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What drives university-industry collaboration: Research excellence or firm collaboration strategy?

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Abstract

Research and innovation policy aims to boost research output and university-industry collaboration (UIC) at least in part to allow firms access to leading scientific knowledge. As part of their mission, universities are expected to contribute to innovation in their regions. However, the relationship between research output and UIC is unclear: research-intensive universities can produce frontier research, which is attractive to firms, but may also suffer from a gap between the research produced and the needs of local firms, as well as mission overload. This may hinder local firms' ability to cooperate with universities altogether or force them to look beyond the region for other suitable universities to interact with. This paper investigates the relationship between the research output of local universities and firms' participation in UICs across different geographical scales. It uses Community Innovation Survey (CIS) data for Norwegian firms and Scopus data on Norwegian universities' research output across various disciplines. The results demonstrate that local university research intensity and quality are negatively associated with firm participation in UICs at the local level. Firm characteristics, in particular the firm's general strategy towards cooperation and its geography, turn out to be much more important than university characteristics in explaining UICs. Notably, firms' cooperation with other external partners at the same scale is a strong predictor of UICs.

Keywords: Research, universities, firms, university-industry collaboration, Norway.

JEL Classification: O31, O32, O33

1. Introduction

The impact of universities on the performance of firms in their vicinity is a major topic in the geography of innovation literature. The presence of research-intensive universities has traditionally been associated with the production of geographically bounded knowledge spillovers, which enhance the innovation capacity of firms located in close proximity to the universities generating frontier research (e.g. Jaffe, 1989). Universities are, consequently, considered fundamental players in models of regional innovation, from triple-helix through learning regions to regional innovation systems. University-industry collaboration (UIC) is regarded as an important channel for the production and diffusion of knowledge from universities to firms, and most commonly takes place in close geographical proximity (Acs, Audretsch, & Feldman, 1994; Piergiovanni & Santarelli, 2001; Zucker, Darby, Furner, Liu, & Ma, 2007). The more advanced the research conducted at local universities, the greater the knowledge production which neighbouring firms can potentially benefit from. Accordingly, research and innovation policies have frequently aimed simultaneously to promote university research excellence and to stimulate UIC with a view to enhance the impact of universities on local firm-level innovativeness. A salient question in this regard is which factors influence firms' decisions to collaborate with universities or not, and how this decision is affected by characteristics of the regional university and of the firm itself.

While the decision to collaborate may be driven by the structure of universities, of the type of research being conducted there, as well as by the characteristics of the firms, most previous research has examined the impact of university or firm characteristics separately, with only a few exceptions (e.g. Garcia, Araujo, Mascarini, Gomes Santos, & Costa, 2015; Maietta, 2015). Hence, an integrated perspective on the drivers of university-industry collaboration is largely missing. In this paper, we focus in particular on the impact of two potentially important factors influencing firms' decisions to collaborate with universities: university research intensity and firm network scope. Furthermore, while geography has a strong influence on university-industry interaction (Fitjar & Gjelsvik, 2018; Laursen, Reichstein, & Salter, 2011), firms may also collaborate with universities at longer distances (Ponds, Van Oort, & Frenken, 2007). This decision can also be driven partly by local university characteristics, which increase or reduce the need to look beyond the region for suitable partners. Little previous research has examined how the underlying drivers may influence collaboration at various scales differently.

But how is university research output related to UIC? On the one hand, more cutting-edge research would lead to potentially more valuable the knowledge spillovers and, consequently, to greater potential advantages for collaborating firms. Firms will therefore be more willing to collaborate with universities with an advanced research output in fields that are relevant to them (D'Este & Iammarino, 2010; Johnston & Huggins, 2017; Laursen et al., 2011). Following this logic, policy-makers increasingly emphasize the need for research excellence as a means to promote innovation. Scarce public R&D resources are thus progressively channeled towards a smaller number of highly research-intensive 'world-class' institutions. However, the pursuit of research excellence by universities can also be detrimental to collaboration with firms (Maietta, Barra, & Zotti, 2017). Universities require their research to have scientific as well as societal impact. A dominant focus on frontier research may lead to a widening of the gap between the knowledge produced by universities and that which can be absorbed by firms in the local environment. Moreover, under conditions of mission overload (Jongbloed, Enders, & Salerno, 2008), research universities may focus more on their research mission to the detriment of interacting with local industry.

While this is an increasingly crucial topic with important implications for innovation policy, the number of studies that have sought to analyse whether the ever increasing pursuit of research excellence by universities is having an impact on university-industry collaboration is scarce (e.g. Minguillo & Thelwall, 2014). In parallel, few studies have looked at the impact of firm innovation strategies on their cooperation with universities at different scales. The move to open innovation implies an increase in the use of external partners in firm innovation processes more generally. This also influences the use of universities as collaboration partners. Besides the general level of external networking, innovation strategies also encompass the geographical scope of firm's innovation networks – be they mainly regional, national or international. However, previous research on university-industry collaboration has not considered how firm networking may have varying effects on collaboration with universities at different spatial scales.

