Working Paper Series

#2015-017

The impact of the regional environment on the knowledge transfer outcomes of public research organisations: preliminary results for Europe

Nordine Es-Sadki and Anthony Arundel

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

The impact of the regional environment on the knowledge transfer outcomes of public research organisations: preliminary results for Europe*

Nordine Es-Sadki[a] and Anthony Arundel[b]

[a] *n.es-sadki@maastrichtuniversity.nl*

Maastricht Economic Research Institute on Innovation and Technology (UNU-MERIT), Keizer Karelplein 19, 6211 TC Maastricht, the Netherlands

[b] *a.arundel@maastrichtuniversity.nl*
University of Tasmania, Hobart 7004, Australia and UNU-MERIT

Abstract

We use survey data for 238 European universities and 24 research institutes to examine the effects of regional factors at the NUTS-1 or NUTS-2 level on three knowledge transfer outcomes of public research organisations: the number of licence agreements, start-ups and R&D agreements with companies. We find that (1) a larger share of regional employment in high and medium-high technology manufacturing sectors in the same region as the public research organisation has a positive impact on the number of licence agreements. (2) A larger share of employment in knowledge-intensive services has a positive impact on the number of start-ups and research agreements, but a negative impact on licence agreements. (3) Competition as measured by the number of public research organisations in a region has a negative impact on all three outcomes.

Acknowledgements

This paper draws on 2012-2013 survey data from ASTP-PROTON and from a Knowledge Transfer survey conducted for the Norwegian Ministry of Education and Research, Kommersialiserring av offentlig finansiert forskning – datainnsamling, systematisering og analyse for Forskningsbarometeret, under sub-contract for DAMVAD. Their support is gratefully acknowledged.

Keywords

University-industry technology transfer, technology transfer offices, regional location

JEL Classifications I23 -O32 – M13 – L24

* This paper will be presented at the FinKT conference Knowledge transfer and entrepreneurship 16-17 April 2015 Rimini, Italy

1. Introduction

Public research organisations (PROs) such as research institutes or universities are increasingly recognised as important actors in the production and delivery of new knowledge. A key facilitator in the process of commercialising knowledge produced by (PROs) is the knowledge transfer office (KTO), with several studies examining the effects 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; Drucker & Goldstein, 2007). For instance, Audretsch et al. (2012) found that regional competitiveness and regional university spill-overs are strong complements in fostering the innovation activities of entrepreneurial German firms.

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). 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). The argument here is that the transfer of university technology often requires face-to-face contact (Mansfield, 1998). A recent study on Spanish universities looked at the relationship between the number of university licence agreements and spin-offs and the regional availability of venture capital and the regional stock of knowledge in the business sector, measured as accumulated R&D expenses per firm (González-Pernía et al. 2013). No significant effects were found. Using Netval data from Italy, Fini et al. (2011) found that the regional financial development index, measured as the probability that a household can access the credit market, is positively correlated with the number of university spin-offs.

This paper analyses the impact of the regional environment and the characteristics of the KTO and the PRO on three knowledge transfer outcomes: the number of start-ups and the number of licensing or R&D agreements with firms. We contribute to the existing literature by examining the competition of other PROs in the region and the influence of the employment share in high and medium-high technology manufacturing and in knowledge-intensive services. The remainder of this paper is organised as follows. In the following section we give a short overview of the literature on the determinants of knowledge transfer activities. Next, we describe the data and methods used for our empirical study. After presenting the results we provide several conclusions.

2. Research on knowledge transfer performance

Previous studies have evaluated the effects of several factors on the knowledge transfer activities of universities and other research institutes, including the characteristics and practices of the knowledge transfer office (KTO), the characteristics and policies of the affiliated institution, and of particular interest to this paper the characteristics of the regional environment.

