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Exploring the determinants of university collaboration: the role of work organization and core knowledge in manufacturing and knowledge-intensive services

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Introduction

As parallel phenomena, stretching back some 30 or more years, universities in developed economies have come under growing pressure to become more commercially 'relevant' and firms have sought to build innovation alliances in increasing numbers. The former is part of what David (1998) termed the "economic instrumentalism" that has come to characterize science and technology policy discussions. Most influentially, this is characterized as a shift from Mode 1 to Mode 2 knowledge production (Gibbons *et al*., 1994), with the former occurring within strict disciplinary boundaries and the latter "in the context of application". Crucially, it also reflects reduced faith in the linear model, most obviously associated with Vannevar Bush's "Endless Fromtier"[1]. Commitment to the 'science-push' model set out by Bush, implied a social contract between science (and the university) and society (and the state): that more public funding of basic science would result in a steady stream of discoveries to be translated into new products (Guston and Kenniston, 1994). This contract endured, with some variation in substance and timing, until the 1980s in most rich countries. However, it appears to have given way to a new social contract under which "there is a clear expectation that, in return for public funds, science and universities must address the needs of 'users' in the economy and society" (Martin and Etzkowitz, 2000). In contemporary debate this new 'contract' is most clearly manifest in universities' pursuit, with considerable policy encouragement, of a 'third mission' aimed at more direct contribution to and interaction with industry (e.g. Etzkowitz and Leydesdorff, 2000).

On the other hand, the growth in innovation alliances is consistent with the new orthodoxy in innovation studies: that innovations are increasingly the product of "interactive learning and collective entrepreneurship" (Lundvall, 1992). As with the changing role of universities, recognition of the limitations of the linear view has spurred interactive modes of innovating. More specifically, increasing uncertainty and cost competition (associated with changing technology and globalisation) has encouraged many firms to concentrate on fewer activities and competencies as a way of generating specialisation economies (Demsetz, 1991; Simmie *et al*., 2002; Krugman, 1991). Moreover, since that the sorts of information and know-how relevant for innovation cannot be easily traded on neoclasssical 'spot markets' (Geroski, 1995), networks are the

[1] Bush, Vannevar, 1945: *Science, The Endless Frontier. A Report to thePresident.* Washington, DC: National Science Foundation.

[ideal] intermediate governance solution between hierarchies and markets (Nooteboom, 1999). Certainly, there appears to be general agreement that innovation activity is 'becoming increasingly distributed, as fewer firms are able to 'go it alone' in technological development' (Tether, 2002, p. 947). As firms concentrate on a narrower range of activities, it is inevitable that many innovation tasks will require complementary resources (including knowledge and information) drawn from outside the boundaries of the firm. Drawing on the resource based perspective (Eisenhardt and Schoonhoven, 1996), firms are heterogeneous with respect to their resource profiles and resources are imperfectly mobile across firms (Quintana-Garcia and Benavides-Velasco, 2003). Accordingly, the transfer of innovation assets between parties may frequently require the framework of a cooperative relationship (Fritsch and Lukas, 2001).

Given the coincidence of these two phenomena, it should come as little surprise that both the academy and the polity have frequently extolled the merits of universities as innovation partners for industry. Correspondingly, we have witnessed a growing number of studies concerned with identifying those firm-level factors which promote the use of universities as sources of knowledge and expertise to support innovation – with a number of common themes recurring. However, whilst a great many of these studies adopt a resource-based perspective, their concern has largely been with the availability of certain types of resources or with resource stocks and not with how these resources are used or organized. Clearly this is a limitation. **There is, for instance, a pressing need to further explore the relationship between workplace organization, knowledge bases and the dynamics of innovation (Arundel *et al*., 2007) – to complement the widespread evidence available from case studies.** This is our aim here. Drawing upon data from a sample of 985 Norwegian firms in both manufacturing and knowledge-intensive service sectors, we attempt to extend prior studies of university-industry interaction by exploring how the manner in which key resources are organized and the nature of core competence influence the propensity to collaborate with universities for innovation. In so doing, we separately estimate models for manufacturing and service firms. Whilst it is common to control for sectoral variations in the propensity to university collaboration, this tells us little about whether or not different influences are at work in these broad sectors. The continued neglect of service firms, both generally and in this specific context, represents a persistent barrier to better understanding broad variations in innovation behaviour (Tether and Tajar, 2008).

The determinants of university industry collaboration

University-industry interactions encompass a broad range of activities, ranging from student placements to industry sponsored research to licensing. Whilst not seeking to downplay the importance of this variety of linking mechanisms (cf. D'Este and Patel, 2007), or any individual mechanism, our interest is much narrower: viz. cooperative innovation activities. Perkmann and Walsh (2007) believe that just such a narrow focus is of particular interest given the currency of 'open innovation' discussions and, at least in part, because relationship-intensive linkages "provide a window on interactive innovation processes" (p. 263). Collaborations often have clear-cut objectives and, based on a thorough prior analysis of the internal competences that are needed, necessitate dense interaction where one's own knowledge is exposed and, as such, requires trust in the relationship (Ebersgerg and Herstad, 2010, Lundvall, 1992).

Certainly, studies using Community Innovation Survey data (e.g. Swann 2002; Monjon and Waelbroeck, 2003) seem to indicate that firms benefit more from formal collaborations with universities than through more distant interactions[2]. However, perhaps a more fundamental consideration is the apparent relationship between 'connectedness' and research productivity (Cockburn and Henderson, 1998). In short, the importance of 'connectedness' arises because the knowledge associated with an invention is rarely (never) completely transferable in codified form. Rather, it requires some form of interaction between the inventor and the recipient firm. In consequence, "firms must be connected to the open science community by being actively involved in sharing research results (publishing) and also engaged in research collaboration" (Agrawal, 2001, p. 287). In the latter case, better understanding the organisation-level factors that encourage strong connections is clearly an important part of developing good business and policy guidance.

Despite this apparent narrowness of focus, a relatively large (and growing) body of work provides empirical precedent from which to build. As noted, the starting point for many concerns resources and the idea that "firms must have resources to get resources" (Eisenhardt & Schoonhoven, 1996, p. 137). In the simplest models, resource access is proxied by firm size (e.g. Cohen *et al*. 2002). Indeed, as Fontana *et al*. (2006, p. 311) record "the role of firm size in influencing the propensity to collaborate with Public Research Organisations is one of the basic tenets of the literature on university-industry relationships". Though there is some theoretical suggestion of a negative association, as large firms are able to rely more on their own R&D (Link and Rees, 1990; Acs et al., 1994; Audretsch and Vivarelli, 1994; Feldman, 1994), the empirical evidence typically records a positive firm-size university collaboration relationship (e.g. Fontana *et al*., 2006; Mohnen and Hoareau, 2003; Segarra-Blasco and Arauzo-Carod, 2008). This, then, is our expectation here[3].

In addition to firm size, group membership is another common 'structural' proxy for resource access. Here two countervailing arguments are offered: on the one hand, that being part of a larger group implies access to greater resources to facilitate collaboration (Segarra-Blasco and Arauzo-Carod, 2008); on the other, that in subsidiary firms centralized R&D leads to university-based collaborative innovation being pursued largely through headquarters (e.g. Mohnen and Hoareau, 2003; Fontana *et al*., 2006). The former suggests a positive relationship between group membership and firm size, whilst that latter suggests a negative relationship at the establishment level. On the balance of empirical evidence (e.g. Tether, 2002), we tend to the former hypothesis; that group

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[2] Interestingly, in a recent review Perkmann and Walsh (2007) relate UK evidence that Higher Education Institutes' (HEIs) income from collaborative research outstrips their income from intellectual property by some 13 times.

