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Engines need belt transmissions: the importance of people in Technology Transfer Offices

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Abstract
Over the last 20 years, universities and Public Research Organizations (PROs)[1] have been strengthening the process of transferring their research results towards industrial applications in order to generate economic and social impact. Among many different actions, universities' Technology Transfer Offices (TTOs)[2] have been reinforced or set up and various studies have analyzed their efficacy and effectiveness. This paper aims to explore the effects of a specific policy action launched by the Italian Ministry of Economic Development (MISE) which led to an increase in the number of people employed in university TTOs in order to assess its effects on TTOs' performance. Our research question is whether more people in the TTOs increase TTOs' performance. Moreover, we also tried to understand the relevance of such effect. The results of our study suggest that the impact has been positive and quite relevant and can therefore have implications for decisions regarding investments in human resources in university TTOs.

[1] In this paper we will often use the term "universities" to refer to both universities and PROs and, with regard to Italy, we will also include a specific type of research hospitals.
[2] Such offices assume different names (e.g. Knowledge Transfer Offices, Valorisation Offices, etc.) and organizational assets in different countries and institutions.

Introduction

The creation of knowledge and its valorization in order to create economic and social impact through new products, services and processes represent crucial challenges in both advanced and emerging economies worldwide. The potential of such valorization processes is also important in poor countries. It is not surprising, therefore, that professors and policy makers are currently discussing a lot about universities' Third Mission and implementing both established as well as new and innovative approaches.

However, knowledge transfer is an extremely complex and multifaceted process. University Technology Transfer Offices (TTOs) are commonly recognized as an important component – albeit not the only one – of such process. In some countries they play an extremely important role, even if some scholars are skeptical about their contribution.

Although countries like the US, UK and Israel have a long tradition in this field, the situation is not homogeneous in the rest of the world. In Italy, for example, it is only since the early 2000s that universities and other PROs have started to set up TTOs and have been progressively reinforcing their TTOs, whose competences have been in the meantime growing.

In 2017 the average number of people employed in Italian universities TTOs according to the Netval Survey was around 5 people which is still far less than in most of other European countries. As a matter of fact, in Italy, especially after 2005, universities have more systematically invested in TTOs, hiring specialized people to sustain technology transfer activities (Algieri, Aquino and Succurro, 2011; Bigliardi, Galati, Marolla and Verbano, 2015). Such a strengthening process of Italian TTOs has been constant but slow, due to the general scarcity of resources in universities and their different degrees of commitment.

In such conditions, in 2015, the Italian Patent and Trademark Office (UIBM), which operates within the Italian Ministry of Economic Development (MISE), has launched an action to strengthen university TTOs, confident that this could have determined an increase in intensity of the technology transfer process, a benefit not only for Italian universities but also for Italian companies, the most direct "beneficiaries" of MISE's actions. Such a scheme, funded on a 50/50 basis by UIBM and applicant universities, has determined an increase in the number of people employed in TTOs. Although the new people have been often involved with temporary contracts and even they are usually young and not extremely skilled in TT, their number has represented a remarkable increase in the total number of TT professionals. Furthermore, the new people have on average relatively low skills in TT but quite high competences in STEM disciplines, with many PhDs.

Among studies which argue that TTOs are useful, some of them try to understand when they are most effective, although indicators used to assess their success represent a complex issue. Within this

literature, some argue that TTOs have to be well positioned in the organization, have a clear mission, receive sufficient empowerment by the university top management and have the "right" staff in both competences and numbers.

Within such a framework, in a country such as Italy, is an increase in TTO staff – ceteris paribus – capable of determining a rise in the performance? This is our main research question.

Since existing empirical evidence shows a significant relationship between the number of people employed in the TTOs and TT outcomes, such as the number of new spin-off companies and licensed patents (Cartaxo and Godinho, 2017; Chapple, Lockett, Siegel and Wright, 2005; Hülsbeck, Lehmann and Starnecker, 2011; Kergroach, Meissner and Vonortas, 2018; Smilor and Matthews, 2004; Vohara, Wright and Lockett, 2004), we identified the UIBM action in Italy as a precious setting to verify such hypotheses.

More precisely, using data from the UIBM action, from Netval and other sources, as well as interviews with several Italian TTOs, the paper aims at analyzing how and to what extent this policy measure may have determined an increase in technology transfer activities.

Despite being aware that an increase in the resources for TT activities is expected to generate results only in the medium-long run, we explored the short-term impact of such a reinforcement (i.e. two years). Furthermore, beyond our main research question about the effect of having more people in the TTOs, we wondered about the size of this effect (RQ1), whether the effect is larger in small, medium or large universities (RQ2), if it is larger when the TTO grows by +1, +2 o +3 staff (RQ3), and finally, how the effect changes on the basis of the starting dimension of the TTO (RQ4).

Our results show that in the short term the effect of additional staff in the TTOs is very clear and significant for both the identification of inventions and others mechanisms of technology transfer, such as patents granted and number of licenses, while the effect is less significant when we consider the creation of new spin-offs or licensing revenues.

The paper is organized as follows. In Section 2 we illustrate the literature related to our research questions. Section 3 contains a description of the dataset and the main methodological instruments. Section 4 is devoted to the empirical findings and the analysis of the results, along with the responses to the research questions. The last section offers some conclusive remarks.

