. Brattström, A. and Wennberg, K. (2017). How young firms achieve growth: reconciling the roles of growth motivation and innovative activities. *Small Business Economics, 49*, 273-293.

Mendes, J. (2010). Inovação e Empreendedorismo na Universidade. Porto: CIENCINVEST.

Mowery, D. (2005). The Bayh–Dole Act and high-technology entrepreneurshipin US universities: chicken, egg, or something else? advances in the study ofentrepreneurship. In G. D. Libecap, *University Entrepreneurship and Technology Transfer (Advances in the Study of Entrepreneurship, Innovation andamp; Economic GrowthAdvances in the Study of Entrepreneurship, Innovation and Economic Growth* (Vol. 16, pp. 39-68). Bingley, West Yorkshire: Emerald.

Nelson, R. (1959). The simple economics of basic scientific research. *Journal of PoliticalEconomy, 67*, 297–306.

Nerkar, A., and Shane, S. (2003). When do start-ups that exploit patented academic knowledge survive? *International Journal of Industrial Organization, 21*, 1391-1410.

Ortín-Ángel, P. and Vendrell-Herrero, F. (2014). University spin-offs vs. other NTBFs: Total factor productivity differences at outset and evolution. *Technovation, 34*, 101-112.

Rodríguez-Gulías, M., Rodeiro-Pazos, D. and Fernández-López, S. (2017). The growth of university spin-offs: a dynamic panel data approach, *Technology Analysis and Strategic Management*, 29 (10), 1181-1195.

Romanelli, E. (1989). Environments and strategies of organization start-up: effects on early survival. *Administrative Science Quarterly, 34*, 369-387.

Rothearmel, F., Agung, S., and Jiang, L. (2007). University entrepreneurship: a taxonomy of the literature. *Industrial and Corporate Change, 16* (4), 691-791.

Schneider, C., and Veugelers, R. (2010). On young highly innovative companies: why they matter and how (not) to policy support them. *Industrial and Corporate Change , 19* (4), 906-1007.

Shane, S. (2001). Technology opportunity and firm formation. *Management Science, 47* (2), 205-220.

Shane, S. (2004). Academic Entrepreneurship: University Spinoffs and Wealth Creation. Norhtampton, MA: Edward Elgar.

Siegel, D. and Wessner, C. (2012). Universities and the Success of Entrepreneurial Ventures: Evidence from the Small Business Innovation Research Program. *Journal of Technology Transfer*, 37, 404-415.

Siegel, D., Wright, M., and Lockett, A. (2007). The rise of entrepreneurial activity at universities: Organizational and societal implications. *Industrial and Corporate Change, 16*, 489-504.

Soetano, D., and Geenhuizen, M. v. (2015). Getting therightbalance: Universitynetworks' influence onspin-offs' attractionoffundingforinnovation. *Technovation, 36-37*, 26-38.

Stokes, D. (1997). Pasteur's Quadrant: Basic Science and Technological Innovation. Washington, DC: Brookings Inst Press.

Teece, D. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy, 15*, 285-306.

Wennberg, K., Wiklund, J., and Wright, M. (2011). The effectiveness of university knowledge spillovers: performance differences between university spinoffs and corporate spinoffs. *Research Policy, 40*, 1128-1143.

Williamson, O. (1975). Markets and Hierarchies: Analysis and Antitrust Implications. New York : Free Press.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics, 126* (1), 25-51.

Wright, M., Clarysse, B., Mustar, P., and Lockett, A. (2008). *Academic Entrepreneurship in Europe.* Cheltenham: Edward Elgar.

Wright, M., Clarysse, Bart, and Mosey, S. (2012). Strategic entrepreneurship, resource orchestration and growing spinoffs from universities. *Technology Analysis and Strategic Management, 9*, 911-927.

Yagüe-Perales, R., and March-Chordà, I. (2012). Performance analysis of research spin-offs in the Spanish biotechnology industry. *Journal of Business Research, 65*, 1782-1789.

Zahra, S., Van de Velde, E., and Larrañeta, B. (2007). Knowledge conversion capability and the performance of corporate and university spin-offs. *Industrial Corporate Change, 16* (4), 569–608.

Zhang , J. (2008). The performance of university spin-offs: an exploratory analysis using venture capital data. *The Journal of Technology Transfer , 34* (3), 255–85.

Appendix A.1 Matrix of Pearson correlations.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Academic spinoff	1.0000						
(2)	Employees	0.0393*	1.0000					
(3)	Sales	0.0109*	0.7120*	1.0000				
(4)	Productivity	0.0200*	0.1096*	0.5170*	1.0000			
(5)	Exports	0.0258*	0.4020*	0.5446*	0.3546*	1.0000		
(6)	R&D	0.0553*	-0.0965*	-0.0829*	-0.0573*	-0.0548*	1.0000	
(7)	Firm age	-0.0161*	0.1994*	0.1734*	0.0711*	0.0734*	-0.0789*	1.0000

Note: * Significant at 5% level.