University entrepreneurial orientation, technology transfer offices and academic spin-offs: an empirical analysis of their relations

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Abstract

The most important knowledge spillovers are generated by universities and public research centres (PRIs). In this framework, the phenomenon of academic spin-offs has raised considerable attention during the last decade as well as the fact that technology transfer offices (TTOs) have been created to foster and support the valorisation of results from public research. The focus of this paper is on the role of TTOs in promoting and sustaining academic spin-offs. Specifically, we analyse the complex causal relationships between the birth and growth of academic spin-offs and resources invested and involved by universities in TTOs in Italy.

A specific law issued in Italy in 1999 authorises researchers and professors, to promote and actively participate in newly established companies aimed at the 'industrial use of research'. Following this legislation, since the 2000s, almost all PROs developed specific regulations for the creation of academic spin-offs. These regulations also concern the supply of services that may be offered to support spin-offs in the period immediately after they are established (start-up or incubation phases). This paper analyses the interconnections between the creation of spin-offs and the establishment, role and activities of TTOs. Our aim is to investigate whether the setting up of spin-offs has determined the investment of PROs in TTOs or if this causal relationship is inverse. We use data referring to the flow of academic spin-offs and resources invested in TTOs in Italian universities for the period 2005-2012.

The paper demonstrates the complex relation between academics and PROs' entrepreneurial orientation. In several cases researchers and PhD students reacted with more readiness to the new opportunities than universities, also given the organizational rigidity that characterizes some PROs. The empirical analysis shows that the size of the TTO has a positive influence on the probability on increasing the number of spin-offs set-up by the university and that in several cases academicians started developing spin-offs even if the university had not set-up a TTO and invested resources in it.

1. Introduction

According to the so-called European paradox, Europe is particularly effective in producing new knowledge, but is not equally able to commercialize its results if compared with other countries such as the US (Mustar, Clarysse, & Wright, 2007). A low level of interactions between firms and public research in the EU can be attributed to a lack in demand from the enterprise side (e. g. specialization on innovation paths that do not require scientific knowledge) or to a lack of structures and institutional factors at the research side (Debackere & Veugelers, 2005). The most important knowledge spillovers are created within University and Public Research centres. If we start from the premise that entrepreneurship is ‘‘why, when, and how opportunities for the creation of goods and services come into existence’’ (Shane & Venkataraman, 2000, p.218) and that scientific research can be a key precursor to this process (Schumpeter, 2000), the continuous interactions among inventors, investors and consumers of technology may accelerate the accumulation of knowledge and discoveries (Cockburn, Henderson, & Stern, 2000, Mathieu, 2011, Agrawal & Henderson, 2002). In this sense, the establishment of technology transfer offices should have the role of accelerating technology spill-over and innovation from universities (D. S. Siegel, Veugelers, & Wright, 2007).

Entrepreneurship is at the heart of many policy questions related to science and technology, sustainability, poverty, employment and regional growth (European Commission, 2011). The surge of policy interest in entrepreneurship has been accompanied by growing academic research that focuses first on understanding the factors affecting entrepreneurial activity and second, on creating an environment supportive of entrepreneurship.

Delivering on the widely supported Europe 2020 objectives of smart, sustainable and inclusive growth depends on research and innovation as key drivers of social and economic prosperity and environmental sustainability. The aim of Cohesion policy is enhancing the capacity of regional economies to change and innovate through the creation of new knowledge-based firms. EU investment focuses on four key elements: R&D and Innovation, Entrepreneurship, ICT, and Human

Capital development (European Commission, 2011).

In this framework, the phenomenon of academic spin-offs has raised considerable attention during the last decade (Djokovic & Souitaris, 2008, David B. Audretsch, Keilbach, & Lehmann, 2006, H Etzkowitz, 2008) as well as the technology transfer offices (TTOs) that have been created to foster and support the valorisation of research outcomes. The attention of researchers has reflected the recent expansion of this phenomenon, stimulated by the changing role of universities towards technology transfer and direct commercialization of research activity, and by the increasing attention and support by governmental institutions at local and national level (Davidsson & Henrekson, 2002, D.B. Audretsch, Lehmann, & Wright, 2012, Bozeman, 2000, Godin & Gingras, 2000; Schulte, 2004). The literature considers universities as key actors in an innovation system where universities work together with industry and government to evolve new competitive industrial forms (Henry Etzkowitz & Leydesdorff, 2000). Several elements have contributed to foster the phenomenon of "entrepreneurial universities" in Europe (OECD, 2003). Several European countries have adopted regulations that gave a significant boost to the adoption and the further development of the so called "third mission" of universities, which includes knowledge and technology transfer (Looy, Debackere, & Andries, 2003, Rasmussen, 2011). Several studies investigate the importance of science-industry exchanges in terms of local spill-overs at regional development (Acs, Anselin, & Varga, 2002; Acs & Varga, 2005), in terms of new technology entrepreneurs (Iacobucci & Micozzi, forthcoming) and the new technology clusters formation (Niosi & Bas, 2001). The investments in science and education on the innovative performance of innovation systems seem to have positive effect on economic development (Furman & Hayes, 2004).

