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The effect of entrepreneurial origin on firms' performance: The case of Portuguese academic spinoffs [1]

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Abstract

We investigate the role of different entrepreneurial origin on firms' performance by comparing academic spinoff firms with their non-academic counterparts and using alternative growth measures. Estimates based upon dynamic panel-data models reveal that academic spinoffs grow through resources accumulation and internationalization. However, comparatively to non- academic counterparts, they fail to translate these advantages into productivity gains. Also, despite younger academic spinoff outperform, in terms of sales growth, firms from different entrepreneurial origin, they fail to retain these scale effects, as they grow older. Portuguese academic spinoffs are contributing to economic development by creating new jobs, yet their relevance as a source of sustained economic value is limited so far. Policy implications are discussed in light of these findings.

JEL Classification: L21, L25, M13, H32

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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; Colombo et al., 2010 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 United Kingdom (UK) toward intellectual property (e.g. Mowery, 2005; Siegel et al., 2007). Current evidence has shown some stylized facts regarding the formation of university spinoffs: they are concentrated in the biotechnology and software industries, they are located near their parent and exhibit higher survival rates relative to wide economy benchmarks (e.g. Agarwal et al., 2004; Shane, 2004; Zhang, 2008; Conceição et al., 2017).

These stylized facts suggest that the entrepreneurial origin of new ventures may have a differential influence on how firms develop over time. In particular, the study of the differences in the founding conditions of academic spinoffs is relevant for a number of reasons. First, innovation is critical to economic growth and social progress and start-ups are important sources of technological innovation and diffusion (Baumol, 2002; Aghion et al., 2009). Academic spinoffs are thus seen as a key vehicle to promote the transfer of knowledge generated by research institutions to the market, thereby promoting innovation diffusion and growth. Second, academic spinoffs may contribute to economic development by creating new and highly skilled jobs and generating knowledge spillovers (Audretsch and Feldman, 2004). Furthermore, recent studies have emphasized that it is young rather than small firms that make the largest contribution to job creation (e.g. Coad, 2009; Schneider and Veugelers, 2010; Czarnitzki and Delanote, 2013; Haltiwanger et al., 2013).

These potential benefits 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. Carroll (2001) casts serious doubts on the presence of positive externalities and capital market imperfections that may justify public support to small business and entrepreneurial firms, while discussing standard efficiency and equity criteria. Also, Harrison and Leicht (2010) argued that the prominence given to spinoffs in relation to technology transfer and the economic impact of universities is misplaced and that academic spinoffs are technology lifestyle businesses rather than dynamic start-ups with high-growth potential. Indeed, empirical studies show the total number of academic spinoffs across Europeans country still remains relatively small and, in many cases, do not achieve high growth (Rothearmel et al., 2007; Djokovic and Souitaris, 2008).

Moreover, academic spinoffs are important to study because they have been described as distinct from other innovative new ventures with respect to the knowledge and capabilities they bring to the industry (Colombo and Piva, 2012; Wright et al., 2012; Agarwal and Shah, 2014). Their entrepreneurial origin is very unique, in that they exhibit peculiar "genetic characteristics" that leave an enduring imprint on firm development (Colombo and Piva, 2012). Founding conditions are important determinants of firm survival (Geroski et al., 2010). Among these, the technological environment (Malerba and Orsenigo, 1997) and the knowledge context (Agarwal et al., 2007; Clarysse et al., 2011) from which a firm originates are particularly important to explain firm growth (Agarwal and Shah, 2014) and survival (Cader and Leatherman, 2011; Hyytinen et al., 2015). The view that the relationship between innovativeness and firm performance may be context-dependent rather than be confined to younger firms is supported by recent emerging empirical works (see, e.g., Cader and Leatherman, 2011; Hyytinen et al., 2015) and call for additional studies that empirically expose the systematic differences among firms originating from different contexts.