2.1 Characteristics of the KTO and the institution

Several KTO features such as its age, size and experience of its staff can influence knowledge transfer outcomes. Previous research has established that older KTOs with presumably more experienced staff perform better than younger KTOs (e.g. Conti and Gaule 2011; Curi et al. 2012) and that the number of KTO employees increases knowledge transfer activities (e.g. Conti and Gaule, 2011), although there are some exceptions. Chapple et al. (2005) found a negative relationship between KTO size and transfer efficiency in UK universities and Van Looy et al. (2011) found no correlation between KTO size and the number of patent applications and research contracts.

Several institutional characteristics can also influence performance. Barjak et al. (2014) find that the number of researchers and the existence of science departments or a medical faculty can influence outcomes. Finally, policies on who owns the IP (the inventor, PRO or research funding body) can influence outcomes.

2.2 Regional characteristics

A number of studies on the transfer performance of universities examined the potential regional market for university technologies, as measured through 1) the technological intensity of the regional economy, 2) the research intensity of the regional economy, 3) regional income and 4) Venture Capital related activities (for a review see Barjak & Es-Sadki, 2015). In this paper we evaluate the first three of these four factors. We were unable to evaluate venture capital activities because of a lack of relevant data at the European regional level.

Technology-intensive regions with many technology firms should increase the demand for knowledge from regional PROs. Empirical studies of American universities found an increase in the number of licences for universities located in a high-technology region (Friedman & Silberman, 2003) and an increase in licensing income (Belenzon & Schankerman, 2009; Friedman & Silberman, 2003; Lach & Schankerman, 2008) compared to universities located in low technology regions. The results for the number of start-ups are inconclusive (Friedman & Silberman, 2003; O'Shea, et al. 2005). In addition, studies using other indicators for technology intensity did not find a positive relationship between intensity and knowledge transfer outcomes. For example, the number of high technology organisations has no effect on the number of licences executed by a university (Sine et al., 2003).

Studies on the research intensity of regional economies have examined the level of industrial R&D expenditures for American states (Link and Siegel, 2005), R&D intensity (Chapple, et al., 2005), the number of R&D staff in a region (Algieri et al., 2013) and regional business R&D spending (BERD) (Barjak and Es-Sadki, 2015; Van Looy et al., 2011). These studies have found a positive effect of private sector R&D on the outcomes of PRO research. Research on public R&D expenditures are inconclusive, with Fini, et al. (2011) reporting a negative effect and others finding that public R&D expenditures at the regional level had a positive effect on the number of university spin-offs (Barjak and Es-Sadki, 2015; Algieri, et al., 2013). To our knowledge only Sine et al. (2003) controlled for the effect of competition between universities marketing technology to local firms. In their study they found that institutions located in areas with a higher population of technology producing universities have lower rates of licensing activities.

A few studies have found no effect of regional income measures on knowledge transfer performance. Using UK data, Chapple et al. (2005) found that regional GDP raises the technical efficiency of KTOs with regard to licence income, but not with regard to the number of licences. Hülsbeck et al. (2013) did not find a relationship between GDP per capita in German regions and the number of invention disclosures at universities.

3 Methodology

3.1 Data collection

Data were collected through two surveys: a UNU-MERIT survey conducted during the autumn of 2014 on the knowledge transfer activities of public research organisations in 2012 and 2013 and the ASTP-PROTON survey. The countries included in the first survey were Austria, Denmark, Finland, the Netherlands, Norway and Sweden. Results for an additional three PROs in Denmark were obtained from the Danish Agency for Science, Technology and Innovation (DASTI), and for three PROs in Norway from the Norwegian research council and from the Nordic Institute for Studies in Innovation, Research and Education (NIFU). The survey was conducted as part of a project funded by the Norwegian Ministry of Education and Research.

The second survey of other European countries was a collaborative endeavour between ASTP-PROTON, a pan-European association for professionals involved in knowledge transfer between universities and industry, and UNU-MERIT. The two organisations collaborated on data collection to reduce the response burden for KTOs.

Both surveys collected data on the characteristics of each KTO (number of employees, age, etc.), a few characteristics of the affiliated university or public research institute, who owns the intellectual property for discoveries, and data on knowledge transfer activities for 2012 and 2013. Full details on the survey methodology are provided by Es-Sadki (2015).