Despite a growing awareness and a vast body of empirical evidence that universities can contribute to the development of local economies, few studies analyse the interconnections between the creation of spin-offs and the establishment and the role of TTOs (Algieri, Aquino, & Succurro, 2011). The empirical findings in Italy show that sizeable financial resources and full-time highly

skilled employees are the key factors for increasing spin-offs. However, the age of the office does not seem to influence the capacity to create additional spin-offs (Algieri et al., 2011). These findings support previous results derived from studies on European universities (Gómez Gras, Galiana Lapera, Mira Solves, Verdú Jover, & Sancho Azuar, 2008).

The focus of this paper is on the role of TTOs in promoting and sustaining academic spin-offs. Specifically, we analyse the causal relationship between the two phenomena. The Italian case is specifically relevant for this issue as the phenomena of spin-offs and TTOs both started to be relevant during the last decade, following a law issued in 1999 that authorised universities and other PRIs to issue regulations that allow researchers and professors, as an exception to existing rules, to participate in the capital and the management of newly established companies aimed at the "industrial use of research".

Following this legislation, in the early years of the 2000' decade, Italian PROs developed specific regulations for the creation of academic spin-offs. These regulations also concern the supply of services needed to support spin-offs in the period immediately after they are established (start-up or incubation). As a result, in the first half of the decade many universities set-up a technology transfer office and started investing resources in technology transfer activities.

The paper wants to analyse the linkage between the creation of spin-offs and the establishment and the role of Technology Transfer Offices (TTOs) to investigate the relation between the two phenomena. The literature usually hypothesizes that efficient TTOs foster academic entrepreneurship. However, spin-off creation depends on many other factors and it may even be that the causal relationship is inverse. In this sense, it could be interesting to determine if the professors, researchers or PhD students have reacted with more readiness to the solicitations of law than the universities, even for the organizational rigidity that sometimes characterizes the educational system in Italy.

We test the relation between investments in TTO and spin-off creation in Italian universities during the period 2000-2012. The availability of data for a long period of time allows us to better examine the casual relations between the two phenomena.

The paper is organized as follows. In section 2 we provide a review of the literature on the role of TTO in spin-off formation and development. Section 3 describes the data and methodology used in the empirical part of the paper. Section 4 discussed the empirical results. Section 5 provides the conclusions.

2. Background literature

The phenomenon of entrepreneurial universities has received considerable attention over the last few decades. An entrepreneurial orientation by academia might put regions and national states in an advantageous position in emerging knowledge-intensive fields of economic activity. At the same time, such entrepreneurial orientation requires reconciliation with the scientific missions of academia. As a matter of fact, the interaction between innovation, entrepreneurship and regional economic development has become a central theme in many policy circles (Van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2004, Varaldo & Di Minin, 2009, M. Lazzeroni, 2010, Michela Lazzeroni & Piccaluga, 2003).

During the last decade, universities have implemented several policies to promote the technology transfer activities even in response to the European Commission's Lisbon Strategy in 2000 that attributes an important role to the creation and diffusion of academic knowledge to foster local economic development. According to these new approaches, universities established procedures? for setting up the academic spin-offs, academic patenting and university-to-industry technology transfer (Mowery & Shane, 2002, Geuna & Nesta, 2006). Up to now the empirical literature on academic spin-offs has focused on the role of such kind of firms to promote high tech and innovative firms, to sustain employment and entrepreneurship (Iacobucci & Micozzi, forthcoming, Colombo et al. 2010) and to facilitate the diffusion of research from academia to firms (Lawton

Smith, 2007, Colombo, D'Adda, & Piva, 2010, Leitch & Harrison, 2010, Wright & Mustar, 2010, Djokovic & Souitaris, 2008). A great deal of the empirical literature have been concerned with the factors affecting the set-up and the growth process of spin- offs (see, among others, Leitch and Harrison, 2010; (Iacobucci, Iacopini, Micozzi, & Orsini, 2011, Chiesa & Piccaluga, 2000, Iacobucci et al., 2011, Fini, Grimaldi, & Sobrero, 2008, Colombo & Piva, 2008, Scott Shane & Stuart, 2002, Rothaemel, Agung, & Jiang, 2007; Salvador, 2009; Teixeira & Mota, 2012). Less attention has been paid to other aspects such as the relation between the strategies and investments of the university in technology transfer activity and the quantity and quality of its spin-offs.