This paper examines how firm and regional university characteristics collectively affect firms' propensity to collaborate with universities, within as well as beyond the region. The paper draws on a dataset compiled from several data sources. Using Norway as the empirical context, we gather information on firm characteristics from three waves of the Community Innovation Survey (CIS) for Norway, supplemented with Norwegian Linked Employer-Employee Data (LEED). This yields a representative sample of over 18,000 firms. In addition, we collect data on the research output of Norwegian universities from the Scopus database.

The results of the analysis, generally, show that local universities' research output and quality relates negatively to the propensity of firms collaborating with universities. This indicates that research intensity or an excellence-oriented mission of universities may have less of an impact on the immediate transfer of knowledge to society than the emphasis of policies would suggest. Pursuing research excellence, rather than maximising the benefits for the local socio-economic systems in the short term, can come at the cost of university-industry collaboration. Conversely, firms' tendency to collaborate with other external partners, such as suppliers, customers, or consultants, is a major driver of UIC. Indeed, firms that collaborate broadly with external partners exhibit a high propensity also to cooperate with universities. Remarkably, this effect is limited mainly to collaborations at the same geographical scale. Finally, distance to the closest university has a curvilinear relationship with collaboration, suggesting that proximity to a university matters only up to a point, after which being more or less close to a university has little influence on the propensity to collaborate. The other firm side controls exhibit positive associations with collaboration across diverse spatial scales. This finding confirms the notion that firm attributes play a substantial role in determining collaboration decisions.

The remainder of the paper is organized as follows. The next section discusses the factors that determine collaboration between universities and firms. The third section describes the data, variables and methods employed in the analysis. The results of the analysis are presented in the penultimate section. The concluding section draws conclusions and highlights some policy implications.

2. Regional university characteristics and firm collaboration strategies as drivers of university-industry collaboration

Universities continue to attract attention in innovation and science policy research as sources of valuable knowledge for innovation in local firms (Bishop, D'Este, & Neely, 2011). As knowledge producers, universities generate new knowledge through research and impart

existing and newly-generated knowledge to students. Firms benefit from this scientific knowledge when they hire graduates or engage the services of academic researchers (Leten, Landoni, & Van Looy, 2014). In addition, forging knowledge exchange linkages with a local university is considered to improve creativity, problem solving, and R&D capabilities at the level of the firm (Perkmann et al., 2011). Furthermore, universities contribute to the regional knowledge pool by transmitting knowledge and attracting talent from their networks outside the region (Atta-Owusu, 2019; Bramwell & Wolfe, 2008). These and other roles universities perform make them potentially significant actors in regional innovation.

However, not all universities perform these functions equally. Universities are not homogenous entities but differ on various dimensions. Some may be prolific at producing and transferring cutting-edge scientific research, while others are more capable at educating qualified graduates for the job market (Kempton, 2019; Sanchez-Barrioluengo, 2014). Because of the advantages of geographical proximity, firms are more likely to collaborate with local universities. Hence, the different profiles of universities may have an important impact on both the performance of firms and on the local economy. Being close to a university that specialises in education will have a different impact on firm innovation and performance than being close to a top research university. Moreover, different universities adopt different *modus operandi* in terms of external engagement activities and, as a consequence, reward the outreach activities of their academics in different ways. While many consider only publication output when evaluating academics for recruitment or promotion, others also have requirements for societal impact or other incentives for such activities.

These contrasts between universities may shape the decisions of local firms to collaborate with the university, and – in case of a negative decision – of whether to look for other universities beyond the region or to drop UICs altogether. Local university characteristics matter for the extent to which firms cooperate with universities within as well as outside their region. The university-related factors examined in the literature include geographical proximity, strategic orientation, faculty size, and research quality or intensity, among others (e.g. D'Este & Perkmann, 2011; Perkmann et al., 2013).

There is some consensus in the literature that geographical proximity fosters interaction and knowledge exchange collaboration between firms and universities. Most research has underlined that knowledge spillovers remain geographically bounded (e.g. Moreno, Paci, & Usai, 2005; Rodríguez-Pose & Crescenzi, 2008; Sonn & Storper, 2008). As such, firms that locate near universities may find it easier to access (especially tacit) knowledge through frequent face-to-face interaction with university researchers and scientists (Adams, 2002; Audretsch & Feldman, 1996; De Fuentes & Dutrenit, 2016; Jaffe, 1989). Additionally, firms require a broader pool of universities from which to select potential partners for collaboration. However, they are usually constrained by limited resources and information. Therefore, many firms restrain their search to proximate institutions, on which they are likely to have more information or existing relations. This allows firms to minimise transaction costs and risk of opportunistic behaviour from unknown universities (Fitjar & Gjelsvik, 2018). Such satisficing choices reduce the cost of accessing and absorbing knowledge, resulting in a predominance of local university-industry collaboration (Audretsch, Lehmann, & Warning, 2005).

Although regional universities remain the primary cooperation candidates, firms, nonetheless, can also – and frequently do – interact with other universities outside their region. Various reasons can account for this, but local university characteristics can serve as a potential "push" factor. Its research specialisation is one such factor. Relatedly, the lack of synergy between the knowledge needs of local industry and the research focus and expertise of a university can equally be a determining factor. Not all universities will have experts in the

area in which a particular firm requires support or have sufficient competence. If the local university has little competence in disciplines relevant for the firm, it may look to universities outside the region for relevant expertise (Gunasekara, 2006). Equally, a university that focuses strongly on attaining and maintaining academic excellence but places weak emphasis on or avoids building linkages with industry may compel local firms to collaborate with more entrepreneurially orientated universities beyond their region (Gunasekara, 2006; Huggins & Johnston, 2009). Certain firms may also seek cutting-edge knowledge that is only being generated in a small number of universities and research centres.

