



**The impact of university quality, competition and  
the regional environment on knowledge transfer  
outcomes**

**Nordine Es-Sadki and Anthony Arundel  
UNU-MERIT - Maastricht University**

**SmartEIZ Final Conference  
Zagreb  
25 – 26 September 2018**

## Introduction

- Public research organisations such as universities and research institutes (PROs) commercialise knowledge. This is facilitated by knowledge transfer offices (KTO).
- Studies examined effect of KTO characteristics on the flow of knowledge from PROs to firms (Barjak et. al. 2015; Barjak & Es-Sadki, 2015; Locket & Wright, 2005; Siegel & Phan 2005).
- Other studies have examined the effects of PROs and other factors on regional economies (Brescia et al. 2014; Audretsch et. al. 2012; Drucker & Goldstein, 2007).
- However, only a few studies have looked at the effects of the PRO's regional environment on its knowledge transfer activities (Barjak & Es-Sadki, 2015)

## The impact of the regional environment on KT outcomes of PROs

- Universities in wealthier and more technology-intensive regions have generally been found to have more knowledge transfer outcomes than universities in poorer and less technology-intensive regions (Belenzon & Schankerman, 2009; Friedman & Silberman, 2003; Lach & Schankerman, 2008; Conti & Gaule, 2011).
- Argument is that the transfer of university technology often requires face-to-face contact (Mansfield, 1998).
- This paper analyses the impact of the regional environment and the characteristics of the KTO and the PRO on four knowledge transfer outcomes: the number of start-ups, the number of licensing or R&D agreements with firms and license income.

## This paper

- We contribute to the existing literature by examining:
  - The competition of other PROs in the region in Europe,
  - University quality as measured by its inclusion and rank in ARWU
  - The influence of other leading universities in the same region as the focal university
  - The influence of the employment share in
    - high and medium-high technology manufacturing and
    - in knowledge-intensive services.

## Main research questions

- Expect that university quality to positively affect knowledge transfer outcome
- Expect that the number of competing universities and research institutes in a region influence outcomes
  - Either positively due to spill over effects of quality universities in a region
  - Or negatively if there is crowding out

## Methodology

- Data collection
  - Two surveys: a UNU-MERIT survey<sup>1</sup> and the ASTP-PROTON survey, both conducted during the fall of 2014 on the knowledge transfer activities of universities in 2012 and 2013.
  - The two sets of survey data were combined. The number of cases for analysis is increased by including all respondents for both survey years.
  - The full dataset includes 292 European universities
  - Regional-level data NUTS-2 levels were added for each university

**1:** Funded by Norwegian Ministry of Education and Research, Kommersialisering av offentlig finansiert forskning – datainnsamling, systematisering og analyse for Forskningsbarometeret, under sub-contract for DAMVAD.

## Country distribution

	Universities			Universities	
Country	#	%	Country	#	%
AT	12	4%	HU	1	0%
BE	6	2%	IE	4	1%
BG	1	0%	IT	57	20%
CH	2	1%	NL	10	3%
CZ	0	0%	NO	10	3%
DE	0	0%	PT	2	1%
DK	7	2%	SE	13	4%
EE	1	0%	SI	1	0%
ES	59	20%	UK	98	34%
FI	8	3%	<b>Total</b>	<b>292</b>	<b>100%</b>

## NUTS-2 coverage

Country	NUTS 2 regions	Covered	Percent	Country	NUTS 2 regions	Covered	Percent
AT	9	5	55.6%	IE	2	1	50.0%
BE	11	5	45.5%	IT	21	20	95.2%
BG	6	1	16.7%	NL	12	7	58.3%
CH	7	1	14.3%	NO	7	6	85.7%
DK	5	5	100.0%	PT	3	2	66.7%
EE	1	1	100.0%	SE	8	6	75.0%
ES	19	17	89.5%	SI	2	1	50.0%
FI	5	3	60.0%	UK	39	32	82.1%
HU	2	1	50.0%	<b>Total</b>	<b>164</b>	<b>114</b>	<b>69.5%</b>

Note: Not all NUTS2 regions have a university in their region



## Dependent variables

- Dependent variables
  - The number of research agreements with firms,
  - The number of licenses,
  - The number of start-ups established
  - The amount of license income.
- Data based on awareness of KTO managers of the transfer of knowledge owned and commercialized by their office.
- The results of this study only apply to institutional knowledge transfer via the KTO.
- In addition, some KTOs do not handle all research agreements and therefore are unable to provide an accurate estimate of the number of research agreements.