Few study have investigated how the investment in TTOs promoted the set-up of spin-offs (Algieri et al., 2011) or how the scientific quality of the university has an impact on the growth process of its spin-offs compared to technology start-ups located in the same area (Colombo et al. 2010).

Also, a reverse causal relation can be hypothesized given that the set-up of spin-offs depends on several factors related to the orientation of the originating university as well as the local context (Mustar et al. 2008, O'Shea, Chugh, & Allen, 2008, Colombo et al. 2010).

On the other side, very few papers investigate the organizational models of TTOs and their governance (Bercovitz & Feldmann, 2006, Chapple, Lockett, Siegel, & Wright, 2005, Schoen, Pottelsberghe de la Potterie, & Henkel, 2012, Conti & Gaule, 2011, Sellenthin, 2009, Lach & Schankerman, 2008). The literature on TTOs and university-industry technology transfer processes mainly focuses on TTO activities related to licensing, spin-out services and research funding (Clarysse, Wright, Lockett, Van De Velde, & Vohora, 2005, Meyer & Leyesdorff, 2006, Markman, Gianiodis, Phan, & Balkin, 2005, Debackere & Veugelers, 2005, Meyer & Leyesdorff, 2006, D. S. Siegel & Phan, 2005, Van Looy et al., 2011).

Giving the increasing importance of technology transfer for universities, industry, and policy makers, some authors investigate the TTO organizational configurations and licensing strategies that are most beneficial to new business formation. The factors that could influence the success of TT activities are organizational structure and practices, characteristics of the TTO such age

(Chapple et al., 2005), independence (Clarysse et al., 2005), level of autonomy (Markman et al., 2005) quality and type of the technology produced by the academic institution, quality of the research institution, and regional demand for technology (Di Gregorio & Shane, 2003, Belenzon & Berkovitz, 2010, Van Looy et al. 2011, Chapple et al., 2005, Thursby & Kemp, 2002, Friedman & Silberman, 2003, O'Shea et al. 2005; Siegel et al. 2003, Boardman & Ponomariov, 2012) the degree of division of labour within the TTO (Hülsbeck, Lehmann, & Starnecker, 2011).

Clarysse et al. (2005) identify the typology of TTO and find that the optimal design of a TTO depends on the university it serves, on its institutional history, and evolves over time. Bercovitz and Feldman (2004) shows as entrepreneurship is a local phenomenon, and some studies confirms that spin-offs remain close to the university that is the sources of competitive advantage, in terms of advantage providing skilled labor, specialized facilities and expertise (Feldman & Francis, 2004, Iacobucci & Micozzi, forthcoming).

Bercovitz and Feldman (2004) find that university policies influence the comparative cost of technology transfer: the national and local policy environment and legal framework, the university environment, and the characteristics of companies influence the efficiency and thus evolution of these university–industry relationships. The legal, economic, and policy environments that comprise the system of innovation determine the rate and type of university knowledge production and thereby influence the rate of technological change.

The university context is related to the institutional and policy environment, the culture and the history that has unfolded within the academic institution. It identities norms, values and attitudes of academic researchers towards combining research and opportunities that originate from this same research. If the university gives important to the third mission (TT), the researchers are more proactive in these activities. Sellenthin (2009) finds that the reward system of universities rewards patents, which creates positive incentives to patent, and supporting infrastructure for patenting and commercialisation creates positive incentives to patent research results.

Van Looy et al. (2005) using data on 105 universities from 14 European countries analyses antecedents of entrepreneurial effectiveness and examine trade-offs between the level of transfer mechanisms and the scientific activities, revealing a strong positive relationship between the scientific productivity of universities and their entrepreneurial performance. Universities with a stronger scientific productivity seem in an advantageous position for developing entrepreneurial activities.