2.1 Research intensity and university-industry collaboration

A university's research quality is widely considered to be a vital driver in university-industry partnerships (D'Este & Patel, 2007; Giunta, Pericoli, & Pierucci, 2016). Firms are attracted to leading research universities out of the conviction that they can harness their novel knowledge to improve internal innovativeness (Mansfield, 1995). Additionally, research-intensive universities often possess other resources, such as excellent facilities, equipment and extensive networks, making them attractive to industrial partners (Santoro & Chakrabarti, 2002). Firms may be more willing to overcome geographical distance to develop relationships with universities conducting cutting-edge research outside their region. Indeed, several studies empirically demonstrate that access to high-quality knowledge overrides proximity effects in firms' cooperation with universities (e.g. Laursen et al. (2011).

To be sure, research intensity can also cause rifts between firms and universities. Many contributions point to the inherent conflicts in university-industry collaborations, due to the different goals, incentives and time horizons of universities and firms (e.g. Bruneel, D'este, & Salter, 2010; Hewitt-Dundas, Gkypali, & Roper, 2019). While university researchers want to publish the results from collaborative projects, firms may want to keep them secret while preparing a patent. Furthermore, university researchers tend to aim for more breakthrough research, spending time to search for the perfect solution, while firms may be looking for something that is good enough and works here and now.

Nonetheless, many studies find evidence of a positive relationship between research excellence and industry support. For instance, building on US data, Mansfield and Lee (1996) find that universities with distinguished faculty attract higher funding from firms than universities with less accomplished academics. Hewitt-Dundas (2012) also finds that research-intensive universities tends to perform more knowledge transfer activities in the UK. Perkmann, King, and Pavelin (2011) show academic quality to be more related with industry engagement in the technology-oriented and basic sciences disciplines. And Bellucci and Pennacchio (2016) observe that academic research quality relates positively to knowledge interaction between universities and industries. Adopting a cross-border perspective, Suzuki (2017) shows that the research quality of partner universities contributed positively to firms realizing benefits from the joint research partnerships.

On the balance of evidence, this leads to the hypothesis that:

H_1. University research intensity is positively associated with firms' collaboration with universities.

2.2 The geography of firm collaboration networks and university collaboration

Innovation remains a dynamic process that entails exchange of diverse types of knowledge among various actors. Besides knowledge exchange with universities, firms can exchange knowledge with their users or customers, with other firms, such as suppliers, competitors or consultants, and with other types of organisations, including research institutes (von Hippel,

1988). Firms adopt different strategies for how they navigate this landscape, in terms of their use of internal or external knowledge sources, the types of external partners they connect with, and the geographical scope of their innovation networks (Drejer & Vinding, 2007; Fontana, Geuna, & Matt, 2006). These broader firm innovation strategies are bound also to affect how firms interact with universities. University-firm interaction is shaped both by the extent to which the firm sources knowledge externally in general, and by the scale at which it develops its innovation networks (Bercovitz & Feldman, 2007; Drejer & Østergaard, 2017). In short, firms with extensive regional networks are more likely to also connect with universities in the region, while firms that maintain global innovation networks will, to a greater extent, also consider universities across the world as potential partners.

Not only that, the connectedness of firms to other partners is equally vital for university interactions (de Faria, Lima, & Santos, 2010). Collaborating with other partners that perform related research is considered to enhance the capacity of firms to absorb complex knowledge from universities (Agrawal, 2001). Firms that maintain R&D collaborations with suppliers or customers increase the chance of establishing new partnerships with other actors in the value chain (Belderbos, Gilsing, Lokshin, Carree, & Fernández Sastre, 2018). Firms that cooperate with external partners are also more likely to establish and reap benefits from research collaboration with universities (Dezi, Santoro, Monge, & Zhao, 2018; Segarra-Blasco & Arauzo-Carod, 2008). Hence, we expect a firm's embeddedness and interaction within external networks to influence its willingness and ability to collaborate with universities. Furthermore, this relationship is likely to be relatively specific to the geography of firms' innovation networks. Accordingly, we propose that:

H_2. Firms' cooperation with other partners is positively associated with university collaboration;

and

H_3. Firms' cooperation with other partners is positively associated with university collaboration at the same geographical scale.

3. Methodology

To explore the determinants of university-industry collaboration decisions, we use data from various sources. Firm characteristics are measured with data from the Norwegian CIS, supplemented with register data from Statistics Norway. Additionally, we utilize information from Scopus to measure the characteristics and, especially, the research intensity of Norwegian universities.

The CIS is the main data source employed in the analysis. This survey monitors innovation investments, processes and outputs of Norwegian businesses. It was first conducted in 1992 and has since been carried out biennially. The population of interest represents firms operating in manufacturing or service industries, as well as petroleum and aquaculture. The sampling is conducted on a tiered basis, such that the survey is a census for all businesses with 50 or more employees. For all firms with less than 50 employees, a random sample, stratified by industry and size class, is implemented. Two characteristics specific to the Norwegian CIS are worth stressing. First, participation is mandatory for sampled firms, with fines for non-respondents. This almost rules out non-response bias. Second, the routing structure ensures all firms report collaboration activities, even those with no innovation output. The total sample for each wave ranges between 6000 and 6500 with a response rate of

over 95 percent. In this study, we rely on data from three waves of the survey: 2006, 2008, and 2010. This yields a combined sample of over 18,000 firms.