## Table 1 Descriptive statistics of dependent variables

<b>Universities</b>	<b>N<sup>1</sup></b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>	<b>Percentage reporting outcome</b>
License agreements	267	14.5	3	34.1	91.4%
Start-ups	284	2.7	1	5.4	97.3%
Research agreements	207	164.2	69	240.2	70.9%
License income <sup>2</sup>	207	0.70	0.02	5.1	70.9%

### Notes

1: Number of respondents reporting results for each outcome (including zero outcomes).

2: Mean, median and SD in million Euros

## Independent variables

- Two **KTO variables** include the number of employees (KTO\_SIZE) and its age (KTO\_AGE).
- Two **institutional variables** include the number of researchers (NUMB\_RES), if the institution has a hospital (HOSP), coded as 1 when present and 0 otherwise.
- We also include a control variable for **ownership status** (OWNERSHIP), coded as 1 when IP is owned by inventor only or by a combination including the inventor and 0 for all other cases.

## Independent dummy variables

Characteristics of the KTO and institution	Universities		
	N	Yes	Percent
<b>HOSP:</b> Institution has a hospital (1), other (0)	292	65	22.3%
<b>OWNERSHIP:</b> IP is owned by inventor only or by inventor and other parties (other=0)	167	43	14.7%

Additional information on IP ownership	Universities		
	N	Yes	Percent
Institution only	167	111	66.5%
Inventor only	167	4	2.4%
Companies only	167	5	3.0%
Combination	167	47	28.1%
			100%

## Independent variables – regional indicators

- Population (million) in 2013 at NUTS-2 level (GROSS\_GRP) is included to control for the size of the region.
- Regional gross product per capita in 2013 at NUTS-2 level is used to measure regional income (PER\_CAP\_GRP).
- Two other independent variables reflect the region's industry structure at NUTS-2 levels, both for the year 2013.
  - regional employment shares in high and medium-high technology manufacturing industries (EMPSHARE\_HMHT) and
  - in knowledge intensive services (EMPSHARE\_KIS)
- The last regional variable is the number of public research organisations at the NUTS-2 level (COMP).

## Descriptive statistics of independent variables

Characteristics of the KTO and institution	Universities			SD
	N	Mean	Median	
<b>NUMB_RES*</b> : Number of researchers in FTE	292	1,614.2	1,197.5	1480.5
<b>KTO_SIZE</b> : KTO staff in FTE	292	17.5	8.0	20.7
<b>KTO_AGE</b> : age of KTO in years	292	15.0	13.0	8.6
<b>Regional characteristics</b>				
<b>POPULATION*</b> : Regional population at NUTS-2(x1,000,000)	292	3.2	2.6	2.6
<b>PER_CAP_GRP*</b> : Regional gross product per capita € (x1,000)	292	29.1	28.2	8.8
<b>EMPSHARE_HMHT</b> : Employment share in high and medium high-technology manufacturing	292	4.2	3.7	2.2
<b>EMPSHARE_KIS</b> : Employment share in Knowledge-intensive services	292	42.5	43.6	8.7
<b>COMP</b> : Number of PROs in the region	292	7.9	5	6.6

Note: \*before logarithmic transformation

## Independent variables – university quality

- **Three quality variables** using data from Academic Ranking of World Universities (ARWU)
- **Two quality variables for each university** in our database are
  - 1) inclusion in the top 500 universities in the 2013 ARWU rankings (coded as 1 if the university is listed in the top 500 ARWU and 0 otherwise (UNI\_TOP) and
  - 2) the rank of the university in the top 500 (RANK-UNI).
- **One quality variables for other universities** in the focal university's region are:
  - 3) SUM\_RANK\_REG is a variable that sums the ranking of all **other** leading universities in the same region as the focal university (**excluding the ranking of the focal university**).
    - This variable provides a measure of the level of excellence of all top ranked universities in each region