Therefore the objective of this paper is twofold. Firstly, 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. Further, the distribution of academic spinoffs is compared with its counterpart of new firms with a different entrepreneurial origin. Secondly, we examine whether academic spinoffs exhibit superior performance than counterparts from different entrepreneurial origins. Although the study of firm's performance has been based on different theoretical frameworks, namely institutional isomorphism (Ensley and Hmieleski, 2005), resourced-based theory of the firm (e.g. Zahra et al., 2007; Clarysse et al., 2011) 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. Hence firms have different knowledge endowments and different capabilities to explore them, which then lead to differences in performance. 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). In addition, the knowledge being converted in new technologies is more complex and difficult than those of incumbents, providing start-ups an enduring advantage relative to other firms (Zahra et al., 2007; Clarysse et al., 2011). Therefore, assessing the relative effectiveness of that entrepreneurial origin is crucial and could provide important implications for public policy related to the support of academic entrepreneurship. As far as we are aware, there is no similar work applied to the Portuguese experience.

This 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 the performance of academic spinoffs and 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; Bruneel et al., 2013; Agarwal and Shah, 2014). Third, we contribute to the broader area of firm growth studies by providing evidence on what extent the reasons leading to growth and the outcome of growth may be different across different firms of different entrepreneurial origin (Delmar et al., 2003). Finally, we contribute to the empirical evidence analyzing the relationship between innovation novelty and firm performance and how this relationship varies with firm age (Cader and Leatherman, 2011; Hyytinen et al., 2015; Coad et al., 2016).

On the empirical side, various studies have investigated performance differences between academic start-ups and independent new ventures (e.g. Zahra et al., 2007; Ensley and Hmieleski, 2005; Wennberg et al., 2011; Clarysse et al., 2011), but they are based on a rather limited sampling frame. Except for Wennberg et al. (2011) the sampling frame of those studies concentrates on a small number of universities and/or spinoff firms, and/or on a single sector, as well as on a short span of years. That 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. With respect to the methodological approach, it is noticeable that only two papers employ panel data techniques (see Colombo et al., 2010 and Wennberg et al., 2011).

In this paper we use a dataset that 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. Further, we employ alternative measures of firm growth, namely labor productivity and export intensity, in addition to employment and sales, which are most commonly used in studies researching academic spinoffs. By using proxies for resource and knowledge accumulation (e. g., employment) and indicators of successful market post-entry (e.g., sales and export intensity) this study attempts to assess whether firms grow in different ways (Delmar et al., 2003).

The paper is as organized as follows. 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?

The link between innovativeness and firm performance has long been discussed in the literature with a number of theoretical arguments running both ways. It has been argued that innovation enhance firms' market power (Schumpeter, 1943), improve their dynamic capabilities (Teece et al., 1997) and absorptive capacity (Zahra and George, 2002). Yet, another set of theoretical arguments has proposed the opposite effect. Innovation is riskier and entails a less linear start-up process (Samuelsson and Dahlstrand, 2005), which may lead to skewed returns (Scherer and Harhoff, 2000). Furthermore, an innovative start-up may face a greater liability of novelty than its non-innovative counterparts (Amason et al., 2006). Overall, empirical literature finds a positive association between innovativeness of new firms and their subsequent survival (e.g. Audrestch, 1995; Cefis and Marsilli, 2012; Helmers and Rogers, 2010). However, emerging empirical evidence suggests that these results may be context- dependent and not necessarily applicable to younger firms (Cader and Leatherman, 2011; Hyytinen et al., 2015).

In the particular case of academic spinoffs, various hypotheses have been advanced to explain why and when they 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 (Shane, 2001; Nerkar and Shane, 2003). 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 (Shane, 2001; Nerkar and Shane, 2003).

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 (Romanelli, 1989; Gans and Stern, 2000). 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. Although they depart from different theoretical frameworks, namely institutional isomorphism (Ensley and Hmieleski, 2005), resourced-based theory of the firm (e.g. Zahra et al., 2007; Clarysse et al., 2011) 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. Hence firms have different knowledge endowments and different capabilities to explore them, which then lead to differences in performance. 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 (Zahra et al., 2007; Clarysse et al., 2011).

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) argue that new ventures arising from a corporate parent should outperform academic spinoffs. 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 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 argue 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. 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. 2010; Colombo and Piva, 2012; Yague-Perales and March-Cordà, 2012; Soetano and Geenhuizen, 2015). 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., 2010).