The two sets of survey data were combined. The number of cases for analysis is increased by including all respondents for both survey years. Since economic conditions and research funding did not change notably between 2012 and 2013, any biases due to combining years should be minor. The full dataset includes 238 European universities and 24 research institutes. Regional-level data at the NUTS-1 and NUTS-2 levels were added for each PRO. The Nomenclature of Territorial Units for Statistics (NUTS) is a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union, and thus only covers the member states of the EU in detail. For each EU member country, a hierarchy of three NUTS levels is established by Eurostat, where NUTS-2 regions are smaller than NUTS-1.

3.2 Variables

Dependent variables

We examine three dependent variables that measure knowledge transfer activities: the number of research agreements with firms, the number of licences, and the number of start-ups established. We do not examine patent applications or grants because they do not capture direct commercialisation activities. Research agreements are often further from commercialisation than licensing or start-ups, but they can also involve solving specific problems with existing products or processes.

The outcome data are based on the awareness of KTO managers of the transfer of knowledge owned and commercialised by their office. As some organisations or countries permit the assignment of IP rights to inventors, this will underestimate the total knowledge transfer output of a university or research institute to the extent that some inventor-owned IP is commercialised through the assistance of organisations other than the responsible KTO (Lissoni et al. 2008). Consequently, the results of this study only apply to institutional knowledge transfer via the KTO. In our database, 73.0% report that only the institution or “companies that fund research conducted by your institution” owns the IP, 4.3% report that only the inventor or ‘others’ own the IP, and 86.5% report that IP can be owned by either the inventor or by the institution or funding companies. We use this information to control for the possibility that inventors or others have first rights to the IP generated at the institution. 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. This is also reflected in the high item non-response rate of 51.7% for research agreements (in contrast to an item non-response rate of 23.9% for licence agreements and 13.9% for start-ups. Hence, the results of the estimations for research agreements should be interpreted cautiously.

<Table 1>

Independent variables

The control variables cover the key influences on transfer performance as assessed in the literature. Two KTO variables include the number of employees (KTO_SIZE) and its age (KTO_AGE). The three institutional variables include the number of researchers (NUMB_RES), if the institution has a hospital (HOSP), coded as 1 when present and 0 otherwise, and the type of institution, coded as 1 when a university and 0 if a public research institute (UNIV). The variable for the presence of a hospital is included to capture activity in health sciences while the type of institution is an important factor in the use of licensing. The full data set shows that the former is more common in research institutes. 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.

<Table 2>

The independent variables of interest include indicators to control for the regional environment for the knowledge transfer activities by public research organisations. Most data have been extracted from Eurostat (see Table 3). Gross regional product in billion PPS in 2011 at NUTS-2 level (GROSS_GRP) was included to control for the size of the region. Regional gross product per capita in 2011 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-1 levels, regional employment shares in high and medium-high technology manufacturing industries[1] (EMPSHARE_HMHT) and in knowledge intensive services[2] (EMPSHARE_KIS), both for the year 2011. For the latter two variables the NUTS-1 level is used due to incomplete data at the NUTS-2 level. Furthermore, the employment shares at the NUTS-1 level are highly correlated with the available NUTS-2 level data. In addition we can assume that KTOs are willing to contact firms further away from their NUTS-2 level region to pursue commercialisation possibilities. The last regional variable is the number of public research organisations at the NUTS-2 level. This has been calculated for most regions using the EUMIDA database and for some regions based on own research.

<Table 3>

Initially we planned to perform the analysis including a set of country dummies, to control for latent national specificities of the academic system and framework for knowledge and technology transfer. However, there is a high level of collinearity between the country dummies and several independent variables, including KTO_EST, OWNERSHIP and GRP per capita that would result in multi-collinearity problems. In addition, the main focus of this paper is to examine the impact of the regional environment. National characteristics are sufficiently controlled for in the independent variables.