[3] Following Mohnen and Hoareau (2003, p. 144) "we opt for the number of employees rather than sales to measure size, because the number of employees is more likely than sales to be exogenous because of its sluggish adjustments".

membership will positively correlate with the propensity to engage in cooperative innovation with universities.

Notwithstanding the frequency with which these 'structural' indicators appear in models of university-industry collaboration, perhaps the most common resource-based arguments relate collaboration propensities with absorptive capacity (classically, Cohen and Levinthal, 1989 and 1990). For instance, Bercovitz and Feldman (2007, p. 934) suggest that "the need to invest in generating absorptive capacity is particularly acute when tapping university-based resources". A firm's absorptive capacity reflects its ability to recognize, evaluate, acquire and use external knowledge and is a function of its prior related knowledge. In Cohen and Levinthal's classic exposition, accumulated R&D expenditure was the primary constituent of absorptive capacity. In recent empirical work (e.g. Escribano, *et al*., 2009; Grimpe and Sofka, 2009; Kodama, 2008), R&D intensity[4] is the typical proxy, and studies support the complementarities between R&D and collaboration (e.g. Schmiedeberg, 2008). Almost invariably, this literature finds that in order to engage in, and benefit from, university collaboration firms must already be involved in R&D (e.g. Hanel and St.-Pierre, 2006).

Unfortunately, though R&D expenditure is the most common proxy for absorptive capacity, it is unlikely to be adequate when studying many [particularly small] firms (Muscio, 2007). Rather, a broader conception of absorptive capacity is required, one which accommodates a more general measure of expertise; emphasizing, in particular, the presence of highly skilled employees (Drejer and Vinding, 2007; Xia and Roper, 2008). Here, measuring the proportion of graduates in the workforce is a common approach (e.g. Grimpe and Sofka, 2009). Intriguingly, in finding a positive correlation between graduate employment and links with specialist knowledge providers (including universities) in the UK CIS-3 data, Tether and Tajar (2008, p. 1089) interpret this "as reflecting the ability of graduates to enhance the firm's ability to engage in networking and boundary spanning by providing and gaining access to social capital within networks of organisations with relatively high densities of graduates in their workforce". To a greater extent this is Cohen and Levinthal's (1990, p. 133) "knowledge of who knows what, who can help with what problem, or who can exploit new information" and we expect it to positively associate with the propensity to cooperate.

Two further controls are customary in empirical models of university-industry cooperation: industry sector and age. In the former case, it is argued that university cooperation is particularly relevant for 'science-based' industries (Schartinger *et al*., 2002; Mohnen and Hoareau, 2003). Certainly, to the extent that different sectors face different technological opportunities (related in part to variations in the nature of knowledge, including the relative emphasis on tacit or codified knowledge – see Marsili, 2002), one would expect variations in the feasibility of university cooperation. As Bekkers and Freitas (2008, p. 1839) note, "collaboration with university seems more likely in sectors in which the technology is developing fast, since firms want to be active in multiple technological trajectories". And this is borne out in the empirical literature, with technology-based firms recording higher incidences of university-based cooperative

[4] Variously measured, for instance, as the proportion of R&D expenditure in sales or as R&D employment.

innovation (e.g. Tether and Tajar, 2008; Segarra-Blasco and Arauzo-Carod, 2008; Hanel and St.-Pierre, 2006).

The argument relating to firm age runs, rather less convincingly, along two lines: the first talks to need, suggesting that younger firms are particularly in need of external sources of knowledge which, even accounting for resource deficiencies, results in a greater propensity to cooperate (Tether and Tajar, 2008); the second, is concerned with receptivity. Such that, start-up (or very young) firms act as “a key vehicle for transferring university research into commercial products” (Cohen *et al*., 2006, p. 19). Though there seems to be some evidence of a link in between age and the use of public research in highly specific samples, more general evidence is slight (Laursen and Salter, 2004). Nonetheless, for completeness, we include age in our base model.

Beyond these factors, recent work has sought to explore the role of ‘openness’ in facilitating university-industry collaborations. Clearly, this builds upon the topicality of open innovation discussions generally (Chesborough *et al*., 2006). However, it more directly follows empirical work by Laursen and Salter (2004), using data from the third UK Community Innovation Survey, on the relationship between ‘openness’ and the perceived importance of universities as a source of information and knowledge for innovation.

These authors argue that, by including openness in their models, they provide “scope for managerial choice” (p. 1203) that is absent from previous models which emphasise the ‘structural’ factors discussed above. Here an ‘open’ strategy is a search strategy. Whilst one might quibble that their dependent variable (the use of universities as a source of knowledge or information in innovation activities) is likely to be a component of ‘openness’ rather than caused by it[5], there is little doubt that the exercise provides additionality. Indeed, Laursen and Salter’s analysis has prompted further testing using very similar measures of ‘openness’, but with different findings (cf. Fontana *et al*., 2006, Tether and Tajar, 2008). Given our narrower focus on university collaboration, there is merit in including a proxy for ‘openness’ in our base model. Not least because, external search spaces are likely to be interwoven with internal organisational dynamics, with the risk that external information exposure extends beyond the ability of organizations to manage it productively (Katila & Ahuja, 2002; Laursen & Salter, 2006). Table 1 summarises the variables included in this base model, their measurement and our expectations.

Table 1. Variables used in the base models.

Variable	Measurement	Expected relationship
Firm size	Log of employment	+
Group membership	Binary (subsidiary = 1; independent = 0)	+
R&D intensity	R&D expd as a % of sales	+
Graduate employment	Binary (employs at least 1 graduate = 1;	+

[5] Certainly, where other knowledge and information sources from the same survey question are used to construct the “openness” scale this seems problematic.

	otherwise = 0)	
Industry sector	Categorical variable identifying: low-tech manufacturing; medium-tech manufacturing; high-tech manufacturing; t-KIBS; p-KIBS; creative services	+ve for high-tech and t-KIBS
Firm age	Binary (firm founded after 2004 = 1, otherwise = 0)	+
Openness	Scale: count of external sources of information used for innovation (1-9)	+

Source: "NIBR-survey 2007/TheCKI-project".

The role of work organization and core knowledge

Whilst testing this base model on our unique dataset (see below) is of some interest, it is not our objective here. Rather, these variables are essentially controls in our final models. Instead, we take as our inspiration Arundel *et al.'s* (2007, p.30) insistence that indicators for innovation not only capture the existence and extent of resource inputs, but also "capture how these material and human resources are used and whether or not the work environment promotes the further development of the knowledge and skills of employees". In other words, work organization and knowledge are to the fore.

The organisation of work

The notion that the organisation of work may influence innovation has a long history in organisation studies. Classically, for instance, Burns and Stalker (1961) proposed two organizational archetypes – mechanistic and organic – occupying extremes of a structural continuum. The choice of appropriate structure was contingent upon the environment: mechanistic firms are more rigid and hierarchical and better suited to stable conditions; whilst in organic firms a more fluid set of arrangements exist, allowing the firm to adapt to conditions of rapid change and innovation. In a related 'organizational design' contribution, Mintzberg (1979), reiterating the contingency of structure, proposed a 'configuration hypothesis'. In short, this hypothesis suggests that firms are likely to be dominated by one of five pure organizational archetypes: simple structure, machine bureaucracy, professional bureaucracy, divisional form and adhocracy (see also Miller, 1986). Mintzberg's 'adhocracies' are largely analogous to 'organic' firms, relying upon considerable employee discretion in temporary project structures, and are thought to be particularly well-suited for innovation – though they are expected to be transitory.