Literature review

The competitiveness of countries in the global economy depends extensively on technological and innovation-based assets. Some studies show that in Europe the flow of basic research into economic exploitation is not without obstacles, revamping a sort of a "European Paradox" according to which Europe suffers from a gap between high levels of scientific performance and lower levels of

contributions to industrial competitiveness and new venture creation. As a consequence, European countries are working a lot in this field, including attention to university TTOs.

Since the mid-1990s, universities worldwide have been progressively involved in commercializing their research results. As a consequence, the phenomenon of entrepreneurial universities has received considerable attention due to the fact that the entrepreneurial orientation of universities could provide advantages in the knowledge-based economy (Bathelt, Kogler and Munro, 2010; Budyldina, 2018; Jain, George and Maltarich, 2009). In such a framework, most universities have established TTOs with the aim of facilitating commercial knowledge transfers through the licensing to industry of inventions or other forms of intellectual property resulting from university research (Siegel et al., 2004), through the creation of spin-off companies and other forms of valorisation. As a matter of fact, a lot of the debate among scholars and policy makers is not if universities should get involved in technology transfer, but rather how they should do it.

In the context of academic entrepreneurship, the empirical literature focuses on the factors that motivate academics to establish spin-offs (Fini, Grimaldi and Sobrero, 2008); the characteristics of spin-offs and their growth processes (Chiesa and Piccaluga, 2000; Iacobucci, Iacopini, Micozzi and Orsini, 2011; Vanaelst et al., 2006), the composition of the promoting team and its impact on performances (Vanaelst et al., 2006), the academic fields of invention disclosures (Thursby et al., 2001; Jensen and Thursby, 2001; Geuna and Nesta, 2006), and the effect of Bayh-Dole Act in providing incentives for universities to increase patenting in fields in which licensing is an effective mechanism for acquiring new technical knowledge (Shane, 2004a, b).

Within this literature, TTOs are also mentioned, since they contribute to deciding whether or not to patent, they interact with researchers and advise them about TT issues, they organize training in the field of TT and entrepreneurship, they keep in touch with industrial partners, they take care of licensing activities, etc.

However, despite the broad range of their activities, TTOs are often expected to generate results in terms of patents/licenses and spin-off companies and they are often assessed using indicators built with these outputs.

Academic spin-offs (ASOs)

In the creation of ASOs, academic entrepreneurs often lack the management competences to evaluate the market potential of their initiatives; they need to write a business plan, get in touch with financial and industrial partners, etc. TTOs can help them in these activities and can also help ASOs in attracting high-profile human resources (Colombo and Piva 2005). Some studies (Algieri, Aquino and Succurro, 2011) show that the availability of financial resources and highly skilled employees

are crucial for ASOs activities (Gómez Gras et al., 2008), and well staffed TTOs can increase the productivity of a university's technology transfer activities (Smilor and Matthews, 2004; Vohara, Wright and Lockett, 2004; Lockett et al., 2005). The factor that appears most relevant for spin-off creation and performance is the presence of qualified employees, which is more important than the number of employees in TTOs (Smilor and Matthews, 2004; Vohara et al., 2004; Lockett et al. 2005; O'Shea et al., 2005; Hulsbeck, Lehmann and Starnecker, 2013). The experience of the TTOs (Friedman and Silberman, 2003), with TTO staff composed by persons that have marketing, technical and negotiation skills (Siegel et al., 2004, Lockett and Wright, 2005; O'Shea et al., 2005), are crucial to foster the creation of ASOs. According to the literature, we therefore propose the following hypothesis:

Hp1: *an increase in the number of employees in TTOs has a positive impact on the creation of spin-offs*.

University patent and licence

In general, less than half of the inventions with commercial potential are disclosed (Jensen, Thursby and Thursby, 2000) and TTOs report that "convincing faculty to disclose inventions is one of our major problems" (Thursby and Thursby, 2003, 2). A strong TTO can facilitate this process, creating an entrepreneurial culture and supporting researchers with interesting inventions.

Della Malva et al. (2013) analyzing the effect of the Innovation Act introduced by the French government in 1999 with the aim of foster the commercialization of academic inventions, demonstrate a positive effect of the presence of a TTO. Arvanitis et al. (2008) concluded that the presence of TTOs is one of the main determinants of patenting.

Our expectation is therefore that *an increase in the number of employees in TTOs has a positive impact on the number of identified invention* (Hp2).

Coupe (2003) shows that universities with a TTO will have a higher expected number of patents than universities without a TTO and the effect of the TTO increases over time.

Disclosures are a function of the number of full-time equivalent personnel in the TTO (Thursby and Thursby, 2002) and the age of TTOs has a positive impact on university patenting and licensing (Carlsson and Fridh, 2002). TTOs can help academics in structuring license contracts to induce inventor cooperation in further development after license execution (Thursby et al. (2001). Colyvas et al., 2002 find that TTO staff size increases the number of licensing.

Another stream of literature found that larger TTOs are less efficient than smaller TTOs (Thursby and Kemp, 2002). A possible explanation might be provided by Heisey & Adelman (2011) who show that TTO size could be a substitute for early entry. As TTOs increase experience, it might be possible

that 'learning by doing' results in greater ability to achieve objectives or to have better performance without increasing staff size.

