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UNIVERSITY REGULATION AND UNIVERSITY--?INDUSTRY INTERACTION: A PERFORMANCE ANALYSIS OF ITALIAN ACADEMIC DEPARTMENTS

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Jelcodes:L31,O32

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Abstract

In a context characterized by public spending reviews and research funding shortages, governments in several countries are putting pressure on universities to increase their applied research activity, intensify their interaction with industry and attract funding from the non-academic domain. The economic literature provides rich evidence on the convergence between institutional factors and individual-level characteristics that are influencing university involvement in knowledge transfer activities. The aim of this paper is to investigate the impact of universities' regulation of knowledge transfer activities on the institutional capability to raise funding from research contracts and consultancies. Based on extensive department-level data on university funding, we address the characteristics of institutional knowledge transfer practices and investigate how they influence the intensity of funding to Italian universities deriving from these activities.

Keywords: University; Academic Engagement; Technology and knowledge transfer; University regulation; Third mission.

JEL codes: L24, L31, O32, O33

1 INTRODUCTION

One of the key institutional challenges governments face in their efforts to support innovation activity is easing the transfer of technology and knowledge more broadly, from academic institutions to businesses and other non-academic public or private entities (OECD, 2003). Although universities are involved in so-called 'third-mission' activities (Geuna and Muscio, 2009), a deeper connection between university and non-academic institutions (mainly, but not exclusively firms) is considered essential for technological progress and economic development. Demands are increasing for universities to produce research that is valuable to agents outside the 'ivory tower' of academia and to intensify the interactions with them. The expectation is that universities should not only produce new knowledge, but that this knowledge be related to established social and economic targets (Laredo, 2007).

Universities themselves may derive several gains from the engagement in knowledge transfer activities. Many of these benefits are associated with patenting and licensing activity (Baldini et al., 2007) and include: increased financial earnings that can be devoted to research activity (AUTM, 2003; OECD, 2003); reinforcement of academic reputation, which helps to attract the smartest students and brightest faculty (Florida, 1999); the establishment of communication channels with companies, which may bring several benefits such as new ideas for research and a better understanding of applications of theoretical fundamentals, training for PhDs, internships and employment for students.

At the institutional level, universities need to find ways to regulate and manage this relatively new set of activities. Knowledge transfer is not something that was discovered ‘‘somehow’’ in recent years, as argued by scholars in the Triple Helix and Mode Two Knowledge traditions (Etzkowitz and Leydesdorff, 2000; Gibbons et al., 1994) who proposed the idea of a new academic revolution characterized by universities’ involvement in knowledge transmission (Geuna and Muscio, 2009).

There is substantial agreement in the economic literature that governments need to put in place the measures necessary to encourage and facilitate knowledge transfer from university to industry and other institutions. A considerable body of scientific literature has focused on the ‘commercialisation’ of academic research results, which essentially involves intellectual property creation and academic entrepreneurship, investigating its drivers and the related business funding opportunities for universities. A more recent stream of work stresses the relevance of academic consultancies, research-to-order and collaborative research – activities, referred to as ‘academic engagement’ (Perkmann *et al.*, 2013) – as effective and common informal channels of knowledge transfer. Their highly relational nature amplifies potential spillovers (Jensen et al., 2010) and activates learning by interaction processes (Perkmann and Walsh, 2008).

At the same time, public budget constraints have pushed several European country governments to increase the pressure on universities to broaden their external research funding options and to modernize their managerial and organizational skills (European Commission, 2008). Geuna (1999) notes that, since the early 1980s, European governments have been intervening more directly to guide national research systems in this sense. This intervention has taken different forms

in different countries, but is driven by similar overall targets, which are promoting a contractual-oriented approach to university research funding, aimed at indirect control of university behaviour through the introduction of (quasi-market) financial incentive schemes. These policies are meant to improve the efficiency of research funding, increase university accountability and induce cost reductions. This last is being forced by the reductions in public budgets as a result of imposition of the Maastricht criteria (see Sörlin, 2007).

The Italian university system for many years has followed on a fully public and highly centralized governance structure with low levels of university autonomy and a key role played by the State (Capano, 2000). Initiatives to support knowledge transfer in Italy have been lacking, but political pressure to transfer the results of academic research has increased,[1] though the emphasis has been almost exclusively put on the development of universities' plans to support the 'commercialisation' of scientific research. As a consequence, by 2005 most Italian universities had established Technology Transfer Offices (TTO) and put in place internal regulation to manage revenue-sharing and intellectual property rights (IPR). On the other hand, less attention has been paid to the design of the governance mechanisms related to the activities referable to 'academic engagement'[2]. Universities have been encouraged to regulate their knowledge transfer activities and to subject research contracts and extra-mural consultancies to certain rules – in fact, a large number of Italian academic institutions now has a 'regolamento contoterzi', which regulates in different ways and to different extents the distribution of revenues and costs, the extension of staff involvement and so forth.

There are several institutional and university-level factors, which together with demand conditions and individual-level characteristics may drive university involvement in knowledge transfer activities (Baldini et al., 2007). For instance, institutional factors such as legislation favouring knowledge transfer and distribution of IPR can influence the intensity of interactions with non-academic institutions and the provision of government funding. Similarly, university-level factors such as provision of incentives to academics, a favourable/competitive environment for invention and commercialisation, and implementation of support for knowledge transfer could all contribute.

However, we know very little about the impact on the intensity of knowledge transfer of university policies and governance systems. In principle, facilitating the collaboration with non-academic entities and the commercialisation of discoveries should be in the interests of both academics and society, the ultimate aim of applied scientific research being to improve the human condition (Litan et al., 2007). Empirical evidence provided by Caldera and Debande (2010) shows that university rules on conflicts of interest between academic teaching responsibilities and external activities have a positive and significant impact on university performance in R&D contracts, licensing and spin-off creation. Also, university royalty sharing policies have a major effect on licensing income, and awarding a higher share of licensing royalties to inventors stimulates licensing activity. In this context, the present paper investigates the impact of academic management practices and internal regulation of knowledge transfer activities on the capability to raise funding from industry via consultancies, contract research and research-to-order, i.e. via 'academic engagement'. Based on extensive data on university

funding and university regulation in Italy, we address the characteristics of institutional knowledge transfer practices and investigate how internal governance and regulation influence the intensity of such sources of funding to universities.

2 University performance in knowledge transfer

2.1 The role of university policies and governance

From a general point of view the effectiveness and the performance of universities in transferring knowledge depends on the complex interplay among elements at different levels (Muscio and Pozzali, 2013): the system level, described in the systems of innovation literature (Edquist, 2005); the institutional level, which explains the differences among universities operating within the same system (Di Gregorio and Shane, 2003); and the individual level (Bercovitz and Feldman, 2008).

In this paper we focus on the institutional level, in particular on university policies, which involve the strategic decisions and the governance design aimed at promoting and regulating knowledge transfer activity and motivating faculty members to engage in interaction with non-academic organizations. The increased scale and variety of university knowledge transfer activities are in fact requiring improved strategies and governance systems, able to cope with both the increased size and complexity of universities and their highly specialized and diverse group based production (Geuna and Muscio, 2009). Therefore, traditional academic tasks are being redefined and expanded as a consequence (Etzkowitz et al., 2000).