<Table 4>

3.3 Analytical methods

The three dependent variables are all measured as counts. We tested for overdispersion, i.e. whether the conditional variance equals the conditional mean of the dependent variable, as described in Cameron and Trivedi (1998: 77-79) and found significant overdispersion for all three dependent variables. This rules out the use of a Poisson model and consequently we chose the Negative Binomial model. As there are large numbers of zero responses for our dependant variables, one might also consider a zero-inflated model. However this type of model is not suitable for this kind of data (see Barjak et al. (2014) for a detailed explanation).

The regressions were first conducted using a dummy variable for the survey year (2012 versus 2013). The survey year had no effect on any of the results (except for the number of licences, indicating that licence activity increased in 2013) and is consequently not included in the final regressions given below. Each regression result includes the AIC value (Akaike Information Criterion), a goodness-of-fit measure in which smaller values are preferable.

[1] This entails the share of employment in NACE Rev. 2 codes, High-technology; C21 and C26, medium-high technology: C20 and C27 to C30.

[2] This entails the share of employment in NACE Rev. 2 codes, H50 and H51, J58 to J63, K64 to K66, M69 to M75, N78, N80, and 84 to 93 sections O,P,Q and R.

4 Results

Table 5 gives regression results for the three dependent variables. The variation in the number of cases is due to missing responses, which is greatest for the number of research agreements. Hence, the estimations for this outcome are the least reliable among the three dependent variables.

<Table 5>

4.1 Characteristics of the KTO and institution

The control variables show strong positive effects for the number of researchers (NUMB_RES) across all three outcomes. The size of the KTO (KTO_SIZE) also has a strong positive effect for the number of licence agreements and research agreements, but not for the number of start-ups. The presence of a hospital (HOSP) has, as expected, a strong positive effect on the number of licence agreements. The type of public research organisation only has a strong negative effect on licence agreements, indicating that research institutes perform better compared to universities. The ownership of IP (1 if inventor or combination with inventor) has as expected a strong negative impact on licence agreements and a positive impact on the number of start-ups. It has no significant effect on research agreements. The age (KTO_AGE) of the knowledge transfer office is positively correlated with the number of R&D agreements and licence agreements.

4.2 Regional characteristics

The regional per capita income (PER_CAP_GRP) has no effect on licence agreements or start-ups but it is negatively correlated with the number of research agreements. The size of the regional economy (GROSS_GRP) has no effect with any of the three outcome measures.

In contrast, regional employment is correlated with several outcomes. An increase in the share of employment in high and medium-high technology manufacturing sectors (EMPSHARE_HMHT) in the same region as the public research institute is positively correlated with the number of licence agreements, but has no effect on the number of start-ups and research agreements. Conversely, an increase in the share of regional employment in knowledge-intensive services (EMPSHARE_KIS) is negatively correlated with the number of licence agreements but positively correlated with the number of start-ups and research agreements.

Of particular interest is the effect of competition (COMP) as measured by the number of public research organisations in a region. This variable is highly significant and negatively correlated with all three knowledge transfer outcomes.

5. Discussion and Conclusions

Due to the cross-sectional nature of the data it is not possible to identify cause and effect, for example if regional characteristics drive performance or if institutions and KTOs alter their strategies as a result of the regional environment, for instance changes in the demand for knowledge by regional firms. However some conclusions can be drawn from this analysis.

The size of the regional economy in GRP in billion PPS is not correlated to any of the three outcome measures. In addition, regional per capita income is not correlated with licence agreements or start-ups, but has a negative correlation with the number of research agreements. Conversely, regional industrial structures, as measured by employment shares in KIS or high and medium-tech manufacturing, contribute to explaining the transfer performance of the region's public research institutions.

- A larger share of employment in high and medium-high technology manufacturing sectors in the same region as the public research institute has a strong positive correlation with the number of licence agreements;
- A larger share of employment in knowledge-intensive services has a strong positive correlation with the number of start-ups and research agreements, and a strong negative impact on licence agreements.

