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Academic Licensing: a European Study

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Abstract

This paper is an empirical analysis of the impact that different organisational forms of the Technology Transfer Offices (TTOs) in Europe have on their licensing activity. Given the great diversity of organization forms prevailing across European TTOs, our paper attempts to shed more light on which of those forms might be more efficient. We use as a measure of efficiency and as dependent variable of our model the number of license agreements concluded. Controlling for staff, invention disclosures, quality of the academic institution, life science orientation and demand for technology, we find evidence for the importance of personnel with a PhD in science in the TTO to facilitate communication between academics and the TTO. We find that the age of the TTO has a significant but negative effect. We do not find a positive effect for private organization of the TTO. Our data is derived from the 2004-2005 survey on TTO activities by the Association of European Science and Technology Professionals (ASTP) and information collected from TTO web sites.

1 Introduction[1]

In its recent communication "Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation- implementing the Lisbon Agenda" (2007), the European Commission notes that “Europe has been less successful [than the US] at commercializing its [academic] R&D results”. It goes on to state there is a "clear need for EU-wide action to reduce the discrepancies between national knowledge transfer legal systems and practices".

The Technology Transfer Offices (TTOs) landscape in Europe is characterised by a bewildering diversity and rapid change. Germany has established patent exploitation agencies (PVAs – Patentverwertungsagenturen) in each of its states. In other countries several initiatives are underway to create national entities to assist academic institutions with technology transfer. The EC observes that "many existing European research and knowledge transfer offices suffer from a lack of critical mass". Yet in the UK, staffing levels above 20 are commonplace. In Belgium and Denmark, Technology Transfer Offices typically have only one staff member with a PhD degree or none at all while in Switzerland about half of TTO employees have a PhD degree. Several Technology Transfer Offices in the UK and Germany are organised as private entities and several French institutions appear to be moving in that direction[2].

This paper is an empirical analysis of the impact that different organisational forms of Technology Transfer Offices in Europe have on their licensing activity. Given the great diversity of organisation forms prevailing across European TTOs, our paper attempts to shed more light on which of those forms might be more efficient. Our dependent variable is the number of licences concluded which we model as a function of two inputs: staff and invention disclosures. We control for the quality of the academic institutions, their life science orientation and the demand for technology. Our variables of interest are the proportion of TTO personnel with a PhD in science, the status of the TTO (public or private) and TTO experience. We use data from the 2004-2005 survey on TTO activities by the Association of European Science and Technology Transfer Professionals (ASTP) and information collected on TTO web sites. We complement these data with certain Eurostat data series and bibliometric indicators from Thomson's ISI Web of Knowledge. Our sample consists of 51 TTOs that we observe over two years and 4 TTOs that we observe over one year.

[1] We thank the Association of European Science and Technology Transfer Professionals (ASTP) for access to data on TTO activities in Europe. We are indebted to Dietmar Harhoff for valuable advice and to Laurent Miéville for his insights into the technology transfer process. We are grateful to Alfonso Gambardella, Patrick Llerena, Mark Schankerman, Reinhilde Veugelers and seminar participants at LMU, Bocconi and the Economics of Technology Policy conference in Monte Verita for valuable comments and suggestions. The views expressed in this paper and any errors are our own.

[2] The INSERM, a major French academic research institution with more than 6000 researchers, has just converted its technology transfer office into a private institution.

We find evidence for the influence of TTO personnel holding a PhD in science on the number of licence agreements concluded. We also find an unexpected negative effect for private organisation of the TTO. Finally, we find that the age of the TTO has a negative and significant effect. We provide some plausible explanations for these results, based on discussions with European TTO representatives.

The role of Technology Transfer Offices in commercializing academic findings has been extensively studied in the economic literature. Most of the authors focus on the activity of technology transfer offices in the US. The interest in US university technology transfer is stimulated by the "dramatic" rise in university licensing since the passing of the Bayh-Dole Act in 1980. However, it is also justified for reasons of data availability. A notable exception is represented by Chapple *et al.* (2005) who analyse the activity of Technology Transfer Offices in the UK.