Table 1 presents studies with empirical evidence on academic spinoffs' performance. In reviewing this evidence our criteria was 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. As shown in Table 1 only six studies meet these two criteria.

Insert Table 1 here

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 two studies employ a larger sample (Wennberg et al., 2011, and Zhang, 2009), but Zhang (2009) is restricted to ventured backed-up firms. With respect to the methodological approach, it is noticeable that only two papers employ panel data techniques (Colombo et al., 2010 and Wennberg et al., 2011).

Focusing now on performance outcomes, we identify the following results. First, and foremost, empirical evidence is mixed. 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 process (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 Zhara et al. (2007) found the opposite. Zhang (2009) 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., 2010; Wennberg et al., 2011) 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., 2010) 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. (2010). For instance, Colombo et al. (2010) 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. During this period there was a total of 580 academic spinoffs, i.e., firms created by universities' faculty members or graduate students, who developed a technology as part of their activity in that institution (see, e.g. Siegel et al., 2007; Wright et al., 2008, for a definition of academic spinoff).

We then merge 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.

Insert Table 2 here

Overall, the distribution of academic spinoffs does not follow the distribution of other 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 3 sectors – 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. 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.

3.2. Empirical variables

In this study the dependent variable aims at measuring firm's performance for heterogeneous firms with heterogeneous process of growth. 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, number of *employees* and *productivity* are used to proxy growth through resources and knowledge accumulation, while *sales* and *export intensity* are indicators of growth through successful market post-entry. The matrix of correlation (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.

Insert Table 3 and Table 4 here

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 seems 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.

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 and then they were re-estimated using several sub-samples in order to evaluate the robustness of the empirical findings.

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.

Insert Table 5 here

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 process of growth. Differences in the founding conditions of academic spinoffs, comparing with firms with other entrepreneurial origin, seem influence how firms develop over time. In particular, academic spinoffs appear to perform better than other firms when firm's growth is measured by number of employees or 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. 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. 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 it requires 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.

Nonetheless, it should be noted that the entrepreneurial origin per se does not seem to induce comparatively positive sale variations and efficiency gains, but investments in R&D have a positive effect on sales and productivity growth. This suggest that R&D intensive firms 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 that 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. Robustness checks

Here, we discuss estimates of the specified growth models using different sub-samples in order to explore the robustness of our findings and to reveal detailed knowledge on the effect of entrepreneurial origin on firm's performance. In particular, we are looking for evidence on the impact of different founding contexts in shaping the way firms grow that allows us to evaluate whether there are some nuances on the comparative assessment of the impact of entrepreneurial origin on firm's performance.

A potential source of concern with the estimates is related to firm's age and its impact on growth. 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). 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 presents estimates for firms founded after 1995 – the beginning of the spreading out of academic spinoffs – and firms with less than five years old.

Insert Table 6 here

Overall, the estimates confirm the positive effect of direct spillovers of university knowledge on firm's employment growth and export intensity. This seems to indicate that firm's age impact on the speed of growth but it does not significantly moderate the direct spillover of university knowledge on firm's performance, as academic spinoffs seem to perform better than firms from other entrepreneurial origin, regardless their founding date. Nonetheless, younger academic spinoffs appear to be more capable to convert employment growth into growth of sales, suggesting that they are more successful into markets than firms in the same cohort of age but with different entrepreneurial origin. This seems to imply that the comparative advantage of academic spinoffs over firms with entrepreneurial origin in terms of market success, measured by growth of sales, vanishes as firms survive in the market. Younger academic spinoffs are likely to perform better than other younger firms but they seem to be unable to maintain such comparative advantage as they compete in the market. This could suggest that the innovativeness of academic spinoffs render market benefits over the first years in the market but other type firms are able to catch up them over time. This catching up process may be due to a market selection effect that progressively eliminates the weakest firms.

