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A new perspective on the European Paradox

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Are the US outperforming Europe in university technology licensing? A new perspective on the European Paradox*

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1 Introduction

"Compared to North America, the average university in Europe, generates far fewer inventions and patents. This is largely due to a less systematic and professional management of knowledge and intellectual property by European universities."

(European Commission, 2007)

"Contrary to the paradox conjecture, European weaknesses reside both in its system of scientific research and in a relatively weak industry."

(Dosi, Llerena, Sylos-Labini, 2006)

The European Commission (EC) has stressed in several occasions[1] that Europe has been less successful than the US at converting its academic results into economic outcomes. In a number of documents it has advocated the importance of improving knowledge transfer between public research institutions and third parties, including civil society and industry partners.

The argument behind the EC's concerns is that while European research institutions are good at producing academic research outputs, they are not as good when it comes to transfer these outputs to the economy. This argument is known as the "European Paradox".

A number of economic studies contested the validity of the claim that European academic institutions are good at producing scientific knowledge (of quality). Controlling for the relative size of Europe and the US, Dosi et al. (2005) show that European countries are significantly lagging behind the US with respect to a number of indicators for academic quality, including the volume of publications and article's citations. Bauwens et al. (2008) point to the "massive" dominance of American universities in the total sample of ISI Highly Cited Scientists. They highlight that the gap in productivity between Europe and the US is due, in part, to a lack of financial resources made available for universities and research in Europe, but also to inefficiencies in the way these resources are managed.

Other studies have investigated whether it is true that the main weakness of European academic institutions lies in translating scientific knowledge into innovations. Crespi et al. (2008) show that while Europe lags behind the US in terms of university-owned patents, the gap becomes smaller when university-invented patents are taken into consideration. They analyzed the situation in six major European countries and showed that two thirds of the patents with at least one university

[1] See, for example, the Green Paper on Innovation (EC, 1995), the Third Report on Science and Technology Indicators (EC, 2003) or the communication titled "Improving knowledge transfer between research institutions and industry across Europe -embracing open innovation - Implementing the Lisbon Agenda" (EC, 2007).

inventor are not owned by universities. Similar results are found by Lissoni et al. (2008) who show that in France, Italy and Sweden most academic patents are not university-owned. These studies all focus on patents as a measure for technology transfer. This was partly due to a lack of quality data on licensing outcomes in Europe.

This study gives a contribution to understanding whether a "European Paradox" exists and, in case, what the causes could be. We tackle a specific aspect of university technology transfer which is the licensing activity of university technology transfer offices (TTOs) and we investigate whether US TTOs conclude more licenses and earn more license revenue than their European colleagues.

For this purpose, we complement public information available on US and European universities with new survey data on university technology transfer offices in Europe and in the US. The survey administered to European TTOs included questions on quantitative outcomes (i.e. number of licenses executed and license income) as well as other questions on objectives, metrics of success, staffing levels and composition. The target population was TTOs of universities located in Western Europe whose researchers published more than 200 scientific articles during the period 2004-2006. The response rate was 59.4%, with 211 answers coming from 15 countries. The survey administered to US TTOs was aimed at integrating the information available from the AUTM survey with questions on objectives, metrics of success and TTOs staffing composition. The target population was selected in the same way as for Europe and the response rate was 58%, with 89 answers.

In the first part of the analysis, we find that, having controlled for measures of academic scientific production and quality, academic orientation, demand for technology, national policies on university intellectual property rights (professor's privilege) and TTO staffing levels and experience, European TTOs do not execute less licenses than their US colleagues. However, they earn significantly less revenue from licenses. These results are robust to different specifications of the econometric model.

These results lead to a reinterpretation of the European Paradox. Differences in scientific performance between Europe and the US, pointed out by Dosi et al. (2005), explain a large of part of the difference in licensing outcomes. Once we control for scientific performance and other relevant factors, the difference between Europe and the US in the number of licenses vanishes while the difference in license revenue remains significant.

In the second part of the analysis, we explore the differences between Europe and the US that might explain why European TTOs earn less income than their US colleagues. We focus on three main hypotheses: 1) US TTOs place a greater emphasis on "generating revenue"as an objective; 2) US TTOs employ more staff with experience in the industry sector who might be more skilled at negotiating the financial clauses of licensing contracts; 3) US TTOs have greater flexibility in the management of their budget, including bonus pay for negotiating high revenue licenses and higher salaries and benefits to attract quality staff.

Contrary to our expectations, US TTOs do not attach more importance than their European colleagues to generating revenue when compared to other objectives such us local development and faculty service. However, 77% of the US respondents contended that the head of their TTO had at least five years experience in industry, while in Europe the percentage was 43%. Finally 67% of the US respondents said that they receive a direct share of license revenue, while in Europe this percentage is 28%.

In line with other studies investigating the "European Paradox", we considered Europe as a homogeneous entity. However, we show there are significant differences among European countries. Specifically, countries that have still in place the professor's privilege (Italy and Sweden), or that have recently abandoned it (Norway and Finland) seem to underperform the other countries. On the other end, countries like Switzerland and Belgium do significantly better than the European average.

The remainder of the paper is organized as follows. Section 2 reviews the determinants of TTOs productivity. Section 3 presents the empirical analysis. Section 4 describes differences in TTO organization and staffing that might explain why European TTOs earn less license income than their US counterparts. Section 5 concludes.

2 A review of the determinants of TTOs productivity

University Technology Transfer Offices are often seen as bridge institutions between universities and industry (Siegel et al. 1999). Their role is to facilitate the transmission of university knowledge to the economy.

Several studies have attempted to discern the factors affecting the productivity of TTOs, measured mainly in terms of number of licenses and license revenue (Thursby and Kemp, 1998; Siegel et al., 1999; Thursby et al., 2001; Jensen and Thursby, 2001; Friedman and Silberman, 2003; Lach and Schankerman, 2003; Chapple et al., 2005; Belenzon and Schankerman, 2007; Macho-Stadler et al., forthcoming). The majority of these studies have analyzed the functioning of TTOs in the US. The interest in US university technology transfer is mainly driven by the "dramatic rise" in university licensing since the passing of the Bayh-Dole Act in 1980. In recent years, university technology transfer has gained momentum also among policy makers and economists in Europe. As mentioned earlier, the European Commission in its communication "Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation – implementing the Lisbon Agenda" (2007), notes that Europe has been less successful than the US at commercializing academic research results. An increasing number of studies have started investigating the phenomenon of university technology transfer in Europe, with analyses at the country (Chapple et al., 2005) or at the academic institution level (Macho-Stadler et al., forthcoming). Inter-country comparisons are still lacking, mainly because of data availability issues.

