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FULL ARTICLE

Collected worker experiences, knowledge management practices and service innovation in urban Norway

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Abstract

Knowledge-intensive services firms prefer to locate in cities that provide access to rich information flows and abundant opportunities for learning-by-recruiting. Focusing specifically on such locations, this paper explores how innovation is associated with work experiences "collected" by employees through their recent career paths and the implementation by current employer firms of practices to manage knowledge. Strong complementarities are found using a unique Norwegian dataset: The statistical association between practices and innovation outcomes depends strongly on variety of experience-knowledge among employees. Conversely, while said variety does not affect innovation in the absence of dedicated practices, it strongly does in their presence.

KEYWORDS

creativity stimulating methods, innovation, knowledge management practices, labour market mobility, services

JEL CLASSIFICATION

J24; O32; R11

1 | INTRODUCTION

Corporate innovation has traditionally been studied from the perspective of scientific knowledge, systematic research and development (R&D) work and formal business network configurations (e.g., Bogliacino & Cardona, 2014; Schøtt & Jensen, 2016; van Beers & Zand, 2014). Yet, structural change has for long favoured services industries where even firms in the knowledge-intensive segment (hereby KIS) might depend less on R&D than on large amounts of human resources (Niosi et al., 2012; Pina & Tether, 2016; Teece, 2003). The strong and persistent preferences exhibited by KIS for locating in the "madding crowd" (Shearmur, 2015) of large city regions (Jøranli & Herstad, 2017; Keeble & Nachum, 2002; Torres & Godinho, 2020) suggest that firms in these locations develop innovation models that are geared towards tapping external knowledge pools through recruitment and localized information search (Glaeser, 1999; Malmberg & Power, 2005; Power & Lundmark, 2003).

Drawing inspiration from management studies (e.g., Dokko et al., 2009; Mawdsley & Somaya, 2015) and evolutionary economic geography (Boschma & Frenken, 2011), efforts have in recent years been made to explore how organizational performance reflects experience-knowledge "collected" (Östbring et al., 2018) by employees at prior places of employment (Boschma et al., 2009; Herstad et al., 2019; Solheim et al., 2020). In parallel, efforts have also been made to broaden the traditional focus of innovation research on R&D to consider impacts of other organizational practices implemented to stimulate creativity, foster learning and facilitate knowledge integration (Arundel et al., 2007; Donate & Sánchez de Pablo, 2015; Lorenz et al., 2016; Revilla & Rodríguez-Prado, 2018). However, the fundamental question of whether experience-knowledge interact with organizational practices to shape innovation in firms remains open.

This question is particularly pressing in the context of KIS due to revealed locational preferences and intrinsic industry characteristics. To address it, we use data from the Norwegian Community Innovation Survey in 2010 (CIS2010) that provide information on different knowledge management practices, and on innovation outcomes. Supplementary employer-employee register data allow us to describe the work experiences that firms" current employees have collected in the past. Our model that predicts innovation probabilities from practically zero to almost 70% finds strong complementarities between variety of collected worker experiences and practices implemented by firms.

2 | CONCEPTUAL FRAMEWORK

Innovation can generally be described as a process of accessing or developing cognitive resources, and combining them into new products or practices (Schumpeter, 1934; Witell et al., 2017). In contrast to manufactured goods that are physical manifestations of resources used in development and production, services are intangible and depend on how 'service encounters' (Sørensen et al., 2013; Voorhees et al., 2017) are structured and what interacting agents bring into them. When encounters take the form of face-to-face interactions between clients and service professionals, the challenge arises for firms of how to link the practices of front-line employees to resources and learning in the larger organization (Dougherty, 2004; Engen & Magnusson, 2018). Encounters can also be facilitated by digital technologies, allowing provision without face-to-face interaction. This tightens interdependencies between "service" and the process by which it is provided. As a result, services firms tend to innovate differently from manufacturing (Sundbo & Gallouj, 2000; Tether, 2005; Tuominen & Toivonen, 2011) in that their efforts are more incremental, interactive and distributed (Sørensen et al., 2013; Sundbo & Gallouj, 2000; Tether & Tajar, 2008) with strong complementary relationships (Amara et al., 2009) and often blurred boundaries between "product," "process" and the larger "organization" (Gallouj & Savona, 2008; Witell et al., 2016).