In turn, the difficulty of academic spinoffs to convert distinctively resources and knowledge accumulation and market success into productivity gains persists not to emerge. Again, the process of growth of younger or older academic spinoffs seems to fail to yield productivity gains, suggesting that there is not a distinct learning-by-doing effect between academic spinoffs and other 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 when compared with other firms. Although learning by doing effects can be expected to be particularly relevant for young firms (Coad et al., 2013), in the case o academic spinoffs it does not seem to be different from firms with other entrepreneurial origin. That is, the entrepreneurial origin per se does not appear to shape distinctively the learning-by-doing effects.

Another source of concern with the estimates is the heterogeneity of industries whose technological opportunities may be significantly different. As academic spinoffs, similarly to opportunity spinoffs using the Bruneel et al. (2013) concept, are likely to bring the innovation to market with high levels of market originality, the type of industry may moderate the effect of the 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 7.

Insert Table 7 here

The chief finding of that robustness check is quite interesting. Academic spinoff superior performance comparatively to firms with other entrepreneurial origin depends on industry context. In particular, 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 other sectors, there are no significant differences on firms' performance, indicating that is that context the entrepreneurial origin is irrelevant to firm's performance. In turn, in high and medium high technology intensive sectors academic spinoffs appear to growth faster both in terms of resource and knowledge accumulation and in terms of market – local or international – success.

Nonetheless, the debility on productivity growth appears not to be vanished when one looks at more homogeneous sectors. Even in high and medium high technology intensive sectors, in which the linkage and relatedness to an university could be an important factor to boost growth and survival, academic spinoffs fail to generate productivity gains when compared to other firms. 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. This is an issue that deserves further research.

5. Conclusions

This paper investigated the growth of firms of different entrepreneurial origin. 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.

A first interesting finding is that Portuguese academic spinoffs distribution across sectors is different from their counterparts. The former are clearly concentrated in knowledge intensive sectors, namely software, scientific activities and health, education and supporting services, whereas the latter are mostly concentrated on non-tech manufacturing and services. In geographical terms, differences in the distribution are less noticeable, with all new firms being localized mostly in the largest cities – Lisbon and Porto. Regarding founding date Portuguese academic spinoffs became more preeminent since 2005, in line with the European trend. A second finding is that the total number of academic spinoffs still remains restricted, which is similar to other European countries experience.

In line with previous evidence, firms' performance outcomes vary across growth measures, highlighting the importance of employing different indicators when measuring firm growth (Delmar et al., 2003). These findings also provide support to the importance of entrepreneurial origin in shaping the way firms' grow (Agarwal et al., 2007; Agarwal and Shah, 2014). Clearly, Portuguese academic spinoffs are following a path of resources accumulation (especially knowledge) and internationalization.

The knowledge accumulation path is consistent with the arguments advanced by both the resource- based (e.g. Zahra et al., 2007; Clarysse et al., 2011) and entrepreneurship theory (e.g. Agarwal et al., 2007; Wennberg et al. 2011) stating that firms gain competitive advantage especially through knowledge accumulation and deployment. Furthermore, our estimates also show that Portuguese academic spinoffs are failing 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 this advantage.

However, our results do not seem to provide support to the argument that these firms should underperform their counterparts because being closer to basic research limits their chances of gaining higher short-term performance (e.g. Zhara et al., 2007) as we found that younger academic spinoffs do outperform their counterparts and, in addition, that irrespective of age these firms outperform their counterparts in research and technology intensive sectors. Indeed, 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). Likewise, the finding that Portuguese academic spinoffs are pursuing growth through internationalization questions the argument that they lack marketing capabilities.

In assessing the role of university-based entrepreneurship our findings indicate that Portuguese academic spinoffs are contributing to economic development by creating new jobs (Audretsch and Feldman, 2004), yet they are failing to convert these gains into efficiency gains. Hence, our findings suggest that further research might usefully 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 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.

Though a limitation of our study is that we were not able to identify corporate spinoffs, we took advantage of a large sample that allowed us to test in a robust way for the differential effect of being an academic spinoff, which in itself is a sufficiently different characteristic (Colombo and Piva, 2012) regarding firms' origins.