When examining the licensing activities of TTOs, the economic literature has made a distinction between TTOs outputs and inputs. In the majority of cases the outputs are represented by the number of licenses and the license revenue. The inputs are usually classified into four main categories.

The first category includes the technology that is produced by an academic institution. As mentioned above, TTOs are expected to work with university inventions and ensure that there are disseminated in the economy. Measuring university technology is not an easy task though. Some economists suggest using the number of invention disclosures. This proxy seems to work well in studies on US university technology transfer. In fact, in the US, at least in principle, faculty members are required to disclose inventions to their TTOs. However, the same is not true in Europe where, in many cases, there are no formal requirements for academic scientists to disclose inventions. Other economists suggest using the number of patents. This measure, however, has serious drawbacks for a number of reasons. First, it is not clear whether patents are an input for licenses or vice-versa. In fact, in many cases, patents are filed only after a license is negotiated between an academic institution and the industry counterpart. Moreover, as we realized by discussing with technology transfer professionals in Europe, patents are often considered as an output *per se* by TTOs. Further, licenses are not always backed by patents as in the case, for instance, of software technology. Finally, in Europe, the same argument as for invention disclosures applies. Since academic researchers are usually not required to disclose their inventions to academic TTOs, the latter do not always have a recording of the patents that are filed by the researchers of their institution. Chapple et al. (2005) have suggested using total research income has a proxy for the stock of university technology, when analyzing the factors affecting TTOs productivity in the UK.

The second category includes the characteristics of the academic institution in which a TTO operates, namely the quality of the institution and its research orientation. The impact of quality on university technology transfer is twofold. On one hand, it affects the quality of the technology that is being produced; on the other hand, it impacts the "perception" a company has of the quality of university technology. As for the research orientation, it is commonly thought that institutions with a strong focus on engineering and life science tend to produce output that is more easily transferred to the industry sector, either because of its applied nature or because industry is interested in absorbing this output.

The third category encompasses the demand for technology in the geographical area where the academic institution is located. The logic is that TTOs will find it easier to conclude licensing agreements if there is a local demand for it. Moreover, the presence of high-tech companies in the proximity of an academic institution might have an influence on the output that is produced by the institution. The problem arising with measures of high-tech density is the definition of the appropriate geographical area. It is not always clear whether the geographic unit should be the county, the state (in case of federal organizations) or in some cases even the whole country.

The last category includes the characteristics specific to a TTO, namely the size of the staff and experience, the latter being measured by number of years since the foundation. It is commonly believed that the relationship between TTO size and output is characterized by diminishing returns to scale. Thus, adding one staff affects positively the number of licenses and license revenue, however the impact is decreasing with the number of staff that is added. Also, TTOs experience is usually found to have a positive effect on the output of a TTO, with a notable exception represented by Chapple et al. (2005).

There are, however, other factors that affect university technology transfer and that only recently have started to be investigated. These factors are: TTOs objectives, incentives and staff skill composition. TTOs objectives are important in shaping the activities performed by these offices. Their definition is often the result of the interplay of a number of institutions, including national and local authorities, the academic administration and the TTO itself. Belenzon and Schankerman (2007) find that TTOs with strong local development objectives earn less revenue from licenses and tend to make more licenses with local startup companies. The role of incentive pay on TTOs licensing activities has been analyzed by Belenzon and Shankerman (2007) who find that the adoption of incentive pay affects positively income earned from licenses. Finally, staff skills are of crucial importance when analyzing TTOs licensing activities. Interviews conducted by Siegel et al. (1999) suggest that staff with experience in the industry sector may better understand the needs and values of private companies. Conti et al. (2007) find evidence for the importance of personnel with a PhD in science to facilitate communication between academics and the TTO.

3 Empirical Analysis

3.1 Survey data

European data. This paper is based on a new survey of university technology transfer offices in Europe conducted in the summer 2008.

Pre-existing European data on university technology licensing suffer from important limitations. Most surveys are national-based and thus limited in scope. There are two surveys from professional associations covering several European countries. The survey from the Association of Science and Technology professionals includes only 75 answers from universities in its 2007 edition. The Proton survey includes more answers but suffers from severe problems of representativity, consistency and sample selection. Finally, none of these surveys have made their results publicly available at a disaggregated level[2], as is the case in the US.

The target population of our survey was TTOs of universities located in Western European countries whose researchers published more than 200 scientific articles during the period 2004-2006. Although there are a number of universities below that threshold, we expected that their technology transfer output would be rather limited and that many of them may not have a technology transfer office in the first place. A total of 351 universities met our eligibility requirements.

The contact persons for technology transfer were identified from university websites. The directors of the technology transfer offices were then contacted by phone and invited to answer an online questionnaire. In a small number of cases no contact person for technology transfer could be identified; we expect these cases to be universities that do not provide technology transfer services to faculty.

The questionnaire included questions on objectives, metrics, organisation, staffing levels and composition as well as licensing outcomes. To increase the response rate, we did not ask for the license income directly but asked respondents in which category their license income fell[3].

The response rate was 59.4% with 211 answers. We have answers coming from 15 countries with four or more answers for each country. Response rates are higher than the average for small countries such as Switzerland, Denmark, Belgium, Norway, Finland, Portugal and Ireland. The lowest response rates are for Germany with 27 answers out of 61 universities in the target population

[2]The ASTP has made the anonymized results of its survey available to some researchers on request.

[3]Prior testing showed that despite our promise of confidentiality some respondents were unwilling to indicate their exact license income, in particular if they had a very large or very small license income. The intervals were: less 30'000 euros, between 30'000 and 100'000 euros, between 100'000 and 300'000 euros, between 300'000 and 1 million euros and more than 1 million euros.

(44.2%) and Italy with 23 out of 51 (46%). The average university in our sample produced 2295 scientific publications in the period 2004-2006, which is slightly higher than the average university in the target population (2182 publications).

US data. Data on university technology licensing in the US is readily available from the Association University Technology Managers (AUTM) survey. We use the data from the publicly available 2006 AUTM survey which includes answers from 154 US universities. The coverage of the AUTM survey is excellent as it includes answers from 85% of US universities that have more than 200 scientific publications in Science and Engineering.