Scopus is an abstract and indexing database developed by Elsevier in 2004. It contains 75 million documents sourced from over 24,000 active titles and 5,000 publishers. The database covers contents from journals, conference proceedings, book series and trade publications in all scientific fields. Additionally, it offers enhanced sorting and searching features enabling researchers to access over one billion citations going back to 1970s. Perhaps the key strength of Scopus is the system of unique identifiers (profiles) that assist users to track research outputs of individual authors and organizations. Using the profiles of authors or institutions, one can compute the number of publications and citations for all subject areas within a particular period (Aldieri, Kotsemir, & Vinci, 2018).

3.1 Data and Variables

Dependent Variable

The dependent variable is created from questions in the CIS on the R&D collaboration activities of firms. In the survey, firms are asked whether they cooperated for R&D or innovation with various types of partners in the last three years. We focus on collaboration with universities (*All collaboration*). Firms that collaborate are asked to indicate if these were within the region (*Local university collaboration*); elsewhere in Norway (*National university collaboration*); or abroad (*International university collaboration*). Collaboration is a binary variable that assumes the value of one if a firm collaborated with a university, and zero otherwise.

Explanatory variables

Number of publications and *non-university collaboration* are the primary explanatory variables included in the analysis. The number of publications is an indicator representing the research output of regional universities in academic fields relevant for a particular firm. We develop this measure through the following steps: We first extract the scientific publications of Norwegian universities from the Scopus database for the period between 2006 and 2010. Given the heterogeneity of university research across disciplines, we group publications under one major subject area following the Scopus All Science Journal Classification (ASJC) system.[1] Next, we assign universities to labour market regions (NUTS 4) based on their address. We merge labour market regions without any universities with the closest region that has a university. This results in a total of 21 regions in the final classification, all having one or more universities. The idea is to match each firm to the university closest to it. We then sum up the publications in each discipline of all universities in a region. That is, we aggregate the data at the level of the region, not university. This creates a measure of the university research capacity available in the firm's own region within disciplines which are relevant to the local industry. Most regions have one main university, although Oslo and Hordaland host three or more universities.

In order to identify which disciplines are most relevant for each firm, we applied the science fields and economic sectors matrix developed by Schartinger, Rammer, Fischer, and Fröhlich (2002) to link scientific disciplines to specific economic sectors which use their knowledge output. We produced this by matching the regional aggregated data by discipline with the industrial sectors in that region at the NACE two-digit level. Applying this framework allows us to identify the number of publications (and citations) in disciplines considered relevant for

[1] Three subject areas (nursing, health professions, and multidisciplinary) were left out because they could not be matched to any industrial sectors included in the CIS.

a particular sector. Three different measures were applied. We first focus on the number of publications in the single most relevant discipline for each industry. As a robustness check, we extend the measure to include the sum of publications in all disciplines which have some relevance.

Finally, we additionally included the total number of citations to the research published between 2006 and 2010. This allows us to go beyond the purely quantitative measure of the number of publications in a particular discipline to also include a proxy for the quality of the research being conducted in the local university and its impact in the scientific community.

Non-university collaboration measures the collaboration of firms with partners other than universities. Just like the dependent variable, it measures whether firms collaborated with other partners (sister companies, suppliers, customers, competitors, consultants, commercial laboratories, and research institutes) within their region, elsewhere in the country, or abroad. In the survey, firms are asked to indicate their responses for these other partners. We constructed an additive index for this variable. We produced this by, first, coding each collaboration as a binary variable. We assign a value of one if a firm collaborated with any of the seven partners and zero otherwise. We then sum up these collaborations such that a firm obtains zero if it had no collaboration with any type of partners, and seven if it collaborated with all types of partners. We build this measure separately for local, national, and international collaboration with non-university partners.

Control variables

Several control variables that have been shown to influence university-industry interactions are additionally included. Distance to university is a variable that measures a firm's proximity to the nearest university. We identify a firm's location based on the municipality where the majority of its employees works, and calculate the road distance from the City Hall (*rådhus*) to the nearest university. Driving distances range between 1 and 347 minutes, with an average and median driving time of 78 and 59 minutes, respectively. Twenty-six percent of firms in the dataset are located within 30 minutes' drive from the closest university. Fifty percent are located within a 60 minutes' drive. Finally, almost 19 percent of Norwegian firms included in the sample are farther away than 120 minutes from a university. This variable is skewed, therefore, we log transform it.

Other variables that capture firm characteristics include Research and Development (R&D) intensity, which is measured by the R&D expenditure of firms. Given its skewness, the variable is log transformed. We also control for firm size, in terms of log total number of employees, and human capital, using the log percentage share of employees with tertiary education. Finally, we include 62 dummies based on the NACE two-digit classifications to control for industry. Because disciplines are matched to industries, these industry fixed effects also account for differences across disciplines in industry interaction. In effect, we are comparing firms within the same industry located in regions with more or less research output in disciplines relevant for this industry. Year dummies were also added to account for variations in firms' collaboration activities in the different survey periods.