Ustundag *et al.* (2011), confirming that human resources are one of the most influential factors on the performance of TTOs, suggest that TTOs may need to be reconfigured into smaller units, since there may be scope for the development of sectors where the local system is specialized. In this sense, an improvement in performance of university TTOs may require the creation of smaller, more specialized TTOs at universities, rather than just increasing the size of technology transfer offices per se. The authors also find that older TTOs are not necessarily more efficient. This may highlight the possibility that older TTOs are staffed by people equipped with a university administration rather than a commercial background and may suggest a need to recruit expertise from the private commercial sector (Chapple *et al.*, 2005).

Other studies in Europe don't confirm the positive impact of TTOs in promoting and valorizing the commercialization of academic research (see Goldfarb and Henrekson 2003 for Sweden; Saragossi and van Pottelsberghe de la Potterie 2003 for Belgium; Krucken et al. 2007 for Germany; Sellenthin 2009 for Germany and Sweden; Muscio 2010 for Italy). Thursby and Thursby (2002) find a negative association between TTO growth and the growth of productivity in licensing, which should suggest as the rapidly expanding TTOs may exhibit lower productivity, because they may be not familiar with faculty or network with innovation and entrepreneurial ecosystem.

Other studies show low efficiency of TTOs, which are even sometimes perceived as obstacles in knowledge transfer processes rather than facilitators (Clarysse et al., 2005; Fini et al., 2011; Hayter, 2013; Meoli and Vismara, 2014).

According to the controversial findings in the literature, we would test the following hypothesis:

Hp 3: *an increase of the number of employees in TTOs has a positive impact on the number of granted patents.*

Hp 4: *an increase of the number of employees in TTOs has a positive impact on the number of licenses.*

With regard to licensing revenue, results are also controversial: Siegel *et al.* (2003) show that TTO staff size doesn't increase licensing revenues, while other authors found that increasing staff size within a TTOs increased the expected licensing revenue for university (Heysey and Adelman, 2011).

According to the controversial findings in the literature, we would also test the following hypothesis:

Hp 5: an increase of the number of employees in TTOs has no effect (in the short term) on licenses revenues.

Empirical model

To build our empirical model we started from the premise that according to the literature, the UIBM-Action represents a sort of a laboratory to explore the effect of a sudden and relevant increase in the number of people employed in TTOs.

In particular, to test our hypotheses, we collected data on new people employed in Italian universities' TTOs employed as an effect of the UIBM action and we crossed these data with a database jointly developed by the Center for Innovation and Entrepreneurship of the Università Politecnica delle Marche and the Institute of Management at Scuola Superiore Sant'Anna, in collaboration with Netval. The database contains information about the characteristics of Italian ASOs - i.e. name, year of foundation, university of foundation, sector of activity, location, etc. - and data on their economic performance (sales, profits, employees, etc.). As for the data on TTOs, we relied on information collected through an annual survey of TTOs in Italian universities carried out by Netval. The survey collects data on age, size (in terms of staff members and budget) and total expenditures of the TTOs. The survey also collects information on the technology transfer activities of universities: patents owned, new patent grants, amount of collaborative research, involvement in technology parks and incubators, etc.

In our empirical analysis, we considered 38 institutions that used the incentives offered by UIBM and employed 75 new people in their TTOs[3]. The very first employees have started to work in January 2016, the very last in October 2017 so that, considering that the last available information on TTOs' performance is related to 2017, the analysis was restricted to those employees who have been working in 2016, i.e. 51 people), ensuring a proper time delay and cause-effect relationship.

Our sample includes information both from those universities which are UIBM-action beneficiaries and those which are not, but universities not recorded in the Netval survey or with a large amount of missing data have been excluded from the analysis. Our final sample contains 24 Italian universities that benefitted from the UIBM action and 36 which did not.

[Table 1 about here]

[Table 2 about here]

[Table 3 about here]

[3] All projects were accepted by UIBM in the first (2015-2017) call. The call was confirmed for a second time (2018-2020) and will be most probably confirmed for a third time (2020-2022).

Table 3 shows that the two groups of beneficiaries and not beneficiaries had very similar characteristics in 2016. This means that their situation at the time the action was launched did not have an influence on their decision of applying or not for the UIBM action.

With regard to performance measures for a TTO, Thursby and Thursby (2002) report the following metrics: a) TT revenue, b) number of invention disclosures, c) number of patent applications, d) number of patents granted, e) number of licenses signed, f) number of start-ups formed, g) research expenditure of university scientists, h) expenditure of patenting activities, i) operation expenditure, j) number of new commercial products, k) employment and productivity growth of startup partners, l) changes in stock prices of industrial partners.

Siegel *et al.* (2003) consider invention disclosures to be the most important measurable input for the TTO, due to the fact that they represent the stock of transferable technology and new ideas.

In this paper we chose to analyse the performance and effectiveness of TTOs using the following variables: number of identified invention, number of granted patents, number of new spin-off companies, number of licenses, the licenses revenues.