Thursby, Jensen and Thursby (2001), Jensen and Thursby (2001), Thursby and Kemp (1998), Siegel, Waldman and Link (1999), Friedman and Silberman (2003), Chapple *et al.* (2005), Lach and Schankerman (2003), and Belenzon and Schankerman (2007) consider licensing as the cornerstone of the commercialisation activity of TTOs. From the survey of Technology Transfer Offices in 62 major US universities conducted by Thursby, Jensen and Thursby (2001) it emerges that 71% of US TTOs reported that the generating revenue from licences is extremely important. The number of licence agreements signed follows with 49% of the TTOs indicating that as being extremely important.

These authors have examined three main aspects of university licensing: characteristics of the knowledge transferred through licensing, evaluation of TTO productivity and the role of incentives in licensing performance. The study of Thursby, Jensen and Thursby (2001) emphasizes that the "majority of inventions are at an early stage when they are licensed". This implies that further involvement of the inventor is required for a firm to be able to commercialise a product based on a university invention. For this reason, "optimal licence contracts cannot rely on only fixed fees, but instead must involve some sort of output-based payments, such as royalties" (Jensen and Thursby (2001)). Thursby and Kemp (1998), Siegel, Waldman and Link (1999), Friedman and Silberman (2003) and Chapple *et al.* (2005) evaluate the productivity of TTOs using as metrics the number of licences and the licensing revenue generated. They find that in addition to traditional TTO inputs such as staff and invention disclosures organisational and environmental factors play an important role in explaining differences in productivity across TTOs. Lach and Schankerman (2003) and Belenzon and Schankerman (2007) analyse the role of performance pay on university technology transfer. They find that incentives for academic researchers matter and that universities adopting performance pay schemes generate more revenue per licence. This effect is more pronounced in the case of private universities. Moreover, Belenzon and Schankerman (2007) analyse how the importance attributed by TTOs to local development affects licence revenue and the number of licence agreements concluded. They find that TTOs placing more importance on local development conclude more licence agreement but generate less revenue per licence.

Although these authors tackle university licensing from different perspectives, we can identify certain common features in their studies. First, these studies take the number of licences issued and the revenue generated as the main outputs of TTOs. Second, they assume that invention disclosures and staff are the main inputs of TTOs. Typically, the greater the number of invention disclosures and the size of a TTO, the greater the number of licences issued by the TTO and the higher the licence revenue generated. Siegel, Waldman and Link (1999) find that licensing activity in the US is characterised by constant returns to scale, while Chapple *et al.* (2005) find decreasing returns to scale for TTO licensing activity in the UK. Some authors control for the quality of the universities and their biomedical orientation. Thursby, Jensen and Thursby (2001) and Belenzon and Schankerman (2007) find university quality has a positive and significant impact on licensing. In addition, they find that the presence of a medical school has a positive impact on licence revenue. Lach and Schankerman (2003) obtain a similar result; their dummy for biomedical orientation affects licence revenue positively. Friedman and Silberman (2003), Lach and Schankerman (2003) and Chapple *et al.* (2005) control for the experience of TTOs, the latter being proxied by the number of years of existence of a TTO. Friedman and Silberman (2003) and Lach and Schankerman (2003) find that older TTOs conclude more licence agreement. Conversely Chapple *et al.* (2005) find that the age of a TTO has a negative impact on the number of licences and the revenue generated. They argue that this result could reflect diseconomies of scale, given the high correlation between their "age" variable and the size of a TTO. Finally, Belenzon and Schankerman (2007), Chapple *et al.* (2005), Friedman and Silberman (2003) and Siegel, Waldman and Link (1999) analyse the impact of local demand for technology on university licensing. They typically find a positive impact of concentration of technological activities on university licensing.

Our study on technology transfer in Europe draws largely from the contributions of these authors. We provide some conclusions on the determinants of TTO performance in Europe, the latter being measured by the number of licence agreements signed. We introduce in our analysis new variables of interest relating to the TTO personnel composition and to the public/private nature of its organisation.