3.2 Estimation and model specification

We run logistic regression analyses separately for firms' collaboration with universities in general and their collaboration with universities at the local, national and international levels. The econometric model takes the following form:

$$Logit[Pr(Collaboration_{isrt})=1] = \alpha + \beta_1 \, Number\ of\ Publications_{sr} + \beta_2 \, Non\text{-}university\ Collaboration_{isrt} + \beta_3 \, Controls_{isrt} + \delta_s + \tau_t + \varepsilon_{isrt} \quad (1)$$

with *i*, *s*, *r*, *t*, denoting firm, sector, region and time, respectively. Collaboration represents the dependent variables measuring firms' cooperation with universities. Four models were estimated, one for each of the measures defined above (All collaboration, Local university collaboration, National university collaboration, and International university collaboration). The explanatory variables are the university and firm characteristics outlined above. Lastly, δ and τ denote the industry and time fixed effects respectively while ε is the error term.

4. Results

Table 1 and Table 2 present the descriptive statistics and the correlation matrix respectively for all variables employed in the analyses. Table 3 reports the results of the logistic regression analyses of firms' collaboration, using the number of publications in academic fields deemed relevant to local firms as the main explanatory variable. In Table 4, the number of publications is substituted by the number of citations to those publications as an indicator of the quality of the research being carried out in the region. An examination of all models shows the results are consistent in terms of the size and direction of the coefficients of the predictor variables.[2]

Table 1. Descriptive statistics

Variables	Obs.	Mean	S.D.	Min	Max
All collaboration	18,235	.070	.256	0	1
Local univ. collaboration	18,235	.035	.185	0	1
National univ. collaboration	18,235	.035	.184	0	1
International univ. collaboration	18,235	.020	.139	0	1
Number of publications (log)	18,235	4.107	2.733	0	8.544
Local non-univ. collaboration	18,235	.221	.788	0	7
National non-univ. collaboration	18,235	.215	.823	0	7
International non-univ. collaboration	18,235	.194	.778	0	7
Distance to university (log)	18,235	2.894	1.164	0	5.849
R&D intensity (log)	18,231	1.892	3.456	0	13.557
Firm size (log)	18,235	3.386	1.275	1.609	9.842
Human capital (log)	18,235	.212	.196	0	.693

Contrary to expectations, firms located in regions with universities that have a high research output in related disciplines are less likely to collaborate with universities. Firms in these regions are less likely to collaborate with universities in general. They are also less likely to collaborate with these regional universities in particular. On top of that, they are also less likely to collaborate with universities in other regions of Norway, perhaps in part due to the inability of local universities to serve as a bridge into networks with universities in other regions. However, they are no less likely to collaborate with foreign universities. Overall, local universities' focus on the research excellence mission – proxied by their research intensity – is associated with a decrease in local and national collaboration. Therefore, H_1 is

[2] As a robustness check, we substituted the variable "Number of publications in most relevant discipline" with a variable measuring the number of publications in all relevant disciplines. Overall, the results obtained – presented in Table A1 in the appendix – were not qualitatively different from the main analyses.

not supported. This may be because pursuing international research excellence, as many universities in Norway and elsewhere in the world now prioritise, creates a gulf between the type of research being produced by universities and the needs of local firms.

Rather than university research intensity, the overall propensity of the firm to collaborate with external partners for innovation emerges as a much more important driver of university-industry collaboration, supporting H_2. Firms that collaborate with suppliers, customers, competitors and other types of partners are far more likely also to collaborate with universities. Furthermore, this effect is remarkably specific to collaboration with partners at the same geographical scale, providing support also for H_3. Specifically, collaboration of firms with other partners within the region is positively associated with local university collaboration. Collaboration of firms with national partners is strongly associated with collaboration with national universities, and collaboration with foreign partners is strongly associated with collaboration with foreign universities. The associations between collaborations at different scales are, conversely, either much weaker or not significant. There is no relationship between collaboration with other partners locally and collaboration with universities at the national and international scales. Moreover, there is no association between collaboration with other partners at the national level and local university collaboration. In contrast, positive associations emerge between both types of non-local collaboration. Finally, the relationship between firms' international collaboration with other partners and university collaboration is positive and significant across all the geographic scales.

Table 2. Correlation matrix of variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1.All collaboration	1.00											
2.Local univ. collaboration	0.70*	1.00										
3.National univ. collaboration	0.69*	0.22*	1.00									
4.International univ. collaboration	0.51*	0.22*	0.30*	1.00								
5.Number of publications (log)	0.05*	0.06*	0.02*	0.04*	1.00							
6.Distance to university (log)	-0.04*	-0.05*	-0.01	-0.03*	-0.34*	1.00						
7. Local non-univ. collaboration	0.52*	0.57*	0.27*	0.22*	0.05*	-0.03*	1.00					
8. National non-univ. collaboration	0.57*	0.29*	0.63*	0.32*	0.02*	-0.00	0.41*	1.00				
9. International non-univ. collaboration	0.53*	0.30*	0.37*	0.58*	0.06*	-0.02*	0.36*	0.46*	1.00			
10.R&D intensity (log)	0.43*	0.30*	0.32*	0.26*	0.15*	-0.08*	0.34*	0.38*	0.41*	1.00		
11. Firm size (log)	0.17*	0.10*	0.16*	0.11*	-0.00	-0.11*	0.12*	0.17*	0.19*	0.24*	1.00	
12. Human capital (log)	0.17*	0.14*	0.11*	0.12*	0.45*	-0.31*	0.12*	0.11*	0.14*	0.33*	0.00	1.00