**Table 5 Independent variables for university quality characteristics**

	# <sup>1</sup>	Percent
<b>UNI_TOP:</b> University in top 500 (1), other (0)	101	34.6%
<b>UNI_RANK:</b> Rank of university in top 500		
-Top 100 (UNI_RANK = 5)	16	5.5%
-Top 101-200 (UNI_RANK = 4)	23	7.9%
-Top 201-300 (UNI_RANK = 3)	29	9.9%
-Top 301- 400 (UNI_RANK = 2)	21	7.2%
-Top 401- 500 (UNI_RANK = 1)	12	4.1%
-Not in top 500 (UNI_RANK = 0)	191	65.4%

	Mean	Median	SD
<b>SUM_RANK_REG:</b> Sum of rank of all leading universities in a region	3.8	3.0	4.7

<u>Additional information</u>	#	Percent
-Number of universities in a region with no leading university	75	25.7%
-Number of universities in a region with 1 leading university	85	29.1%
-Number of universities in a region with 2 leading universities	68	23.3%
-Number of universities in a region with 3 leading universities	39	13.4%
-Number of universities in a region with 5 leading universities	25	8.6%
<b>Total</b>	<b>292</b>	<b>100%</b>

Notes

1: Number out of 292 universities.



## Coverage of top universities by ARWU 2013 ranking in database by country

Country	Number	Covered	Country	Number	Covered
Austria	7	7	Ireland	3	1
Belgium	7	4	Italy	19	17
Bulgaria	0	-	Netherlands	12	10
Switzerland	7	1	Norway	4	4
Denmark	4	4	Portugal	4	1
Estonia	0	-	Sweden	11	8
Spain	10	10	Slovenia	1	0
Finland	5	3	United Kingdom	37	36
Hungary	2	0	<b>Total</b>	<b>133</b>	<b>106</b>

## Analytical methods

- The three dependent variables are all measured as counts
- Overdispersion rules out Poisson
- Negative Binomial model with log-link relationship as is done in previous research
  - Not used zero-inflated as zero in our database is actual outcome (see Barjak et. al. (2014) for details)
- OLS is used for the analyses of license income as a dependent variable.

## Mean and number of the four knowledge transfer outcomes across four groups

	Number <sup>1</sup>	Percentage		License agreements	Start-ups	Research agreements	License income <sup>3</sup>
University not leading and not in region with a leading university	75	25.7%	N <sup>2</sup>	71	73	48	44
			Mean	5.1	1.8	128.1	0.04
University not leading but in region with at least one leading university	116	39.7%	N <sup>2</sup>	108	113	91	89
			Mean	4.4	2.0	79.6	0.06
University leading, in region with no other leading university	36	12.3%	N <sup>2</sup>	32	36	24	29
			Mean	45.4	4.0	390.5	0.98
University leading, in region with at least one other leading university	65	22.3%	N <sup>2</sup>	56	62	44	45
			Mean	28.6	4.1	254.9	2.43
<b>Total</b>	<b>292</b>	<b>100.0%</b>	<b>N<sup>2</sup></b>	<b>267</b>	<b>284</b>	<b>207</b>	<b>207</b>
			<b>Mean</b>	<b>14.5</b>	<b>2.7</b>	<b>164.2</b>	<b>0.70</b>
Statistical significance difference between all groups (p-value)				0.000	0.015	0.000	0.060
Statistical significance difference between pairs of not leading universities leading (p-value)				0.595	0.802	0.065	0.532
Statistical significance difference between pairs of leading universities (p-value)				0.153	0.915	0.097	0.477

Notes: 1: Number of universities in each category. 2: Number of universities that reported results for each outcome. 3: License income mean in million Euros.