The remainder of this paper is organised as follows. In Section Two we introduce our hypotheses on the determinants of TTO productivity. In Section Three we describe our dataset. In Section Four we describe the model and the econometric methodology adopted. In Section five we present our results. The last section concludes.

2 The determinants of TTO productivity

2.1 TTO output

We use the number of licences negotiated as a measure of TTO output. This is consistent with the fact that TTOs themselves perceive the number of licences (together with licensing revenue) as their main output. Studies of university TTOs based on US and UK data have typically used both licensing volume and licensing revenue as dependent variables (see Belenzon & Schankerman (2007), Chapple *et al.* (2005), Friedman and Silberman (2003), Thursby and Kemp (1998), Siegel, Waldman and Link (1999), Thursby, Jensen and Thursby (2001)). Other measures of TTO productivity that have been used include number of patents, number of start-ups and amount of industry-sponsored research.

In this paper we use European data and for reasons of data availability we are unable to estimate regressions using licensing revenue. While TTOs that seek to maximise the diffusion of university technology can probably be expected to negotiate as many licences as possible, those seeking to maximise revenue may prefer to focus on a small set of promising technologies [3]. In this case, we may be underestimating the performance of revenue-maximising TTOs. Another limitation is that we do not know the nature and details of the licence, including whether or not it is exclusive.

2.2 TTO Input

In this section we examine the determinants of TTO productivity, the latter being measured by the number of licence agreements concluded.

We distinguish between four main factors affecting the licensing activity of TTOs: those relating to the organisation of TTOs, invention disclosures, quality of the academic institutions and regional demand for technology. We are careful to distinguish between the productivity of TTOs and that of their academic institutions, the latter being defined by the number of invention disclosures and their quality.

We begin by examining the factors relating to the organisation of TTOs, specifically: staff, the proportion of employees holding a PhD, the experience a TTO has, and whether a TTO is a private or a public organisation.

Staff. We expect that TTOs with a large number of employees will conclude a greater number of licensing contracts. In fact, in a large TTO employees may

[3] Interestingly, Lita Nelsen, director of technology transfer at MIT, argues that universities should always adopt a volume strategy (Nelsen, 2006): rather than attempting to pick winners which is too difficult since university technology is at an early stage, TTOs should conclude as many licensing contracts as possible in order to maximise the probability of making a big hit.

specialise in those tasks they are most suited. This higher degree of specialization leads in turn to a higher number of licences. However, we expect that the relationship between the number of licences made and staff to be characterized by diminishing returns: beyond a certain size, any additional increase in staff yields fewer and fewer additional licences.

Proportion of employees holding a PhD in science. Among the factors affecting TTO productivity, the skill composition of TTOs plays an important role. We expect that TTOs employing staff with a PhD degree in science will conclud more licence agreements. To our knowledge, this hypothesis is new in the economic literature assessing the productivity of TTOs but it is consistent with the importance attached by several TTOs in Europe to recruting personnel with a PhD degree in science.

In a simple technology transfer model, an academic researcher makes an invention and then contacts the TTO to commercialize the invention. However, the relationship between TTO and researcher entails coordination costs that may be reduced when the TTO and the researcher have similar academic backgrounds and share common values. Thus, the importance of hiring PhDs in science lies in the reduction of the coordination costs involved in the knowledge transfer. However, while the presence of PhDs in a TTO is important, the TTO also needs personnel with experience in dealing with industry partners. Therefore, we expect the proportion of PhDs in science in a TTO to have a positive but decreasing impact on the number of licences made by a TTO. Moreover, beyond a certain level, an increase in the proportion of PhDs in science causes a reduction in the number of licences issued by a TTO.

Experience of a TTO. We expect the experience accumulated by a TTO to have a positive impact on the number of licence agreements concluded. In fact, TTOs are likely to negotiate a greate number of licensing agreements as they learn from experience. Lach and Schankerman (2003), Friedman and Silberman (2003) Chapple *et al.* (2005) adopt the age of a TTO as proxy for experience.