The first results is in line with a result from a large scale study on the knowledge transfer activities of public research organisations in Europe that found that biomedical IP is the largest generator of licence revenue, accounting for 87.0% of the total licence revenue for 2011 (Arundel, et al., 2013). This suggests that the presence of firms operating in NACE category C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations in the same region as the public research institute could result in above average performance for licence agreements and licence income. This possible explanation will be examined in future research.

The result showing a strong negative relationship for the number of public research organisations in the region (a measure of competition between PROs) and the three outcome variables is of high interest, as it suggests that there is limited demand for the knowledge outputs of PROs, such that increasing the supply of outputs does not increase private sector demand. It also indirectly suggests that a significant share of demand must come from regional firms instead of firms located in other regions or internationally. More research is required on the quality of outcomes when there is considerable regional competition between PROs. Cluster theory would suggest that a high concentration of PROs should increase the quality of knowledge outcomes, with a possible trade-off between quantity and quality. If true, a decline in the number of licences in regions with greater competition could be balanced by an increase in quality as proxied by licence revenues.

References

Algieri, B., Aquino, A., & Succurro, M. (2013). Technology transfer offices and academic spin-off creation: the case of Italy. The Journal of Technology Transfer, 38(4), 382-400.

Audretsch, D. B., Hülsbeck, M. and Lehmann, E. E. (2012). Regional competitiveness, university spillovers, and entrepreneurial activity. Small Business Economics 39. pp. 587-601.

Arundel, A., Es-Sadki, N., Barjak, F., Perrett, P., Samuel, O., & Lilischkis, S. (2013). Knowledge Transfer Study 2010 – 2012. Final Report to the European Commission, DG Research & Innovation. Retrieved from http://ec.europa.eu/research/innovation-union/pdf/knowledge_transfer_2010-2012_report.pdf.

Barjak, F., Es-Sadki, N., & Arundel, A. (2015). The effectiveness of policies for formal knowledge transfer from European universities and public research institutes to firms. Research Evaluation (2015) Volume 24, Issue 1 - pp. 4-18.

Barjak, F. and Es-Sadki, N. (2015). Influences of the regional and national economic environment on the technology transfer performance of academic institutions in Europe. In D. Audretsch, E. Lehmann, M. Meoli, and S. Vismara (eds.) University Evolution, Entrepreneurial Activity and Regional Competitiveness. Springer.

Belenzon, S., & Schankerman, M. (2009). University Knowledge Transfer: Private Ownership, Incentives, and Local Development Objectives. Journal of Law & Economics, 52, 111-144.

Brescia, F. Colombo, G. and Landoni, P. (2014) Organizational structures of Knowledge Transfer Offices: an analysis of the world's top-ranked universities. The Journal of Technology Transfer, published online 10 December 2014.

Cameron, A Colin and Trivedi, Pravin K (1998), Regression analysis of count data, eds Peter Hammond and Alberto Holly (Econometric Society Monographs; Cambridge: Cambridge University Press).

Chapple, W., Lockett, A., Siegel, D., & Wright, M. (2005). Assessing the relative performance of U.K. university technology transfer offices: parametric and non-parametric evidence. Research Policy, 34(3), 369-384.

Conti, A., & Gaule, P. (2011). Is the US outperforming Europe in university technology licensing? A new perspective on the European Paradox. Research Policy, 40(1), 123-135.

Curi, Claudia, Daraio, Cinzia, and Llerena, Patrick (2012), 'University technology transfer: how (in)efficient are French universities?', Cambridge Journal of Economics, 36 (3), 629-54.

Drucker, J., & Goldstein, H. (2007). Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches. International Regional Science Review, 30(1), 20-46.

Es-Sadki, N. (2015 forthcoming). Respondent report of the knowledge transfer survey 2014. UNU-MERIT, May 2015.

Fini, R., Grimaldi, R., Santoni, S., & Sobrero, M. (2011). Complements or substitutes? The role of universities and local context in supporting the creation of academic spin-offs. Research Policy, 40(8), 1113-1127.

Friedman, J., & Silberman, J. (2003). University Technology Transfer: Do Incentives, Management, and Location Matter? The Journal of Technology Transfer, 28(1), 17-30.