With regard to our case study, Italy is a large European country with a relevant manufacturing presence and the need to increase the innovative/technological component of its industrial structure. The productivity of its scientific system is good, despite the lower number of researchers in comparison with similar countries. In such a situation it is not surprising that the importance of the university third mission has been intensively growing during the last years (Bax et al. 2014; Cesaroni et al. 2005), and within such mission, technology transfer from university to industry has also obtained growing interest among both academics and policy makers. As a consequence, most Italian universities have set up their TTOs during the last decade. Nonetheless, if we compare the Italian, European and the US situations, it emerges that Italian TTOs are much smaller than TTOs set up in other European countries and in the US (Piccaluga and Cesaroni, 2015).

On the basis of the hypotheses that TTO size does matter in terms of performance, in order to assess the existence of differences in the performances of the TTOs which have been beneficiaries of the UIBM action and TTOs which have not been, we computed two types of growth rates of the principal outcome variables:

- the growth rates of each performance variable between 2015 and 2016 and between 2016 and 2017, denoted by g^1 (y/y-1);
- the growth rates of each performance variable computed as the ratio between the value in 2016 and the average value of 2013-2014-2015 and computed as the ratio between the value in 2017 and the average value of 2014-2015-2016, denoted by g^2 (y/y-1,y-2,y-3).

Results on tests on performance variables' growth rates by year are shown in Table 4.

[Table 4 about here]

Using each single outcome variable, we estimated several models of panel linear and Poisson (according to the type of dependent variable) GEE population averaged regression, each specifically tailored for the 4 RQs. Moreover, to answer RQ4, universities have been classified according to the quartiles of the distribution of the dimensions of TTOs (without considering the increase in the staff due to the UIBM-Action).

If we consider the number of identified inventions (Table 5), having more people in the TTOs has a positive and statistically significant effect. The effect of the additional TTO employees is positive and significant for small, medium and big universities. The effect is positive, significant and similar for +1, +2 and +3 additional units in the TTOs; however, the intensity of the effect is stronger in the +3 case. Moreover, the effects of additional employees are positive and significant for TTOs belonging to the quartiles of the distribution of TTOs' dimension, with higher impact for the third and fourth quartiles, that include the largest universities.

[Table 5 about here]

Concerning the number of licenses (Table 6), having more people in the TTOs does not affect performance in general terms. However, the effect of additional staff is positive and significant for medium and large size universities and when the TTO grows by 3 units and only for the TTOs belonging to the second and third quartile (small-medium and medium-large previous dimension of TTOs).

[Table 6 about here]

Regarding revenues from licenses (Table 7), more people in the TTOs do not affect the performance in the short term (the effect is generally positive but not significant). However, the effect of additional staff is positive and significant for big universities, for +3 additional TTO units and for TTOs belonging to the first, third and fourth quartile (small, medium-large and large previous dimension of TTOs).

[Table 7 about here]

If we consider the number of granted patents (Table 8), we find positive and significant effects for medium and big universities and when the TTO grows by 2 or 3 units. Furthermore, the effects of additional employees are positive and similar for all the four identified quartiles.

[Table 8 about here]

Considering the number of new spin-offs (Table 9), having more people in the TTOs does not affect performance in general terms. Positive and significant effects of additional TTO employees only appear for small universities and when the TTO grows by 3 units.

[Table 9 about here]

Table 10 reports a summary of the significant effects of the regression models.

[Table 10 about here]

Discussion

The results of the empirical analysis show that adding staff in the TTOs has a very clear and positive effect with regard to the identification of inventions. In fact, as it could be expected, more people in the TTO allow more contacts and interactions with researchers, since TT staff can go the labs, organize meetings, calls, etc. It is like looking for mushrooms. The mushrooms are out there in the wood. More people equals more eyes and therefore more mushrooms collected.

However, we found less effect on patents granted. This is not a surprise, since patenting activity is the result of medium term investments and the presence of new TTO staff cannot determine an increase in the number of patents in the short term. Since more inventions have been identified, it is likely however that - after some time - more patent applications will be made and more patents will be granted. Nonetheless, a positive trend is already emerging from our regression analysis, even if it considers a very short period of time such as a one-year delay in the performance outcome.

The positive effect on licenses and revenues is beyond our expectations and so, after the tests on performance variables' growth rates, we run regressions in order to be sure that the results are robust and not influenced by other factors, even if the two starting groups (UIBM-MISE Action beneficiaries and not beneficiaries) were quite similar in terms of size and age (Table 3). To better understand the impact of such action, we run the regressions for the whole set of TTO performance variables available in Netval: inventions, licenses and revenues, granted patents and new spin-off. After this

check (Table 10), we found that the positive effect is still robust and particularly stronger for small TTOs, generally associated with small universities. This means that universities with small TTOs were the "woods" where there were more additional mushrooms to be collected and where more TT people were particularly useful. Universities with small TTOs are probably younger in the job, less expert and they really needed new people in this job to do a relatively codified task, such as invention disclosure.

As a matter of fact, the effect on the number of licenses is generally positive but not significant. However, there are some positive (and significant) effects for medium-sized and big universities, probably because the identification of more inventions is something that characterizes smaller TTOs, whereas licensing (and revenues) is something more typical of medium sized TTOs. In these TTOs, most probably, there was already some interesting IP and may be some potential contacts with licensees. As a consequence, the involvement of new staff has allowed to achieve the results which had been somehow prepared by those who worked before them. This is not the case in larger TTOs, where probably new staff has been directed towards longer term activities, whose fruits will be collected in the future.