In a more recent review and synthesis of the organizational design and lean production literatures, Lam (2005) proposed two polar ideals of innovative organisation: the 'J-form' and the 'adhocracy'. The former, taking its name from the idealized 'Japanese type' of organisation described in Nonaka and Takeuchi's (1995) *The Knowledge Creating Company*, is adept at cumulative learning, with innovative capabilities stemming from collective competencies and problem solving routines. The latter, drawing directly from

Mintzberg (1979), "tends to rely more upon individual specialist expertise organized in flexible market-based project teams" (p. 18). Lam contends that both the 'J-form' and 'adhocracy' are learning organizations with developed innovative capabilities. However, they differ markedly in their structure and patterns of learning, and in the types of innovative competences these generate.

Table 2. Factor Analysis of Work Organisation (PCA with Varimax rotation)

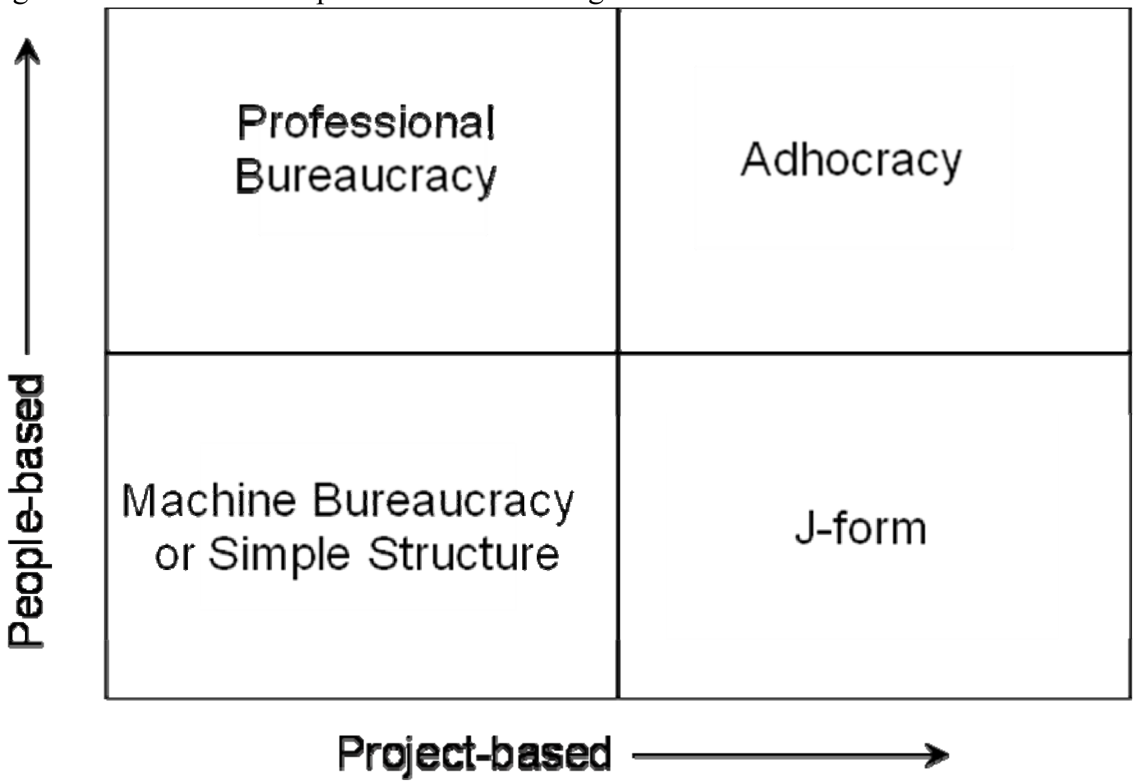
Variable	People	Projects	Mean	Stdev
Work organized in projects	0.251	**0.754**	3.21	0.973
The company employs short-term working	0.215	**0.484**	2.00	0.949
Work organized in autonomous working groups	**0.890**	0.102	2.62	1.082
Work is delegated to working parties	**0.908**	0.070	2.72	1.090
Employees rotate between different tasks	**0.557**	0.110	2.64	1.050
Work organized in permanent tasks	0.162	**-0.703**	2.26	1.127
Eigenvalues	2.234	1.152		
N	933			

Source: "NIBR-survey 2007/TheCKI-project"

In the current study respondents were asked to characterise the organisation of work within their company using 6 statements scored on a 4-point semantic differential scale[6]. The results of a factor analysis of responses to this multiple item question are shown in table 2. As the data indicate, two latent factors are apparent: the first, loading on autonomy and delegation, we term 'people-based'; and the second, loading on projects and impermanency, we term 'project-based'. Importantly, these two factors are orthogonal. Firms may score high on both, low on both or any other combination. This suggests the possible distribution of firms along a two dimensional space as indicated in figure 1. Taking these two dimensions, we tentatively suggest a correspondence between scores on our factors and ideal forms proposed in the organizational design literature. For instance, a high level of autonomy organized in short-term projects seems to accord with 'adhocracies' (the top right quadrant in our figure). At the other extreme, permanent work organisation and limited discretion suggests a 'machine bureaucracy' or, in very small firms, a 'simple structure'. For the mixed outcomes, project-based work with limited delegation of authority, may hint at a J-form type of organizing (although an administrative adhocracy, as distinct from an operating adhocracy, may also feature), whilst high levels of discretion, organized permanently suggests a professional bureaucracy.

[6] Where 1 = "not at all" and 4 = "to a large extent".

Figure 1. Tentative correspondence between organizational structures and factors



This tentative correspondence is offered merely to help structure our discussion and to better link into a longstanding body of work. The implication is that we expect firms towards the top right quadrant of figure 1 (high degree of delegation and project-based working) to be most innovative and those tending towards the bottom left quadrant (little delegation and permanent work structures) to be least innovative. Our interest, however, is not in the relative innovativeness of firms, rather, on the propensity to collaborate with universities for innovation. The focus, then, is on the interrelatedness of different forms of work organization and their external interfacing and the tensions between different internal systems and resources and different forms of external interaction (Lam, 2000; Schmidt, 2005). To this end, we elaborate upon Arundel *et al*'s (2007, p. 2) observation "that how firms organize production and the distribution of responsibilities among their work force could have a significant effect on learning and hence on innovation capabilities".

In the elaboration, work organisation does not simply influence the volume of learning and innovation, but also the manner in which firms learn and innovate. For instance, in our earlier discussion on the influence of graduates on university collaboration, we noted the importance of social capital in sourcing specialist expertise (Tether and Tajar, 2008). Following Giuliani and Arza (2009), one might go further, noting that key knowledge often resides in skilled workers, with the direction of their learning bound by the discretion they enjoy in exploiting and *exploring* new ways to solve problems. This is consistent with both theory and research indicating that technology and information exchange at the individual level is central to successful industry-university alliances

(Sherwood and Covin, 2008). In the case of project-based working, the foundation of our hypothesis is simpler. On the basis of supplementary interview data with industry respondents, Fontana *et al*. (2006) record differences in 'ways of working' amongst the more prominent barriers to university collaboration. To the extent that university research is, in practice, largely organized on a project basis (Guena and Martin, 2003) we anticipate that similar styles of working in firms will facilitate collaboration.

These dual arguments lead us to propose the following hypotheses:

H1a: High levels of people-based working will positively correlate with cooperative innovation involving universities.

H1b: High levels of project-based working will positively correlate with cooperative innovation involving universities.