2.1 | Knowledge management practices

The need to innovate along multiple, interrelated dimensions of the business means that creation of workspaces where employees can develop and share their knowledge is crucial. This can be facilitated by different "knowledge management practices instead of # defined by Donate and Sánchez de Pablo (2015, p. 362) as "activities, initiatives and strategies that companies can use to generate, store, transfer and apply knowledge for the improvement of organisational performance." Such practices include systematic research and development work (R&D), but extend into what Popper and Lipshitz (1998) referred to as integrated, dual-purpose learning mechanisms, that is, those that at the outset are interwoven with task performance (Arundel et al., 2007; Jensen et al., 2007) but facilitate also reflection and sharing outside of ongoing work practices (Dougherty, 2004; Engen & Magnusson, 2015).

Three such practices have received considerable attention over the years (Arundel et al., 2007; Leiponen, 2006; Lindbeck & Snower, 2000; Nonaka, 1995), recently under the heading of "creativity stimulating mechanisms" (Doran & Ryan, 2017; Revilla & Rodríguez-Prado, 2018): (i) Rotation of jobs (tasks) between employees; (ii) rotation of employees between teams; and (iii) brainstorming sessions (Arundel et al., 2007; Chuang et al., 2016; Lindbeck & Snower, 2000; Santos et al., 2017). *Job rotation* can reveal to managers and other employees specialized skills or talents that would otherwise be hidden (Ortega, 2001; Santos et al., 2017). Moreover, it can nurture creativity, lubricate interactive learning, and foster the collective understanding of interlinked business processes that makes knowledge more fluid and easier to put into practice (Eriksson & Ortega, 2006; Nonaka, 1994; Revilla & Rodríguez-Prado, 2018). Similarly, *teamwork* defined as collaborative activities that locate, share, create and apply knowledge among groups of people (Chuang et al., 2016), often from different functional areas (Keller, 2001), is emphasized as highly important—(e.g., Batt-Rawden et al., 2019; Erhardt, 2011; Leiponen, 2006) because teams with different compositions (e.g., project groups) can be established in response to shifting needs. Teamwork enhances the range of information that is available and ease coordination and overlap of tasks (Eisenhardt & Martin, 2000: 1109). Finally, *brainstorming sessions* can be arranged to access on a broader basis the organisations' distributed knowledge, stimulate creativity (Doran & Ryan, 2017; Revilla & Rodríguez-Prado, 2018) and compile insights that employees have gained through their practices (Donate & Sánchez de Pablo, 2015; Engen & Magnusson, 2018). Based on this, a first hypothesis can be formulated:

> **H1.** The implementation of creativity-stimulating mechanisms (CSMs) is positively associated with innovation in knowledge-intensive services firms.

The knowledge management framework of Donate and Sánchez de Pablo (2015) follow in the tradition of innovation research more generally by paying particular attention to different aspects of the practice that is R&D; defined by the OECD (2015, p. 28) as "systematic work undertaken in order to increase the stock of knowledge [….] and to devise new applications of available knowledge." Due to this attention, the importance of corporate R&D for in-house knowledge development and the capacity to absorb from the external environment (Cohen & Levinthal, 1989; Cohen & Levinthal, 1990) is well documented (e.g., Cassiman & Veugelers, 2006; Grimpe & Kaiser, 2010). In the discussion by Popper and Lipshitz (1998), R&D is considered a dedicated, non-integrated learning practice, namely, one that operates in (relative) isolation from ongoing business activities for the sole purpose of learning and innovation. The service innovation literature reflects this view in that R&D generally is considered less relevant for innovation due to lower direct technological content and dependence instead on knowledge that is practice-based and distributed among employees (Gallouj, 2002; Karlsson & Skålén, 2015; Sørensen et al., 2013; Tuominen & Toivonen, 2011). While accepting that R&D might generally be less common in services industries, documented intra-industry heterogeneity (e.g., Pina & Tether, 2016) forces the expectation that such work might well be conducted and then impact on innovation:

> **H2.** R&D is positively associated with innovation in knowledge-intensive services firms.