The AUTM survey did not include some of the questions we were interested in. Thus we contacted the respondents of the AUTM survey and asked them to answer a small number of additional questions from our European survey. We sent the survey to the 154 TTOs who had answered to the 2007 AUTM survey. We received 89 answers out of the target population of 154 respondents, i.e. a response rate of 58%. Our sample is broadly representative of the total population but smaller institutions are somewhat over-represented. The average number of publications for our respondents is 3835, whereas the average number for the entire population is 4381.

In the quantitative part of the paper we use the full AUTM sample (i.e. all AUTM survey respondents) while in the qualitative part we use the results of our US survey.

3.2 Descriptive statistics on licensing outcomes

It is interesting to first consider the differences in raw numbers between the US and Europe. Figure 4 displays a box plot of the numbers of licenses executed by US and European Universities. The mean number of licenses for European universities is only 7.8 compared to 26.4 for the US. The difference is not due to just a small number of strong performers in the United States. In fact, the median number of licenses for European universities is only 4 compared to 13 for US universities.

The differences in license income are equally striking. Figure 2 displays the number of universities who earn license revenues in the relevant categories[4]. Only 18 European universities have license revenues in excess of one million euros, whereas 71 US universities do. At the other end of the distribution, 81 European universities have license revenues below 30'000 euros, whereas only 9 US universities do.

[4]For US universities we know the exact license income figures but we convert the them to intervals to make them comparable with European data. We used the exchange rate prevailing on the first of January 2007 to convert the dollar amounts in euros.

Figure 1: Number of licenses

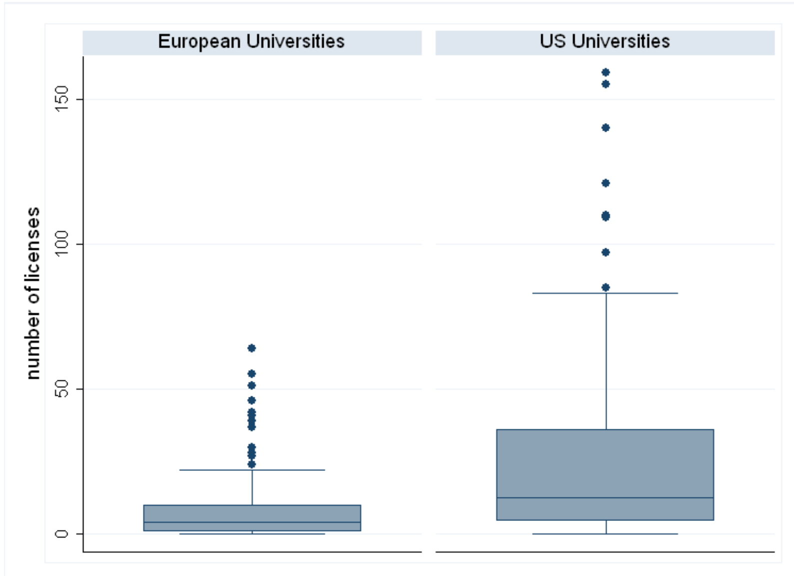
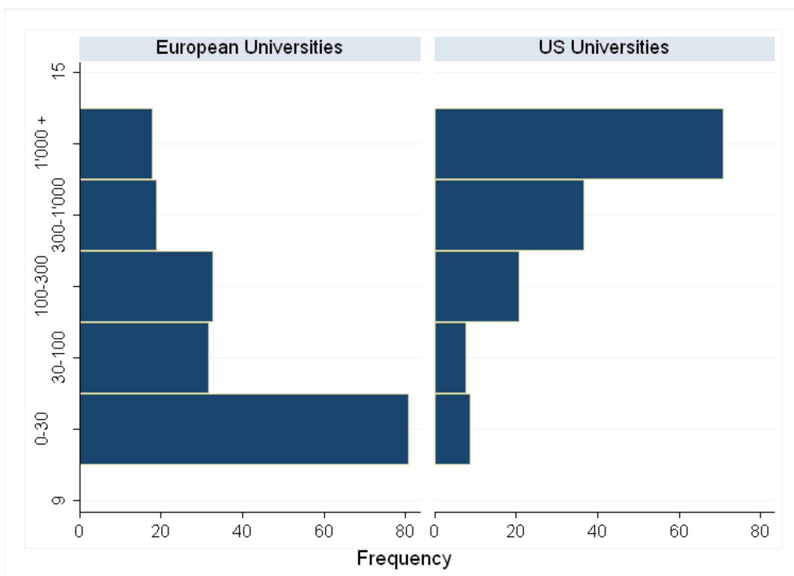


Figure 2: License income in thousand euros



These raw numbers suggest a superior licensing performance for US universities. However, this could be caused by US universities producing more knowledge or putting more effort into technology licensing.

3.3 Econometric specification

Regressions of the number of licenses. Since the number of licenses can take only discrete and positive values, we assume it is governed by a Poisson process. In order to account for overdispersion, we use a negative binomial specification which generalizes 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 = vector of control variables
- $\delta_i \sim \Gamma(\frac{1}{\alpha})$ with $\alpha > 0$, which implies $E(\delta_i) = 1$ and $Var(\delta_i) = \alpha$

Regressions of the license income. We do not observe the exact value for license income but only the interval in which it falls. Moreover, the observations are right-censored as we observe only that license income is greater or lower than the threshold value, 1.000.000 EUR, but we do not know what the upper bound is. For these reasons, we use the interval regression specification that allows addressing both types of issues. Interval regression assumes that data come from a normal distribution. In our case, license income is not distributed normally, however we can assume that its log follows a normal distribution. Therefore, if license income falls within our survey categories, its log should fall within the logs of these categories.

Interval regression is a generalization of the censored regression model, where the latent variable, y_i^*, is expressed as a function of x_i explanatory variables:

$$y_i^* = x_i'\beta + u_i \qquad \text{with } u_i \sim N(0, \sigma^2)$$

What we observe is $y_i = y_i^*$ if $y_{iL} \leq y_i^* \leq y_{iR}$ and $y_{iR} = y_i^*$ if $y_{iR} \leq y_i^*$.

All regressions are run with robust standard errors.

3.4 Determinants of licensing outcomes

Publication volume. We use the total number of articles in Science and Engineering during the period 2004-2006, published by researchers of the university, as reported in ISI Web of Science.

Quality of the academic institution and composition of the research. We experimented different measures of the quality of the academic institutions. In our preferred specification, we take the number of stars in life science and in engineering affiliated with the university. A star is defined as appearing on the ISI Web of Science list of highly cited researchers. Zucker et al. (1998) suggest that star scientists play a central role in both the development of the science and its successful commercialization. Their importance derives from the tacit component of breakthrough discoveries which cannot be easily diffused without involving the academic inventor.