Core knowledge

With regards to core knowledge, our starting point is the observation that learning (or innovating using) different types of knowledge tends to take place in different ways and through different channels (Jensen *et al*., 2007). Commonly, discussions of 'knowledge' default to a simplifying duality: viz. explicit (or codified) and tacit; or, in a looser formulation, formal and practical (see, for example, Senker, 1995; Johnson *et al*., 2002). Indeed, from these Jensen *et al*. (2007) suggest two learning modes; a Science, Technology and Innovation (STI) mode and a Doing, Using and Interacting (DUI) mode. The former emphasizes the development of explicit and global 'know-why' knowledge[7], whilst the latter is more firmly rooted in tacit and 'know-how' knowledge learned, in large part, by doing and using. Interestingly, Jensen *et al*. (2007) note that, whilst there are innovation benefits to emphasising either learning mode, the highest innovation premiums fall to those firms balancing both modes.

In the current study, firms were asked to note the importance, to their core competence, of a list of seven factors. Again, responses were scored on a 4 point semantic differential scale[8]. As with work organisation, responses to this multi-item question were subject to factor analysis, the results of which are reported in Table 3. Two latent factors were apparent. The first, loading on a variety of internal practice-based competences, we label "practical"; the second, loading on formal education-based knowledge and external expertise, we label "formal". Clearly these are analogous to the standard dualism between tacit and explicit (though the correspondence is likely to be imperfect). Again, factor scores are orthogonal; such that firms may score high on both "practical" and "formal" knowledge, low on both or some other combination.

Table 3. Factor Analysis of Core Knowledge (PCA with Varimax rotation)

Variable	Practical	Formal	Mean	Stdev

[7] Though they recognize that the tacit knowledge of lead scientists plays an important role in design and interpretation of experiments and that STI learning may be triggered by practical concerns.
[8] Where 4 = very important and 1 = not significant.

Formal knowledge of employees	-0.076	**0.888**	3.29	0724
Practical knowledge of employees	**0.391**	0.030	3.81	0.436
Leadership competence	**0.546**	0.223	3.63	0.592
Product development competence	**0.714**	0.127	3.41	0.770
Production methods, routines competence	**0.674**	-0.052	3.37	0.748
Competence about markets	**0.670**	0.151	3.54	0.638
Close contact with external expertise	0.357	**0.640**	2.96	0.764
Eigenvalues	2.215	1.070		
N	960			

Source: "NIBR-survey 2007/TheCKI-project"

Following Jensen *et al*. (2007), we might speculate that a competence strongly built upon either practical or formal knowledge would associate with innovativeness, but that one which builds on both would associate with higher levels of innovation. However, again, our interest is not in the extent to which the knowledge base variously correlates with innovation outcomes. Rather, we are interested in its influence on the manner in which innovation takes place, and specifically on the propensity to collaborate with universities for innovation. To this end, we note the central reference to tacit knowledge in most studies of cooperative innovation (e.g. Bougrain and Haudville, 2002). As noted earlier, the knowledge associated with an invention is rarely perfectly transferable in codified form. Rather, much of the knowledge remains tacit and it is only through relationship intensive, face-to-face interactions that tacit knowledge may effectively pass from one organisation to another. However, this speaks to the substance of knowledge transfers within cooperative relations and not to the relative attractiveness as innovation partners or the motivations to and capabilities for cooperative innovation with universities.

In the case of competence vested in formal knowledge, one might infer greater relative 'cognitive proximity' to universities. As Boschma (2005) notes in his review "…the capacity of actors or firms to absorb new knowledge requires cognitive proximity. That is, their own cognitive base should be close enough to the new knowledge in order to understand and process it successfully". By building on shared experiences and understandings, cognitive proximity facilitates effective communication and collaboration (Nooteboom *et al*., 2007).

Notwithstanding the centrality of tacit knowledge transfers (Agrawal, 2001), it is less clear what may be its role in inducing, encouraging or facilitating collaboration. As Kogut and Zander (1992) note, incentives to collaborate come from numerous and flexible possibilities to merge tangible and intangible resources. In contrast, there is a longstanding suggestion in the innovation studies literature that a competence based on tacit knowledge may act as a disincentive to cooperate given the danger of unintended spillovers (Teece, 1986). However, this is likely to be less of a concern where universities are the prospective partner. Indeed, universities, because they have limited incentives to act opportunistically, may be preferred as research partners when firms face appropriability concerns" (Bercovitz and Feldman, 2007, p. 936). Rather, for structuring purposes, we tend to the simpler hypothesis that firms with a generally "stronger knowledge base", manifest in better searching and exploiting capabilities, are more likely to collaborate with external sources of knowledge and expertise, including universities

(Giuliani and Arza, 2009).They are also more likely to be attractive partners from the perspective of universities.

Taken together, these arguments lead us to propose the following hypotheses:

H2a: A strong emphasis on formal knowledge as the basis of core competence will positively correlate with cooperative innovation involving universities.

H2b: A strong emphasis on tacit knowledge as the basis of core competence will positively correlate with cooperative innovation involving universities.

Finally, part of our contribution is in our ability to test these hypotheses for manufacturing and knowledge-intensive services together and separately. As Tether and Tajar (2008) note, a continuing limitation of many similarly motivated studies (e.g. Laursen and Salter, 2004) is that the analysis is confined to manufacturing firms. Even where authors indicate a "rare" focus on manufacturing *and* services (e.g. Segarra-Blasco and Arauzo-Carod, 2008), in practice this involves little more than including a series of industry dummies in aggregate models. Whilst this is useful in identifying the relative propensities to cooperate across sectors, it sheds no light on whether different variables (or variables differently) influence the propensity to cooperate in different sectors.

A priori, it is not clear what differences may exist. Many authors emphasise 'service peculiarities'; the peculiarities of the type of innovation found in services, the peculiarities of the knowledge creation processes, the distinct cooperative arrangements with external partners and, further, the greater reliance upon project-based work in business-services (Soete and Miozzo, 1989; Evangelista, 2000; Gallouj and Gallouj, 1997; Gallouj and Weinstein, 1997; Sundbo; 1998; Hipp 2010; Simmie and Strambach, 2006). Similarly, one could note evidence of the relative reliance of services innovation on highly qualified staff (e.g. Tether, 2004). However, neither of these suggests hypotheses that might discriminate between cooperators and non-cooperators within sectors. However, between sectors, Tether et al. (2000) observed that, whilst service firms had collaborative innovation projects at nearly the same intensity as manufacturing firms, collaborations involving universities were significantly less common. At this point, empirical precedent simply leads us to expect that services will be less likely to cooperate with universities than manufacturing, all other things being equal (e.g. Segarra-Blasco and Arauzo-Carod, 2008). How *intra*-sector influences might moderate our hypotheses is an open question.

Data

The main data source is a web-based survey (CKI[9]) carried out in the end of 2007. The survey's main focus was on knowledge intensive industries, identified as industries with comparatively high levels of R&D investments and/or employees with higher education

[9] The CKI-survey is a part of the project: "Cityregions, knowledge bases and innovation support systems" (CKI), which has been founded by the Research Council of Norway in the DemosReg program.

(OECD, 2001). The survey also included 2 reference sectors consisting of 2 parts; one which is based on the 'specific knowledge-intensive user sectors' (the petro-maritime industries) known to be very knowledge-intensive users; and, producers of experience-based knowledge together with 'creative services', an industry known to make demands on both human capital and experience of the labour force (e.g. Power and Scott, 2004). In the case of the petro-maritime industries, the numbers of observations were small and these are excluded from the current analyses. The other part of the reference group included low-tech manufacturing and service industries. Again, given the absolute infrequency of university cooperation we set aside this latter group in our analyses.