Concerning ASOs, the empirical analysis shows that the age of TTOs is significant in increasing the number of spin-offs. For granted patents, adding number of employees in TTOs has a positive effect, especially in big and medium universities.

Conclusion

Confirming our hypotheses, adding more people in the TTOs has had a very clear effect on the variable which can be realistically influenced in the short term, i.e. invention disclosures. In other words, more people in the TTOs had more opportunities of creating contacts with researchers and therefore producing an increase in the number of invention disclosures within a short period such a as a few months. The same positive effect generally emerges also for other TTOs' performance variables such as the number of licenses, licenses revenues and the number of granted patents. On the other side, we observe less impact on the number of new-spinoffs.

We need to emphasize that this effect has been produced in less than two years, considering that new people were - on average - involved in the TTOs at the beginning of 2016 and outcomes refer to 2017. The use of lagged TTO outcomes allowed us to detect a significant increase also in output variables, which require a period longer than few months to be observed. In other words, we can say that more people in the TTOs determine an increase in the number of patent applications, the number of patents granted and the licenses/revenues, especially when the TTO grows by 3 units.

The first UIBM action brought new people in a number of Italian TTOs in 2016 and we analyzed data from 2012 to 2017. However, the UIBM action was renewed in 2018. As a result, most previous beneficiaries have had the opportunity of confirming their "new" staff and new beneficiaries have been included. It will then be interesting to use output data from 2018 to verify the robustness of the achieved results in the long term. Moreover, it will be interesting, with new 2018 data, to observe if results about invention disclosures will be confirmed, i.e. if there will be an additional growth or if most of the potential has been collected in the first two years.

In general, the fact that we observed a positive impact of the involvement of new people in the TTOs even in a short period of less than two years leads us to argue that the impact may be even stronger after a longer period, considering both the fact that the people will increase their professional competences and the fact that results in the field of the valorization of research results usually need several years of work.

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Table 1 – Organizations (universities and other public research centres) which were beneficiaries of the UIBM-MISE Action

Organization	Additional TTO staff from 2016	Organization	Additional TTO staff from 2016
Centro di riferimento oncologico	1	Università di Cagliari	
Consiglio Nazionale delle Ricerche	1	Università di Camerino	
Istituto Nazionale di Astrofisica (I.N.A.F.)	1	Università di Ferrara	
Istituto Nazionale di Fisica Nucleare	1	**Università di Firenze (*)**	**1**
Politecnica delle Marche (*)	**3**	**Università di Messina (*)**	**2**
Politecnico di Milano (*)	**3**	**Università di Milano "Bicocca" (*)**	**3**
Politecnico di Torino (*)	**3**	**Università di Modena e Reggio (*)**	**1**
Scuola Int. Superiore di Studi avanzati di Trieste (*)	**1**	Università di Palermo	
Scuola Superiore Sant'Anna di Pisa (*)	**2**	**Università di Pisa (*)**	**2**
Università "Ca' Foscari" di Venezia (*)	**3**	Università di Salerno	
Università Campus Bio-Medico di Roma		Università di Siena	
Università degli Studi di Napoli Federico II (*)	**3**	**Università di Torino (*)**	**1**
Università degli Studi Mediterranea di Reggio Calabria	2	**Università di Trento (*)**	**1**
Università del Sannio (*)	**1**	**Università di Trieste (*)**	**1**
Università della Calabria		**Università di Udine (*)**	**3**
Università dell'Aquila (*)	**3**	**Università di Urbino (*)**	**1**
Università di Bari (*)	**2**	Università di Verona	
Università di Bologna (*)	**2**	**Università IUAV di Venezia (*)**	**1**
Università di Brescia (*)	**1**	**Università Tor Vergata di Roma (*)**	**1**
Università di Cagliari			

(*) *Universities that belong to the final sample.*

Table 2 - Universities included in the final sample for our study

NON BENEFICIARIES OF THE UIBM-MISE ACTION	BENEFICIARIES OF THE UIBM-MISE ACTION
Libera Università di Bolzano	Politecnica delle Marche
Politecnico di Bari	Politecnico di Milano
Scuola IMT Alti Studi Lucca	Politecnico di Torino
Scuola Normale Superiore di Pisa	Scuola Internazionale Superiore di Studi avanzati di Trieste
Seconda Università di Napoli	Scuola Superiore Sant'Anna di Pisa
Telematica G. Marconi	Università "Ca' Foscari" di Venezia
Università Campus Bio-Medico di Roma	Università degli Studi di Napoli Federico II
Università degli Studi della Tuscia	Università del Sannio
Università degli Studi dell'Insubria	Università dell'Aquila
Università del "Piemonte Orientale"	Università di Bari
Università del Molise	Università di Bologna
Università del Salento	Università di Brescia
Università della Basilicata	Università di Firenze
Università della Calabria	Università di Messina
Università della Valle D'Aosta	Università di Milano "Bicocca"
Università di Bergamo	Università di Modena e Reggio
Università di Cagliari	Università di Pisa
Università di Camerino	Università di Torino
Università di Catania	Università di Trento
Università di Chieti-Pescara	Università di Trieste
Università di Ferrara	Università di Udine
Università di Foggia	Università di Urbino
Università di Genova	Università IUAV di Venezia
Università di Macerata	Università Tor Vergata di Roma
Università di Milano	
Università di Padova	
Università di Palermo	
Università di Parma	
Università di Pavia	
Università di Perugia	
Università di Salerno	
Università di Sassari	
Università di Siena	
Università di Teramo	
Università di Verona	
Università Magna Grecia di Catanzaro	