As robustness check we use the score on the Shanghai world ranking of universities or specific components of that score (number of highly cited researchers, publications in *Nature* and *Science*, number of staff who have received the Nobel Prize or the Fields medal).

The number of stars in life science and in engineering also control for the composition of the research. Institutions with a strong focus on life science and engineering tend to produce output that is more easily transferred to the industry sector, either because of its applied nature or because industry is interested in absorbing this output. We control also for whether the university has a medical school or is a polytechnic school.

Age of the TTO. For European universities we do not know the exact year when the TTO was created because in the survey we only asked for intervals (between 2003 and 2007, between 1997 and 2002, etc.). Thus we create a discrete variable that takes increasing values for earlier years of fundation[5]. The age variable is defined in such a way that the coefficient of this variable in a regression can be interpreted as the effect of one additional year of experience.

Professor's privilege. Several European countries used to have a law (commonly referred to as "professor's privilege") in place according to which the intellectual property generated from university inventions belonged to the researcher rather than to the university. The professor's privilege was abolished in Germany (2001), Norway (2002), Denmark (2004) and Finland (2007). However, the professor's privilege is still in place in Sweden and was introduced in Italy in 2005. One implication of this regime is that university researchers are under no obligation to even report

[5]The variable takes the value 3 if the TTO has been created between 2003 and 2007, the value 8 if created between 1998 and 2002, 13 if created between 1993 and 1997, 18 if created between 1988 and 1992 and 23 if created earlier than 1988.

licensing activities to the technology transfer office. To take this into account we construct a dummy that assumes the value one if the university is located in Sweden, Italy or Finland. We included Finland in the definition of the countries with professor's privilege because it abolished the privilege only very recently. However, our results are robust to not including Finland in the definition of countries with professor's privilege.

Demand for technology. We use the gross domestic product per capita at the regional level (Europe: country level; US: state level). While we would have preferred to use other controls for the demand for technology, we could not find series at the regional level that are both available for all our observations and comparable across countries.

Staffing level. For the US we know how many licensing staff (full time equivalents) are employed by the TTO. For Europe, we know the total staff in the TTO and the percentage of time they spend on licensing. Therefore by multiplying the two we have a measure that is equivalent to the US variable.

Descriptive statistics. Table 1 presents descriptive statistics for the control variables, distinguishing between European Universities and US universities. Large differences are apparent. The average US university in our sample produces almost twice as many publications as the average European university in our sample. US universities also have far more highly cited scientists in biology and engineering. Furthermore, the TTOs from US universities are older and tend to employ more staff devoted to licensing than their European counterparts.

Table 1 - Descriptive Statistics

	Europe (n=177)				US (n=142)			
Variable:	μ	σ	**Min**	**Max**	μ	σ	**Min**	**Max**
Publications	2331	1908	200	8893	4438	4054	200	26366
Stars bio	0.48	1.406	0	12	2.415	5.615	0	50
Stars engineering	0.271	0.901	0	8	1.767	3.526	0	23
Poly	0.079	-	0	1	0.056	-	0	1
Medical School	0.028	-	0	1	0.112	-	0	1
Age	9.6	6.2	3	23	17.4	5.99	3	23
Privilege	0.197	-	0	1	0	-	0	0
GDP per capita	37'683	9887	17053	63588	36'895	5'659	24477	56496
Staff	2.277	2.711	0	24	4.584	3.98	0	22

3.5 Results

The results of the regression on the number of licenses are displayed in table 2. In column I we show that if we do not include any control, the coefficient on the US is large and significant. Once we control for the quantity, quality and composition of the research as well as GDP per capita (column II), the coefficient on US drops by half but remains significant at the 1% confidence level. This reduction is hardly surprising as US universities produce more publications and employ more stars than European universities. In column III, we control for countries that either have in place the professor's privilege (Italy and Sweden) or that have recently abolished it (Finland). This reduces the coefficient on US further. In column IV we add the age of the TTO and the number of staff employed in licensing. This specification constitutes our preferred, or baseline, regression. When we add these controls, the coefficient on US becomes small and no longer significant.

In the last column, we allow for interaction effects between US and staff as well as between US and age. These effects are not significant[6]

The regression results lead us to conclude that there is no large difference between US universities and European universities when we consider the number of licenses and control for the relevant inputs. This continues to be true in various alternative specifications detailed later.

In table 3 we conduct the same exercise with the license income (in log) as the dependent variable. In column I we introduce the dummy US without adding any control. The coefficient on US is large, positive and highly significant. When we progressively add the controls as we did for the number of licenses (columns II, III, IV), the coefficient on US is reduced. However, it remains large and significant at the 1% confidence level.

As we did before, we include in column V interaction terms between US and age and between US and staff. Their coefficients are positive but not significant.

[6]This is also the case for other interaction effects not reported here.

Table 2 - Results on the number of licenses

	(I)	(II)	(III)	(IV)	(V)
	Number of licenses				
US	1.197a	0.612a	0.436a	0.023	-0.336
	[0.133]	[0.144]	[0.143]	[0.146]	[0.374]
poly		0.600b	0.633b	0.423b	0.481b
		[0.277]	[0.247]	[0.187]	[0.194]
med_school		0.020	0.048	0.021	0.002
		[0.211]	[0.209]	[0.182]	[0.178]
publications		0.220a	0.234a	0.123a	0.112a
		[0.028]	[0.027]	[0.025]	[0.024]
stars_engineering		0.031	0.029	0.022	0.015
		[0.022]	[0.021]	[0.018]	[0.018]
stars_bio		-0.038	-0.046c	-0.031c	-0.031c
		[0.028]	[0.027]	[0.019]	[0.018]
GDP_capita		0.011	0.009	0.009	0.010
		[0.009]	[0.008]	[0.009]	[0.009]
privilege			-1.314a	-0.975a	-0.990a
			[0.236]	[0.216]	[0.216]
staff (log)				0.660a	0.556a
				[0.110]	[0.144]
age				0.039a	0.036a
				[0.010]	[0.012]
staff (log) interacted with US					0.280
					[0.198]
age interacted with US					0.001
					[0.019]
Constant	2.086a	0.986a	1.175a	0.292	0.420
	[0.090]	[0.349]	[0.326]	[0.402]	[0.425]
Observations	319	319	319	319	319
McFadden R^2	0.03	0.08	0.095	0.12	0.121