Hülsbeck, M., Lehmann, E. E., & Starnecker, A. (2013). Performance of technology transfer offices in Germany. The Journal of Technology Transfer, 38(3), 199-215.

González-Pernía, J. L., Kuechle, G., & Peña-Legazkue, I. (2013). An Assessment of the Determinants of University Technology Transfer. Economic Development Quarterly, 27(1), 6-17.

Lach, S., & Schankerman, M. (2008). Incentives and invention in universities. The RAND Journal of Economics, 39(2), 403-433.

Link, A. N., & Siegel, D. S. (2005). Generating science-based growth: an econometric analysis of the impact of organizational incentives on university–industry technology transfer. The European Journal of Finance, 11(3), 169-181.

Lissoni, Francesco, et al. (2008), 'Academic patenting in Europe: new evidence from the KEINS database', Research Evaluation, 17, 87-102.

Lockett, A., & Wright, M. (2005). Resources, capabilities, risk capital and the creation of university spin-out companies. Research Policy, 34, 1043-1057.

Mansfield, E. (1998). Academic research and industrial innovation: An update of empirical findings. Research Policy 26: 773-776.

O'Shea, R. P., Allen, T. J., Chevalier, A., & Roche, F. (2005). Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. Research Policy, 34(7), 994-1009.

Siegel, D. S., & Phan, P. H. (2005). Analyzing the effectiveness of university technology transfer: Implications for entrepreneurship education. In G. D. Libecap (Ed.), University entrepreneurship and technology transfer (Advances in the Study of Entrepreneurship, Innovation & Economic Growth; Vol. 16, pp. 1-38). Bingley, England: Emerald Group.

Sine, W. D., Shane, S., & Di Gregorio, D. (2003). The Halo Effect and technology licensing: the influence of institutional prestige on the licensing of university inventions. Management Science, 49(4), 478-496.

Van Looy, B., Landoni, P., Callaert, J., van Pottelsberghe, B., Sapsalis, E., & Debackere, K. (2011). Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and trade-offs. Research Policy, 40(4), 553-564.

Table 1 Descriptive statistics of dependent variables

	Universities							
	N[1]		Mean		Median		Standard deviation	
	2012	2013	2012	2013	2012	2013	2012	2013
License agreements	181	185	6.6	7.6	1	2	14.1	16.6
Start-ups	205	206	2.5	2.8	1	1	5.4	5.8
Research agreements	115	118	201.9	190.6	77	88.5	308.2	277.5
	Research institutes							
	N[1]		Mean		Median		Standard deviation	
	2012	2013	2012	2013	2012	2013	2012	2013
License agreements	16	17	15.4	16.3	2	2	24.7	27.5
Start-ups	21	19	2.5	3.4	1	1	3.5	6.3
Research agreements	10	10	132.7	132.1	47.5	40	199.5	205.4

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

Table 2 Independent dummy variables						
	Universities			**Research institutes**		
	N	**Yes**	**Percent**	**N**	**Yes**	**Percent**
Characteristics of the KTO and institution						
HOSP: Institution has a hospital	238	31	13.0%	24	0	0.0%
UNIV: University (1), other (0)	238	238	100.0%	24	24	100.0%
OWNERSHIP: IP is owned by inventor only or by inventor and other parties (other=0)	164	37	22.6%	21	5	23.8%
Country dummies						
AT	238	13	5.5%	24	2	8.3%
BE	238	6	2.5%	24	1	4.2%
BG	238	2	0.8%	24	0	0.0%
CH	238	3	1.3%	24	1	4.2%
CZ	238	1	0.4%	24	0	0.0%
DE	238	0	0.0%	24	2	8.3%
DK	238	12	5.0%	24	2	8.3%
EE	238	1	0.4%	24	0	0.0%
ES	238	70	29.4%	24	1	4.2%
FI	238	11	4.6%	24	2	8.3%
FR	238	1	0.4%	24	0	0.0%
HU	238	1	0.4%	24	0	0.0%
IE	238	5	2.1%	24	0	0.0%
IT	238	65	27.3%	24	1	4.2%
LU	238	1	0.4%	24	0	0.0%
NL	238	10	4.2%	24	3	12.5%
NO	238	13	5.5%	24	7	29.2%
PT	238	3	1.3%	24	0	0.0%
SE	238	17	7.1%	24	2	8.3%
SI	238	1	0.4%	24	0	0.0%
UK	238	2	0.8%	24	0	0.0%