Finally, our concern is exclusively with SMEs (i.e. less than 250 FTEs). Our rationale here is twofold: firstly, the number of firms employing more than 250 FTEs is small, at 24. Moreover, 83% of the group conducts some R&D; 46% cooperate with universities; and almost 80% employ doctorates. This compares with 50%, 23% and 11%, respectively in the sample as a whole. In other words, along important dimensions, large firms are statistical outliers. However, perhaps more importantly for our current concern, it seems likely that large firms will exhibit a greater variety of organisational forms, given the greater scope of their operations. This is likely to result in less illumination in their responses to the relevant survey question. In contrast, small firms are more likely to be characterised by a dominant organisational form. Moreover, if one accepts this postulate, then decisions to pursue an organisational form to promote innovation must be balanced against the need for a suitable work organisation for day-to-day operations. We return to this issue in our concluding remarks.

The questionnaire was sent to a random selection of 5200 firms (with more than 1 employee). The sample consists of 1375 firms with approximately complete answers (26%), but only with 1302 complete answer (25%). After excluding petro-maritime, low-tech services and large firms, the remaining 985 answers were used in the analyses reported below. The questionnaire includes 20 questions on different topics regarding the firms' establishment, knowledge bases, innovation forms, networks and barriers. The sample is fairly representative of the knowledge intensive firms regarding sub-branches, firm-sizes and locations. Because of the voluntariness to answer, the self selection process may have resulted in a somewhat biased sample (compared to a survey based on an obligation to answer as in public statistics by Statistics Norway). If answering the respondents will have a summary of the results free of charge. This may imply a possibility of overrepresentation of the most motivated respondents and/ or knowledge searching or monitoring firms.

Analysis and discussion

Brief descriptive statistics

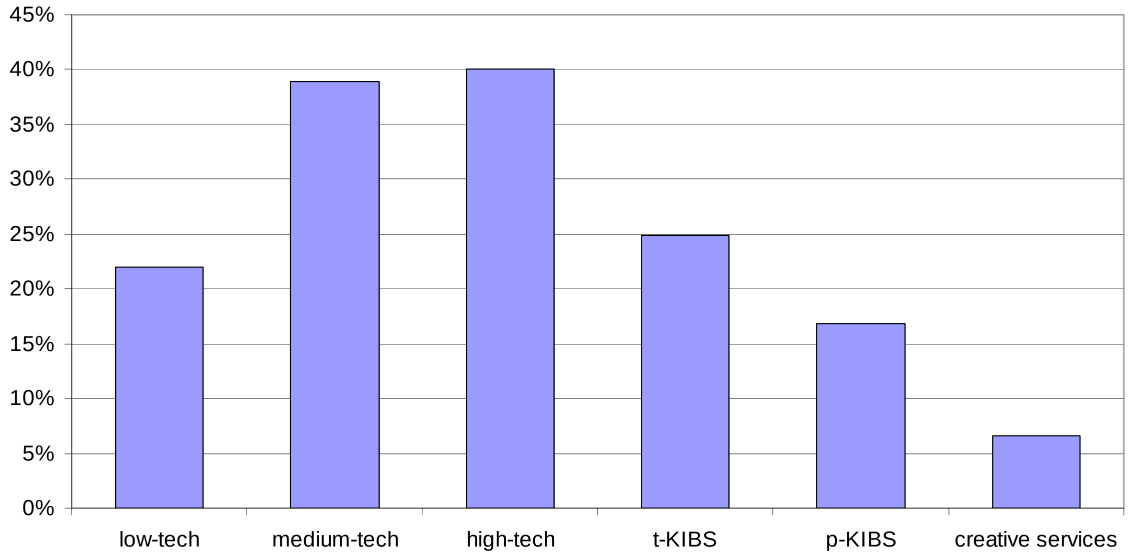
In opening the analysis and discussion section, it seems useful to present a variety of descriptive statistics which illuminate some broad patterns and give a 'feel' for the data used in the multivariate analyses that follow. In large part, these patterns accord with our prior expectations. For example, figure 2 charts the propensity to engage in cooperative research with universities by industry sector, further disaggregating manufacturing and services by categories commonly employed in the empirical literature. From this, it seems clear that manufacturing firms are generally more likely to collaborate than (even knowledge-intensive) services – 30% and 19% respectively. Moreover, within each of these broad sectors, firms in technology-based subsectors record the highest levels of collaboration (40% of high-technology manufacturers compared with 22% of low-technology manufacturers; 25% of t-KIBS compared with under 7% of creative services).

Beyond sectoral considerations, tables 4 and 5 present further descriptive statistics for our intended independent variables, separately for manufacturing and services and for cooperators and non-cooperators. In all cases, excepting firm size, the observed differences between cooperators and non-cooperators are statistically significant. However, in the case of firm age, the relationship is in the opposite direction from that anticipated. That is, older firms appear more likely to cooperate than younger firms. Given our earlier equivocation regarding the effects of age, this is not greatly concerning.

As expected, there is a positive relationship between 'openness' and the propensity to cooperate. However, whilst this is statistically significant for the whole sample, and for manufacturing firms, it is not significant for services. It is worth noting that the overall difference between manufacturing and services in the number of information sources is small. We return to this issue below.

Finally, with regards to our key variables of interest: both the two 'organisation' factor scores and the two 'core knowledge' factor scores significantly discriminate between cooperators and non-cooperators in the whole sample and in the manufacturing and services subsamples. Moreover, it is interesting to note the relative emphasis on formal knowledge in services and practical knowledge in manufacturing. And the relative emphasis on project-based working in services and Speople-based working in manufacturing. Though not reported here, simple t-tests indicate that these differences are statistically significant. And, as indicated at the end of section three, they are broadly as anticipated.

Figure 2. Sectoral variations in university cooperation[1]



[1]All observed differences are statistically significant at the 1% level – both across sectors (χ^2=52.81) and within manufacturing (χ^2=14.305) and services (χ^2=20.61). *Source:"NIBR-survey 2007/TheCKI-project*

Though there are presentational merits to including these descriptive statistics, there are also clear limitations to interpreting the apparent relationships. For instance, there is ample empirical evidence that firm size may have a confounding effect on the relationship between R&D expenditure and cooperation propensities. Our interest here is in the unique (marginal) effect of each measured independent variable on the propensity to engage in innovation-related cooperation with universities. This requires a multivariate framework, which is the subject of the next section.

Table 4. Descriptive statistics for cooperating and non-cooperating firms (simple arithmetic means)

	All firms (n = 224+761=985)				Manufacturing (n = 119+282=401)				Service (n = 105+479=584)			
	Coop	Non-coop	all	t-test	Coop	Non-coop	all	t-test	Coop	Non-coop	all	t-test
Employment	64.34	42.69	47.61	1.22	85.71	79.98	81.68	0.15	40.12	20.74	24.22	1.22
R&D	17.52	5.71	9.21	6.41	12.72	4.21	6.74	3.58	22.95	6.59	9.53	5.92
Openness	6.31	5.90	6.02	2.39	6.51	5.95	6.12	2.19	6.10	5.86	5.90	0.95
Practical k-h	0.176	-0.054	0.014	3.26	0.284	0.126	0.173	1.65	0.053	-0.160	-0.122	2.03
Formal k-h	0.331	-0.103	0.026	5.89	0.212	-0.366	-0.194	5.59	0.466	0.052	0.126	3.90
People-based	0.270	-0.087	0.019	5.21	0.377	-0.075	0.059	5.26	0.149	-0.094	-0.050	2.23
Project-based	0.191	-0.060	0.014	3.57	-0.091	-0.464	-0.353	3.77	0.510	0.177	0.237	3.68

[a] significant at 1% level; [b] significant at 5% level. *Source: "NIBR-survey 2007/TheCKI-project*