Robust standard errors in brackets; a significant at 1%, b at 5%, c at 10%

Table 3 - Results on license income

	(I)	(II)	(III)	(IV)	(V)
	License income (log)				
US	3.213a	2.489a	2.125a	1.636a	0.249
	[0.308]	[0.273]	[0.271]	[0.272]	[0.706]
poly		0.69	0.747	0.535	0.589
		0.485]	[0.471]	[0.444]	[0.44]
med_school		-0.468	-0.441	-0.27	-0.205
		[0.501]	[0.483]	[0.464]	[0.467]
publications		0.366a	0.408a	0.252a	0.231a
		[0.078]	[0.077]	[0.078]	[0.0791]
stars_engineering		-0.0064	-0.0297	-0.055	0.063
		[0.104]	[27,720]	[0.0964]	[0.0976]
stars_bio		0.278a	0.270a	0.242b	0.0296b
		[0.098]	[0.104]	[0.0986]	[0.1]
GDP_capita		0.04a	0.031b	0.034b	0.034b
		[0.015]	[0.14]	[0.0142]	[0.014]
privilege			-1.62a	-0.993b	-1.076a
			[0.41]	[0.403]	[0.399]
staff(log)				0.789a	0.624b
				[0.237]	[0.258]
age				0.0623a	0.0396c
				[0.0198]	[0.0233]
staff(log) interacted with US					0.476
					[0.522]
age interacted with US					0.0576
					[0.43]
Constant	10.78a	8.298a	8.867a	7.644a	8.115a
	[0.193]	[0.669]	[0.608]	[0.65]	[88,708]
Observations	313	313	313	313	313
McKelvey and Zavoina R^2	0.238	0.318	0.349	0.391	0.382

Robust standard errors in brackets; a significant at 1%, b at 5%, c at 10%

3.6 Robustness checks

Given that the number of observations is relatively small, there is a legitimate concern that our results may be sensitive either to the definition or to the composition of the sample. For this reason we conducted a number of robustness checks to verify that the results of modest or no difference in licensing number but significant difference in license income still hold.

The robustness checks for the number of licenses are displayed in table 7 in the appendix. In column I we show the baseline regression. In column II, we exclude 5% of observations that had the largest residuals and 5% that had the smallest residuals. Successively, in column III, we run the regression without including Finland in the definition of countries with professor's privilege. Finally, in column IV, we run the regression without the top performers, Switzerland and Belgium. The coefficient on US is never significant and remains small. Other robustness checks, not reported here, such as different proxies for the quality of the institution and for the composition of the research led to the same conclusion.

The robustness checks for the license income are displayed in table 8 in the appendix. Again, column I is the baseline regression. In column II we exclude the outliers. In column III, we include Germany, Norway and Denmark in the definition of professor's privilege countries. As these countries abolished the professor's privilege only recently, the effect of the old legislation might still be felt on current license income. In column IV and V, we estimate the baseline specification using an ordered logit and ordered probit model, respectively. In all cases, the coefficient on US is positive and significant at the 1% confidence level.

3.7 Heterogeneity within Europe

In our analysis, we have implicitly assumed that Europe was an homogeneous group. Even though we took into account the professor's privilege, cross-national differences may go beyond regulations of intellectual property ownership. While we do not have enough data to analyze cross-national differences within Europe in detail, the residuals of our regressions may provide some clues.

Figure 3 displays the residuals of the license number regression, averaged by country. A positive value indicates that on average universities from the relevant country do more licenses than predicted by our model, while a negative value indicates the opposite. To facilitate the interpretation of the graph, we computed the residuals from the baseline regression (column IV) but without the professor's privilege dummy. As it appears from the figure, Switzerland and Belgium have high positive residuals, i.e. they make more licenses than predicted by our model. Conversely, Finland, Norway, Sweden and to a lesser extent the UK have high negative residuals, meaning that they do less licenses than predicted by the model.

Similarly, figure 4 displays the residuals of the license income regression averaged by country. Sweden and Norway make substantially less license income than predicted. The worse performance of Scandinavian countries in licensing outcomes should be related to the fact that professor's privilege is either still in place or was only recently abolished in those countries. We control for this in the baseline regression. We have no immediate explanation for the strong performance of Switzerland and Belgium.

Figure 3: Residuals of the license number regression

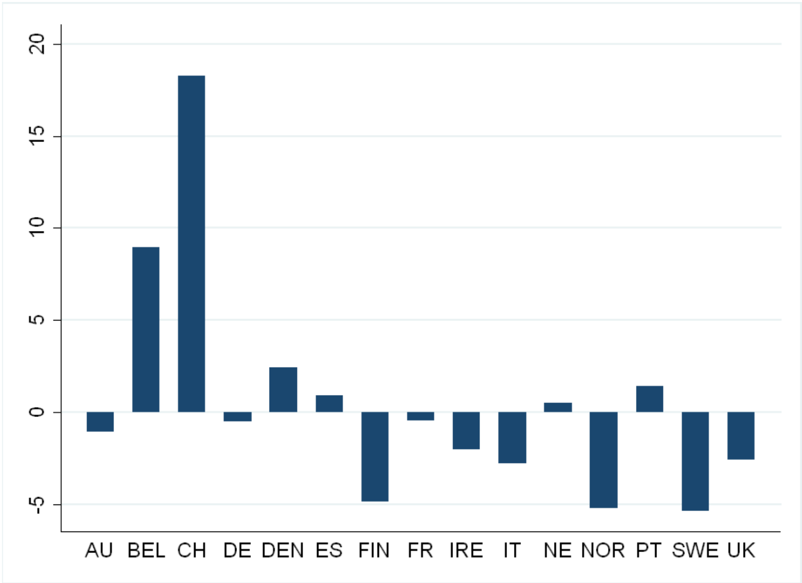
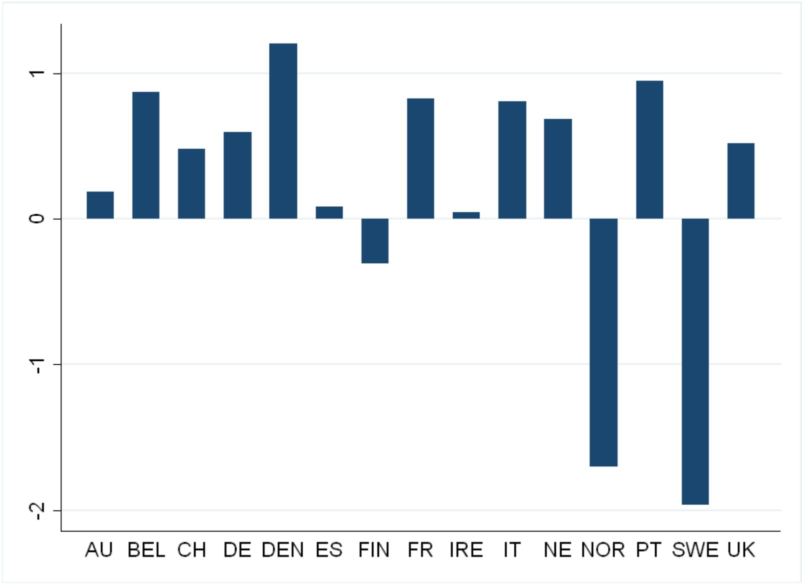