Clarysse et al. (2005) show as in a context characterized by high levels of innovation or R&D the context plays the role of incubator for the spin-out companies. In contrast, the technology transfer office could play an active incubation role in environments characterized by a weak entrepreneurial community, low level of innovation and a lack of key resources.

The authors design different types of TTOs and the different tasks of TTOs such as 'informal visits to the research labs', 'organization of a business plan competition', 'structured brainstorming with research groups', 'mapping of the research activities'. Each model is analyzed by several levels: 1) Opportunity search and awareness creation, 2) Strategic choice how to commercialize R&D, 3) patent, 4) Incubation and business plan development, 5) Funding process and control of the spin-out process after start-up, 6) Organizational resources, 7) Human resources, 8) Technological resources, 9) Physical resources, 10) Financial resources and 11) Networking resources.

In terms of knowledge development, reaching scientific excellence in research is a necessary first condition for TT. Attractiveness for industrial partners demands competence at universities both in short-term oriented R&D and in long-term oriented strategic research. Developing scientific excellence requires the presence of the necessary resources related to personnel qualification and capabilities, as well as a clear research orientation and research mission of the university. More particularly, obtaining scientific excellence in those disciplines that link to science based technologies like biotechnology, life sciences, nanotechnology and ICT, will create a high demand for TT.

D. Siegel, Waldman, & Link (1999), based on interviews at five major research universities, identify several critical organizational factors for university technology transfer offices. The most prominent ones are: adequate faculty tenure, promotion policies, adequate royalty and equity distribution systems, as well as the staffing practices within transfer offices, requiring a mix of scientists, lawyers and managers acting within a highly professional environment (Polt, 2001).

Markman et al. (2005) find a complex set of relationships between TTO structure and strategies, new venture formation, and business incubation. Based on interviews with 128 TTO directors, they show that whereas for-profit TTO structures are positively related to new venture formation, traditional university and non profit TTO structures are more likely to correlate with the presence of university-based business incubators. Licensing for equity strategy is positively related to new venture formation and the licensing-for-cash strategy is least correlated to new venture formation.

A content analysis of TTO mission statements also revealed an overemphasis on royalty income and an under emphasis on entrepreneurship. Another finding is that the UTTO motivation to maximize cash flows and minimize financial and legal risks often lead to a strategic choice that undermines new venture creation. Finally they found that universities are increasingly viewing themselves as catalysts of new venture formation and regional development.

In this paper we try to understand if the characteristics of TTO (in terms of size, founds, year of foundation) influence the type(s) of spin-out companies that are generated.

In analysing this complex mechanism we consider even the external context in terms of the supporting infrastructure and financial resources availability.

3. Data and methodology

The paper takes advantage of two large datasets about TTOs and academic spin-offs in Italian universities for the period 2000-2012.

In Italy, only since the early 2000s, following the adoption of a specific legislation, has the phenomenon of research spin-off become significant. In particular, art. 2 of the DLG. July 27, 1999

n.297 authorizes universities and other public research institutions (PRI) to issue regulations that allow researchers and professors, as an exception to existing rules, to participate in the capital and the management of newly established companies aimed at the industrial use of research. Following this legislation, in the early years of the '2000, the PRI developed specific regulations governing the involvement of their permanent staff (such as professors and researchers) and temporary staff (such as doctoral students, research grant holders, etc.) in spin-off companies. These regulations also allow universities to supply services to support spin-offs before and after their establishment (start-up or incubation). For this reason, in the first years of activity (usually the first three years), spin-off companies have the opportunity to grow in a "protected environment" thanks to both the free services that many institutions provide, and the possibility to use staff and research facilities free of charge or at lower than market prices. In most cases this 'incubation' of new initiatives is undertaken directly, taking advantage of the research facilities of the institution where the researchers involved in the initiative are employed; in other cases ad hoc structures have been created with the support of public institutions in the area. The PRIs may also participate with minority shares in the capital of the new company.

The availability of longitudinal data for a whole decade allows us to analyze the relation between the investment in financial and human resources in TTOs and the set-up and subsequent growth of spin-offs, by taking into account other factors that may affect the creation and growth of spin-offs, such as the characteristics of the university and of the local context.

As dependent variable we consider the number of academic spin-offs set-up in Italian universities. Data about spin-offs refers to the population of academic spin-offs set-up during the period 2000-2012. The variable $SPIN_{it}$ identifies the spin-offs set-up in the university i ($i=1…58$) at time t. ($t=2000…2012$).

As independent variables we consider several factors that may be relevant to explain the propensity of a university to generate academic spin-offs.