Note: *p<0.05

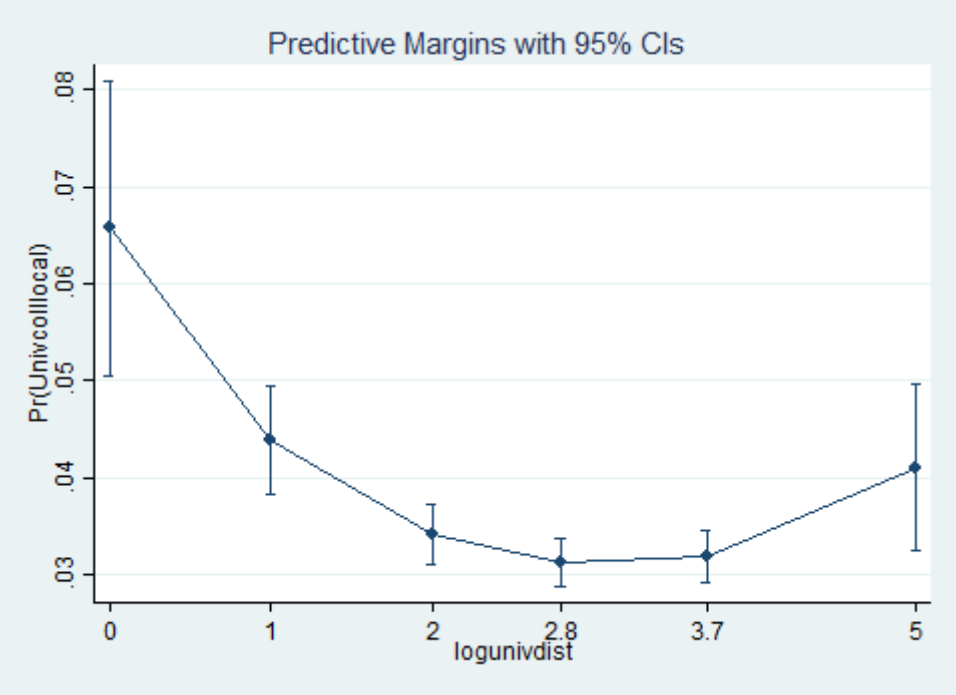
Table 3: Logistic regression analyses of collaboration, using the number of publications as the main explanatory variable

Model	**(1)** All Collaboration	**(2)** Local univ. collaboration	**(3)** National univ. collaboration	**(4)** International univ. collaboration
Independent variables				
Number of publications (log)	-0.058**	-0.067**	-0.090***	-0.039
	(0.024)	(0.030)	(0.031)	(0.041)
Local non-univ. collaboration	0.776***	1.111***	-0.014	0.061
	(0.035)	(0.037)	(0.053)	(0.062)
National non-univ. collaboration	0.727***	0.015	1.067***	0.224***
	(0.037)	(0.045)	(0.042)	(0.052)
International non-univ. collaboration	0.588***	0.119***	0.161***	1.020***
	(0.040)	(0.043)	(0.042)	(0.049)
Control variables				
Distance to university (log)	-0.657***	-0.893***	-0.135	-0.051
	(0.136)	(0.164)	(0.175)	(0.250)
Distance to university $(\log)^2$	0.106***	0.144***	0.025	-0.015
	(0.024)	(0.030)	(0.032)	(0.045)
R&D intensity (log)	0.182***	0.175***	0.210***	0.159***
	(0.015)	(0.018)	(0.021)	(0.029)
Firm size (log)	0.169***	0.107**	0.202***	-0.102
	(0.041)	(0.048)	(0.052)	(0.072)
Human capital (log)	2.715***	2.968***	2.704***	2.471***
	(0.394)	(0.472)	(0.482)	(0.655)
Survey year 2008	-0.296***	-0.229*	-0.112	-0.222
	(0.110)	(0.134)	(0.139)	(0.185)
Survey year 2010	-0.403***	-0.257**	-0.308**	-0.266
	(0.108)	(0.131)	(0.146)	(0.180)
Industry fixed effects	Included	Included	Included	Included
Constant	-3.847***	-3.901***	-5.851***	-4.727***
	(0.457)	(0.539)	(0.552)	(0.622)
N	18,178	18,178	17,561	17,232
Pseudo R^2	0.576	0.509	0.553	0.549

Note: Robust standard errors clustered over firms in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The distance of firms to the local university also influences collaboration at the local level. As expected, distance to the local university has a significant and negative association with local collaboration, whereas the effects are insignificant for national and international collaborations. We introduced a quadratic term to establish whether this relationship is non-linear. The coefficient for squared distance is positive and significant, indicating a curvilinear relationship. This implies that distance to the university decreases collaboration up to a point, after which it no longer matters. Figure 1 plots this relationship. The predicted likelihood of collaboration falls rapidly from around 6.5 percent for an average firm that is co-located with the university to around 3.5 percent for firms located more than 7 minutes (e^2=7.3) drive away from the university. Beyond this distance, there is no significant difference in the predicted likelihood of collaboration between firms located closer or farther away from the university.