Table 5. Further descriptive statistics for cooperating and non-cooperating firms

	All firms			Manufacturing			Services		
	Coop	Non-coop	χ^2	Coop	Non-coop	χ^2	Coop	Non-coop	χ^2
Younger	15.7%	84.3%	15.038	19.0%	81.0%	5.982	14.6%	85.4%	3.874
Older	26.7%	73.3%		32.8%	67.2%		21.0%	79.0%	
Independent	18.9%	81.1%	34.535	23.7%	76.3%	18.912	16.0%	84.0%	8.817
Subsidiaries	38.7%	61.3%		46.2%	53.8%		29.4%	70.6%	
Graduates	24.9%	75.1%	14.002	34.6%	65.4%	17.300	19.1%	80.9%	2.873
No graduates	9.4%	90.6%		9.7%	90.3%		9.1%	91.1%	

[a] significant at 1% level; [b] significant at 5% level

Source: "NIBR-survey 2007/TheCKI-project

Multivariate analysis

The question used to define our dependent variable – whether firms cooperated for innovation with universities or not – is similar to the standard cooperation question used by the Community Innovation Surveys (CIS). That is, it asks firms whether they had cooperated with a variety of potential innovation partners (e.g. customers, suppliers, and so on), at a variety of spatial scales "in the past 5 years". By collapsing the spatial scales we construct a simple binary variable, taking 1 if the firm had been engaged in at least one collaborative venture with a university (at any spatial scale) and 0 if it had not.

Given the binary nature of the dependent variable, logits are suggested. Logit equations allow us to compare those firms which cooperate for innovation with those that do not, and to estimate which of the measured independent variables exhibit a systematic influence on the propensity to cooperate with universities. On the whole, the models seem to have a number of satisfactory properties. For instance, tests for multi-collinearity (using correlation matrices and multiway frequency analysis (Tabachnik and Fidell, 2001)) give no cause for concern. In the correlation matrix reported (Table 6), the highest bivariate correlations are those between group membership and size, and between size and age. Both of these are to be anticipated and, in neither instance, are they large enough to suggest redundancy. Finally, as the data in table 7 indicate, the models appear reasonable predictors of the propensity to cooperate – significantly improving upon constant only prediction at the 1% level.

More specifically, table 7 presents estimates for 6 logit equations: base and final models for the whole sample, the manufacturing sub-sample, and the knowledge-intensive services subsample. In terms of the detail, the most prominent base findings concern R&D expenditure and firm size. R&D intensity, for instance, is a positive predictor of the propensity to cooperate in all six models. This is as anticipated and is the most consistent finding in the empirical literature. This finding reflects Cohen and Levinthal's (1990, p. 40) assertion that "when outside knowledge is less targeted to the firm's particular needs and concerns, a firm's own R&D becomes more important in permitting it to recognize the value of knowledge, assimilate and exploit it". Universities are, typically, a source of such less-targeted knowledge. With regards to firms size, both the number of employees and group membership (our other proxy for access to size-related resources) exert a positive and statistically significant influence on the propensity to cooperate in all models, excepting the final manufacturing model – though here too the sign on the coefficient is in the 'right' direction. Again, these size effects are a 'usual suspect' in the empirical literature. We interpret them, in standard fashion, to indicate greater access to resources for searching, forming and maintaining relationships (e.g. Fontana *et al*., 2006). Despite discussions framed in terms of 'public goods', university knowledge is not costless to use (Agrawal, 2006). Of course, there may be an additional, complementary, influence at stake. Certainly one anticipates (opportunity) costs playing a role in partner selection from a universities perspective, which might make collaborations with fewer, larger firms more appealing than the many small firm relationship required to meet the same scale.

Table 6. Correlation matrix of independent variables

	1	2	3	4	5	6	7	8	9	10	11
Firm Age (binary)	.										
Firm Size (log)	0.299	.									
Group (binary)	0.126	0.399	.								
R&D intensity (log)	0.073	0.047	0.068	.							
Education (binary)	-0.001	0.163	-0.163	0.167	.						
Openness (scale)	0.013	0.081	-0.078	-0.003	-0.051	.					
Industry	-0.168	-0.225	0.225	0.122	0.171	-0.039	.				
Practical knowledge	0.024	0.070	-0.061	0.127	-0.080	0.114	-0.132	.			
Formal knowledge	-0.025	0.043	0.052	0.088	0.105	0.142	0.182	0.000	.		
People-based	0.032	0.238	0.088	0.069	0.051	0.148	-0.011	0.158	0.121	.	
Project-based	-0.113	-0.134	0.179	0.246	0.158	0.007	0.281	0.053	0.172	0.000	.

Source: ”NIBR-survey 2007/TheCKI-project

Table 7. Logit estimations on the probability of cooperation for innovation with universities

	All (1)	All (2)	Manufact. (1)	Manufact. (2)	KIS (1)	KIS (2)
Firm Age (young - binary)	-0.306 (2.103)	**-0.366 (2.859)c**	-0.363 (1.009)	-0.456 (1.499)	-0.267 (1.041)	-0.320 (1.380)
Firm Size (log)	**0.242 (10.614)a**	**0.213 (7.524)a**	**0.186 (3.250)c**	0.148 (1.875)	**0.292 (7.189)a**	**0.294 (6.422)a**
Group (binary)	**0.543 (5.680)b**	**0.485 (4.230)**	**0.542 (3.208)c**	0.415 (1.685)	**0.579 (2.765)c**	**0.625 (2.996)c**
R&D intensity (log)	**0.660 (93.050)a**	**0.611 (71.738)**	**0.629 (34.364)a**	**0.586 (24.497)a**	**0.692 (57.978)a**	**0.654 (47.543)a**
Employee education (binary)	0.518 (2.105)	0.432 (1.396)	**0.882 (3.590)c**	**0.946 (3.886)b**	-0.035 (0.004)	-0.312 (0.292)
Openness (scale)	**0.093 (5.321)b**	0.055 (1.768)	**0.138 (5.970)a**	0.090 (2.367)	0.040 (0.483)	0.006 (0.009)
Medium-tech industry	0.204 (0.465)	0.167 (0.293)	0.245 (0.631)	0.225 (0.489)		
High-tech industry	0.027 (0.006)	-0.136 (0.131)	0.057 (0.025)	-0.140 (0.714)		
t-KIBS	-0.381 (2.006)	**-0.571 (3.984)b**			**0.715 (2.994)c**	**0.801 (3.563)c**
p-KIBS	-0.216 (0.552)	**-0.574 (3.273)c**			**0.939 (4.878)b**	**0.964 (4.750)b**
Creative services	**-1.169 (7.975)a**	**-1.450 (11.369)a**				
Practical knowledge		0.146 (1.745)		-0.067 (0.148)		**0.309 (4.428)b**
Formal knowledge		**0.480 (20.448)a**		**0.487 (9.808)a**		**0.504 (11.399)a**
People-based		**0.254 (5.774)b**		**0.595 (10.672)**		0.070 (0.275)
Project-based		**0.186 (2.754)c**		0.118 (0.551)		**0.291 (3.110)c**
Nagelkerke R^2	0.304	0.351	0.284	0.355	0.299	0.351
-2 Log-likelihood	795.049	758.523	377.259	352.932	414.548	392.749
Model/step χ^2	204.307	36.526	83.686	24.327	109.531	21.799
N	893	893	371	371	522	522

Sectoral reference is low-tech manufacturing in “All” models and “Manufact.” models; Creative services is the reference group in the “KIS” models. Coefficients shown, with Wald χ^2 statistics in parenthesis. *Source: ”NIBR-survey 2007/TheCKI-project*

Beyond these three variables, findings for the other ‘base’ variables are less consistent across the different models. For instance, the effect of age is only statistically significant in the whole sample full model – where youth negatively correlates with the propensity to cooperate. In all other models, the influence is also negative, though non-significant. This is in line with the descriptive statistics, but counter to our stated expectations – where we hypothesised a higher propensity to cooperate amongst young firms. In truth, we were equivocal in our expectation and this uncertainty is borne out in the data. It would seem that, if at all, age exerts a weak influence on the propensity to cooperate.