First we consider the presence of a TTO and of the resources allocated to it. Data are available for the period 2002-2011. Resources allocated to TTO are measured with two variables: the number of employees and the budget. EMP_{it} and BUD_{it} refer respectively to the number of employees and the budget (in thousands of Euros) in university *i* at year *t*.

We take into consideration also the following variables which are relevant to explain spin-off creation.

Variables referring to the characteristics of the university:

- The size of the university in terms of number of academicians. We consider both the total number of researchers and those in the fields of science and technology.
- The amount of public funds supporting university research.
- The presence of incubators
- The number of patents by universities (total 2004-2010)
- The amount of industry-funded research by university (total 2004-2010)

Variables about the local context refer to the economic structure of the local system in which the university is located and the overall entrepreneurial dynamics.

- We distinguish two macro areas: South and Center North
- The number of high tech companies in the province of the university

Table 1 shows some descriptive statistics of the main variables; data refer to 62 universities for the period 2002-2010, which is the sub-period for which all the variables are available.

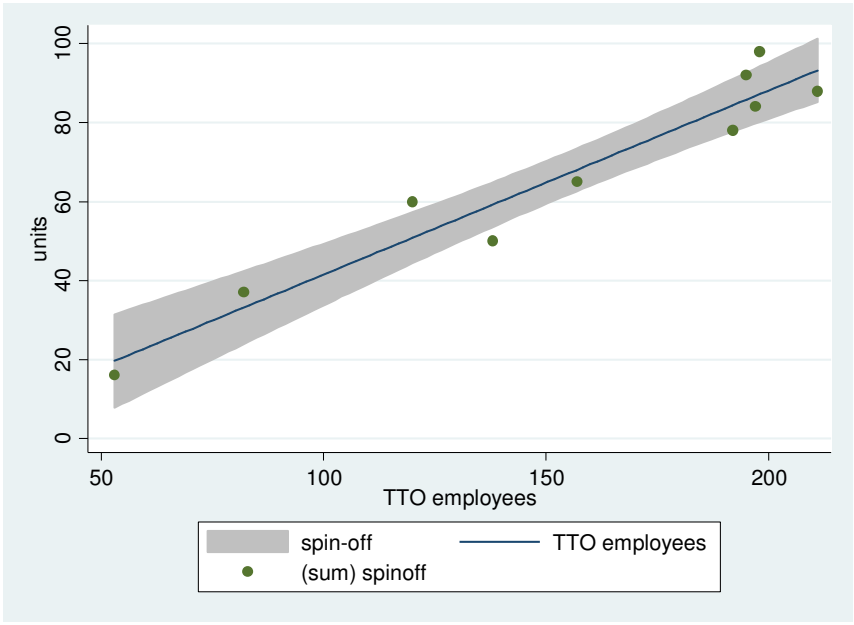
Table 1 – Descriptive statistics

Variable		Observations	Mean	Std. Dev.	Min	Max
SPIN	Spinoff (units)	558	1	2	0	9
EMP	TTO employees (units)	558	2	3	0	14
FAC	Science faculty (units)	558	601	598	0	3275
BUD	Budget TTO (thousands of Euros)	558	84	166	0	1543
RFUN	Reserach funds (thousands of Euros)	558	1456	1589	0	9218

4. Empirical analysis

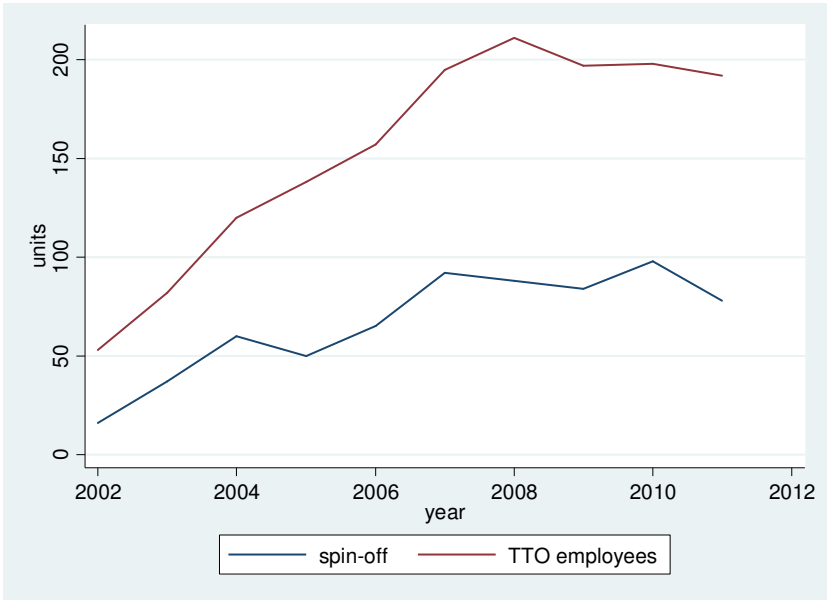
Spinoffs' and TTOs growth followed a similar path during the decade after the introduction of the above-mentioned legislation in 1999. As a result, if we consider the sum of spinoffs and TTO employees in Italian universities there is a strong linear association between the two phenomena.