Table 3 – Sample descriptives about TTOs (both UIBM beneficiaries and not)

Beneficiaries of the UIBM-MISE Action	**N (%)**	**TTO age in years Mean (St. Err.)**	**TTO size (n. people) before the UIBM-MISE Action Mean (St. Err.)**	**TTO size (n. people) after the UIBM-MISE Action Mean (St. Err.)**
N	36 (60)	10.31 (0.79)	3.37 (0.38)	3.37 (0.38)
Yes	24 (40)	11.25 (0.79)	3.47 (0.60)	5.34 (0.63)
Total	*60 (100)*	10.69 (0.57)	3.41 (0.33)	4.24 (0.37)

Table 4 – Tests on growth rates by performance variables

		Growth rates year 2016			Growth rates year 2017		
Performance variable	**Growth rate type**	**UIBM-MISE Action beneficiaries Mean (St. Err.)**	**No UIBM-MISE Action beneficiaries Mean (St. Err.)**	**P-value (*)**	**UIBM-MISE Action beneficiaries Mean (St. Err.)**	**No UIBM-MISE Action beneficiaries Mean (St. Err.)**	**P-value (*)**
Number of identified inventions	g^1 (y/y-1)	+23.5% (11.81)	+1.0% (9.44)	**0.065 ***	+464.0% (233.9)	+66.1% (62.6)	**0.051 ***
	g^2 (y/y-1,y-2,y-3)	+20.2% (8.45)	+0.3% (7.43)	**0.038 ****	+607.3% (256.9)	-5.7% (20.7)	**0.006 ****
Number of licenses	g^1 (y/y-1)	+35.0% (12.55)	+12.6% (10.12)	**0.084 ***	+57.7% (37.5)	-77.9% (11.3)	**0.003 ****
	g^2 (y/y-1,y-2,y-3)	+30.0% (11.10)	+11.1% (8.26)	**0.086 ***	+115.1% (69.8)	-9.4% (48.0)	**0.075 ***
Licenses revenues	g^1 (y/y-1)	+25.5% (18.55)	-5.0% (12.53)	**0.082 ***	NA	NA	
	g^2 (y/y-1,y-2,y-3)	+25.2% (16.35)	-1.6% (11.92)	**0.091 ***	-74.4% (22.1)	+48.8% (120.0)	0.880
Number of granted patents	g^1 (y/y-1)	+13.9% (11.18)	+0.1% (10.87)	0.198	+902.2% (523.3)	-66.9% (10.2)	**0.018 ****
	g^2 (y/y-1,y-2,y-3)	-1.5% (10.56)	-6.9% (9.13)	0.353	+843.2% (508.6)	+54.5% (84.8)	**0.037 ***
Number of new spin-off	g^1 (y/y-1)	-14.0% (12.12)	+3.9% (13.55)	0.825	+37.2% (48.2)	+43.4% (36.5)	0.541
	g^2 (y/y-1,y-2,y-3)	-21.1% (10.70)	-18.2% (10.56)	0.575	+69.5% (59.6)	+26.6% (37.6)	0.263

(*) Hp.: Mean(UIBM-Action=Yes) > Mean(UIBM-Action=No)

Table 5 – Poisson panel regressions, GEE population-averaged models (number of identified inventions)

Poisson panel regressions, GEE population-averaged models	**Mod. 1**			**Mod. 2**			**Mod. 3**			**Mod. 4**		
Outcome = Number of identified inventions	**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**	
TTO staff (etp) total	**0.02**	0.006	**									
TTO staff (etp) without additional UIBM staff				**-0.03**	0.000	***	**0.03**	0.000	***	**-0.03**	0.000	***
Age TTO	**0.11**	0.000	***	**0.14**	0.000	***	**0.14**	0.000	***	**0.14**	0.000	***
Small university	0.19	0.397		-0.09	0.705		-0.02	0.940		0.08	0.716	
Medium university	-0.10	0.500		**-0.30**	0.062	*	**-0.46**	0.004	**	**-0.31**	0.053	*
Big university	**1.07**	0.000	***	**0.78**	0.000	***	**0.83**	0.000	***	**0.84**	0.000	***
Small university * num. additional TTO staff (UIBM)				**0.24**	0.004	**						
Medium university * num. additional TTO staff (UIBM)				**0.12**	0.001	**						
Big university * num. additional TTO staff (UIBM)				**0.25**	0.000	***						
TTO additional staff = 1 (ref. category = 0)							0.15	0.004	**			
TTO additional staff = 2 (ref. category = 0)							0.37	0.000	***			
TTO additional staff = 3 (ref. category = 0)							0.70	0.000	***			
1st quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.22**	0.000	***
2nd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.11**	0.006	**
3rd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.25**	0.000	***
4th quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.25**	0.000	***
Year 2012	**-0.08**	0.031	**	**-0.07**	0.064	*	**-0.07**	0.062	**	**-0.07**	0.065	*
Year 2013	**0.13**	0.001	**	**0.12**	0.001	**	**0.12**	0.001	**	**0.12**	0.001	**
Year 2014	-0.06	0.100		**-0.05**	0.150		-0.05	0.152		**-0.05**	0.158	
Year 2015	**0.25**	0.000	***	**0.28**	0.000	***	**0.28**	0.000	***	**0.28**	0.000	***
Year 2016	**0.32**	0.000	***	-0.002	0.957		**0.03**	0.524		**0.01**	0.733	
Year 2017	**0.41**	0.000	***	0.12	0.002	**	**0.15**	0.000	***	0.13	0.001	**