In extension of this, we need to consider interaction effects between the two knowledge management practices that are CSMs and R&D. A *complementary relationship* is implied when Grant (1996), Jensen et al. (2007) and others on a general basis emphasizes that success in R&D work depends on access to a broader range of knowledge and ideas than can be contained within dedicated R&D departments. In this perspective, the use of CSMs can serve to mobilize practice-based knowledge from the broader organization, and thereby increase the productivity of R&D. At the same time, it can also be argued that the absence of R&D efforts increases the importance of non-R&D efforts, that is, CSMs; and/or expected that effects of R&D on innovation override effects of CSMs when firms engage in both practices. This suggests a *substitutive relationship*. More generally, management scholars have found "too much of a good thing" effects to be widespread in organizational design and strategy (Pierce & Aguinis, 2013). Such effects could here take the form of diminishing returns to individual practices due to growing overall complexity of organizational processes when they are combined. Accordingly, we formulate a third hypothesis that leaves the sign of the expected interaction effect open for the empirical analysis to explore:

H3. The association between R&D and innovation in knowledge-intensive services firms depends on whether or not CSMs are implemented.

2.2 | Collected worker experiences and urban location

While the service research field discusses how to foster and then capture for innovation learning from ongoing task execution in the organization (Engen & Magnusson, 2018; Sundbo & Gallouj, 2000), the geography literature points out that employees enter into firms with knowledge (Timmermans & Boschma, 2014), networks (Agrawal et al., 2006) and behavioural attributes (Dokko et al., 2009; Herstad et al., 2015) that reflect their learning at prior places of employment. The relevance of viewing this as "resources" available for integration into "service" (Witell et al., 2017) is underscored by contributions finding recruitment to be the most important mechanism for competence upgrading in KIS (Jøranli, 2018; Keeble & Nachum, 2002; Tether, 2003) and the networks of employees to be extensively used for information search (Deprey et al., 2011; Reihlen & Apel, 2007; Tödtling et al., 2006). This more than hints that knowledge intensive services prefer to locate in cities for access to "the large amounts of human resources" on which they depend. Urban labour markets facilitate ongoing employer-employee matching (Duranton & Puga, 2004; Eriksson & Rodríguez-Pose, 2017; Helsley & Strange, 1990), and provide individuals with opportunities for "learning-by-doing" that "speed the accumulation of human resources" (Glaeser & Maré, 2001) as evident from persistent wage premiums on careers in cities (Glaeser, 1999; Gordon et al., 2015). Thus, a focus on what individuals carry from their prior work experience (cf. Dokko et al., 2009) to current employer KIS is required, and fully in line with the literature on knowledge spillovers through labour market mobility (Almeida & Kogut, 1999; Møen, 2005; Oettl & Agrawal, 2008; Singh & Agrawal, 2011).

To approach this, we draw on the concept of "collected worker experiences" introduced by Östbring et al. (2018). In this perspective, whether experiences can be integrated into (new) services depends how well they interact and combine in firms. At a general level, "cognitive resource diversity theory" in human resource research (cf. Horwitz, 2005) proposes that firms benefit from diverse experiences because they represent a range of knowledge and ideas, networks and perspectives that trigger learning and facilitate innovation through "new combinations" (Van Engen & Van Woerkom, 2010, p. 133). Against this, work within the "similarity attraction paradigm" (cf. Horwitz, 2005; Horwitz & Horwitz, 2007) argues that more effective communication between less divergent perspectives enhance the execution of tasks and provide the basis for continuous incremental improvements of products and practices. This, however, comes with the risk of "myopia" prohibitive of more fundamental changes (Levinthal & March, 1993). Very diverse attributes, on the other hand, could lead to distrust, a lack of shared understanding and a high risk of conflicts that may also reinforce the firm's focus on retaining rather than adjusting established products and practices (Horwitz, 2005; Jehn et al., 1999; Madsen et al., 2003).