Table 3 Descriptive statistics of independent variables								
	Universities							
	N		Mean		Median		Standard deviation	
	2012	2013	2012	2013	2012	2013	2012	2013
Characteristics of the KTO and institution								
NUMB_RES: Number of researchers in FTE	201	201	1,414.3	1,413.8	868.0	899.0	1,437.5	1,440.7
KTO_SIZE: KTO staff in FTE	218	218	7.9	8.0	4.3	4.3	10.5	10.7
KTO_AGE: age of KTO in years	212	212	12.3	12.3	9.0	9.0	8.2	8.2
Regional characteristics								
GROSS_GRP: Gross regional product in billion PPS € (x1,000)	235	235	91.5	91.5	59.0	59.0	78.5	78.5
PER_CAP_GRP: Regional gross product per capita € (x1,000)	238	238	28.1	28.1	28.2	28.2	7.4	7.4
EMPSHARE_HMHT: Employment share in high and medium high-technology manufacturing	238	238	4.6	4.6	3.8	3.8	2.0	2.0
EMPSHARE_KIS: Employment share in Knowledge-intensive services	238	238	39.4	39.4	35.9	35.9	7.4	7.4
COMP: Number of PROs in the region	238	238	7.2	7.2	6.0	6.0	5.8	5.8
	Research institutes							
	N		Mean		Median		Standard deviation	
	2012	2013	2012	2013	2012	2013	2012	2013
Characteristics of the KTO and institution								
NUMB_RES: Number of researchers in FTE	22	22	617.0	609.5	465.0	440.0	566.9	556.9
KTO_SIZE: KTO staff in FTE	21	21	7.4	7.4	3.0	3.5	10.5	10.6
KTO_AGE: age of KTO in years	16	16	14.0	14.0	11.0	11.0	11.3	11.3
Regional characteristics								
GROSS_GRP: Gross regional product in billion PPS € (x1,000)	23	23	66.3	66.3	55.8	55.8	48.2	48.2
PER_CAP_GRP: Regional gross product per capita € (x1,000)	238	238	36.1	36.1	36.6	36.6	6.8	6.8
EMPSHARE_HMHT: Employment share in high and medium high-technology manufacturing	24	24	5.0	5.0	4.0	4.0	3.3	3.3
EMPSHARE_KIS: Employment share in Knowledge-intensive services	24	24	46.6	46.6	48.6	48.6	5.5	5.5
COMP: Number of PROs in the region	24	24	10.9	10.9	8.0	8.0	8.1	8.1

Table 4 Correlation matrix											
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	NUMB_RES										
(2)	KTO_SIZE	**.447**									
(3)	HOSP	**.190**	**.103**								
(4)	UNIV	**.178**	.014	**.116**							
(5)	OWNERSHIP	-.022	-.077	.050	-.009						
(6)	KTO_EST	**.256**	**.404**	-.090	-.053	**-.357**					
(7)	PER_CAP_GRP	**.117**	.003	**.190**	**-.298**	**.121**	-.081				
(8)	GROSS_GRP	.056	**.113**	**-.153**	**.094**	**-.260**	.092	**.127**			
(9)	EMPSHARE_HMHT	-.088	-.006	-.074	-.057	-.022	.012	**.195**	**.195**		
(10)	EMPSHARE_KIS	**.153**	**.098**	**.259**	**-.276**	**.402**	**-.113**	**.482**	**-.273**	**-.292**	
(11)	COMP	**.127**	-.081	-.026	**-.179**	**.272**	**-.134**	**.306**	**.200**	.039	**.131**
Sign. at 5%-level in bold											