Economic incentives within the TTO. This is an area of particular interest as economists believe in the importance of incentives in many different settings. Although we have little information on the structure of incentives for TTO employees, we can observe whether a TTO is a private or a public organisation. Incentives may well differ according to the status of the TTOs as a private TTO may have different HR practices (salaries, bonus pay, hiring and firing). Thus we expect TTOs that are organised as private companies to offer stronger incentives to their employees resulting in more licences.

Invention disclosures. In most countries, university inventors are required by law to report new inventions to the TTO. We think of these invention disclosures as a primary input for the Technology Transfer Office. We expect that more invention disclosures will result in more licences. In addition, the technical composition of invention disclosures may matter, with academic inventions in certain fields being in greater demand than in others. Life science inventions appear to be special in this regard. Although we do not have data on the technical composition of invention disclosures, some institutions in our sample are focus exclusively on biomedical research. We control for this with the expectation that a focus on life sciences will result in more licences.

Institution quality. It is not just the volume of invention disclosures but also the quality of inventions disclosed to the TTO that matters. Invention quality cannot be observed- otherwise technology transfer would be an easier exercise! However, invention quality might be correlated with the quality of the academic institution, which can be more readily observed- for instance in terms of the bibliometric performance of its researchers. Potential licencees themselves probably take this correlation into account so that TTOs located in prestigious universities find it easier to find licencees (Sine, Shane and Di Gregorio, 2003). Therefore, we expect TTOs located in institutions whose researchers publish in top journals to generate more licences- either because inventions are of a better quality or because licencee think they are.

Demand for licences and concentration of technology firms. We expect TTOs located in regions with intensive technological activity to negotiate more licences. Firms operating in technology sectors tend to perceive academic institutions as a source of complementary assets, including licences for academic inventions. Therefore a high concentration of technology firms may constitute an incentive for academic institutions to produce the complementary assets required by firms, including a greater number of licences. Due to lack of data on concentration of technological firms, we assume a positive correlation between concentration of technological firms and regional wealth, the latter being proxied by regional GDP.

Impact on # licences	Expected
Staff	+
Staff squared	-
Proportion of employees holding a PhD	+
Proportion of employees holding a PhD squared	-
Experience of a TTO (proxied by age of a TTO)	+
Whether a TTO is a private organisation	+
Invention disclosures	+
Whether a research institution is specialised in biomedicine	+
Quality of university (proxied by # of articles in Science & Nature)	+
Demand for technology (proxied by regional GDP)	+

3 Data

3.1 The ASTP survey on European Technology Transfer Activities

Our empirical analysis is based on information provided by the ASTP 2006 Survey, integrated with additional sources of information (Eurostat, Thomson ISI Web of Knowledge and information extracted from the websites of European TTOs). The ASTP is the Association of European Science and Technology Transfer Professionals that provide technology transfer services to approximately 180 research institutions. According to the Proton Study for the European Union, ASTP, with its 209 members, represents 20% of approximately 1000 TTOs in Europe..

	AUTM Survey	UK Survey	Spanish Survey	ASTP Survey
Administered by :	Association of University Technology Managers (AUTM)	Initiated by Chapple et al. (2005) and UK Based Universities Company Association (UNICO)	RedOtri-Network of Spanish University TTOs	Association of Science and Technology Professionals (ASTP)
Since:	1996	2002	2001	2006
Coverage	Universities and research institutions in the US	Universities in the UK	Universities in Spain	Universities and research institutions in Europe (22 countries)
Number of respondents (usable answers in brackets)	190-380	~100 (40)	51 (40)	101 (~60)
Focus of the Survey	Licensing: # of contracts and revenue	Licensing: # of contracts and revenue	R&D contracts: # of contracts and revenue	Licensing: # of contracts (limited response rate for other measures of TTO output)
Used by:	See literature review	Chapple et al. (2005)	Caldera & Debande (2006)	Unused as of July 2007 (to the best of our knowledge)

Most of the studies on Technology Transfer Offices have used US data from the Association of University Technology Managers (AUTM). There have been studies of studies on technology transfer in European countries (Chapple *et al.* (2005) and Caldera and Debande (2006)). To the best of our knowledge, however, a multi-country sample of European TTOs has not yet been used