The economic geography literature (cf. Östbring et al., 2018) echoes this debate when discussing benefits from (Marshallian) specialization versus (urban) diversity (Beaudry & Schiffauerova, 2009; Firgo & Mayerhofer, 2018; Frenken et al., 2007). Translated to the KIS sector under consideration here, this debate is one of whether firms in cities benefit from specialized labour pools that reflect concentration of services employment, or the different recruitment channels that urban diversity open to other domains of the economy (cf. e.g. Jøranli & Herstad, 2017). Focusing on the firm level, Timmermans and Boschma (2014) agree with the earlier Boschma et al. (2009) that positive productivity effects from inflows generally demand that labour dispatching domain are sufficiently different so that a learning potential exists yet not too distant so that the potential can captured; that is, "related." However, they also find that firms in urban locations, and in extension services, respond differently. Similarly, while, Herstad et al. (2015) inflows form "related" industries positively associated with innovation in a sample of manufacturing and services firms, the later Herstad (2018) found the services segment of the same sample dependent on more diverse cognitions than the manufacturing counterpart (cf. also Firgo & Mayerhofer, 2018). In line with this, Herstad et al. (2019) found KIS benefitting for product innovation from combining a broad range of experience-knowledge drawn specifically from the labour markets of large cities. This is consistent with the notion that innovation in the rapidly changing market environments of services demand bridging of different cognitive domains (Bugge, 2011; Jøranli, 2018; Pershina et al., 2019). Still, the discussion of what amount and type of variety is required extends into questions of definition and operationalization (Whittle & Kogler, 2020). Thus, we here simply assume that variety of experiences matter for innovation and leave open for the empirical analysis to address what is the requisite type. A fourth hypothesis is formulated on this basis:

H4. Variety of collected worker experiences is positively associated with innovation knowledge-intensive services firms.

Even though the literature on absorptive capacity suggests that the type and amount of cognitive variety that firms effectively can assimilate and exploit depend on efforts made in this respect (Cohen & Levinthal, 1990; Zahra & George, 2002), research on collected worker experiences (Herstad et al., 2019; Östbring et al., 2018) and the antecedent literature on aggregate movements in the labour market (Boschma et al., 2009; Herstad et al., 2015; Timmermans & Boschma, 2014) has insofar only occasionally (cf. Solheim et al., 2020: on R&D in the manufacturing industry) considered moderating effects of knowledge management practices (here understood as R&D and/or CSMs). Similarly, research on such practices has paid limited attention to the actual composition of organizational knowledge bases that they are implemented to manage. In the context here, a *complementary relationship* exists if the implementation of practices allow firms to exploit a broader range of experience-knowledge for innovation, whereas a *substitutive relationship* exists if collected experiences foremost matter for innovation in the absence of dedicated learning and knowledge integration efforts on the side of firms. Accordingly, a final hypothesis is formulated:

H5. The relationship between collected worker experiences and innovation in knowledge-intensive services firms depend on the implementation of knowledge management practices.

3 | METHODOLOGICAL APPROACH

The analysis uses innovation data sampled by the governmental agency Statistics Norway in the seventh round of the pan-European Community Innovation Survey (CIS2010) that build on definitions and guidelines provided in the third edition of the Oslo Manual (OECD, 2005). In contrast to many other European countries, participation in the Norwegian surveys is compulsory for sampled firms. The 2010 survey is unique in that information on the use of "creativity stimulating mechanisms" during the reference period 2008–2010 is provided in addition to the standard information on R&D, innovation activities and outcomes. For the purpose here, the data have been merged with Linked Employer-Employee Registers (LEED) covering the years 2004–2008.

KIS are defined as described in Table A1 in the Appendix. To allow growth, labour replacement and collected worker experiences to be captured as detailed below, only firms established before 2006 are included in the analysis. The sample is also restricted to the firms with 10 employees or more that responded to the full CIS questionnaire, thus providing all required information. These criteria give 1,124 KIS observations, of which 795 were located in one of the four urban housing and labour-market regions of Norway as originally defined by Jukvam (2002) and updated in Gundersen and Jukvam (2013). Given that non-conventional location choices suggest different business strategies and innovation models (e.g., Herstad et al., 2019; Shearmur, 2015), KIS located outside these urban labour market regions are excluded from the analysis.