Figure 1 – Relation between TTO employees and the number of spinoffs (totals referring to all universities)



However, when looking at the evolution of the two phenomena over time, the number of spinoffs seems to react more quickly to external conditions (such as the crisis started in 2008) while TTO employees follows with some delay.

Figure 2 – Number of spin-offs and TTO employees in Italian universities by year



As expected, the employees in TTO show a greater persistence over time than the number of spin-offs. The first order autocorrelations for spin-offs is about 0.5 and drops below 0.3 after 5 years; on

the contrary the first order autocorrelation of TTO employees is well above 0.8 and remains over 0.6 after five years.

Table 2 – Correlations between spin-off start-ups per year

Spin-off		L.1	L2.	L3.	L4.	L5.
2012	1					
L1. 2011	0.5274	1				
L2. 2010	0.3817	0.5036	1			
L3. 2009	0.3683	0.3769	0.4941	1		
L4. 2008	0.3269	0.3740	0.3966	0.4729	1	
L5. 2007	0.2633	0.2973	0.3729	0.4188	0.4990	1

Table 3 – Correlations between employees in TTO per year

		L.1	L2.	L3.	L4.	L5.
2012	1					
L1. 2011	0.844	1				
L2. 2010	0.7706	0.8637	1			
L3. 2009	0.7436	0.7781	0.8954	1		
L4. 2008	0.7079	0.7633	0.8194	0.9117	1	
L5. 2007	0.6143	0.679	0.7382	0.7841	0.8742	1

The correlation matrix between the independent variables (Table 4) shows a high correlation between the number of people in science faculties, the amount of research funds granted by the university, the amount of external collaborations with firms and the number of patents. For this reason we will avoid using the above-mentioned variables in the same regression, when considered in absolute terms.

Table 4 – Correlation matrix between the independent variables

	TTO employees	Research funds	Science faculty	Incubators	High-tech firms	Patents	Funds from firms
TTO employees	1						
Research funds	0.3099	1					
Science faculty	0.4429	0.8855	1				
Incubators	0.3793	0.332	0.3414	1			
High-tech firms	0.2499	0.2582	0.2787	0.0626	1		
Patents	0.5553	0.6564	0.6587	0.4643	0.4357	1	
Funds from firms	0.4305	0.724	0.7585	0.3296	0.4065	0.7477	1

A pooled multiple regression shows the statistical associations between variables. All variables show the expected signs except for the number of high tech firms in the province of location of the university and the patents (which are normalized with the number of researchers).

Table 5 – Pooled OLS, independent variable: number of spinoffs

	Coef.	t	P>t
TTO employees	0.1774***	5.5900	0.0000
Research funds	0.0001**	2.1800	0.0300
Incubators	0.3708**	2.4300	0.0160
High-tech firms	0.0000***	-4.1800	0.0000
Area	0.2694**	2.1200	0.0340
Sponsord research	0.0000***	2.9800	0.0030
Patents	-0.8708***	-2.7700	0.0060

Number of obs	558
F(7, 550)	14.09
R-squared	0.2094

Legend: *** significant at 1%; ** significant at 5%; *significant at 10%.

In the case of high-tech firms, a recent paper (Iacobucci, Micozzi, forthcoming) demonstrated that the most active universities in terms of spin-offs are medium sized universities located in areas with a low density of high-tech firms. This means that up to now the phenomenon of spin-offs in Italy is the result of the autonomous 'push' by entrepreneurial universities and is not much influenced by the surrounding environment.

In the case of patents, the negative relation with the number of spin-offs may be attributed to a substitution effect, being spin-offs and patents alternative ways of transferring research results to the market.