Figure 1. The relationship between collaboration and distance to university



The firm-level control variables (R&D intensity, firm size and human capital) also have the expected impact on university collaboration. Firm R&D intensity has a positive and significant effect on university collaboration in all the models. In other words, firms that allocate a high share of their budget to R&D activities are more likely to cooperate with universities, other things being equal. Consistent with the findings of prior studies, the size of a firm is positively related to university collaboration in all the models except model 4 (e.g. Fontana et al., 2006; Levy, Roux, & Wolff, 2009). This means larger firms are more likely to collaborate with universities within their localities and with other national universities. Surprisingly, firm size appears not to matter when it comes to collaboration with universities abroad. Lastly, firms' human capital influences collaboration with universities. The coefficients are positive and significant across all the models, in line with results from other studies (Laursen & Salter, 2004; Muscio, 2007; Tartari & Breschi, 2012).

What about if the collaboration between local universities and firms is not driven by the intensity of this research but, as indicated among others by D'Este and Patel (2007) and Giunta et al. (2016), by the quality of the research? In order to check whether this is the case, we substitute (in Table 4) the number of publications by the overall number of citations to research published by local universities during the period of analysis. This serves as a proxy of the quality and impact of local university research. The results highlight that the university's excellence in research is no different from its research intensity for the development of UIC. When universities actively pursue research intensity and achieve success in terms of quality – proxied by the number of citations to the papers produced by researchers at the university – the links with local and national firms are weakened (Table 4). Focusing on excellence in research seems to drive universities apart from the problems of local firms, rendering them less valuable partners for firms.

Table 4. Logistic regression analysis of collaboration, using the number of citations as the main explanatory variable

Model	**(1)** All collaboration	**(2)** Local univ. collaboration	**(3)** National univ. collaboration	**(4)** International univ. collaboration
Independent variables				
Number of citations (log)	-0.047**	-0.051**	-0.074***	-0.025
	(0.019)	(0.024)	(0.024)	(0.032)
Local non-univ. collaboration	0.777***	1.111***	-0.013	0.061
	(0.035)	(0.037)	(0.053)	(0.062)
National non-univ. collaboration	0.727***	0.017	1.068***	0.224***
	(0.037)	(0.045)	(0.042)	(0.052)
International non-univ. collaboration	0.587***	0.118***	0.160***	1.019***
	(0.040)	(0.043)	(0.042)	(0.049)
Control variables				
Distance to university (log)	-0.653***	-0.886***	-0.129	-0.045
	(0.136)	(0.164)	(0.175)	(0.250)
Distance to university $(\log)^2$	0.105***	0.143***	0.024	-0.015
	(0.024)	(0.030)	(0.032)	(0.045)
R&D intensity (log)	0.182***	0.175***	0.210***	0.159***
	(0.015)	(0.018)	(0.021)	(0.029)
Firm size (log)	0.169***	0.106**	0.202***	-0.102
	(0.041)	(0.048)	(0.052)	(0.072)
Human capital (log)	2.713***	2.958***	2.713***	2.454***
	(0.393)	(0.471)	(0.480)	(0.656)
Survey year 2008	-0.296***	-0.230*	-0.112	-0.222
	(0.110)	(0.134)	(0.139)	(0.185)
Survey year 2010	-0.403***	-0.258**	-0.308**	-0.267
	(0.108)	(0.131)	(0.146)	(0.180)
Industry fixed effects	Included	Included	Included	Included
Constant	-3.860***	-3.933***	-5.861***	-4.766***
	(0.455)	(0.535)	(0.550)	(0.621)
N	18,178	18,178	17,561	17,232
Pseudo R^2	0.576	0.509	0.553	0.549

Note: Robust standard errors clustered over firms in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions

Universities are often regarded – especially in many regional innovation and development strategies – as a beacon for innovation at firm level. University-industry partnerships are being recommended as a way to improve the innovation capacity, productivity and competitiveness of firms. Hence, local firms and universities are regularly urged to engage in collaboration. Yet, this collaboration is often proving elusive. One reason for this may be that, although the pursuit of excellence in research is desirable for society as a whole, it may widen the gap between the production of knowledge and the needs of local firms. This is corroborated by our research, which finds that increasing the intensity and quality of the research of universities is not conducive to greater collaboration with local firms. When analyzed at the firm level, university-industry collaboration appears to be fundamentally driven by the characteristics of the firm rather than by the intensity and quality of the research conducted at the university. All firm-related factors are much stronger predictors of collaboration with universities across all scales than the type, intensity and quality of the research being conducted at the university. Notably, firms collaborate with universities when

they already engage with other partners. The decision of Norwegian firms to collaborate with the local university appears to be driven more by the strategic decision of the firm to develop its innovation process in localized networks than by what the local university itself has to offer. Similarly, firms that collaborate with national or international universities often do so as part of broader approaches involving various other types of national or international partners.