Figure 4: Residuals of the income regression



4 Why are European TTOs earning less income from licenses than their US counterparts? A qualitative analysis

As we have shown in the previous section, European TTOs earn less income from licenses than their US counterparts, having controlled for academic quality and research orientation, demand for technology and TTOs characteristics.

In this section we present evidence on differences between the organization of European and US TTOs that might explain why European TTOs earn less license income. Because of small sample size and limited variability within the US for the variables of interest, we are unable to pin down econometrically the differences in license income performance. However, the set of interrelated organizational factors discussed here provides a very plausible explanation.

We conjecture the following three hypotheses: 1) US TTOs might be more oriented towards generating revenue than their European counterparts; 2) US might employ more staff with experience in the industry sector than their European counterparts; 3) US TTOs have greater flexibility than their European counterparts in managing their budget. These hypotheses were formulated after discussions we had with technology transfer representatives in Europe and following the literature on objectives and incentives at US TTOs. The rationale for the three hypotheses is the following. If a TTO has generating revenue as primary objective, then it will focus on negotiating those licenses that ensure higher revenue rather than maximizing the number of licenses negotiated. Moreover, staff with experience in the industry sector may be more apt at negotiating licenses with private companies and, especially, financial clauses. Finally, TTOs with greater flexibility in managing their budget, have also more freedom in setting bonus pay for negotiating high revenue licenses and offering higher salaries and benefits to attract quality staff.

In both the European survey and the US survey, we asked questions on: 1) the objectives pursued by TTOs; 2) their metrics of success; 3) whether the head of the TTO has at least five year experience in the industry sector; 5) how many employees have an experience of at least five years in the industry sector; 6) whether the TTO receives a direct share of license income.

4.1 Objectives and metrics of success

US and European TTOs were asked to evaluate the following objectives: 1) promote diffusion of scientific knowledge and technology; 2) generate revenues; 3) promote local economic development; 4) promote national economic development; 5) attract and retain faculty through quality of technology transfer services. We used a 5-point Likert scale ranging from “not important” to “extremely

Table 4: Relative importance of objectives

	EU	**US**
Generating revenue is more important than promoting local development	20.5%	21.3%
Generating revenue is equally important than promoting local development	34.8%	27.0%
Generating revenue is less important than promoting local development	44.7%	51.7%
Generating revenue is more important than attract and retain faculty	24.8%	24.7%
Generating revenue is equally important than attract and retain faculty	31.4%	28.1%
Generating revenue is less important than attract and retain faculty	43.8%	47.2%

important". Our prior is that US TTOs tend to focus more on "generating revenue" than their European counterparts.

The results of the survey show that, in absolute terms, US TTOs tend to value more the objective of "generating revenue" than their European counterparts. In fact, the percentage of US TTOs indicating that "generating revenue" is either important, or very important or extremely important is 80.7%, while the same percentage in Europe is 72.9%[7].

However, US TTOs do not give more importance than their European counterparts to generating revenue, relative to "promoting local development" and "attracting and retaining faculty". In fact, Table 4 shows that the percentage of TTOs that indicated that "generating revenue" is more important than "promoting local development" is very similar for US and Europe. However, the percentage of respondents estimating that "generating revenue" is less important than "promoting local development" is greater in the US than in Europe. Similar results are obtained, when comparing the objective of "generating revenue" relative to "attracting and retaining faculty".

We also asked TTOs to evaluate the following metrics of success: 1) license income; 2) number of licenses/options executed; 3) number of patents awarded; 4) number of startups established.

In absolute terms, US respondents attach more importance to license income than their European counterparts. In fact, 86.4% of the US respondents declared that license income is either important, or very important or extremely important, while in Europe this percentage is 71.4%[8]. These results are in line with what we found for the importance of "generating revenue" as an objective, which seems to be more relevant, in absolute terms, to US TTOs than to European ones.

In relative terms, US TTOs attach less importance than their European counterparts to license income when compared to the number of licenses negotiated and the number of startups created.

[7]The percentage of total respondents who indicated that "generating revenue" is either very important or extremely important is 42.1% for US TTOs and 33.8% or European TTOs.

[8]When we look at the percentage of respondents who indicated that license income is either very important or extremely important, again this percentage is higher in the US (50%) than in Europe (40%).

Table 5: Relative importance of metrics of success

	EU	**US**
License income is more important than # licenses	27.5%	19.5%
License income is equally important than # licenses	51.4%	47.2%
License income is less important than # licenses	29.1%	41.6%
License income is more important than # startups	26.2%	22.5%
License income is equally important than # startups	31.4%	39.3%
License income is less important than # startups	42.4%	38.2%
License income is more important than # patents	32.4%	48.3%
License income is equally important than # patents	36.7%	38.2%
License income is less important than # patents	30.9%	13.5%

However, US TTOs attach more importance than their European colleagues to license income relative to the number of patents filed.

4.2 Staff with experience in the industry sector

Our second hypothesis was that US technology transfer professionals are more experienced at negotiating the financial clauses of licensing contracts. Very often, when discussing with academic researchers and private companies in Europe, we heard the story that TTOs personnel lack adequate experience to negotiate with private companies because they do not understand industry logic and goals.

To verify whether US technology transfer professionals are more experienced at negotiating licenses, we decided to include in our survey two questions asking whether the head of a TTO has at least five year experience in industry and how many licensing staff have at least five year experience in industry. The logic behind these questions is that TTOs staff with experience in industry is more acquainted with the goals and the *modus operandi* of private companies than staff with no such experience. Moreover, the question relative to the head of a TTO was motivated on the basis that the goals and the activities a TTO pursues can be influenced, at least in part, by the convictions of their head.