Following Algieri et al. (2011) we initially define the dependent variable as a dummy variable that takes the value 1 in case of an increase in the number of spinoffs and zero otherwise. We than perform a logit estimation to estimate the variables that influence the probability of an yearly increase in the number of spin-offs over the period considered (see

Table 6).

Table 6 – Econometric estimates – logistic regression. Dependent variable: yearly increase in spin-offs

	β ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***	***β*** ***(p value)*** ***Odd ratio***
EMP_t	.1477*** (0.000) 1.16	.1833*** (0.000) 1.20	.1464*** (0.000) 1.16	.1729*** (0.000) 1.19	.1987*** (0.000) 1.22	.2014*** (0.000) 1.22	.2150*** (0.000) 1.24
AREA	.1994 (0.329) 1.22	.2288 (0.268) 1.26	.0479 (0.823) 1.05	.1249 (0.567) 1.13	.0884 (0.715 1.09	-.0369 (0.884) .96	.0208 (0.936) 1.02
BUD_t		-.0009 (0.142) .99	-.0020*** (0.007) .99	-.0022*** (0.003) .99	-.0026*** (0.002) .99	-.0030*** (0.001) .99	-.0030*** (0.001) .99
$TOTSPIN_t$			.0751*** (0.000) 1.08	.0630*** (0.000) 1.07	.0862*** (0.002) 1.09	.0876*** (0.000) 1.09	.0946*** (0.000) 1.10
FAC_t				0.001*** (0.005) 1.00	.0009** (0.016) 1.00	.0001** (0.019) 1.00	.0009** (0.018) 1.00
FAC_t^2				-0.0001*** (0.008) .99	-.0001*** (0.005) .99	-.0001** (0.010) .99	-0.001*** (0.009) .99
$RESFUN_t$					-.0000 (0.715) .99	-.0001 (0.628) .99	-.0001 (0.569) .99
PAT						-1.4635 (0.178) .23	-1.5548 (0.156) .21
EXTFUN						0.001* (0.099) 1.00	0.0002 (0.107) 1.00
AGE_t							-.0543 (0.220) .95
N	620	620	620	620	558	558	558
LR chi^2	23.3	26.21	53.59	61.79	70.53	73.44	75.02
Prob>chi^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R^2	0.03	0.04	0.07	0.08	0.11	0.11	.011

We find confirmation about the influence of the number of employees in TTO in the probability of observing an increase in the number of spin-off. On the contrary, the budget allocated to TTO has a negative sign. This confirms that the fundamental resource for TTO when promoting spin-offs are the people employed rather than the additional resources allocated to its activity.[1]

The positive role of TTO employees remains even after controlling for the stock of spin-off already set-up within the university (TOTSPIN). This latter variable has a positive coefficient and is always significant. It means that there is a relevant cumulative effect in the set-up of new spin-offs.

The size of the university (in terms of the number of faculty members) shows a non-linear inverted U-shaped relation with the probability of increasing the number of spin-offs. This result is in accordance with the empirical evidence according to which the most active universities in promoting spin-offs are medium sized universities.

[1] Resources allocated to TTO could be more important for other technology transfer activities, such as patenting.

The amount of public research funds gathered by the university does not have a direct impact on the probability of increasing the number of spin-offs.[2] On the contrary the research funds obtained from external sources (mainly as contract research from firms) shows a positive influence on the probability of increasing the number of spin-offs. However, the coefficient of this variable is not highly significant and the magnitude of the effect is negligible. As in the case of patents, also for contract research, there are opposite forces at work: on the one hand research conducted in collaboration with firms may be more close to innovation and business applications, thus stimulating patents and spin-offs; on the other hand these different mechanisms of technology transfer may be seen as alternative instruments, thus showing a substitution effect.