The 2006 ASTP survey was administered by the Maastricht Economic and social Research and training centre on Innovation and Technology (MERIT) on behalf of ASTP. This gathers information on technology transfer activities in 2004 and 2005. The survey response rate is 59%. We excluded from our final sample respondents who did not provide complete answers to the questions of interest[4]. Therefore, our final sample is composed of 51 academic institutions for which we have 2004 and 2005 data and 4 academic institutions for which we have 2005 only data. The institutions are based in 18 European countries (16 of which provided information for 2004): 38 are universities (34 of which provided information for 2004), 13 are research institutes and 4 are government agencies. Northern European countries account for the majority of the observations while Southern European countries are barely represented. This reflects in part the ASTP membership composition: only 19% of the 209 members belong to Southern European countries (Portugal, Spain, Greece and Italy).

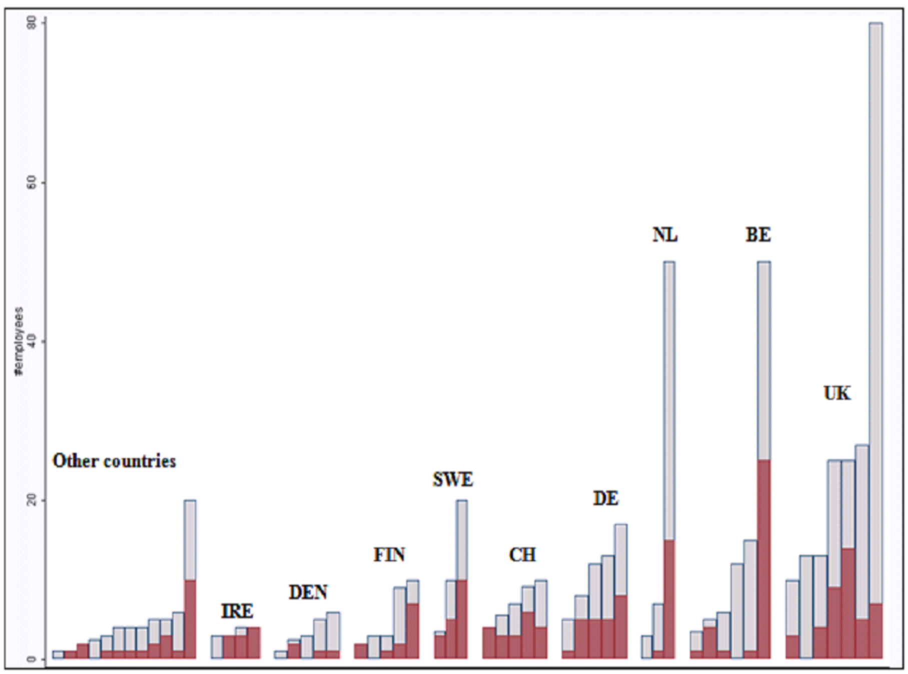
	Universities	Research institutes	Government agencies	Total
Austria	2	0	0	2
Belgium	5	0	1	6
Czech Republick	1	0	0	1
Denmark	4	1	0	5
Finland	4	0	1	5
France	0	2	0	2
Germany	2	3	0	5
Hungary	1	0	0	1
Iceland	1	0	0	1
Ireland	3	0	1	4
Norway	1	0	0	1
Portugal	0	1	0	1
Spain	1	1	0	2
Sweden	2	1	0	3
Switzerland	5	0	0	5
The Netherlands	0	2	1	3
Turkey	1	0	0	1
UK	5	2	0	7

[4]Since our sample includes only institutions that were able provide to information on their technology transfer activities, it is not random.

3.2 Staffing level and composition of European TTOs

Discussions with TTO representatives in Switzerland suggested that recruting personnel with a strong scientific background might facilitate the relationship with academic researchers and increase TTO productivity. To test this hypothesis in our sample, we manually collected information on TTO staffing composition. To facilitate data collection we asked for the number of employees with a PhD without indication of the field in which the PhD was obtained. However, several checks confirmed that that TTO employees with a PhD almost always obtained it in science.