This process of internal transformation is evident in several academic initiatives adopted at academic institutions. In order to adequately present their characteristics as well as the related empirical evidence, it is useful to recall the distinction briefly made in the preceding section about the multiple ways in which university research results are transferred (D'Este and Patel, 2007; Muscio, 2010; Salter and Martin, 2001). The wide variety of channels and their possible manifold natures, in fact, makes important to assess whether they are affected by the same drivers or not and, consequently, whether they can be addressed through homogeneous policies and governance criteria or not. Hence, following Perkmann et al. (2013) knowledge transfer channels can be classified in two main categories: commercialisation and academic engagement. Commercialisation – or 'technology transfer', includes patenting and licensing, as well as various forms of academic entrepreneurship (for instance spin-offs, incubators). It has received a strong attention by policy makers and researchers, so there is a large evidence-base (O'Shea et al., 2008; Phan and Siegel, 2006; Rothaermel et al., 2007). Academic engagement, includes knowledge-related collaborations (collaborative research, contract research and consulting) by academic researchers with non-academic entities (see: D'Este and Patel, 2007; Muscio, 2010; Perkmann et al. 2011). It is often considered as a less formal type of knowledge transfer, as individuals generally carry out the related activities without relying on the intermediation and the support of specialised university bodies. Most of these collaborations are in fact governed solely by contracts, sometimes framed only through specific university regulation. The attention paid to academic engagement by researchers and policy maker is relatively recent and the empirical evidence presented in

studies is scarce and often mixed. According to the scientific literature, university policies and governance options aimed at fostering commercialisation and academic engagement can be summarized in three broad categories: *setting knowledge and technology transfer infrastructures; granting rewards to faculty members*; *managing conflict of interests.*

Setting knowledge and technology transfer infrastructures

Since academic engagement is by its nature more autonomously driven by individuals and less organisationally embedded than commercialisation (Perkmann et al., 2013), policies related to the establishment of infrastructures aimed at facilitating university-industry collaborations have primarily drawn the attention of the studies on technology transfer. In fact, in order to encourage scientists to consider commercialising their research results and to support them through the process, many universities have established knowledge and technology transfer offices (O'Gorman et al. 2008). The presence of technology transfer intermediaries is generally found to be a relevant, positive determinant of research commercialisation (Markman et al., 2005a, 2005b; Phan and Siegel, 2006). Formal technology transfer intermediation between academics and businesses helps to reduce the 'cognitive distance' between them (Muscio and Pozzali, 2013) and can provide valuable support in bringing university IP to the market. However, there is mixed evidence regarding their actual impact. There are several recent studies, that focus on understanding the relative performance of TTOs (Chapple et al. 2005), their impact on the creation of spin-off companies (Lockett and Wright 2005) and their potential role in second-order spin-off

activities (Leitch and Harrison 2005). The results of these studies indicate that in the case of the UK, TTOs have low levels of efficiency, very heterogeneous performance and decreasing returns to scale. Siegel et al. (2007a) show that the involvement of TTO can slow down the commercialisation process through their greater interest in safeguarding researchers' interests and maximizing university returns. In the case of Italy, Muscio (2010) finds that the establishment of a TTO does not increase the frequency of university-industry interaction; however, the author finds that better managed TTO and greater use of their services by university departments positively affect the probability of the TTO being involved in university–industry collaboration. Coupé (2003) found evidence that those US universities that had TTO seemed to have increased their patenting activity more than those that did not. Chukumba and Jensen (2005) also demonstrate that the older the TTO the higher is its performance.

As already hinted, insufficient attention has been paid in the scientific literature at studying university policies for setting infrastructures/mechanisms specifically designed to facilitate academic engagement. Indeed, the only measure universities typically adopt in this area consists in setting rules and guidelines on research contracts, collaborative research and consultancies, thus providing a framework for contracting. To the best of our knowledge, only Caldera and Debande (2010) investigate the impact of the existence of R&D contracts regulation on R&D income (the dummy is not statistically significant) and on the number of R&D contracts (the dummy shows a negative coefficient) in Spanish universities.

Granting rewards to faculty members

Even in the case of policies aimed at bearing on the faculty members' (rational and monetary) incentives scheme for engaging in knowledge transfer activities, studies and evidences are much more substantial and consolidated as far as commercialisation is concerned, although the subject has recently received some attention even in academic engagement related literature.

Within the context of technology transfer, it has been suggested that IPR offers important incentives to commercialise academic discoveries (Murray and Stern, 2007). There is consensus on the fact that rewards that faculty receive for their participation in technology transfer activities are an important driver of commercialisation (Geuna and Muscio, 2009). There are a variety of mechanisms used to reward faculty for these activities, including consideration of patents and licences in promotions and tenure negotiations, and allowing faculty members a larger share (relative to that retained by the department/university) of licensing or equity revenues. Royalty rewards to faculty may explain some of the variation in technology licensing outcomes (Di Gregorio and Shane, 2003). There is evidence that universities allocating a higher percentage of royalty payments to faculty members tend to be more efficient in technology transfer activities (Phan and Siegel, 2006; Siegel, et al., 2003). As also suggested in Friedman and Silberman (2003) and in Lach and Schankerman (2004), organizational incentives for university technology transfer therefore appear to be an important determinant of success. However, as Friedman and Silberman (2003) show, it must be noted that greater pecuniary rewards to university inventors (as measured by the amount of royalty income they receive personally) are not significantly associated with the probability of achieving commercialisable outputs. Nevertheless, it must be noted

that much hoped for basic extrinsic rewards such as monetary rewards and the prospect of promotion for university staff have changed little over the years in many countries (Geoghegan and Pontikakis, 2008).

- *Managing conflict of interests*

Some authors have pointed out the potential conflict of interests (and the necessity to regulate them) between academic engagement with industry and the direction of research or time devoted by researchers to traditional academic activities. When marketing technology to firms and entrepreneurs, academic institutions and the TTO in particular must navigate potential conflicts of values and conflicts of interests between academics and industry (Bradley et al., 2013).

Many licensing agreements include 'delay-of-publication' clauses, which explain why faculty might resist disclosure before their findings are published (Thursby and Thursby, 2002). Therefore Markman et al. (2005) argue that faculty may disengage from technology licensing processes because it conflicts with tenure and promotion policies, delays publication, and hinders professional advancement.

Caldera and Debande (2010) provide evidence of the potential effects of university regulation on both the frequency and financial value of R&D contracts. They find that university rules relating to conflicts of interest have a positive effect on the amount and volume of R&D contracts. This indicates that regulation related to conflicts of interest between researchers' teaching commitments and external activities can improve performance by reducing moral hazard problems and uncertainty in the appropriation of revenues from external research activities. The authors find also that universities' regulation of researchers' participation in

contract research and rules on ownership of inventions have a negative effect on the number of R&D contracts, but no effect on income. Such rules give the university the rights to a share of the researcher's benefits from the commercialisation of the intellectual property generated in an external research activity. This finding suggests that such rules impair university knowledge transfer activity by decreasing researchers' incentives to engage in external activities.

2.1.1 University strategies for knowledge transfer

Few studies underline the importance of universities regulating and adopting an institutional strategic approach to the valorisation of their research to foster knowledge transfer (Siegel et al., 2007a). According to Debackere and Veugelers (2005), in order to facilitate knowledge transfer, universities need to establish a clear strategy and a set of guidelines to manage the transfer process that does not impinge on teaching and research activity.

The definition of an institutional strategy may increase the commitment of faculty members to the university third mission and increase the rate of knowledge transfer activity. More generally, the attitudinal and motivational aspects of knowledge transfer activities, as well as the ways in which the university governance mechanisms and policies shape the rational and monetary incentives scheme for academics, are acquiring increasing importance. Even concerning this, the evidence is much more consolidated for commercialisation activities, while the picture is quite fragmented and less understood as far as academic engagement is concerned.

The personal involvement of faculty is considered critical for the process of knowledge transfer from universities to firms, in particular because most university technologies are embryonic and need further development to become real commercial assets (Thursby and Thursby, 2004). Etzkowitz (1998, 830) describes different degrees of involvement in arrangements with private firms from 'hands-off' scientists who leave everything to the university TTO, to 'seamless web' arrangements where researchers' actively try to integrate their research with the research programmes of collaboration partners. Some perverse effects of the policies adopted by TTO managers in the US are highlighted in Litan et al. (2007) which finds that too often TTO become bottlenecks to rather than facilitators of innovation dissemination. The authors stress that the implementation of what they define as the ''revenue maximization model of technology transfer'', inhibits innovation dissemination, rewarding university TTOs on the basis of the revenues they generate rather than the number of inventions that universities transfer to industry. Furthermore, as Siegel and Phan (2005) note, university TTO have to make a strategic choice about commercialising inventions via the licensing or spin-offs. This complicates the choice made by universities over royalty regimes to maximize (or not) income distribution and frequency of university–industry interactions.