The influence of graduate employment is only apparent in the manufacturing models, where it is positively associated with the propensity to cooperate, as anticipated. In addition to improving absorptive capacity (or reducing cognitive distance), this is likely to reflect, as noted, the social selectivity of search process; such that “they are likely to be influenced by existing inter-personal networks” (Perkmann and Walsh, 2007, p. 272). Given the emphasis on such ‘soft’ sources of innovation capability in the services literature (Tether, 2004), the absence of a corresponding significant relationship with cooperation in Knowledge-Intensive Services (KIS) is a little puzzling. Indeed, though non-significant, the signs on the coefficient are negative. One wonders if a general reliance on graduates in KIS firms is at play – where most firms employ graduates, graduate employment will poorly discriminate particular firms. In the current sample, over 90% of KIS firms employ at least one graduate.

Over and above these ‘structural’ considerations, a more ‘open innovation’ strategy is positively associated with cooperation in the all sample and manufacturing sub-sample models; though, in both cases, its influence is moderated by core knowledge emphasis and work organisation. In manufacturing firms, at least, this is consistent with prior findings (e.g. Cassiman and Veugelers, 2002; Laursen and Salter, 2004; Fontana *et al*., 2006) and suggests a complementarity between universities and other sources of knowledge. In knowledge-intensive services, the relationship is weaker and non-significant. A generally open disposition does not seem to increase the likelihood of cooperating with universities for innovation in KIS firms. We are agnostic to why this might be the case. Our intuition had been that KIS may be more generally marked by ‘openness’ than manufacturing firms, such that ‘openness’ becomes less useful in discriminating between cooperating and non-cooperating firms[10]. However, this was not borne out by the descriptive statistics (recall Table 4). It is possible, of course, that it merely reflects inadequacy in our ‘openness’ measure. Certainly, our scale includes fewer items than those using CIS data (e.g. Laursen and Salter, 2004, for instance use a 15 point scale[11]). Interestingly, Tether and Tajar’s (2008), exploring linkages with “Specialist Knowledge Providers” (SKPs) in both manufacturing and service firms, find evidence of a non-linear relationship between use of SKPs and ‘openness’. These authors employ a similar 9 point scale to ours, but include a quadratic term in openness in their models. They rationalise the significant finding as “implying slightly increasing returns” (Tether and Tajar, 2008, p. 1090) to ‘openness’. An alternative explanation, and one which we lean towards, is that different forms of work organisation may entail different degrees of

[10] In much the same way we rationalised the graduate employment ‘non-finding’.
[11] Constructed from 15 different “sources of information or knowledge”.

generality and specificity in search processes, with implications for 'openness' in the general sense measured by scales of this kind. For instance, search processes in project-based firms are likely to be more targeted and specific.

Finally, the correspondence between the data and our expectations, in terms of sectoral considerations, is mixed. On the one hand, the all sample model clearly shows that, even controlling for other structural and strategic factors, manufacturing firms are more likely to cooperate with universities than the most sophisticated services. On the other, whilst sectoral technology intensity associates with cooperation in the services subsample, it does not in the manufacturing subsample. This may reflect the idea that sectoral technology intensity is, to a greater extent, described by average R&D expenditures in manufacturing; whilst, this is less so in services. Beyond this, it ought to counsel against the myopia that sees intensive university-industry links as something that are peculiar to high-technology manufacturing (refs).

Our 'control variables', then, provide us with some interesting results, largely in line with extant literature. And, they provide a useful platform from which to gauge the influence of our variables of interest – work organisation and core knowledge. To this end, adding our work organisation and core knowledge variables significantly improves our models. As the data in table 7 show, the explained variance increases by 4.7%, 7.1% and 5.2% for the whole sample, manufacturing and KIS models, respectively. Aspects of work organisation and core knowledge are an important adjunct in understanding which firms cooperate with universities for innovation.

In terms of our stated hypotheses: only H2a is universally supported. That is, a greater emphasis on formal knowledge associates with university cooperation for both manufacturing and services (and in the whole sample model). We interpret this as indicating the role of formal knowledge as a 'ticket to the game'; reinforcing the absorptive capacity and social capital effects of R&D and graduate employment. Universities are important repositories and sources of formal knowledge, the importance of which is often understated (Senker, 1995). A highly developed formal knowledge-base helps reduced cognitive distances between firms and universities, by building upon shared experiences and understandings to facilitate better communication and collaboration (Nooteboom, 1999) – even where that collaboration involves tacit knowledge transfers. The implications of this for business and government policy relate to the importance or formally acquired knowledge and skills in innovation policy and to mechanisms for improving demand-side conditions of the university-industry interface. We return to these issues in our concluding remarks.

Our other hypotheses are partially supported only. Beginning with practical knowledge: this is supported for KIS firms only. Indeed, the coefficient for practical knowledge carries a negative (though non-significant) sign in our full manufacturing model. In line with our expectations, an emphasis on practical knowledge positively correlates with the propensity to cooperate with universities in KIS. Our hypotheses was framed on the basis of a generally "stronger knowledge base" being manifest in better searching and exploiting capabilities. Analyses of service innovation in general observe that the innovation process arise out of practice and not from R&D (Sundbo, 2010 p. 282), however, formal knowledge were also found as an important factor in explaining university cooperation for KIS. The complexity of service product seems to require a differentiated set of knowledge – both a DUI and a STI approach (Jensen et al., 2007). And our KIS firms seem to be able to combine the complexity of both DUI and STI modes of learning. The findings may also relate to the relative emphasis on project-based work in KIS. If the knowledge requirements of such projects are, more often, defined in shorter-duration and specific terms, practical ('how-to') knowledge may play a larger role as service firms rarely have methods and traditions that can delimit, define and maintain the new service in advance. This 'fluidness' makes it harder to define what it is attempting to innovate, the innovation being labile and apparently not very efficient and seldom leading to radical innovations (Sundbo, 2010; European Commission 2004). That is, the emphasis may be upon exploiting more than exploring (March, 1991). Of course, given the cross-sectional nature of our data, one cannot rule out the notion that an emphasis on practical knowledge is a consequence of university collaboration rather than a cause. Though this seems less likely, strictly we may only note the association. The absence of a similar finding for manufacturing is, perhaps, more intriguing. Where manufacturing firms are the dominant users of university expertise, it may reflect the "inherent, intractable mismatch between the essentially long-term research interests and focus of most HEIs [Higher Education Institutions] and the short-term, near-to-market needs of most" smaller firms (Hoffman *et al*., 1998, p. 48). Though this often seems like an overstatement, there is undoubtedly a sense that universities seem to prefer to engage in longer-term strategic research partnerships, than in the sorts of shorter-term research 'assistance' that many firms require. Again, we return to these issues below.