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Table 1: Empirical studies on academic spinoff firms' performance

	High and Medium High technology intensive sectors				Medium Low and Low technology intensive sectors			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
Academic Spinoff	0.136***	0.087**	0.024	0.438**	0.038	-0.092	0.057	0.192
	(0.040)	(0.041)	(0.043)	(0.153)	(0.048)	(0.078)	(0.118)	(0.244)
Firm Age	-0.021	-0.087	-0.026	-0.620***	-0.025	-0.009	-0.139*	-0.418***
	(0.037)	(0.081)	(0.071)	(0.154)	(0.021)	(0.052)	(0.078)	(0.117)
$R\&D_{(t-1)}$	-0.014	0.066**	0.016	0.032	0.027**	0.037**	-0.002	0.037
	(0.018)	(0.026)	(0.023)	(0.044)	(0.008)	(0.015)	(0.013)	(0.054)
$Employees_{(t-1)}$	0.633***				0.722***			
	(0.086)				(0.043)			
Sales	0.326***		0.202**	1.009***	0.233***			0.714**
	(0.063)		(0.075)	(0.165	(0.033)			(0.157)
$Sales_{(t-1)}$		1.034***				0.997***		
		(0.060)				(0.047)		
$Productivity_{(t-1)}$			0.602**				0.800***	
			(0.176)				(0.216)	
$Exports_{(t-1)}$				0.201				0.469***
				(0.120)				(0.106)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes		
Time effects	Yes	Yes	Yes	Yes	Yes	Yes		
N	6152	6477	5653	2052	10973	11412	9893	2688
N groups	2733	2886	2570	911	5373	5552	5030	1421
Hansen test	15.91[12]	17.61[15]	17.99[13]	79.49[77]	25.59[14]	17.84[17]	17.69[14]	83.97[75]
AR(1)	-6.80***	-5.85***	-3.54***	-2.47***	-10.22***	-5.055***	-3.79***	-3.42***

	High and Medium High technology intensive sectors				Medium Low and Low technology intensive sectors			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
AR(2)	-0.64	1.00	1.75*	-1.69*	-1.17	-0.24	1.86*	0.85
AR(3)	0.30	-0.48	-1.00	1.15	-1.15	0.60	0.47	0.12

Notes: All columns 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-3 and t-5 for the equations in levels. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator. 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.

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.

Table 3: Variables description and measurement.

Variable	Description and measurement
Academic spinoff who	Firm created by universities' faculty members or graduate students, 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 measured.
Productivity	Labor productivity measured as the natural log of value added to the number employees ratio.
Exports	Exports intensity measured as the natural log of the percentage of exports to total sales.
R&D	R&D intensity measured as the natural log of the amount of R&D investment to total sales ratio.
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

		Academic spinoff firms			
Variable	Obs.	Mean	Std. Dev.	Min	Max
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			
Variable	Obs.	Mean	Std. Dev.	Min	Max
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 $p<0.05$.

Table 5: The academic spinoff effect on firm growth.

	Employees	Sales	Productivity	Exports
Academic Spinoff	0.103***	0.039	0.002	0.272**
	(0.028)	(0.042)	(0.034)	(0.115)
Firm Age	-0.059***	-0.132***	-0.030	-0.432***
	(0.017)	(0.036)	(0.040)	(0.075)
R&D$_{(t-1)}$	0.011	0.043**	0.052**	0.024
	(0.009)	(0.017)	(0.021)	(0.017)
Employees$_{(t-1)}$	0.653***			
	(0.049)			
Sales	0.295***			0.884***
	(0.027)			(0.144)
Sales(t-1)		1.171***	0.085	
		(0.040)	(0.077)	
Productivity$_{(t-1)}$			0.880***	
			(0.156)	
Exports$_{(t-1)}$				0.491***
				(0.101)
Sector dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
N	17562	18389	15966	4918
N groups	8314	8689	7809	2420
Hansen test	23.378[23]	29.782[22]	21.855[18]	49.174[40]
AR(1)	-11.453**	-8.286**	-5.484**	-4.207**
AR(2)	-1.379	0.973	2.319	0.319

Notes: 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. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator. 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.

Table 6: Robustness checks by founding date and firm age.