**Table 9 Research agreements**

Model	1	2	3	4	5	6	7
N	138	138	207	207	207	207	207
AIC	1634.6	1634.9	2386.9	2388.8	2388.3	2384.5	2380.7
<b>Characteristics of the KTO and the university</b>							
NUMB_RES (LOG)	0.672***	0.718***	0.766***	0.764***	0.724***	0.631***	0.715***
KTO_SIZE	0.004	0.002	-0.005	-0.005	-0.005	-0.006	-0.003
HOSP	0.327	0.610**	0.640***	0.646***	0.544***	0.268	0.557***
OWNERSHIP	-0.433**	-0.512**					
KTO_AGE	0.016	0.008	0.015	0.014	0.016*	0.020**	0.014
<b>Regional characteristics</b>							
PER_CAP_GRP (LOG)		-0.660	0.128	0.142	0.054	-0.203	0.687
POPULATION (LOG)		0.138	0.162	0.196	0.154	0.124	0.346**
EMPSHARE_HMHT		0.120**	0.083*	0.085*	0.079*	0.078*	0.052
EMPSHARE_KIS		0.012	-0.025**	-0.025**	-0.024**	-0.023*	-0.020
COMP		-0.025	-0.023	-0.042	-0.021	-0.014	-0.011
COMP <sup>2</sup>				0.001			
<b>University quality characteristics</b>							
UNI_TOP					0.193		
UNI_RANK						0.175***	
SUM_UNI_RANK_REG							-0.085***
Constant	-0.121	-0.936	-2.835	-3.308	-2.261	-0.568	-6.898***

\* = p < .10, \*\* = p < .05, \*\*\* = p < .01

**Table 10 License agreements**

Model	1	2	3	4	5	6	7
N	152	152	267	267	267	267	267
AIC	1005.0	1003.7	1642.4	1638.5	1641.9	1640.1	1643.96
<b>Characteristics of the KTO and the university</b>							
NUMB_RES (LOG)	0.559***	0.588***	0.670***	0.646***	0.576***	0.540***	0.685***
KTO_SIZE	0.015***	0.011*	0.008**	0.008**	0.008**	0.007**	0.008**
HOSP	1.036***	1.058***	1.160***	1.252***	1.004***	0.864***	1.170***
OWNERSHIP	-0.414**	-0.417*					
KTO_AGE	0.017	0.016	0.025***	0.027***	0.026***	0.026***	0.025***
<b>Regional characteristics</b>							
PER_CAP_GRP (LOG)		-0.057	0.239	0.162	0.175	0.115	0.098
POPULATION (LOG)		0.123	0.074	-0.078	0.061	0.058	0.025
EMPSHARE_HMHT		0.138***	0.109***	0.108***	0.097**	0.100**	0.114***
EMPSHARE_KIS		0.021	0.018	0.017	0.020	0.021*	0.017
COMP		-0.035*	-0.014	0.096*	-0.014	-0.013	-0.016
COMP <sup>2</sup>				-0.004**			
<b>University quality characteristics</b>							
UNI_TOP					0.337*		
UNI_RANK						0.142**	
SUM_UNI_RANK_REG							0.019
Constant	-2.374***	-5.278**	-6.525***	-4.313**	-5.593***	-5.147***	-5.466**

\* = p < .10, \*\* = p < .05, \*\*\* = p < .01

**Table 11 License income**

Model	1	2	3	4	5	6	7
N	138	138	207	207	207	207	207
AIC	4614.4	4451.2	5163.5	5165.1	5165.2	5153.7	5159.64
<b>Characteristics of the KTO and the university</b>							
NUMB_RES (LOG)	-0.116	-0.137	0.325***	0.331***	0.297***	0.138	0.388***
KTO_SIZE	0.089***	0.096***	0.028***	0.028***	0.028***	0.027***	0.028***
HOSP	2.856***	1.745***	1.042***	1.038***	0.996***	0.650***	1.114***
OWNERSHIP	-0.947***	-1.623***					
KTO_AGE	0.129***	0.166***	0.105***	0.104***	0.106***	0.111***	0.103***
<b>Regional characteristics</b>							
PER_CAP_GRP (LOG)		1.749***	2.848***	2.856***	2.812***	2.574***	2.412***
POPULATION (LOG)		-0.986***	-0.426***	-0.377***	-0.424***	-0.418***	-0.606***
EMPSHARE_HMHT		0.197***	0.100**	0.099**	0.096**	0.082*	0.111***
EMPSHARE_KIS		0.059***	-0.005	-0.003	-0.004	0.002	-0.014
COMP		0.001	-0.031**	-0.063	-0.032**	-0.034**	-0.039***
COMP <sup>2</sup>				0.001			
<b>University quality characteristics</b>							
UNI_TOP					0.116		
UNI_RANK						0.222***	
SUM_UNI_RANK_REG							0.068**
Constant	-2.051***	3.155	-7.403***	-8.071***	-7.167***	-5.702***	-3.582