The effects of applied activity on academic research are debatable. In principle, as Baldini et al. (2007) suggest, interaction with firms can delay university publication (Rahm, 1994; Blumenthal et al., 1997; Cohen et al., 2002), which might slow faculty career advancements. Siegel et al. (2003) highlight the negative effects of patenting activity on career progression and Jensen and Thursby (2001) point to

the risk, especially in Europe, that researchers will have less time to devote to research because of the burden of legal and bureaucratic issues related to collaboration. However, Muscio and Pozzali (2013) find no evidence of any negative effect of interactions with industry on academics' perceptions of the factors hampering technology transfer, while the OECD (2003) stresses the positive influence of patenting on researchers' careers and earnings.

The empirical literature focuses mainly on the role of governance in providing appropriate incentives to academics to disclose their inventions to business or to university intermediaries such as TTOs. Recent evidence suggests that correct university policies can encourage academics to disclose inventions and enable their commercialisation. Jensen and Thursby (2001) and Macho-Stadler et al. (2007) show that well-defined licensing contracts can address, at least in part, the problems highlighted in Siegel et al. (2007a) concerning disclosure of inventions to TTOs. According to Lach and Schankerman (2008) universities giving a higher share of royalties to the inventor produce more inventions and generate higher licensing income. This finding is consistent with the ones proposed by D'Este and Perkmann (2011) and Perkmann et al. (2013), according to which monetary incentives are amongst the main motivation of commercialisation activities, while academic engagement seems to be mainly motivated by research considerations.

One of the keys to stimulating knowledge transfer is rewarding faculty members for their participation in these activities. Geuna and Muscio (2009) point to the various mechanisms used to reward faculty for knowledge transfer activity, such as the inclusion of patents and licences, among the criteria for promotions and

tenure negotiations, or the attribution of a larger share (relative to that retained by the department/university) of licensing or equity revenues to faculty members. Adverse selection issues also play a large role in determining the right incentives: according to Siegel et al. (2007a), universities' and TTO's strategies are likely to be determined by the universities' perceptions of the expected financial returns from invention disclosure and their desire/commitment to generating economic/knowledge spillovers to the community.

3 Empirical analysis

3.1 Data and research methodology

The empirical analysis is based on three main data sources:

1. The first data source is a publicly available database which provides detailed information at the department level on the volume and sources of academic funding and the composition of research staff. The data are collected annually by the Italian Ministry of University and Research (MIUR) and currently available in a standardised format for the period 2005-2011. The database includes 1,708 academic departments (which represent the whole population of academic departments in Italy) belonging to 64 public universities (including 4 polytechnic universities). In our analysis we select all the departments for which financial data are available for at least three consecutive years. Financial data are then matched to an index of research quality constructed by MIUR using the evaluation of research output conducted in 2001-03. This composite

indicator takes account of peer review evaluations of research activity carried out at academic institutions (patents, journal impact factors, etc.).

2. The second data source is a questionnaire survey carried out from September 2012 to February 2013, addressed to the central administration offices of the whole population of Italian public universities. Among the 64 universities contacted, 61 completed the questionnaire. The short questionnaire requested information on university knowledge transfer policies currently in place as expressed in the so called 'regolamento conto-terzi' and the year in which the 'regolamenti conto-terzi' was adopted. The survey asked about internal university regulation of the following: (i) private contracts, intellectual property rights and creation of spin-offs; (ii) academic scientists' conflicts of interest related to teaching and external activities; (iii) the amounts of external income withheld in order to cover internal administration costs; (iv) the imposition of a limit (ceiling) on extra remuneration to researchers and administrators involved in external consulting activity; (v) charges for transfers of patents; (vi) withholding of royalties from the sale of IP; and (vii) the share of royalties to be paid to inventors. The questionnaire survey showed that 95% of universities already had formally established a regulation for research contracts in 2007. The survey provides information on the particular year in which universities adopted a particular knowledge transfer policy and we use this information to account for "time invariant" academic strategy at the university level by including the specific year of adoption of a particular policy by a particular university, in the analysis.

3. The third data source is a web survey carried out in 2007 on university technology transfer activities.[3] The 197 academic departments in Italy which responded to the survey, provided data on the characteristics of university technology transfer offices (TTOs) such as the year of creation, and type of management (*see* Muscio, 2010). This information is available for 45 University out of 61. We double-checked the reliability of this data source using information provided in the NETVAL survey, which collects information on academic technology transfer activity in Italy on a yearly basis.

Our final sample, obtained merging these three data sources, covers 1283 academic departments which represent 75% of the whole population of Italian departments belonging to 43 public universities, located in 40 municipalities. In order to ensure consistency across the three data sources we restricted the frame period of analysis to the years 2007-2011.[4]

Table 1 reports the distribution of departments across the 14 scientific areas (SA) classified by the Italian University Council (CUN).[5] Overall, the departments engaged in research in all nine Scientific Areas of the Engineering and Physical Sciences (EPS) represent 63% of the whole sample, while the remaining departments operate in the fields of Social Sciences. Medicine accounts for the largest number of departments (256 units), and represents almost 20% of units. Engineering and Architecture (areas 8 and 9) account for about 16%.

3.2 Econometric specification

Table 2 presents information on the variables used in the analysis. The dependent variable is the amount of funding raised by the university department from research contracts, research-to-order and consultancies commissioned by public and private organizations and subject to university regulations (f_acadeng). We use f_acadeng as defined above as a proxy for 'academic engagement' activities at the department level.[6]

Our explanatory variables include controls for university knowledge transfer policies and the characteristics of intermediaries (age, type of management, etc.) in order to estimate the effect of university policies on departments' academic engagement performance. Table 3 reports some descriptive statistics for the variables included in the regressions.

Since a large fraction of departments received no external funding for contract research and consultancies in the period considered, our dependent variable is partly continuous with a positive and large probability mass around zero. We model the response variables in order to account for the presence of a corner solution outcome. We allow also for persistence in the process of collecting such types of external funding by introducing a 1-year lag in the dependent variable, in order to investigate the existence of an accumulation advantage along the lines of the Matthew effect argument (Merton, 1968).

We use y_{it} to denote department *i*'s funding from external non-academic sources collected at time t; the dynamic panel Tobit model with unobserved department effects is:

$$y_{it}^{*} = x_{it}'\beta + \delta y_{it-1} + c_i + c_t + u_{it}, \qquad i = 1,...,N,\ t = 1,...,T$$
$$y_{it} = \max(0, y_{it}^{*}) \tag{1}$$

where x_{it} is a set of department specific characteristics including controls for university knowledge transfer policies[7], y_{it} is the one year-lagged dependent variable, c_i are (random) department-specific effects, c_t are year effects, u_{it} is the error term. Year effects are included to account for cyclical variations in external funding.[8] In order to handle the initial condition problem in a dynamic, non-linear unobserved effects model, we follow the methodology suggested by Wooldridge (2005).[9]

The vector x_{it} also contains a set of covariates that might be correlated with department capability to engage in knowledge transfer activity, such as (twice lagged) public funding from MIUR and the European Commission,[10] department size (both in term of administrative and research staff), quality/reputation, management, location, research areas and university structural characteristics, and external spillovers.

<INSERT TABLE 2 HERE>

<INSERT TABLE 3 HERE>

3.3 Results

Table 4 reports the estimation results for the Tobit model. Columns (1) and (2) report the results (coefficients and marginal effects respectively) for the pooled Tobit model which ignores the presence of unobserved random effects; columns

(3) to (6) focus on the unobserved effects dynamic Tobit model, which is our preferred specification.