With regards to H1a and H1b, our data again provide partial support. In the all sample model, both project-based organizing and people-based organizing associate with the propensity to engage in cooperative innovation. That is, both hypotheses are supported. However, the separate manufacturing and KIS models suggest that this is largely a function of a positive people-based relationship in manufacturing and project-based relationship in knowledge-intensive services. This, of course, mirrors the relative emphases on people and projects in manufacturing and services noted in the descriptive data (recall Table 4). However, that they discriminate between cooperators and non-cooperators talks to more than simply the relative dispositions of the sectors. One possibility is that the findings may hint at different typical uses of universities by manufacturing and services – even when linkages are defined narrowly as innovation-related cooperation. It may be that, for instance, shorter-term project-based interactions are more the norm in knowledge-intensive services than in manufacturing, supporting that there are some 'service peculiarities' with regard to work organization and innovation collaboration in contrast to a more uni-linear, rational R&D-based innovation development that manufacturing firms are supposed to follow (Sundbo, 2010). According to Sundbo and Gallouj (2000) much of the service sector can be characterized as loosely coupled systems with non-fixed behavioral patterns and traditions and lack of coherence in terms of technological and professional trajectories, suggesting that the general innovation collaboration project can be characterized as 'temporary systems' with ‘institutionalized termination’ (Lundin and Söderholm, 1995) mostly operating in weak-tie milieus (Ibert, 2007, Granovetter, 1973).

In contrast, delegation and autonomy seem more likely to spur cooperation in manufacturing than services. This may also serve to underscore the importance of the social aspects of university cooperation in manufacturing, previously alluded to in our discussions graduate employment. Certainly, the data indicate the presence of different organisational dynamics in our two subsectors (Arundel *et al*., 2007), and a varying influence of these on the propensity to engage in collaborative innovation with universities. Tentative implications are drawn out in closing.

Concluding remarks

In this paper we exploit data from a recent large-scale survey of Norwegian firms to explore the relationship between work organisation, core knowledge and the propensity to engage in innovation-related cooperation with universities. For this, our inspiration was provided by the dual phenomena of a growing emphasis on the economic role of universities (Lawton-Smith, 2006) and the increasingly settled view that innovation is most often a process of interactive learning (Lundvall, 1992). In this context, as Bercovitz and Feldman (2007, p. 931) note, “the university-firm dyad is a particularly unique mechanism for cross-boundary learning for firms as universities operate with different incentives, goals, routines and decision-making incentives than for profit entities”. Moreover, as developed economies continue to shift from industrial capitalism to knowledge capitalism, universities are likely to be an increasingly important source of skills, knowledge and innovation (Lawton-Smith, 2006).

In exploring the firm-level determinants of university cooperation, we adopt ideas suggested by Arundel *et al*. (2007) to extend existing work on the propensity to cooperate with universities. Past studies have, by and large, confined themselves to the measuring ‘structural’ factors; such as firm size, R&D expenditure, industry sector. Where strategy has been considered, it is in the recent application of ‘open innovation’ ideas (e.g. Laursen and Salter, 2004). Here, we are able to add work organisation and core knowledge to this mix – allowing us to explore the possibility “that how firms organise production and the distribution of responsibilities among the workforce could have a significant effect on learning and hence innovation capabilities” (Arundel *et al*., 2007, p. 2). And, not just an effect on the volume of innovation outputs, but on the dynamics of innovation.

At present, of course, our focus is narrow – cooperative innovation involving universities. However, our findings do point to the influence of organisational and knowledge-related factors. Whilst it may be to overstate the case, Volberda and van den Bosch’s (2004, p. 25) instruction to the Dutch government has considerable merit: “…investments in management and organization determinants of absorption of knowledge and its successful application should have a higher priority than investments in technological innovations”. We might chose, at this stage, to delete the final 5 words from this sentence.

The work reported here is explorative and part of only a small number of studies seeking to use survey research to throw light on how material and human resources are used for innovation, and whether or not work environments encourage the further development of employee knowledge and skills (Arundel *et al*., 2007). Much needs to be done before confident policy recommendations may be proffered. However, a few provisional (and general) themes suggest themselves:

In the first instance, we follow Tether and Trajar's (2008, 1080) lead; that "it is useful to know whether the behaviour of service firms is fundamentally similar to, or different from, the behaviour of manufacturing firms". The evidence presented here suggests some important difference in behaviour and on the varying influence of these behaviours on innovation dynamics. Specifically, we note the relative emphases or people-based and project-based organising, in manufacturing and knowledge-intensive service firms respectively, and the consequent influences on the propensity to cooperate with universities. We also noted the greater role of practical knowledge in discriminating cooperating service firms and wondered at its relation with work organisation. Do services firms more often engage in shorter-term, more exploitation oriented collaborations than their manufacturing peers? The data hints at this possibility. If so, appreciating this has ramifications for policy designed to encourage industry-university links – especially in services dominated economies – and to take into account that type of collaboration partner requires different organizational practices and contractual arrangements (Laursen and Salter 2006). The evidence presented here, further confirms the notion that, perhaps with the exception of technical service firms, services have manifestly weaker direct links with the public-science base than do manufacturers (Tether and Tajar, 2008).

Secondly, we note the importance of formal knowledge in facilitating collaboration. Whilst the resource-based literature has long been keen to place tacit knowledge at the heart of competitive advantage (e.g. Kogut and Zander, 1993; Teece and Pissano, 1998), it is often at the neglect of formal knowledge (Senker, 1995). The imitability, mobility or transferability of formal knowledge undermines its role in building unique competitiveness. However, as our results show, it still has a key role in gaining access to other sources of potential competitive advantage. Moreover, whilst measures to improve tacit knowledge are likely to be the preserve of individual firms, improving stocks of formal knowledge is more amenable to policy intervention. And, would be consistent with the view that innovation policies should begin with skills policies.

Thirdly, we worry that the absence of a relationship between project-based working and collaboration in manufacturing may reflect a relative emphasis on longer-term strategic research in universities – buttressed by policy incentives. From their interview data, Fontana *et al*. (2006, p. 314), for instance, note that: "Among the reasons for not collaborating with universities, firms cited discrepancies between the objectives of the two parties, the length of time involved in university research, the different focus and hence different research questions addressed by universities and firms". Perhaps there is room for work which bridges the gap between the shorter-term, development work required by many (especially small) firms and the longer-term, basic research endeavours that universities necessarily undertake.

Finally, we are entirely sympathetic to Fontana *et al*.'s (2006) view that policies to promote university-industry collaboration should be better balanced between the supply and demand sides of the equation. Too much is currently done to encourage universities to make themselves open to industry collaboration, "with no acknowledgment that in the absence of appropriate 'demand' little will be achieved" (Fontana, *et al*., 2006, p. 321).

Limitations

A number of limitations are inevitable in a study of this kind. Some, such as the cross-sectional nature of our data and the need to build imperfect proxies of the phenomena in which we are interested, are likely to be familiar to the reader and well understood. Another common limitation, but one which warrants further elaboration, is the peculiarity of context. Our study is concerned with only one country – Norway. So far, we have said little about the Norwegian context, in part because we believe the broad thrusts of our study apply more generally. However, there is evidence that work organisation and innovation modes vary significantly across countries (Arundel *et al*., 2007) and similar work in further jurisdictions would be welcome.

In European terms, Norway's higher education system is relatively young and small. Norway has only 6 universities (2 of which gained university status in 2005). These are supplemented by 6 scientific colleges, 25 state colleges and 26, mostly small, private institutions. Many of the colleges and several of the universities enjoy particularly strong links with (often local) industry. This undoubtedly goes some way to explaining the relatively high incidence of university cooperation that we observe. As Gulbrandsen and Nerdrum (2004, p. 24) record: "industry surveys (CIS) show that the innovation activities in Norwegian firms are often oriented at collaboration, and that universities/colleges and research institutes are more frequent partners and sources of information for the firms than in most other European countries". In other words, Norway appears to have a highly collaborative innovation system.

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MARKS ----To follow.

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