\* = p <.10, \*\* = p <.05, \*\*\* = p <.01

**Table 12 Start-ups**

Model	1	2	3	4	5	6	7
N	160	160	284	284	284	284	284
AIC	712.3	701.7	1150.2	1146.7	1152.1	1152.2	1151.44
<b>Characteristics of the KTO and the university</b>							
NUMB_RES (LOG)	0.685***	0.728***	0.693***	0.668***	0.665***	0.688***	0.672***
KTO_SIZE	0.009	0.001	0.001	0.002	0.001	0.001	0.001
HOSP	-0.288	-0.258	-0.143	-0.151	-0.162	-0.149	-0.161
OWNERSHIP	-0.288	-0.397*					
KTO_AGE	-0.051***	-0.046***	-0.041***	-0.036***	-0.041***	-0.041***	-0.041***
<b>Regional characteristics</b>							
PER_CAP_GRP (LOG)		-0.582	-0.571	-0.703*	-0.600	-0.579	-0.390
POPULATION (LOG)		0.361**	0.300**	0.114	0.300**	0.299**	0.372***
EMPSHARE_HMHT		0.106*	0.080*	0.084**	0.079*	0.080*	0.079*
EMPSHARE_KIS		0.063***	0.043***	0.041***	0.044***	0.043***	0.045***
COMP		-0.054**	-0.041**	0.087	-0.041**	-0.041**	-0.039**
COMP <sup>2</sup>				-0.005**			
<b>University quality characteristics</b>							
UNI_TOP					0.079		
UNI_RANK						0.004	
SUM_UNI_RANK_REG							-0.027
Constant	-3.035***	-9.371***	-7.791***	-4.994**	-7.56***	-7.736***	-9.316**

\* = p <.10, \*\* = p <.05, \*\*\* = p<.01

## Results

- Results of basic characteristics (control variables) in line with previous research (Conti and Gaule, 2011, Barjak et. al. 2014, Barjak & Es-Sadki, 2015, Carlsson & Fridh, 2002)
- Regional industrial structures contribute to explaining the transfer performance of the region's public research institutions.
  1. A larger share of HMHT employment in region has strong positive effect on KT outcomes.

All of these results suggests that a larger client base in high and medium-high technology manufacturing increases engagement in knowledge transfer with universities.

2. A larger share KIS employment in region has strong positive effect on start-ups.



## Results for competition effect and quality

- The result showing a negative effect for competition of other PROs in the region is of high interest,
  - Suggests that there are limited possibilities for start-ups and
  - Lower returns of license income
- Research excellence arguments suggest that the behaviour of potential partners of universities will be influenced by external perceptions of them
- Top ranked universities perform better on licence agreements which is in line with Sine et. al. (2003). In addition, higher ranked top universities perform better on license agreements, license income and research agreements.

## Excellence and quality

- Greater and better quality competition as measured by the sum of the rank of all top 500 universities in the same region **has significant positive effects on the amount of license income.**
- Quality of the knowledge transferred from universities to firms as proxied by license income is thus positively affected by the presence and ranking of leading universities in the same region as the focal PRO.
- This result suggests that there are spillover effects of leading universities to non-leading universities in the same region.
  - (focal university can be either leading (ARWU) or not leading)

## Excellence and quality

- On the other hand greater and better quality competition as measured by the sum of the rank of all top 500 universities in the same region has **negative effects on the number of research agreements**.
- This indicates that universities in regions with greater and better quality competition have fewer research agreements per university.
- This result suggests that there are crowding-out effects of competing top universities/ limited demand from firms for establishing research agreements with universities.

**THANK YOU!**

Nordine Es-Sadki

[n.es-sadki@maastrichtuniversity.nl](mailto:n.es-sadki@maastrichtuniversity.nl)

Anthony Arundel

[a.arundel@maastrichtuniversity.nl](mailto:a.arundel@maastrichtuniversity.nl)