<INSERT TABLE 4 HERE>

Regarding the effect of university 'academic engagement' policies on departments' research-to-order, contract research and consulting activities, first, the presence of formal university level rules on academic engagement activities has a positive effect on the average amount of external funding received by researchers. The estimated coefficient is highly significant in both models (M1) and (M2), implying, ceteris paribus, a difference in the amount of funding from research contracts, research-to-order and consultancies equal to 1,500 Euros for researcher (see Column (4) and (6)). The estimated effects accounts for more than 50% of the observed difference in the volume of funding from academic engagement activities between departments with a dedicated regulation and departments without such a regulation. This result clearly indicates that regulation that provides a set of guidelines to manage the transfer process and to precisely specify the role of researchers and institutions is positively correlated with the likelihood of departments to engage in academic engagement. Second, the presence of a limit on the economic benefit that the researcher might obtain from these external research activities has a negative impact on the department's likelihood of collaborating with non-academic entities. The same disincentive effect arises when considering the amounts withheld to cover the costs related to patent transfers. Finally, we find that royalty sharing arrangements are key determinants of

performance. The estimated coefficient of the inventor royalty share is positive and significant. Increasing the inventor's royalty share by 10 percentage points results in an average increase in the volume of external research funding of about 100 euro per researcher with an implied elasticity of around 23%.

The next ranked determinant is knowledge transfer intermediaries. We include dummies for the presence of an Industry Liaison Office (ilo) and/or an office managing European patents (epo_mngmt). We control also for the characteristics of the ILO, such as the age, type and management. The presence of an ILO seems to have a positive effect (Table 4 columns 3 and 4), although this effect disappears when we control for ILO characteristics (Table 4, column 5 and 6). The remaining characteristics do not impact significantly on departmental external research activity. Among the variables that control for differences in university and department characteristics, reported in Table 4, we find that the presence of a medical school has a negative effect on department funding from academic engagement activities. This is explained mainly by the fact that medical schools are treated as autonomous cost centres, which means that research contracts, research-to-order and consulting activities are typically managed without departmental involvement. On the other hand the dummy for polytechnic universities has a positive (though only marginally significant) effect on consulting-contract research revenues. Departments in large sized universities are more likely to engage in collaborations. There are positive effects of critical mass in large academic institutions on external funding, expressed in terms of university reputation, visibility and research team size. Among department characteristics, our regressions show that structural characteristics have an impact on academic

engagement funding for departments. A department's capacity to raise financing from external sources depends largely on the type of research carried out by the department. Departments assigned to research areas a9 (Industrial Engineering) and a8 (Civil Engineering and Architecture) and to a lesser extent a7 (Agriculture and Veterinary) are more involved in external research activity. We find also that research performance (rating) has a large and significant impact on external research funding to universities, which means that high quality research generates valuable knowledge that can be passed to industry and that research performance provides a signal to industry of the best university departments. Finally, as also demonstrated in Muscio et al. (2013), the results confirm that public funding (from national sources and the European Commission) plays an important role in stimulating academic engagement activities.

Since the incentive systems to knowledge transfer set at the university level may have a different impact according to the department's intrinsic attitude to cooperate with non-academic institutions, in the next step of our analysis we analyse whether the effects of policies and strategies aimed to enhance departments and non-academic institutions interactions are homogeneous across different research areas. Following Coccia and Rolfo (2008), we classify our research departments into four homogeneous scientific research areas: (1) Basic sciences (B), which defines research departments operating in the field of mathematics, physics and chemistry; (2) Life Sciences (LF), which defines departments working in the fields of geology, medicine, biology and molecular biology; (3) Engineering and technology (ING), which defines departments operating in the fields of engineering, architecture and technology; and (4)

Humanistic, Social and Economic Sciences (HSE) which defines departments operating in the fields of sociology, psychology, law, economics and political science. We then use the same econometric specification as in (1) on the four groups separately. The results are reported in Table 5.

<INSERT TABLE 5 HERE>

Table 5 shows that 'academic engagement' policies at the university level have a significant and strong impact on the capability of collecting funding from contract research, research-to-order and consultancies in those departments operating in applied fields of research such as engineering and life sciences (column 2 and 3 respectively). For departments operating in these research areas, the presence of well-defined strategies at the university level aimed at regulating academic engagement activities provides incentives to academic researchers to engage in external collaborations. Similar effects, though the coefficients are smaller in magnitude and/or less precisely estimated, can be found for departments operating in the field of human and social sciences (column 4). Departments that are more basic research-oriented and less involved in external collaborations (column 1) do not respond to incentives aimed at regulating knowledge transfer features. Such a difference can be related to the fact that basic research oriented departments face obstacles to industry collaborations which are intrinsically linked to the nature of their research activity and, as such, more difficult to mitigate.

A strong role on the capability of attracting external funding is played even by monetary incentives as far as engineering and life sciences departments are concerned. In this case, both the limit on individual compensation and charges for patents/IPR sale/transfer influence departments' involvement in knowledge transfer activities. On the contrary, very weak or no evidence of this is found for basic sciences and social sciences departments.

4 Policy recommendations

4.1 Policy implications for national and supranational policy makers

There is unanimous agreement that universities can play an important role in fostering innovation and economic growth by intensifying knowledge transfer in favour of non-academic public and private institutions.

However, quite often policy makers, at least in Europe have pushed forward university knowledge transfer channels mainly to find additional sources of funding for university research, ensuring the financial sustainability of universities in a situation characterized by relevant government spending reviews. Indeed, the concern about the financial sustainability of universities is grounded. As Estermann and Claeys-Kulik (2013) underline, the high level of public funding in budgets of most European universities means that any reduction is bound to have a major impact on them. Nevertheless, our empirical results clearly show that public funding, in its several origins and forms (national or EU), is complementary

to external funding from academic engagement activities, which suggests not only that a shift from public to external funding is far from being neutral in terms of universities' capabilities of transferring knowledge through these less formal channels, but also that the possible cuts of public funding to universities should be operated selectively.

Secondly, it is worth noting that policy effort has been recently devoted to inducing universities to adopt strategic management tools with the aim of preserving their financial sustainability. In particular, there is an increasing political pressure for universities to adopt the 'full cost method', according to which universities should identify and calculate all direct and indirect costs of their activities, including projects, in order to ascertain whether they are financially sustainable or not (European University Association, 2008; Estermann and Claeys-Kulik, 2013) and to gather the necessary information to price external project-based academic research in a way which does not distort competition with other non academic research institutions operating in the market (European Commission, 2008). Discussing pros and cons of full costing as a methodology, as well as its antitrust implications, is beyond the scope of the present article. Nevertheless the emphasis put on the need of the adoption of a full costing methodology in universities cannot be seconded uncritically, as it could have heavy counter-indications in terms of university research performances and knowledge transfer capabilities. The most immediate and obvious consequence of uncritical full costing adoption is the increase in prices,[11] which would inevitably restrain non-academic institutions' demand for contract research and consultancies in case the full costs based price exceed their willingness to pay. In other words, considering that research activities

are often characterized by the presence of high and indivisible fixed costs (Arrow, 1962) and relatively low marginal ones, there is the possibility that a socially desired amount of research activities not be carried out, to the detriment of knowledge transfer.

Another, more subtle, element of concern related to the adoption of the full costing methodology is the risk of an 'academic drift' on a funding basis, i.e. universities could be led to undertake external research activities/projects chosen by giving priority not to their scientific appeal, but rather to the fact that they be fully funded.

As a general consideration, if universities, as expected, are asked to contribute to innovation and economic growth, then the policy measures addressing the academic institutions should be aimed at maximizing the amount and the rapidity of knowledge transfer activities, rather than the income deriving from them. Even if financial sustainability of universities is an important issue which has to be adequately taken into account when designing policy measures, it should not be set as the leading policy priority, as this would de facto neglect the crucial role played by publicly funded universities in remedying to innovation market failures.