Table 6 – Poisson panel regressions, GEE population-averaged models (number of licenses)

Poisson panel regressions, GEE population-averaged models	**Mod. 1**			**Mod. 2**			**Mod. 3**			**Mod. 4**		
Outcome = Number of licenses	**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**	
TTO staff (etp) total	**0.03**	0.059	*									
TTO staff (etp) without additional UIBM staff				-0.02	0.948		-0.03	0.246		-0.01	0.753	
Age TTO	**0.07**	0.005	**	**0.10**	0.000	***	**0.10**	0.000	***	**0.10**	0.000	***
Small university	**-1.47**	0.010	**	**-1.43**	0.014	**	**-1.44**	0.011	**	**-1.58**	0.007	**
Medium university	**-1.63**	0.000	***	**-1.86**	0.000	***	**-1.81**	0.000	***	**-1.77**	0.000	***
Big university	-0.45	0.209		-0.57	0.128		-0.57	0.119		**-0.70**	0.067	*
Small university * num. additional TTO staff (UIBM)				0.20	0.417							
Medium university * num. additional TTO staff (UIBM)				**0.40**	0.000	***						
Big university * num. additional TTO staff (UIBM)				**0.32**	0.000	***						
TTO additional staff = 1 (ref. category = 0)							0.07	0.665				
TTO additional staff = 2 (ref. category = 0)							0.28	0.186				
TTO additional staff = 3 (ref. category = 0)							**0.99**	0.000	***			
1st quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.30	0.000	
2nd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.27**	0.030	***
3rd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.46**	0.000	***
4th quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.30	0.000	
Year 2012	-0.11	0.379		-0.09	0.460		-0.09	0.451		-0.09	0.429	
Year 2013	0.09	0.471		0.10	0.390		0.09	0.386		0.09	0.398	
Year 2014	-0.06	0.641		-0.05	0.687		-0.05	0.691		-0.05	0.647	
Year 2015	**0.26**	0.023	**	**0.28**	0.010	**	0.28	0.008	**	**0.27**	0.011	**
Year 2016	**0.37**	0.002	**	-0.08	0.531		-0.02	0.882		-0.12	0.329	
Year 2017	**0.39**	0.002	**	0.03	0.807		0.12	0.385		0.01	0.944	

Table 7 – Linear panel regressions, GEE population-averaged models (licenses revenues)

Linear panel regressions, GEE population-averaged models	**Mod. 1**		**Mod. 2**			**Mod. 3**			**Mod. 4**		
Outcome = Licenses revenues	**Coeff.**	**P-value**	**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**	
TTO staff (etp) total	813.4	0.205									
TTO staff (etp) without additional UIBM staff			-190.5	0.764		72.6	0.912		119.5	0.858	
Age TTO	-163.9	0.712	28.8	0.945		-75	0.863		-45.3	0.916	
Small university	538.6	0.943	1782	0.806		2060.2	0.781		1272.6	0.862	
Medium university	1993.3	0.728	4434.3	0.415		3156.3	0.572		3003.4	0.590	
Big university	11243.9	0.108	**11624.4**	0.079	*	13119.7	0.054		**12281.5**	0.070	*
Small university * num. additional TTO staff (UIBM)			3188.3	0.662							
Medium university * num. additional TTO staff (UIBM)			1162.4	0.702							
Big university * num. additional TTO staff (UIBM)			**13446.6**	0.000	***						
TTO additional staff = 1 (ref. category = 0)						1320.5	0.833				
TTO additional staff = 2 (ref. category = 0)						4563	0.607				
TTO additional staff = 3 (ref. category = 0)						**29340.3**	0.000	***			
1st quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)									**9445**	0.002	**
2nd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)									4864.8	0.253	
3rd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)									**11372.9**	0.004	**
4th quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)									**8312.2**	0.011	**
Year 2012	-1879.2	0.672	-1537.9	0.718		-1596.4	0.710		-1545.8	0.721	
Year 2013	-1118.9	0.799	-808.7	0.847		-833.2	0.844		-819.1	0.848	
Year 2014	-5139.8	0.239	-4978.7	0.234		-4985.7	0.238		-4939.7	0.246	
Year 2015	52.2	0.990	520.7	0.899		389	0.925		437	0.917	
Year 2016	5855.8	0.192	-1576.7	0.736		584.8	0.905		-1656.1	0.729	
Year 2017	2224.5	0.642	-3429.2	0.480		-2417.7	0.631		-4269.5	0.387	