Figure 1: Staffing level and composition of European TTOs



The graph above shows the number of TTO staff with a PhD (black bar) and the number of TTO staff without a PhD (grey bar); academic institutions are grouped by country. Staffing levels and composition exhibit substantial variation across academic institutions. Certain national patterns emerge: in the UK, TTOs tend to have many employees but only a small fraction of those have a PhD degree. In Germany, Switzerland and Sweden, TTOs tend to be small but with a high proportion of PhD personnel. Irish and Danish TTOs are both very small but differ in their composition, Irish TTOs having a high proportion of PhD personnel and Danish TTOs having a low one.

3.3 Description of variables

Our empirical specification of the number of licences issued by a TTO is based on the hypothesis we made in the previous section:

$$\begin{aligned}\#licences \quad = \quad & f(staff,\ staff2,\ share\_PhD,\ share\_PhD2,\ age,\ status,\ gov\_agency, \\ & disclosures,\ biomedical,\ top\_publications, GDP\_regio)\end{aligned}$$

Where:

- *# licences*= number of licences issued by a TTO in 2004 and in 2005
- *staff*= number of employees responsible for technology transfer services
- *staff2*=number of employees responsible for technology transfer services squared
- *share_PhD*=proportion of employees holding a PhD
- *share_PhD2*=proportion of employees holding a PhD squared
- *age*= years of existence of a TTO
- *status*=dummy variable that takes the value of 1 if the TTO is a private organisation and 0 if the TTO is a public organisation
- *gov_agency*= dummy variable that takes on the value of 1 if the TTO is part of a governmental agency and 0 otherwise
- *disclosures*= number of invention disclosures reported by an academic institution to the TTO in 2004 and 2005
- *biomedical*=dummy variable that takes the value of 1 if the academic institution is specialized in biomedical research
- *top_publications*=number of articles in Science and Nature reported by an academic institution in 2004 and 2005
- *GDP_regio*=regional GDP in million EUR

Data on the number of licence agreements concluded by a TTO and the organisation of a TTO (staff, staff2, age, gov_agency) originate from the 2006 ASTP survey. Data on the proportion of employees holding a PhD, whether a

TTO is a public or private organisation and on whether an academic institution focuses on biomedical research were manually constructed by gathering information from the websites of European TTOs and academic institutions. Data on the number of articles in Science and Nature reported by an academic institution in 2004 and 2005 were extracted from the Thomson ISI Web of Knowledge. Finally, data on regional GDP at the NUTS (Nomenclature of territorial units for statistics) 2 level breakdown came from the Eurostat REGIO database.

3.4 Summary statistics

We have 106 observations from 55 distinct TTOs. The distribution of licences is skewed to the left with many institutions with a very low number of licences and a few institutions with a large number. This is reflected in the fact that the mean number of licences is 22.9 while the median is only 4.5. The top 25% observations account for almost 87% of the total number of licences. This is not so surprising, however, since TTOs vary in their main inputs (staff, disclosures) with similar (although less sharp) patterns. The median TTO size is 5.75 and the mean is 10.9 employees. 88% of our TTOs had received at least five invention disclosures but the top 25% account for 62% of total invention disclosures. It is interesting to note that the proportion of PhD personnel varies substantially: about 30% have a proportion of PhD personnel of more than half while 18% had no PhD employees. A sizeable portion of our sample consists of young institutions (25% of observations have an age of 5 or less). About a quarter of our observations come from TTOs organised as private companies while only a few (7.5%) are government agencies. As for variables related to the academic institution as a whole, 11.3 % of our observations come from institutions focused exclusively on biomedical research, 30% of institutions in our sample had no publications in Science and Nature in 2004-2005 while 40% had more than five.