4.2 Policy implications for the university level

The empirical results of our work clearly emphasize that the presence of a formal university regulation of academic engagement has a positive effect on departments' capability of becoming involved in these activities, which signals that non academic institutions are evidently more prone to demand for contract

research and consultancies to universities where clear and transparent economic and legal conditions are specified.

Going into details, within academic engagement regulation the most relevant issue seems to be the design of an appropriate monetary incentives scheme for faculty members to become involved in academic engagement activities. In fact, lower limits to individual compensation for academics that pursue these activities has a severe negative impact on the overall engagement of the department in knowledge transfer activities. Moreover, the amount withhold by university/department/centre is found not to be statistically significant in the aggregate regression, while it appears to be relevant and significant for departments mainly involved in 'life sciences' or 'engineering and technology'. Concerning this, it must be noted that 'life sciences' and 'engineering and technology' scientific areas are those in which research activities generally heavily rely on university technical facilities and laboratories, which implies that academic engagement activities in these areas are inevitably disclosed to university administrators and carried out officially. Differently, it is likely that our data do not capture the actual volume of academic engagement 'social sciences' areas and to a lesser extent in 'basic sciences', as the related research activities are often carried out on the basis of individual private contracts between the academic researcher and the external institution. Such differences between research areas suggest that departments belonging to the same university, rather than being constrained by a university-level knowledge transfer policy and regulation, should be enabled to autonomously define their on knowledge transfer strategy and regulation, in order

to calibrate them according to the peculiarities of the research activities they specialise in.

Finally departments' performance results positively influenced even by the amount of royalties share destined to participating academics, while it shows to be negatively associated to the level of withholdings charged by the university administration for patents' sale/transfer. Therefore, even in this case monetary incentives play a fundamental role in explaining departments' knowledge transfer performance.

Overall our empirical evidence suggests that university administrators should follow few but important policy recommendations. The norms regulating university knowledge transfer activities should embody effective monetary incentives schemes, designed in order to reward academics' participation into these activities. Possible withholdings in favour of the university/department/centre should be limited to those cases in which specific university facilities, laboratories and equipment are used within the research activity and calculated in order to cover the incremental costs. Furthermore, if universities are asked to put knowledge transfer among their priorities, then the inherent conflict of interest between the traditional academic reward system (focused on peer reviewed publications) and the knowledge transfer reward system (focused on revenue generation from commercialisation and academic engagement activities) should be adequately addressed (Siegel et al., 2007b), both at the national and at the local level. For instance the involvement in knowledge transfer activities, in their several forms, could be taken into account for advancement in academic career.

5 Concluding remarks

The recent scientific literature emphasizes that, in addition to the activities related to the commercialisation of academic research (essentially intellectual property creation and academic entrepreneurship), there are other less formal channels of knowledge transfer that many companies consider even more valuable than commercialisation (Cohen et al., 2002) and that can significantly contribute to innovation and economic growth. Contract research, research-to-order and consulting, activities which, following Perkmann et al. (2013), can be referred to as 'academic engagement', represent a powerful and effective way through which academic knowledge is transferred into the non-academic domain. 'Academic engagement' includes informal channels of collaboration which are highly relational and produce important learning-by-interacting effects (Perkmann and Walsh, 2008).

This paper contributes to our understanding of the role of university policies and governance systems on departments' ability to attract external funding via 'academic engagement'. We provide empirical evidence that the presence of rules regulating research contract and consultancy activity is beneficial for departments, and that monetary incentives and research income for researchers are crucial for explaining the different performance of departments in terms of their ability to collect external funding through academic engagement activities.

Furthermore, very interesting is that this type of external funding to departments seems to be positively affected more by the performance of academic research

(which evidently provides a quality signal to non academic institutions) than by the presence of an ILO or patent office. This suggests that university policies should focus more on increasing the quality of research than building facilities aimed at easing the process of knowledge transfer to industry, especially when these facilities are managed with the main objective of maximizing revenues instead of maximizing the number and the frequency of knowledge transfer opportunities.

Our findings confirm the existence of complementarities between public research funding (in its several forms) and funding from consulting and contract research activities, which is in line with other recent scientific contributions. From a theoretical point of view, there is a positive relationship between public and funding from contract research and consultancies insofar as expanding the knowledge base and accumulating technical and human capital enabled by public research funding increase the marginal rate of return (or reduce the incremental cost) of externally demanded research. This implies that the regulation of academic consultancies and research-to-order activities should be inscribed within a systemic framework to avoid possible conflicting effects: it could be that the possible positive impact on knowledge transfer to industry associated with government efforts to increase public research funding to universities would be nullified by poorly designed university consultancy regulation, i.e. regulation that weakens researchers' (monetary and rational) incentives to engage in research activities demanded by non-academic institutions. In this work, it has also been emphasized that national and supranational university policies, when designed without a comprehensive vision, could have perverse effects on universities'

capability of transferring knowledge, as in the case of the adoption of the full costing methodology.

It is well known that Italian universities are facing a decline in public funding which is forcing them to more carefully consider external funding options as a way to increase their financial sustainability. Therefore, universities often withhold a forfetary share of revenues from consulting and research-to-order activities that rely on university facilities (i.e. laboratories, technical and administrative personnel) in order to cover part of the related costs and/or overheads. However, the amounts withheld are often arbitrary and not directly related to the scientific area involved or the use of university facilities, and do not necessarily benefit the departments involved. This funding is sometimes used to finance initiatives totally unrelated to the research that generated the revenue, in some cases even to finance indiscriminate, all-round distribution to the entire administrative personnel (curiously labelled 'incentive projects'). This reduces the incentive for researchers to engage in consultancy activities, and may induce them to collaborate with industry unofficially (especially in departments such as humanities where no university technical facilities are involved).

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TABLES

TABLE 1: Sample Composition for Scientific Area

Code	Scientific Area	Frequency	Percent
Engineering and Physical Sciences (EPS)			
1 MAT-INF	Mathematics & Computer Science	61	4.75
2 FIS	Physics	41	3.20
3 CHIM	Chemistry	55	4.29
4 GEO	Geology	27	2.10
5 BIO	Biology	89	6.94
6 MED	Medicine	256	19.95
7 AGR-VET	Agriculture & Veterinary	76	5.92
8 ICAR	Civil Engineering & Architecture	100	7.79
9 ING IND-INF	Industrial Engineering	109	8.50
Social Sciences			
10 HUM	Humanities	136	10.60
11 SOC-PSY	SA Sociology, philosophy and psychology	94	7.33
12 LAW	SA Law	86	6.70
13 ECO	SA Economics and Statistics	107	8.34
14 POL	SA Political Sciences	46	3.59
TOTAL		1283	100

TABLE 2 : Data Source and Definitions

Variable	Definition	Data source
f_acadeng	Volume of funding from research contracts and consultancies from public and private organisations raised in the last financial year (2006-11)	MIUR
University technology transfer policies		
reg_pt	Regulation private contracts (yes/no)	Web survey
conflict	Rules regulating teaching and research activity (yes/no)	Web survey
amm_with		Web survey
h	Total amount of withholdings (%)	
limit_com	Limits on individual compensations (yes/no)	Web survey
charges_pa		Web survey
t	Charges for patents transfer costs (yes/no)	
roy_ric	Inventor royalty share (%)	Web survey
University technology transfer intermediaries		
ilo	Presence of an Industry Liaison Office	MIUR
epo_mngm	Presence at the university of an office managing European patents.	MIUR
t	Normally this task is carried out by offices for valorisation of research results or by TTOs. These offices have the mission of supporting research staff in commercialising the results of scientific research establishing collaborations and mediating between agents.	
ilo_age	Number of years of ILO activity	Web survey
ilo_univ	ILO at university level	Web survey
ilo_iter	ILO at inter-university level (base group)	Web survey
ilo_ext	Professional non-academic manager	Web survey
ilo_prof	University professor manager	Web survey
ilo_adm	University administrative manager	Web survey
Departments' source of revenue		
f_ec	Research funding from the EC (2005-11)	MIUR
f_miur	Research funding from MIUR (2005-11)	MIUR
f_uni	Research funding from own university (2005-11)	MIUR
f_pbadmit	Research funding from other national and regional governmental bodies (2006-11)	MIUR
Departments' characteristics		
p_research	Number of research staff (full professors, associate professors, assistant professors, research officers) and PhD students (2005-11)	MIUR
sh_s	Share of senior research staff	
rating	Research rating published by MIUR in 2007, based on the evaluation of research output carried out over the period 2001-03. This composite indicator takes into account peer review evaluations of research activity carried out at academic institutions (patents, impact factor of journal articles, etc.)	CIVR VTR (MIUR, 2007)
Scientific areas	Predominant departmental scientific research area	MIUR-CINECA
- a1	SA Mathematics & Computer Science	
- a2	SA Physics	
- a3	SA Chemistry	
- a4	SA Geology	
- a5	SA Biology	
- a6	SA Medicine	
- a7	SA Agriculture & Veterinary	
- a8	SA Civil Engineering & Architecture	
- a9	SA Industrial Engineering	
- a10	SA Humanities	
- a11	SA Sociology, philosophy and psychology	
- a12	SA Law	