3.1 | Innovation

Being typically described as fluid and dynamic, with blurred boundaries between product, process and organization (Gallouj & Savona, 2008; Witell et al., 2016), two dependent variables are used in the analysis to capture innovation "in services." On the one hand, it is strictly defined as "service innovation" with the variable SERVINNO taking on the value 1 if firms reported that they during the reference period introduced a new or significantly improved service onto their markets. On the other, a broader definition is applied as the variable SUPPINNO for "supportive innovation" takes on the value 1 if firms reported process, organizsational or marketing innovation as specified in the CIS.[1] As would be expected given these definitions and their theoretical backdrop, Table 1 shows that SUPPINNO is the most common form while SERVINNO without SUPPINNO is particularly rare.

3.2 | Knowledge management practices

As previously noted, we focus on the two types of knowledge management practices that are R&D traditionally defined and those more recently labelled "creativity stimulating mechanisms" (CSMs). The binary variable "R&D" takes on the value 1 if firms reported intramural research and development work during the reference period. The binary variable CSM takes on the value 1 if firms reported using at least two of the three following practices: (i) brainstorming sessions; (ii) multidisciplinary or cross-functional work teams; or (iii) job rotation of staff to different departments or other parts of their enterprise group. The strict definition is applied to capture only firms that engage systematically, and broadly, in such efforts. As can be seen from Table 2 below, a somewhat larger proportion of firms implement CSMs compared to R&D. However, the most striking pattern is that more firms engage in both practices than in either one.

TABLE 1 Description of innovation outcomes

	SERVINNO		
SUPPINNO	**No**	**Yes**	**Total**
No	377	35	412
Yes	230	153	383
Total	607	188	795

TABLE 2 Knowledge management practices

	CSM		
R&D	No	Yes	Total
No	346	147	493
Yes	111	191	302
Total	457	338	795

3.3 | Collected worker experience

To describe the composition of experience-knowledge present in firms at the start of the CIS2010 reference period in 2008, matrixes have been generated that uses industry codes to categorize the past workplaces of employees as observed over a period. Constructing such matrixes demands consistent sector classifications. Standards have changed, and entirely new classes have been added in response to structural change in the economy. For the period 2004–2008, the data allow the previous SN2002 (building on NACE Rev. 1.1) to be harmonized with the current and more detailed SN2007 (building on NACE Rev. 2). Thus, the analysis focuses on experiences collected during this five-year period.[2] As an example, consider the median firm with 36 employees in 2008. As observed here, the firm contains 36 (size in 2008) $\times$ 5 (years employees are observed) $=$ 180 experience-years. Each experience-year has been assigned to the five-digit industry codes in which it was obtained. Years during the period 2004–2007 in which employees of the focal firm in 2008 were not in employment are not counted because no work experiences were gained.

Based on these matrixes, the essential *collective* dimensions that is how employees' experiences relate to one another when combined in the focal employer firms has been described using entropy measures computed in accordance with Jaquemin and Berry (1979). The variable VAR_BETWEEN is the distribution of experience-years *between* two-digit main industry groups. The variable VAR_WITHIN is the weighted sum of distributions at the 3-digit level *within* 2-digit main groups where the weights are the proportions of all experience-years accounted for by each 2-digit group. Total variety (VAR_TOTAL) is the sum of _BETWEEN and _WITHIN, which equals the entropy of the distribution between 3-digit groups. This operationalization is as originally applied by Frenken et al. (2007) to describe the composition of employment in regions and later adapted to capture the composition of experience- knowledge in firms (Östbring et al., 2018; Solheim et al., 2020); however, we refrain from using the terminology "related" versus "unrelated" *skills* to avoid making substantive assumptions from a method for empirically distinguishing the composition only of industry *experiences* without taking into account occupations or educations.