			Quantiles				
	mean	sd	min	p25	p50	p75	max
licences	22.91	73.24	0	1	4.50	16	544
staff	10.89	14.05	1	3	5.75	12	80
share PhD	0.39	0.31	0	0.17	0.33	0.56	1
age	10.88	7.89	1	5	9	17	37
status	0.25	-	0	-	-	-	1
gov agency	0.08	-	0	-	-	-	1
disclosures	41.02	42.20	0	9	23.50	67	194
biomedical	0.11	-	0	-	-	-	1
top publications	14.07	32.90	0	0	3	13	179
GDP regio	182.28	329.61	7.63	51.45	84.52	164.38	1792.89

Note: 106 observations from 55 distinct TTOs
(for 51 TTOs we have data for both 2004 and 2005, for 4 TTOs we have data for 2005 only)

4 Econometric estimation

We have a panel of observation over two years. However, we did a variance decomposition and found that 99.5% of the variance was due to the cross-sectional dimension of our panel. Since the variability between cross-sectional units is so much greater than variability across time, we chose to pool observations and treat our sample as a cross-section, ignoring the time dimension of the panel. However, we take into account the fact that two observations coming from the same cross-sectional unit may have something in common by correcting the standard errors with clustering on the cross-sectional identifier.

Since our dependent variable, the number of licences made by a TTO, can take only discrete and positive values, we assume it is governed by a Poisson process. In order to take overdispersion into account, we use a negative binomial specification which generalises the Poisson distribution by introducing an individual, unobserved effect into the conditional mean. The conditional expectation of the number of licences negotiated by a TTO can then be expressed as:

$$E\left[Y|X\right] = \exp(X_i\beta + e_i) = \exp(X_i\beta)\exp(e_i) = \exp(X_i\beta)\delta_i$$

Where:

- $y = \#licences$
- X_i =*staff, staff2, share_PhD, share_PhD2, age, status, gov_agency, disclosures, biomedical, top_publications, GDP_Regio*
- $\delta_i \sim \Gamma(\frac{1}{\alpha})$ with $\alpha > 0$, which implies $E(\delta_i) = 1$ and $Var(\delta_i) = \alpha$

For variables where we hypothesise a quadratic relationship (staff and share_PhD), we test the significance of higher order coefficients and drop them if insignificant.

5 Results

Independent variables	(1) Dependent variable= # licences	(2) Dependent variable= # licences	(3) Dependent variable= # licences
staff	0.128***	0.135***	0.149***
	(0.034)	(0.037)	(0.048)
staff2	-0.00156***	-0.00165***	-0.00165***
	(0.00038)	(0.00040)	(0.00054)
share_PhD	3.518*	3.528*	6.864***
	(1.83)	(1.85)	(1.93)
share_PhD2	-4.035**	-4.055**	-6.652***
	(1.88)	(1.88)	(2.11)
age	-0.0978***	-0.0929***	-0.0859***
	(0.022)	(0.022)	(0.027)
status	-0.616	-0.688*	-0.480
	(0.40)	(0.37)	(0.40)
gov_agency	-1.649***	-1.636***	-0.893
	(0.45)	(0.48)	(0.61)
biomedical	2.378***	2.617***	2.664***
	(0.51)	(0.46)	(0.58)
disclosures	0.0195***	0.0196***	
	(0.0035)	(0.0036)	
top_publications	0.0201***	0.0198***	0.0188***
	(0.0042)	(0.0047)	(0.0055)
GDP_regio	0.000356		
	(0.00050)		
Constant	0.487	0.450	0.452
	(0.40)	(0.42)	(0.44)
Observations	106	106	106
Clusters	55	55	55
Log Likelihood	-316.49	-316.92	-335.84
Chi-squared	294.28	268.93	116.15
Pseudo-R2	.187	.186	.137

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regression results are reported in the table above. The dispersion parameter alpha is significant which confirms that there is overdispersion in the model and justifies the use of a negative binomial rather than a Poisson. Our baseline model is reported in column (1). In column (2) we report the same model without regional GDP and in column (3) we exclude from the model regional GDP and disclosures. In our baseline model regional GDP is not significant, perhaps reflecting the fact that it may be a poor proxy for local demand for technology[5]. The number of invention disclosures is potentially problematic as it might be an output of the TTO and thus endogenous. Most of our results are robust to the three different specifications.