- a13	SA Economics and Statistics	
- a14	SA Political sciences	
University characteristics		
d1-d4	Size of the academic institution where the department is located. University size is expressed in terms of number of students: 1 small (<10,000); 2 medium (10,000-15,000); 3 large (15,000-40,000); 4 mega (>40,000)	MIUR (2007)
polytech	Location of the department in a polytechnic university (four in Italy)	University website
med_school	Presence of a medical school	University website
Indicators of local demand for technology		
geo_s, geo_c, geo_nw geo_ne	Geographical location of the department respectively in Southern, Central, North-East and North-West Italy	
firmsize	Average size of manufacturing companies in the administrative province where the department is located	ISTAT 2001 Census
epoprov	Number of European patents granted to industrial researchers resident in the administrative province where the department is located during the period 2000-06	PATSTAT database elaborated by Centro KITES, Università Bocconi

TABLE 3: Descriptive Statistics

Variable name	Description	Obs.	Mean	S.d.	Min	Max
	University technology transfer policies					
	Regulation private contracts					
reg_pt	Regulation private contracts (yes/no)	61	0.95	0.22	0	1
conflict	Rules regulating teaching and research activity (yes/no)	61	0.44	0.50	0	1
amm_withh	Total amount of withholdings (%)	61	0.18	0.17	0	0.86
	for the University	60	0.10	0.08	0	0.42
	for the Department	51	0.06	0.11	0	0.69
	for the Centre	50	0.04	0.06	0	0.27
limit_com	Limits on individual compensations (yes/no)	61	0.61	0.49	0	1
	on administrative staff	58	0.58	0.50	0	1
	on research staff	55	0.50	0.50	0	1
	Regulation Intellectual Property (IP)					
reg_ip	Regulation intellectual property (yes/no)	61	0.36	0.48	0	1
charges_pat	Charges for patents sale/transfer (%)	61	0.31	0.29	0	1
roy_ric	Researcher royalty share (%)	55	0.49	0.37	0	1
	University technology transfer intermediaries					
	TTOs					
ilo	Industry Liaison Office (yes/no)	61	0.77	0.43	0	1
epo_mngmt	Patent Office (yes/no)	61	0.72	0.45	0	1
	ILO characteristics (if ilo=yes)					
ilo_age	ILO age	47	1.08	2.03	0	8
ilo_univ	University ILO (yes/no)	47	0.82	0.39	0	1
ilo_inter	Inter-university ILO (yes/no) – *Base group* -	47	0.18	0.35	0	1
	ILO manager (if ilo=yes)					
ilo_prof	University professor (yes/no)	45	0.52	0.51	0	1
ilo_adm	University administrative (yes/no)	45	0.32	0.47	0	1
ilo_ext	Professional non-academic (yes/no) – *Base group* -	45	0.16	0.37	0	1
	Other University characteristics					
University structure						
med_school	medical school	64	0.56	0.50	0	1
polytech	polytechnic university	64	0.06	0.24	0	1
d1	small university (<10000 students)	60	0.20	0.40	0	1
d2	medium university (10000-14999)	60	0.17	0.38	0	1
d3	large university (15000-39999)	60	0.47	0.50	0	1
d4	mega university (>39999)	60	0.17	0.38	0	1
Geographical characteristics						
geo_c	centre	64	0.23	0.43	0	1
geo_s	south	64	0.34	0.48	0	1
geo_ne	north-east	64	0.20	0.41	0	1
geo_nw	north-west –*Base group* -	64	0.22	0.42	0	1
epoprov	number of European patents granted in the local area	64	9.93	17.13	0	58.70
firmsize	average size of manufacturing firms in the local area	64	7.72	2.36	3.11	11.78
	Department characteristics					
Financial revenues per researcher (in thousands of Euros)						

		563		11.5		162.2
f_acadeng	Research contracts and consultancies	6	5.82	3	0	9
	Italian Ministry of University and	563				152.4
f_miur	Research (MIUR).	6	2.22	5.12	0	0
		563		10.6		426.5
f_ec	European Commission	6	2.50	5	0	0
		563				
f_uni	Internal transfers	6	3.35	3.75	0	47.40
		563				243.4
f_pbadmit	Other public bodies	6	3.43	9.79	0	2
Researchers characteristics						
		563	32.3	19.9		
p_research	Research staff	6	2	5	2	201
		563				
sh_s	share of senior research staff	6	0.30	0.10	0	0.93
					0.	
		563			3	
rating	Research rating published by MIUR	6	0.78	0.10	7	1
Scientific areas dummies						
	SA Mathematics & Computer Science –	563				
a1	*Base group*-	6	0.05	0.22	0	1
		563				
a2	SA Physics	6	0.03	0.18	0	1
		563				
a3	SA Chemistry	6	0.04	0.20	0	1
		563				
a4	SA Geology	6	0.02	0.14	0	1
		563				
a5	SA Biology	6	0.07	0.25	0	1
		563				
a6	SA Medicine	6	0.20	0.40	0	1
		563				
a7	SA Agriculture & Veterinary	6	0.06	0.24	0	1
		563				
a8	SA Civil Engineering & Architecture	6	0.08	0.26	0	1
		563				
a9	SA Industrial Engineering	6	0.08	0.28	0	1
		563				
a10	SA Humanities	6	0.10	0.31	0	1
		563				
a11	SA Sociology, philosophy and psychology	6	0.07	0.26	0	1
		563				
a12	SA Law	6	0.07	0.26	0	1
		563				
a13	SA Economics and Statistics	6	0.08	0.27	0	1
		563				
a14	SA Political Sciences	6	0.04	0.18	0	1

TABLE 4: Dynamic Panel data tobit regressions.