Table 8 – Poisson panel regressions, GEE population-averaged models (number of granted patents)

Poisson panel regressions, GEE population-averaged models	**Mod. 1**			**Mod. 2**			**Mod. 3**			**Mod. 4**		
Outcome = Number of granted patents	**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**	
TTO staff (etp) total	0.002	0.827										
TTO staff (etp) without additional UIBM staff				**-0.03**	0.001	**	**-0.03**	0.000	***	**-0.02**	0.074	*
Age TTO	**0.07**	0.000	***	**0.04**	0.001	**	**0.04**	0.005	**	**0.03**	0.015	**
Small university	**0.48**	0.058	*	**0.75**	0.003	**	0.28	0.345		0.30	0.320	
Medium university	**-0.61**	0.004	**	**-0.36**	0.087	*	-0.05	0.784		-0.26	0.201	
Big university	**0.99**	0.000	***	**1.43**	0.000	***	**1.50**	0.000	***	**1.49**	0.000	***
Small university * num. additional TTO staff (UIBM)				-0.18	0.119							
Medium university * num. additional TTO staff (UIBM)				**0.36**	0.000	***						
Big university * num. additional TTO staff (UIBM)				**0.19**	0.000	***						
TTO additional staff = 1 (ref. category = 0)							**-0.28**	0.001	**			
TTO additional staff = 2 (ref. category = 0)							**0.49**	0.000	***			
TTO additional staff = 3 (ref. category = 0)							**0.51**	0.000	***			
1st quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.38**	0.000	***
2nd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.23**	0.000	***
3rd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.23**	0.000	***
4th quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										**0.13**	0.000	***
Year 2012	-0.05	0.363		-0.04	0.427		-0.04	0.379		-0.05	0.327	
Year 2013	**0.24**	0.000	***	**0.25**	0.000	***	**0.25**	0.000	***	**0.26**	0.000	***
Year 2014	**0.42**	0.000	***	**0.44**	0.000	***	**0.44**	0.000	***	**0.45**	0.000	***
Year 2015	**0.32**	0.000	***	**0.35**	0.000	***	**0.35**	0.000	***	**0.37**	0.000	***
Year 2016	**0.28**	0.000	***	0.001	0.993		0.06	0.246		-0.05	0.310	
Year 2017	**0.33**	0.000	***	**0.14**	0.012	**	**0.21**	0.000	***	**0.13**	0.011	**

Table 9 – Poisson panel regressions, GEE population-averaged models (number of new spin-off)

Poisson panel regressions, GEE population-averaged models	**Mod. 1**			**Mod. 2**			**Mod. 3**			**Mod. 4**		
Outcome = Number of new spin-off	**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**		**Coeff.**	**P-value**	
TTO staff (etp) total	0.01	0.679										
TTO staff (etp) without additional UIBM staff				0.01	0.753		0.005	0.845		0.01	0.800	
Age TTO	**0.06**	0.002	**	**0.06**	0.001	**	**0.06**	0.001	**	**0.06**	0.001	**
Small university	-0.26	0.715		-0.35	0.640		-0.25	0.724		-0.26	0.713	
Medium university	-0.53	0.032		**-0.53**	0.030	**	**-0.52**	0.032	**	**-0.52**	0.038	**
Big university	0.03	0.925		0.04	0.881		0.03	0.906		0.04	0.889	
Small university * num. additional TTO staff (UIBM)				**0.28**	0.089	*						
Medium university * num. additional TTO staff (UIBM)				0.10	0.126							
Big university * num. additional TTO staff (UIBM)				0.03	0.742							
TTO additional staff = 1 (ref. category = 0)							-0.09	0.640				
TTO additional staff = 2 (ref. category = 0)							0.01	0.978				
TTO additional staff = 3 (ref. category = 0)							**0.19**	0.350	***			
1st quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.0005	0.997	
2nd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.09	0.370	
3rd quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.12	0.413	
4th quartile TTO staff without additional UIBM staff * num. add. TTO staff (UIBM)										0.04	0.445	
Year 2012	0.21	0.243		0.21	0.243		0.21	0.242		0.21	0.242	
Year 2013	0.05	0.783		0.05	0.784		0.05	0.782		0.05	0.782	
Year 2014	0.26	0.164		0.26	0.166		0.26	0.163		0.26	0.164	
Year 2015	0.14	0.427		0.15	0.431		0.15	0.420		0.15	0.425	
Year 2016	-0.03	0.883		-0.09	0.695		-0.05	0.838		-0.09	0.685	
Year 2017	-0.05	0.788		-0.10	0.600		-0.06	0.753		-0.09	0.638	

Table 10 – Significant interaction effects of the regression models (✔=positive, ✘=negative)

Effect of additional TTO staff	Number of identified inventions	Number of licenses	Licenses revenues	Number of granted patents	Number of new spin-offs
Small universities	✔				✔
Medium universities	✔	✔		✔	
Big universities	✔	✔	✔	✔	
TTO +1 unit				✘	
TTO +2 units				✔	
TTO +3 units		✔	✔	✔	✔
Small TTOs	✔		✔	✔	
Small-medium TTOs	✔	✔		✔	
Medium-large TTOs	✔	✔	✔	✔	
Large TTOs	✔		✔	✔	