The coefficients for staff and disclosures, which are the main TTO inputs, always have the correct signs and are significant at the 1% confidence level. The staff squared coefficient is significant and negative, which is consistent with our hypothesis of diminishing returns to recruiting more TTO employees. The biomedical coefficient has the correct sign and is both very significant and large.

The relationship between the proportion of employees with a PhD degree and the number of licences made by a TTO appears to be quadratic. The coefficient for the PhD_share variable is positive and significant at the 10% significance level, while the coefficient for PhD_share2 is negative and significant at the 5% significance level. When we exclude the number of invention disclosures and regional GDP, the coefficients for PhD_share and PhD_share2 become significant at the 1% confidence level. Increasing the proportion of employees with a PhD degree seems to have a positive but decreasing impact on the number of licences issued by a TTO. Beyond a certain level, increasing the proportion of PhDs causes a reduction in the licence agreements concluded by a TTO.

Our control for the quality of the academic institutions- the number of articles published in Science and Nature- shows a positive and significant effect (at the 1% significance level) on the number of licences issued by a TTO. Our interpretation is that invention disclosed by high quality institutions are easier to commercialize.

Contrary to our expectations, age has a negative and significant effect on the number of licences issued by a TTO. We have three possible explanations for the negative coefficient.

First, when TTOs are created they may inherit a stock of invention from the past that have not yet been commercialised. Thus young TTOs having access to a larger pool of inventions to commercialise may negotiate more licences. Second, it may be that when TTOs become more mature they diversify their activities and spend less time negotiating licences. Finally, when answering to the survey question on the "creation year" some TTOs might have given the date at which an "embryonic" intellectual property office was converted into a more

[5] We considered other proxies for local demand for technology; it is however hard to obtain complete series for the regions in our sample.

structured TTO. Discussions with European TTO representatives confirmed the plausibility of these explanations.

The status of a TTO (defined as 1 if a TTO is a private organisation and 0 otherwise) has an unexpected negative sign and is even significant at the 10% confidence level in model (2). Our prior was that TTOs organised as private companies offer stronger incentives to their employees, thus leading to more licences. However, we find that organising the TTO as a private institution does not have a positive effect on TTO productivity and may even decrease it.

An explanation for this result is that private and public TTOs may have different strategies and objectives. In particular, private TTOs may prefer to focus on a smaller set of technologies in an attempt to maximise expected licensing revenue rather than the number of licences.

Alternatively, it might be the case that private organisation of the TTO makes interactions between academic researchers and TTO staff more difficult as the two institutions are less likely to share the same values and organisational culture. Moreover, private organisation of the TTO might diminish TTO employees' identification with the university and erode their intrinsic motivation. Interestingly, private TTOs also have a lower proportion of PhD personnel than public TTOs, which could enhance these effects.

Effect on # licences	Expected	Estimated
Staff	+	+
Staff squared	-	-
Share of employees holding a PhD	+	+
Share of employees holding a PhD squared	-	-
Experience of a TTO	+	-
(proxied by its age)		
Whether a TTO	+	-
is a private organisation		(insignificant)
Invention disclosures	+	+
Whether a research institution		
is specialized in biomedicine	+	+
Quality of University	+	+
(proxied by # of articles in Science & Nature)		
Demand for technology	+	+
(proxied by regional GDP)		(insignificant)

6 Concluding remarks

This paper investigated the licensing activity of Technology Transfer Offices in Europe. We undertook a quantitative analysis to derive evidence on issues of immediate policy interest such as staffing and organisation of the TTO. We used data from the 2006 ASTP survey and modelled the number of licences made by a TTO as a function of two main inputs - staff and the number of invention disclosures - and other control and policy variables.

Having controlled for the quality of academic institutions, their life science orientation and the conditions of local demand for technology, we find that the skill composition of a TTO plays an important role in determining its productivity. Employing PhDs appears to reduce the coordination costs arising from interactions between the TTO and academic researchers. Moreover, we find a negative and significant effect for age on the number of licences made by a TTO. Private organisation of the TTO seems to have a negative impact on the number of licences negotiated.

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