Dependent variable: f_acadeng	**Pooled Tobit**		**Random Effects Tobit (M1)**		**Random Effects Tobit (M2)**	
	coeff.	marginal effects	coeff.	marginal effects	coeff.	marginal effects
	(1)	(2)	(3)	(4)	(5)	(6)
University technology transfer policies						
reg_pt	2.908***	1.230***	3.562***	1.451***	3.778***	1.536***
	(0.791)	(0.304)	(1.012)	(0.367)	(1.312)	(0.471)
conflict	-0.613*	-0.285*	-0.619	-0.282	-0.403	-0.184
	(0.324)	(0.151)	(0.416)	(0.190)	(0.582)	(0.266)
amm_withh	0.564	0.262	0.623	0.284	-0.0367	-0.0167
	(0.387)	(0.181)	(0.496)	(0.227)	(0.601)	(0.274)
limit_com	-0.794**	-0.372**	-0.867*	-0.398*	-1.077*	-0.498*
	(0.394)	(0.186)	(0.502)	(0.233)	(0.601)	(0.282)
charges_pat	-2.119***	-0.983***	-3.038***	-1.381***	-3.265***	-1.491***
	(0.756)	(0.350)	(0.976)	(0.443)	(1.142)	(0.521)
roy_ric	1.632***	0.757***	2.170***	0.986***	2.445***	1.117***
	(0.516)	(0.239)	(0.665)	(0.302)	(0.749)	(0.342)
Technology transfer intermediaries						
Ilo	0.806	0.367	1.029*	0.457*	-0.400	-0.131
	(0.513)	(0.229)	(0.621)	(0.277)	(1.418)	(0.663)
epo_mngmt	-0.218	-0.101	-0.364	-0.166	-1.062	-0.496
	(0.427)	(0.200)	(0.543)	(0.250)	(0.723)	(0.397)
ilo_age					0.100*	0.0457*
					(0.061)	(0.024)
ilo_univ					1.766	0.792
					(1.248)	(0.549)
ilo_prof					-0.254	-0.116
					(1.035)	(0.471)
ilo_adm					0.620	0.285
					(0.982)	(0.455)
University characteristics						
med_school	-2.035***	-0.985***	-2.384***	-1.139***	-3.104***	-1.521***
	(0.431)	(0.218)	(0.552)	(0.276)	(0.634)	(0.331)
polytech	0.782	0.372	0.829	0.387	1.314	0.625
	(0.753)	(0.366)	(0.968)	(0.462)	(1.095)	(0.541)
d2	-1.751***	-0.777***	-1.841**	-0.799**	-0.708	-0.317
	(0.672)	(0.285)	(0.864)	(0.358)	(1.132)	(0.497)
d3	1.566***	0.733***	1.811**	0.833**	2.965***	1.376***
	(0.601)	(0.284)	(0.772)	(0.359)	(0.838)	(0.395)
d4	1.890***	0.892**	2.276**	1.056**	4.227***	2.000***
	(0.730)	(0.350)	(0.939)	(0.444)	(1.108)	(0.542)
Other financial revenues (departments)						
f_acadeng(-1)	0.725***	0.336***	0.611***	0.278***	0.650***	0.297***
	(0.0107)	(0.0058)	(0.0188)	(0.010)	(0.0245)	(0.0125)
f_miur(-2)	0.079***	0.037***	0.092***	0.042***	0.088***	0.040***
	(0.019)	(0.009)	(0.020)	(0.009)	(0.0205)	(0.0094)
f_ec(-2)	0.0254*	0.0118*	0.0262*	0.0119*	0.0163*	0.00745*
	(0.0141)	(0.0065)	(0.0148)	(0.0067)	(0.0098)	(0.0045)
f_uni(-2)	-0.0259	-0.0120	-0.0193	-0.00876	-0.0447	-0.0204

	(0.0347)	(0.0161)	(0.0369)	(0.0168)	(0.0373)	(0.0170)
f_pbadmit(-2)	-0.0031	-0.0014	-0.0054	-0.0025	-0.0057	-0.0026
	(0.0132)	(0.00612)	(0.0140)	(0.00638)	(0.0150)	(0.0068)
Other department characteristics						
a2	-0.267	-0.123	-0.267	-0.120	-0.419	-0.189
	(0.843)	(0.384)	(1.103)	(0.493)	(1.053)	(0.469)
a3	2.237***	1.112***	2.508**	1.231**	2.451***	1.207**
	(0.757)	(0.403)	(0.994)	(0.525)	(0.950)	(0.503)
a4	3.775***	1.979***	4.336***	2.262***	4.154***	2.166***
	(0.936)	(0.549)	(1.232)	(0.728)	(1.176)	(0.692)
a5	1.327*	0.640*	1.789*	0.857*	1.641*	0.787*
	(0.707)	(0.355)	(0.921)	(0.464)	(0.886)	(0.445)
a6	2.488***	1.215***	2.761***	1.328***	2.703***	1.304***
	(0.614)	(0.315)	(0.801)	(0.407)	(0.774)	(0.393)
a7	3.256***	1.665***	3.738***	1.896***	3.748***	1.915***
	(0.752)	(0.421)	(0.980)	(0.550)	(0.976)	(0.553)
a8	4.285***	2.249***	5.185***	2.728***	5.141***	2.715***
	(0.695)	(0.409)	(0.909)	(0.545)	(0.893)	(0.536)
a9	6.022***	3.305***	7.606***	4.251***	7.090***	3.933***
	(0.675)	(0.431)	(0.903)	(0.600)	(0.908)	(0.591)
a10	-5.488***	-2.195***	-6.175***	-2.388***	-6.089***	-2.367***
	(0.715)	(0.243)	(0.919)	(0.298)	(0.891)	(0.290)
a11	-2.462***	-1.062***	-2.926***	-1.224***	-2.855***	-1.201***
	(0.716)	(0.287)	(0.926)	(0.355)	(0.901)	(0.348)
a12	-3.545***	-1.481***	-4.186***	-1.687***	-3.993***	-1.624***
	(0.757)	(0.283)	(0.975)	(0.346)	(0.959)	(0.344)
a13	0.397	0.186	0.0885	0.0403	0.146	0.0671
	(0.745)	(0.354)	(0.969)	(0.443)	(0.949)	(0.437)
a14	-0.138	-0.064	-0.486	-0.218	-0.267	-0.121
	(0.866)	(0.398)	(1.125)	(0.496)	(1.094)	(0.491)
rating	3.139*	1.456*	2.706	1.230	4.361*	1.992*
	(1.879)	(0.871)	(2.411)	(1.096)	(2.449)	(1.118)
p_research	0.0148**	0.007**	0.013*	0.006*	0.015*	0.007*
	(0.0064)	(0.003)	(0.008)	(0.004)	(0.008)	(0.004)
sh_s	0.269	0.125	0.584	0.266	0.451	0.206
	(1.300)	(0.603)	(1.593)	(0.724)	(1.568)	(0.716)
Geographical characteristics						
geo_s	-2.755***	-1.253***	-3.495***	-1.551***	-3.971***	-1.768***
	(0.680)	(0.303)	(0.879)	(0.381)	(1.196)	(0.519)
geo_c	-1.757***	-0.787***	-2.401***	-1.042***	-3.165***	-1.357***
	(0.650)	(0.281)	(0.844)	(0.349)	(0.980)	(0.393)
geo_ne	-1.523***	-0.682***	-1.960***	-0.851***	-3.363***	-1.423***
	(0.539)	(0.232)	(0.699)	(0.290)	(0.975)	(0.381)
epoprov	0.0226	0.0105	0.0296	0.0134	0.0685**	0.0313**
	(0.0173)	(0.00801)	(0.0223)	(0.0101)	(0.0300)	(0.0137)
firmsize	0.106	0.0490	0.0952	0.0433	0.299*	0.137*
	(0.106)	(0.0492)	(0.135)	(0.0614)	(0.160)	(0.0730)
Constant	-7.018***		-6.557**		-8.898***	
	(2.209)		(2.824)		(2.984)	

Year dummies	yes	yes	yes
Pseudo-R^2	0.423	0.421	0.441
Random effects vs. pooled Tobit (H_0: rho=0)		χ^2=78.99 (p-value=.000)	χ^2=32.22 (p-value=0.000)
Observations	5,636	5,636	5,467
Number of groups		1,283	1,244

Note: *, **, *** significant at 10%, 5%, 1%. Standard errors in parenthesis. Longitudinally-averaged explanator variables for each department and the initial outcome values are also included in the regressions Wooldridge (2005).