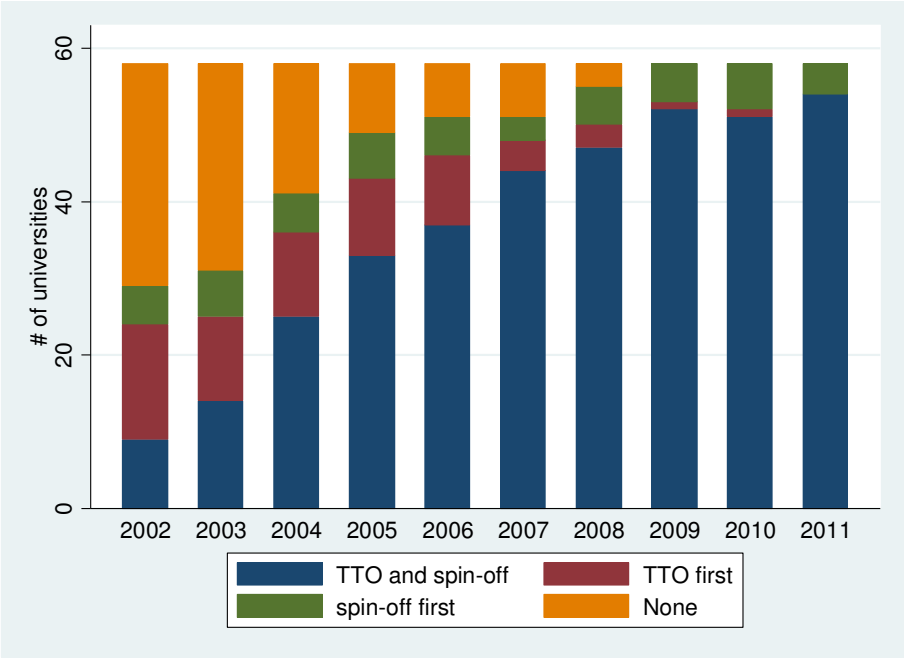
The positive coefficient of the number of employees in TTO is robust when controlling for the cumulative number of spin-offs. However, this can only partially account for the high level of correlation between the size of TTO and the number of spin-offs, which mostly justifies the positive relations between TTO employees and the increase in the number of spin-offs.

We must also take into account that we are analyzing the two phenomena during a period that was for the major part characterized by a significant increase of both phenomena.

When using dynamic models that take into account the cumulative nature of the two phenomena, the relations between the two appears much more complex. If we use the variation of employees in TTO to predict the probability of an increase in the number of spin-off the former variable remains positive but not statistically significant. The complexity of relations between spin-off creation and TTO activity is shown in Figure 3.

Figure 3 – Universities by status of TTO employees and spin-offs.

[2] It is likely that there is a time lag between the allocation of research funds to universities and the transfer of its results into marketable opportunities. We replicated the estimation with different time lags but get similar (i.e. non statistically significant) results. The question would require a more in depth analysis.



Notes:

- TTO and spin-off: universities that have at least 1 spin-off and 1 employee in the TTO
- TTO first: universities that have at least 1 employee in the TTO but no spin-offs
- Spin-off first: universities that have at least 1 spin-off but no employees in the TTO
- None: universities that have no spin-offs nor employees in the TTO

At the beginning of the period for which we have data on TTO (2002) about half of the universities considered in the analysis had no employees in the TTO nor spin-offs. Up to 2006 the TTO first (i.e. that had employees in the TTO but no spin-offs) were prevailing on those universities in which spin-offs were set-up between the formal creation of a TTO.

However, the latter situation remains significant during all the period and remains significant also in the last few years of observations. This means that in a significant number of universities professors and researchers have autonomously promoted spin-offs, following the possibility opened by the new regulations, even though their parent universities did not invest resources in the TTO.

5. Conclusions

This paper is a first attempt at analyzing the relations between the investment of resources in technology transfer offices and the formation of spin-offs, looking at a sufficiently long (10 years) period of time.

The country (Italy) and the period chosen (2000-2012) are specifically relevant for this analysis as it coincides with the introduction and first development of the spin-off phenomenon. In fact, only after a new legislation passed in 1999 were Italian academicians allowed to be involved in the start-up of academic spin-offs. The period also coincides with the formal introduction of the 'third mission' in the activities of universities and the subsequent investment of resources in the set-up of TTOs.

The main aim of the paper was to analyze how universities and academicians reacted to the possibilities opened by the new legislation. Specifically our aim was to assess whether academicians reacted more quickly than their parent institutions to the new context or whether universities governance bodies made the first step by investing resources in TTOs with the aim of stimulating the technology transfer activity of their researchers.

As usual when analyzing the relations between organizational and individual level behavior, we found that the two are highly correlated and is not easy to isolate the direction of causal effects.

Our empirical analysis shows that the size of the TTO has a positive influence on the probability on increasing the number of spin-offs set-up by the university. This positive influence is associated with the employees in the TTO rather than the financial resources allocated to it. This points out to the importance of the professional services provided to academicians to foster technology transfer. However, the casual relation between the two phenomena is not straightforward.

The empirical analysis shows that in a significant number of cases academicians started developing spin-offs even if the university had not set-up a TTO and invested resources in it. This situation has maintained its relevance up to recent years.

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