The results of our survey reveal clearly that in the US there is a larger number of TTO directors with experience in industry than in Europe. 77% of the US respondents declared that the head of their TTO had at least five years experience, while in Europe this percentage was 43%.

We are conscious that our measure for experience in industry is imperfect, mainly because we do not know in what consists this experience. We examined some of the CVs (available on line) of TTO directors in the US to verify whether they held qualified positions while working for industry.

We present some examples. The head of the TTO of the MIT spent 20 years in industry, primarily in the fields of membrane separations, medical devices and biotechnology at such companies as Amicon, Millipore and Applied Biotechnology. The head of the TTO of the Emory University, served as in-house patent counsel for an international pharmaceutical corporation for seven years. The head of the TTO of the University of Vermont has ten year of experience in the Science and Medical Products Divisions of Corning Glass works. The head of the TTO of the University of Boston had co-founded two companies: Kytogenics Inc. and Genmap Inc. Presenting the whole list would be too long. The message, however, is that by going through the CVs of TTOs directors in the US it emerges that, in the vast majority, they have held very qualified positions while working in private companies.

When we look at the number of staff with experience in industry, once again the difference between the US and Europe is significant. On average the US respondents have in 2.6 licensing staff with experience in industry, while in Europe 0.8.

In conclusion, our initial prior on US TTOs being more acquainted with industry values and *modus operandi* and more skilled at negotiating license contracts seem to be confirmed by our survey results.

4.3 Flexibility in managing TTO budget

Our third hypothesis was that US technology transfer professionals might have a greater flexibility in managing their budget than their European counterparts. This, in turn, might imply greater freedom in setting bonus pay to reward TTOs staff for negotiating high revenue licenses. It might also imply that TTOs have greater discretionality in offering better salaries and bonus to attract quality staff.

As a proxy for budget flexibility we use whether a TTO receives a direct share of license income. By direct share we mean that a portion of license income has to be directly allocated to the TTO, rather than being first assigned to the university and then reassigned to the TTO, on a discretionary basis.

The results of our survey tend to confirm our prior and show that there is a significant difference between the US and Europe in terms of whether TTOs receive a direct share of license income. 67.1% of TTOs in the US receives a direct share of license income, while in Europe the percentage is 28.3%.

5 Conclusions

Are the US outperforming Europe in university technology licensing? The answer is: yes but only for license income.

Using new survey data on university technology transfer offices in US and in Europe together with public information available on US and European universities, we examined whether US technology transfer offices conclude more licenses and earn more license revenue than their European colleagues.

Our first result is that, having controlled for the quality of the academic institutions, their research orientation and the number of publications, for the local demand of technology and TTOs staff and age, we cannot conclude that US TTOs make more licenses than their European counterparts. In fact, the coefficient for the US dummy is small and insignificant. This result is robust to various combinations of the controls and to removing observations with high residuals from the sample.

Our second result is that, having controlled for the same factors as for the number of licenses, US technology transfer offices earn more revenue from licenses that their European counterparts. The coefficient for US is positive and highly significant with any combination of the controls we tried.

The situation in Europe is not homogeneous. Switzerland and Belgium outperform the other European countries, whereas Sweden, Italy and Finland underperform the rest of Europe. The professors' privilege policy, in place in Sweden and in Italy and recently abolished in Finland, seems to be the most likely cause for these countries to generate less licenses and less license revenues.

We undertook a qualitative analysis to understand the differences in organization and staffing that might explain why US technology transfer offices earn more license revenue. We conjectured that US TTOs have more staff with experience in industry and, thus, they understand better the *modus operandi* of firms and they are more skilled at negotiating the financial clauses of licensing contracts. On average, US TTOs employ 2.8 staff with experience in industry, against 0.8 in Europe. Moreover, 77% of the US respondents contended that their head had at least five years experience in industry, while in Europe this percentage was 43%.

Our qualitative analysis also points at substantial differences in the way TTOs are financed. 67% of the US respondents said that they receive a direct share of license revenue, whereas in

Europe this percentage is only 28%. This could translate into better licensing performance through greater flexibility in hiring practices, bonus pay and the organization of the TTO in general.

Our priors were that US TTOs tend to give more importance to "generating revenue" as objective than their European counterparts and, therefore, that they have more incentive to negotiate licenses that potentially generate high revenue. Here, the evidence is mixed. In absolute terms, US TTOs tend to give more importance to generating revenue than European TTOs. However, they do not give more importance than European TTOs to revenue generation relative to other objectives such as local development and faculty service.

We believe our analysis has important policy implications. Within the context of the "European Paradox", we analyzed how European TTOs compare to their US counterparts. Our findings highlight the importance of university inputs, such as publications, and of TTOs size and experience as factors explaining the gap in the US and Europe in terms of number of licenses concluded and license revenue.

The different performance in terms of license income need not in itself be a source of concern. There is nothing in economic theory to suggest that TTOs should maximize license revenue. Social welfare might be better served by TTOs facilitating local economic development or helping with the translation of academic research into products.

However, to the extent that revenue generation is an objective (and many TTOs say it is), then policy changes are advisable to close the gap between the US and Europe. Our qualitative analysis points at the usefulness of industry experience for TTO staff members and of flexibility in the organization of the office. However, the exact nature of organizational practices that TTOs should employ remains a subject for further research.

References

[1] Association of European Science & Technology Transfer Professionals (ASTP), 2006 Survey Report.

[2] Bauwens L, Mion G. and Thisse J.F.(2008): "The Resistible Decline of European Science", CORE Discussion paper N. 92.

[3] Belenzon, S., and Schankerman, M. (2007): "Harnessing Success: Determinants of University Technology Licensing Performance", CEPR Discussion Paper, No. 6120.

[4] Conti A., Gaulé P. and Foray D. (2007): "Academic Licensing: a European Study", CEMI Working Paper.

[5] Chapple W., Lockett A., Siegel D. S., and Wright M. (2005) "Assessing the Relative Performance of University TTOs in the UK", *Research Policy* 34.

[6] Crespi G. A., Geuna A. and Verspagen B. (2006): "University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient?", SPRU Electronic Working Paper Series 154.

[7] Dosi G., Llerena P, and Labini M.S. (2006): "The relationships between science, technologies and their industrial exploitation: an illustration through the myths and realities of the so-called 'European Paradox", *Research Policy* 35.

[8] European Commission (1995): "Green paper on innovation. December 1995".