	Founding date after 1995				Young Firms			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
Academic Spinoff	0.132***	0.110**	0.036	0.333**	0.166***	0.100***	-0.051	0.530***
	(0.038)	(0.037)	(0.062)	(0.148)	(0.049)	(0.047)	(0.100)	(0.128)
R&D$_{(t-1)}$	0.005	0.017	0.006	0.037	0.024	0.068**	0.251***	-0.005
	(0.015)	(0.028)	(0.040)	(0.033)	(0.024)	(0.032)	(0.072)	(0.056)
Employees$_{(t-1)}$	0.603***				0.537***			
	(0.055)				(0.065)			
Sales	0.362***			0. 755***	0.397***			0.851***
	(0.037)			(0.201)	(0.056)			(0.209)
Sales(t-1)		1.063***	0.379**			1.025***	0.131	
		(0.144)	(0.121)			(0.093)	(0.175)	
Productivity$_{(t-1)}$			0.642***				0.072	
			(0.163)				(0.299)	
Exports$_{(t-1)}$				0.574***				0.328**
				(0.151)				(0.143)
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	12836	13496	11499	3209	8472	8953	7481	1896
N groups	5956	6249	5526	1566	4297	4525	3941	1056
Hansen test	22.04[22]	16.51[13]	20.29[5]	54.07[52]	26.11[22]	21.07[21]	9.67[13]	53.73[52]
AR(1)	-10.31***	-4.63***	-4.13***	-3.16**	-8.48***	-4.78***	-2.08**	-2.48**

	Founding date after 1995				Young Firms			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
AR(2)	-1.84*	1.12	1.54	0.53	-1.29	0.76	-1.54	1.39
AR(3)	-0.70	-0.41	-0.76	0.70	-1.18	0.09	1.85	0.39

Notes: 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. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator. 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.

Table 7: Robustness checks by technological intensity.

	High and Medium High technology intensive sectors				Medium Low and Low technology intensive sectors			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
Academic Spinoff	0.136***	0.087**	0.024	0.438**	0.038	-0.092	0.057	0.192
	(0.040)	(0.041)	(0.043)	(0.153)	(0.048)	(0.078)	(0.118)	(0.244)
Firm Age	-0.021	-0.087	-0.026	-0.620***	-0.025	-0.009	-0.139*	-0.418***
	(0.037)	(0.081)	(0.071)	(0.154)	(0.021)	(0.052)	(0.078)	(0.117)
R&D$_{(t-1)}$	-0.014	0.066**	0.016	0.032	0.027**	0.037**	-0.002	0.037
	(0.018)	(0.026)	(0.023)	(0.044)	(0.008)	(0.015)	(0.013)	(0.054)
Employees$_{(t-1)}$	0.633***				0.722***			
	(0.086)				(0.043)			
Sales	0.326***		0.202**	1.009***	0.233***			0.714**
	(0.063)		(0.075)	(0.165	(0.033)			(0.157)
Sales(t-1)		1.034***				0.997***		
		(0.060)				(0.047)		
Productivity$_{(t-1)}$			0.602**				0.800***	
			(0.176)				(0.216)	
Exports$_{(t-1)}$				0.201				0.469***
				(0.120)				(0.106)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes		
Time effects	Yes	Yes	Yes	Yes	Yes	Yes		
N	6152	6477	5653	2052	10973	11412	9893	2688
N groups	2733	2886	2570	911	5373	5552	5030	1421
Hansen test	15.91[12]	17.61[15]	17.99[13]	79.49[77]	25.59[14]	17.84[17]	17.69[14]	83.97[75]
AR(1)	-6.80***	-5.85***	-3.54***	-2.47***	-10.22***	-5.055***	-3.79***	-3.42***

	High and Medium High technology intensive sectors				Medium Low and Low technology intensive sectors			
	Employees	Sales	Productivity	Exports	Employees	Sales	Productivity	Exports
AR(2)	-0.64	1.00	1.75*	-1.69*	-1.17	-0.24	1.86*	0.85
AR(3)	0.30	-0.48	-1.00	1.15	-1.15	0.60	0.47	0.12

Notes: All columns 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-3 and t-5 for the equations in levels. Hansen is a test of the validity of overidentifying restrictions based on the efficient two-step GMM-System estimator. 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.

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.