At the university side, its research intensity in disciplines relevant for the firm and the quality of this research appear not to be major drivers of collaboration. On the contrary, the analysis shows that the research intensity of local universities has an adverse impact on local firms' participation in university collaboration. Firms located in regions with research-intensive and high-quality universities are less likely to collaborate with these local universities. Because university-industry collaboration is often local, this implies that they also tend to collaborate less with universities in general. In addition, because local universities may help firms enter networks involving other national universities, these firms also tend to collaborate less with other Norwegian universities outside their region.

What are the implications of all this? For higher education policy, it is important to realize that university-industry collaboration may be more about the strategies and characteristics of firms than those of universities. Hence, measuring universities' performance on their ability to collaborate with local firms runs the risk of placing the credit for collaboration (or the blame for lack of collaboration) on the wrong end of the partnership. Beyond stimulating universities to interact with firms, policy-makers who want to foster university-industry collaboration need to think about how firms' strategies and networks can be geared in the direction of promoting greater collaboration with universities as well.

For universities, the lesson is that research quality or intensity may contribute to pulling the university closer to the research frontier and farther up the rankings, but may do little to make it an attractive partner for local firms. Additional actions are needed to bridge the gap between the worlds of academia and industry. Indeed, universities that focus exclusively on their research mission may experience a reduction in firm collaboration. In order to ensure that firms have access to high-quality research, it is important that leading research universities in particular manage to reach out to firms. Finally, for firms seeking to enter into collaborations with universities, existing networks with other firms often serve as bridges to the university. Building on their local, national or international networks can help to identify suitable university partners with whom to connect.

The findings also come with limitations that must be acknowledged. First of all, we do not know with which specific university the firms collaborate, only at which scale university collaboration occurs. Hence, we cannot use specific details on the university's characteristics in the model, but rely on the characteristics of the local universities (or the sum over all local universities in regions with more than one). Second, we do not know the outcome of collaboration and hence do not know which types of collaborations with which universities are more or less successful. Finally, the study is limited to R&D collaboration and is not able to identify other ways in which firms interact with universities.

The limitations notwithstanding, this research raises a word of caution about the role of universities for creating partnerships within the local environment and, therefore, for innovation activity and growth. Increasingly, universities in Norway and around the world are racing to produce more and better research. This competition is in itself good, as it can result in more knowledge generation. However, not all universities can be at the research frontier in all fields. Pursuing research intensity and quality may, as we have seen, come at the price of limiting the capacity of universities and firms to build bridges. This in turn has implications

for the innovativeness of local firms and the economic development potential of the regions hosting universities. Hence, universities have to strike a difficult balance about what their mission in society is, as any decision regarding the balance between the functions of teaching, research and outreach to society will have significant implications. This requires universities to think hard about how, through the mix of activities they do, they can maximise their benefits to society. Different universities would need to pursue different mixes of objectives in order to achieve this goal. What is becoming increasingly clear is that pursuing the same objective of prioritising research intensity and excellence above all other functions and purposes across the board has consequences that have deep impacts on the local environment and on society as a whole.

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Appendix

Table A1: Logistic regression analysis of collaboration, using the number of publications in all relevant disciplines as the main explanatory variable

Model	**(1)** All collaboration	**(2)** Local univ. collaboration	**(3)** National univ. collaboration	**(4)** International univ. collaboration
Independent variables				
Number of publications (log)	-0.062***	-0.066**	-0.085***	-0.045
	(0.024)	(0.030)	(0.031)	(0.041)
Local non-univ. collaboration	0.770***	1.101***	-0.009	0.054
	(0.035)	(0.038)	(0.053)	(0.062)
National non-univ. Collaboration	0.726***	0.019	1.073***	0.220***
	(0.037)	(0.045)	(0.042)	(0.052)
International non-univ. collaboration	0.595***	0.128***	0.156***	1.023***
	(0.040)	(0.044)	(0.042)	(0.049)
Control variables				
Distance to university (log)	-0.648***	-0.877***	-0.134	-0.052
	(0.136)	(0.164)	(0.175)	(0.252)
Distance to university $(\log)^2$	0.104***	0.143***	0.024	-0.017
	(0.024)	(0.030)	(0.032)	(0.045)
R&D intensity (log)	0.182***	0.175***	0.210***	0.159***
	(0.015)	(0.018)	(0.021)	(0.029)
Firm size (log)	0.168***	0.102**	0.208***	-0.098
	(0.041)	(0.048)	(0.052)	(0.072)
Human capital (log)	2.598***	2.737***	2.764***	2.551***
	(0.410)	(0.514)	(0.483)	(0.658)
Survey year 2008	-0.275**	-0.197	-0.108	-0.227
	(0.112)	(0.137)	(0.139)	(0.185)
Survey year 2010	-0.409***	-0.262**	-0.302**	-0.286
	(0.108)	(0.131)	(0.146)	(0.181)
Industry fixed effects	Included	Included	Included	Included
Constant	-3.788***	-3.857***	-5.847***	-4.648***
	(0.458)	(0.544)	(0.556)	(0.629)
N	18,278	18,278	17,654	17,317
Pseudo R2	0.576	0.507	0.556	0.551

Note: Robust standard errors clustered over firms in parentheses. *** p<0.01, ** p<0.05, * p<0.1.