[9] European Commission (2003): "Third Report on Science and Technology Indicators 2003".

[10] European Commission (2007), "Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation –Implementing the Lisbon Agenda", Communication to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions.

[11] Friedman, J., and Silberman, J. (2003) "University Technology Transfer: Do Incentives Management, and Location Matter?", *Journal of Technology Transfer* 28.

[12] Jensen R. and Thursby M. C. (2001) "Proofs and prototypes for sale: The licensing of university inventions", *American Economic Review* 91(1).

[13] Lach S. and Schankerman M. (2003): "Incentives and Inventions in Universities", NBER Working Paper, No. 9727.

[14] Lissoni F., Llerena P, McKelvey M and Sanditov B (2008) "Academic patenting in Europe: new evidence form the KEINS database" *Research Evaluation* 17(2)

[15] Macho-Stadler I., Pérez-. Castrillo, J. D. and Veugelers R., "Designing Contracts for University Spin-offs", forthcoming in *International Journal of Industrial Organization.*

[16] ProTon Europe, 2006 Annual Report.

[17] Siegel D., Waldman D., and Link A. (1999): "Assessing the Impact of Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study", NBER Working Paper, No. 7256.

[18] Thursby J. G., Jensen R., and Thursby M. C. (2001): "Objectives, Characteristics and Outcomes of University Licensing: a Survey of Major US Universities", *Journal of Technology Transfer* 26.

[19] Thursby J. G., and Kemp S. (1998): "An Analysis Of Productive Efficiency of University Commercialization Activities", *Research Policy*, 31.

[20] Zucker L. G., Darby M. R., and Brewer M. B. (1998): "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises," *American Economic Review* 88.

A Appendix

A.1 Table of correlations

Variables	#lic.	US	poly	med_sch.	pub.	star_eng	stars_bio	GDP_cap.	priv.	staff	age
#licenses	1.000										
US	0.351	1.000									
poly	0.081	-0.066	1.000								
med_school	-0.022	0.116	-0.041	1.000							
publications	0.721	0.238	-0.025	-0.020	1.000						
stars_eng	0.685	0.252	0.072	-0.045	0.800	1.000					
stars_bio	0.581	0.207	-0.012	0.055	0.852	0.753	1.000				
GDP_capita	0.123	-0.009	0.097	0.102	0.137	0.120	0.147	1.000			
privilege	-0.173	-0.290	0.078	-0.051	-0.057	-0.075	-0.073	-0.092	1.000		
staff	0.663	0.341	0.045	0.025	0.568	0.487	0.423	0.165	-0.212	1.000	
age	0.459	0.501	-0.037	0.048	0.314	0.252	0.236	-0.024	-0.299	0.487	1.000

A.2 Robustness checks: number of licenses

VARIABLES	(I) licenses	(II) licenses	(III) licenses	(IV) licenses
US	0.023	-0.027	0.118	0.052
	[0.128]	[0.120]	[0.127]	[0.127]
poly	0.423b	0.413b	0.338c	0.412b
	[0.194]	[0.186]	[0.198]	[0.195]
med_school	0.021	0.160	0.056	0.029
	[0.206]	[0.190]	[0.202]	[0.207]
publications	0.123a	0.140a	0.100a	0.125a
	[0.028]	[0.029]	[0.028]	[0.028]
star_engineering	0.022	0.025	0.027	0.023
	[0.024]	[0.027]	[0.024]	[0.024]
superstars_bio	-0.031	-0.012	-0.031c	-0.031
	[0.020]	[0.024]	[0.019]	[0.020]
GDP_capita	0.009	0.007	0.001	0.008
	[0.006]	[0.006]	[0.007]	[0.006]
privilege	-0.975a	-0.878a	-0.833a	-1.015a
	[0.195]	[0.180]	[0.194]	[0.223]
lstaff_good	0.660a	0.640a	0.732a	0.645a
	[0.110]	[0.101]	[0.117]	[0.111]
cat_age	0.039a	0.036a	0.040a	0.037a
	[0.009]	[0.008]	[0.009]	[0.009]
Constant	0.292	0.251	0.486c	0.337
	[0.276]	[0.260]	[0.285]	[0.281]
Observations	319	289	306	319
McFadden R^2	0.12	0.138	0.126	0.119
	(baseline)	(excluding outliers)	(excluding CH & BE)	(not counting FIN as privilege)

Standard errors in brackets

a significant at 1%, b at 5%, c at 10%

A.3 Robustness checks: license income

VARIABLES	(I)	(II)	(III) log license income	(IV)	(V)
	interval regression	interval regression	interval regression	ordered logit	ordered probit
US	1.636a	1.654a	1.630a	1.708a	1.005a
	[0.272]	[0.253]	[0.286]	[0.286]	[0.166]
poly	0.535	0.518	0.526	0.535	0.296
	[0.444]	[0.415]	[0.447]	[0.467]	[0.267]
med_school	-0.271	-0.182	-0.230	-0.278	-0.182
	[0.465]	[0.434]	[0.470]	[0.472]	[0.280]
publications	0.252a	0.259a	0.237a	0.272a	0.147a
	[0.078]	[0.075]	[0.079]	[0.082]	[0.047]
star_engineering	-0.056	0.029	-0.057	0.009	-0.022
	[0.096]	[0.102]	[0.097]	[0.108]	[0.058]
superstars_bio	0.242b	0.215b	0.228b	0.265b	0.159a
	[0.099]	[0.094]	[0.099]	[0.115]	[0.060]
GDP_capita	0.034b	0.028b	0.042a	0.031b	0.019b
	[0.014]	[0.013]	[0.014]	[0.015]	[0.009]
privilege	-0.994b	-0.848b	-0.444	-0.952c	-0.548b
	[0.403]	[0.374]	[0.321]	[0.509]	[0.274]
lstaff_good	0.789a	0.783a	0.799a	0.755a	0.483a
	[0.237]	[0.222]	[0.246]	[0.255]	[0.144]
cat_age	0.062a	0.066a	0.071a	0.063a	0.038a
	[0.020]	[0.018]	[0.020]	[0.021]	[0.012]
Constant	7.644a	7.746a	7.285a		
	[0.651]	[0.607]	[0.642]		
Observations	313	293	313	313	313
	(baseline)	(excluding outliers)	(privilege for DE, NOR, DEN)	(ordered logit)	(ordered probit)
R^2	0.391	0.442	0.375	0.276	0.277

Standard errors in brackets
a significant at 1%, b at 5%, c at 10%