TABLE 5: Dynamic panel data tobit regressions by main scientific research areas

Dependent variable: f_acadeng

	Basic Sciences	Life Sciences	Engineering and Technology	Social Sciences
	(1)	(2)	(3)	(4)
University technology transfer policies				
reg_pt	0.809	2.647***	1.802*	0.997***
	(1.753)	(0.818)	(1.011)	(0.330)
conflict	-0.298	-0.129	0.321	-0.415*
	(0.918)	(0.564)	(2.121)	(0.220)
amm_withh	1.220	-1.471**	-1.372**	-0.270
	(0.931)	(0.692)	(0.664)	(0.245)
limit_com	-1.452	-1.628**	-0.526	-0.173
	(0.976)	(0.661)	(1.704)	(0.250)
charges_pat	-2.190	-1.028*	-6.623**	-0.354
	(1.491)	(0.539)	(2.686)	(0.464)
roy_ric	-0.0841	1.266**	3.153*	0.639**
	(1.077)	(0.653)	(1.783)	(0.310)
Technology transfer intermediaries				
ilo	-1.709	2.194	1.851	0.547
	(2.578)	(2.635)	(3.445)	(0.529)
epo_mngmt	-2.038	-0.246	-2.898	-0.0100
	(2.166)	(0.590)	(1.830)	(0.239)
ilo_age	0.113	0.221	0.924*	0.0698*
	(0.128)	(0.135)	(0.515)	(0.0412)
ilo_univ	0.314	3.122**	-0.0191	-0.206
	(1.561)	(1.290)	(3.603)	(0.495)
ilo_prof	1.674	-0.672	1.450	-0.773*
	(1.637)	(1.103)	(2.355)	(0.439)
ilo_adm	0.498	1.020	-0.464	-0.0480
	(1.549)	(1.190)	(2.806)	(0.425)
University characteristics				
med_school	-1.893	-2.632**	-1.186	-1.457***
	(1.241)	(1.100)	(1.593)	(0.327)
polytech	-1.297	-0.0211	0.272	2.109*
	(1.173)	(1.223)	(2.956)	(1.246)
d2	-0.277	0.691	0.311	-0.376
	(2.047)	(1.256)	(2.504)	(0.392)
d3	1.527	3.035**	1.347	0.639
	(1.213)	(1.220)	(2.013)	(0.421)
d4	2.436	4.267***	1.732	1.024*
	(1.886)	(1.126)	(2.727)	(0.595)

Other financial revenues (departments)				
f_acadeng(-1)	0.196***	0.431***	0.486***	0.0625***
	(0.0338)	(0.0113)	(0.0217)	(0.0165)
f_miur(-2)	0.0381**	0.0231*	0.0856**	0.0371*
	(0.0170)	(0.0137)	(0.0363)	(0.0198)
f_ec(-2)	-0.000948	0.0291**	0.00410**	0.0132
	(0.0144)	(0.0135)	(0.00212)	(0.0146)
f_uni(-2)	-0.0232	-0.0242	-0.0125	0.00404
	(0.0354)	(0.0303)	(0.0717)	(0.0192)
f_pbadmit(-2)	0.0262*	-0.0238***	0.0141	0.0139
	(0.0149)	(0.00907)	(0.0421)	(0.00919)
Other department characteristics				
a1	*ref.*			
	-			
a2	0.365			
	(0.596)			
a3	1.010**			
	(0.504)			
a4		-0.326		
		(0.563)		
a5		-1.201***		
		(0.433)		
a6		-0.641*		
		(0.351)		
a7		*ref.*		
		-		
a8			-1.520**	
			(0.687)	
a9			*ref.*	
			-	
a10				-1.137***
				(0.225)
a11				-0.545***
				(0.205)
a12				-0.671***
				(0.206)
a13				0.268
				(0.232)
a14				*ref.*
				-
rating	-3.104	4.796**	-5.622	0.587
	(4.266)	(2.305)	(7.458)	(0.831)
p_research	-0.00352	0.00590	-0.00104	-0.00147
	(0.00752)	(0.00668)	(0.0163)	(0.00360)

sh_s	0.345	1.627	1.083	-1.393**
	(2.170)	(1.284)	(3.258)	(0.547)
Geographical characteristics				
geo_s	-1.093	-2.588***	-0.917	-1.611***
	(1.647)	(0.892)	(2.820)	(0.468)
geo_c	0.779	-1.761***	-1.401	-0.965***
	(1.354)	(0.650)	(2.410)	(0.325)
geo_ne	-0.350	-2.662***	-0.0593	-0.746**
	(1.340)	(0.608)	(2.324)	(0.301)
epoprov	0.00906	-0.0110	0.0230	-0.0153
	(0.0455)	(0.0313)	(0.0912)	(0.0136)
firmsize	0.137	0.342**	0.234**	-0.0400
	(0.274)	(0.145)	(0.102)	(0.0725)
Year dummies	yes	yes	yes	yes
Pseudo-R^2	0.37	0.41	0.37	0.32
Random effects vs. pooled Tobit (H_0: rho=0)	χ^2=25.55 (p-value=.000)	χ^2=15.72 (p-value=.000)	χ^2=22.30 (p-value=.000)	χ^2=15.98 (p-value=.000)
Observations	702	1,912	891	1,962
Number of groups	150	445	206	443

Note: *, **, *** significant at 10%, 5%, 1%. Marginal effects. Standard errors in parenthesis. Longitudinally-averaged explanatory variables for each department and the initial outcome values are also included in the regressions Wooldridge (2005).

1 E.g.: national laws D.L. 27/7/1999 no. 297 and D.M. 8/8/2000 no. 593 encourage and regulate the creation of university TTO. Art. 65 of the Codice dei Diritti di Proprietà Industriale, 10/02/2005, grants intellectual property rights to scientists for their scientific discoveries.

2 Though there are several links and overlaps between 'commercialisation' and 'academic engagement', these activities may have different peculiarities as the former refer to inventions generated within universities and mainly exploited with the objective to reap financial benefits, the latter are characterized by an ex ante sharing of research projects and are pursued for varying objectives (Perkmann et al., 2013).

3 The survey was part of the research project 'The Governance of Technology Transfer in Italy',

funded by the Italian Ministry of University and Research (MIUR), and the FIRB project: 'A Multidimensional Approach to Technology Transfer'.

4 The financial data from MIUR database are available since 2005. However, given that the econometric model includes among the controls up to two lags of the financial variables (see paragraph 3.2), the empirical analysis refers exactly to the period 2007-2011.

5 The National University Council (CUN) classification of scientific areas is similar to that applied by the OECD in its Frascati Manual (OECD, 2002). The scientific areas considered here correspond to the areas identified by the Frascati Manual as: 1. Natural Sciences, 2. Engineering & Technology, 3. Medical Sciences, 4. Agricultural Sciences and 5. Social Sciences

6 The dependent variable f_acadeng does not include business funding to departments that is not compensated for by research results (such as in the case of private contributions to conferences and events, scholarships and prizes for proficient young researchers, etc.). These resources are counted as separate sources of revenue and in general are relatively small. f_acadeng also does not account for funding from research programmes/contracts that do not allow income distribution to research staff.

7 The variables included are a dummy for the presence of a regulation of private contracts in a given sample year, a dummy for the presence of rules regulating teaching and research activity, a dummy for the presence of university/department/centre withholding on revenues from academic engagement activities, the amount of withholdings, a dummy for the presence of limits on individual compensations, the amount (%) of charges for patents transfer costs and the share (%) of royalties retained by the inventor. See Table 2 and Table 3 for details of data source, definitions and descriptive statistics.

8 See Tables 2 and 3 for a more detail on the controls used in the model and some summary statistics.

9 The approach suggested in Wooldridge (2005) can be easily implemented for the Tobit and probit regressions through straightforward estimation using standard econometric software. This

methodology implies longitudinally-averaged explanatory variables for each department and the initial outcome values should be used as additional regressors. The coefficients of longitudinally-averaged explanatory variables are not reported here but are available from the authors upon request.

10 Both MIUR and EC funding are lagged twice, in order to avoid potential endogeneity or collinearity with the lagged dependent variable.

11 In fact, for the consulting and the contract research activities supplied to non-academic institutions universities will set higher prices because of the inclusion of indirect costing in the calculation base. Furthermore there are objective difficulties in calculating indirect costs at the project level, for the criticalities in identifying reasonable drivers in complex organizations as well as in figuring out the expected amount of projects which these overheads should be spanned over.