Table 5 Regression results						
	License agreements		**Start-ups**		**Research agreements**	
N	244	242	262	260	214	212
AIC	1457.2	1438.3	1128.5	1116.9	2553.8	2520.5
Characteristics of the KTO and institution						
NUMB_RES	0.255***	0.289***	0.333***	0.303***	0.300***	0.315***
KTO_SIZE	0.024***	0.021***	0.010	0.007	0.031***	0.029***
HOSP	0.949***	1.146***	-0.067	-0.348	0.179	0.124
UNIV	-0.987***	-0.855***	-0.099	-0.101	0.300	-0.060
OWNERSHIP	-0.724***	-0.497**	1.058***	0.877***	-0.277	-0.057
KTO_AGE	0.016*	0.017*	-0.011	-0.006	0.039***	0.023**
Regional characteristics						
PER_CAP_GRP		0.013		-0.003		-0.035**
GROSS_GRP		-1.113		0.173		0.811
EMPSHARE_HMHT		0.083**		-0.022		-0.058
EMPSHARE_KIS		-0.025*		0.034**		0.025**
COMP		-0.033**		-0.053***		-0.046***
Constant	1.893***	2.199***	0.309	-0.523	3.290***	4.308***
* = p <.10, ** = p <.05, *** = p<.01						

The UNU-MERIT WORKING Paper Series

2015-01 *How does firms' perceived competition affect technological innovation in Luxembourg?* by Wladimir Raymond and Tatiana Plotnikova
2015-02 *The effect of supplementation with locally available foods on stunting. A review of theory and evidence* by Mutinta Nseluke Hambayi, Wim Groot and Nyasha Tirivayi
2015-03 *Ethnic divisions, political institutions and the duration of declines: A political economy theory of delayed recovery* Richard Bluhm and Kaj Thomsson
2015-04 *Offshoring of medium-skill jobs, polarization, and productivity effect: Implications for wages and low-skill unemployment* by Ehsan Vallizadeh, Joan Muysken and Thomas Ziesemer
2015-05 *Risk preference or financial literacy? Behavioural experiment on index insurance demand* by Yesuf M. Awel and Théophile T. Azomahou
2015-06 *Poverty persistence and informal risk management: Micro evidence from urban Ethiopia* by Théophile T. Azomahou and Eleni A. Yitbarek
2015-07 *Research joint ventures in an R&D driven market with evolving consumer preferences: An evolutionary multi-agent based modelling approach* by Salih Çevikarslan
2015-08 *The effects of remittances on support for democracy in Africa: Are remittances a curse or a blessing?* by Maty Konte
2015-09 *The location strategies of multinationals from emerging countries in the EU regions* by Riccardo Crescenzi, Carlo Pietrobelli and Roberta Rabellotti
2015-10 *North-South FDI and Bilateral Investment Treaties* by Rod Falvey and Neil Foster-McGregor
2015-11 *Evolutionary convergence of the patterns of international research collaborations across scientific fields* by Mario Coccia and Lili Wang
2015-12 *Innovation and productivity in services and manufacturing: The role of ICT investment* by Diego Aboal and Ezequiel Tacsir
2015-13 *Human capital, innovation and the distribution of firm growth rates* by Micheline Goedhuys and Leo Sleuwaegen
2015-14 *Inside the Black Box: Contributions to the discussion on official development assistance* Editors: Ian Freeman, Tamara A. Kool, Charles Low, Sam Salsal and Emilia Toczydlowska
2015-15 *Innovation in natural resources: New opportunities and new challenges. The case of the Argentinian seed industry* by Anabel Marin and Lilia Stubrin
2015-16 *Technology foresight and industrial strategy in developing countries* by Carlo Pietrobelli and Fernanda Puppato
2015-17 *The impact of the regional environment on the knowledge transfer outcomes of public research organisations: preliminary results for Europe* by Nordine Es-Sadki and Anthony Arundel