All workers present in the firm in 2008 are considered, independently of their roles, whether they worked full-time or part-time in 2008 or previous years, and their education levels. Restricting the analysis to certain roles or occupations would be in conflict with the proposition in service innovation theory that learning and innovation have distinct collective, distributed and informal dimensions. Excluding part-time employees in 2008 would suggest also excluding individuals who worked part-time at certain points in earlier years, potentially introducing biases due to over-representation of demographic groups less inclined to work part-time (e.g., middle-aged male workers). Finally, restricting the analysis to include only employees with education above a set threshold level would entail making decisions about what that level *generally* should be that are non-trivial given sector heterogeneity and the real option open for individuals of following the vocational training rather than higher education qualification route. Examples of relevant vocational training programs include, for example, web design, media and communication that rank low on the education level scale yet qualify for skill-intensive apprenticeships and subsequent knowledge-intensive work. Moreover, skills acquired through experience might well compensate for lack of formal training, academic or vocational.

3.4 | Control variables

Stability of staff inherently reduces the experience-variety hypothesized to influence innovation positively, while high turnover, for example, of low-skilled workers that are mobile between firms and industries might increase variety with limited influence on innovation. To control for this, the variable CHURN0608 is included that is the proportion of employees present in 2006 that was replaced with new employees during the two-year period leading to the start of the CIS reference period in 2008. Similarly, experience variety can be affected by the growth rate of the firm e.g. through absorption of unskilled labour during fast expansions, and growth can be dynamically interlinked with itself (positive or negative serial correlations cf. e.g. Coad (2007) as well as with innovation (Bogliacino et al., 2017; Herstad & Sandven, 2020). Therefore, the variable GROWTH0608 captures employment growth during the two-year period leading up to the start of the CIS2010 reference period in 2008.

Aspects of urban location that we need to control for to isolate the interaction of practices with collected experiences include market orientation (Isaksen, 2004; Keeble & Nachum, 2002), proximity to (a broad range of) potential collaboration partners (Herstad & Ebersberger, 2015), exposure to information flows more generally (Doloreux & Shearmur, 2012; Shearmur, 2015; Storper & Venables, 2004), and overall higher education levels among employees in cities compared to outside (e.g., Aslesen et al., 2008). The variable FORMAR is included that takes on the value 1 if the firms" most important market is outside Norway. Collaboration is strictly defined in the CIS to capture only *active participation for innovation* with other enterprises or non-commercial institutions. As firms can access external resources also from other sources than partners, and by other means than active participation, we implement instead the control variable SEARCH that captures the use by firms of information from partners as well as non-partner organizations (e.g., competitors) and public sources such as publications and databases. Following Laursen and Salter (2006), the variable is a count of how many of the 11 sources specified in the CIS that are used. The variable EDULEVEL08 is the average education level of firms' employees in 2008, described on the standard eight-level scale used in the registers.

Variety measured as entropy is influenced by the size of the firm, which may also affect innovation propensities. This is captured by the variable SIZE that is the natural logarithm of employment in 2008. Knowledge intensive services is a heterogeneous industry, meaning that labour market linkages and innovation propensities might differ substantially between subgroups. Therefore, 14 dummy variables are included in all regressions as controls for 15 two-digit industry groups described in Table A1 in the Appendix. Dummy variables are also included to capture previously documented inter- and intra-regional differentiation (cf. Herstad & Ebersberger, 2015) in the Norwegian urban hierarchy: OSLO C captures locations within the capital city itself. OSLO W captures locations in the bordering south-western municipalities where ICT and other technical services remain heavily concentrated (Isaksen, 2004; Jøranli & Herstad, 2017), while OSLO O captures locations in the outer dwelling municipalities of the capital labour market regions. BERGEN is the second-largest housing and labour market region; STAVANGER is the third and TRONDHEIM the fourth.

3.5 | Estimation strategy

As the two outcome variables are binary and service innovation theory suggest they are interdependent (Amara et al., 2009; Gallouj & Savona, 2008; Witell et al., 2016), both are estimated simultaneously using the bivariate probit estimator in which the (potential) correlation between the binary outcomes is captured by the conditional correlation of the error terms (Filippini et al., 2018; Greene, 2018). When interaction effects are included in probit (or logit) models as here, it is necessary to compute marginal effects to evaluate sign, size and significance (Ai & Norton, 2003; Brambor et al., 2006; Hoetker, 2007). Reflecting expected interdependencies and literature suggesting that "bundles of complementary innovations" are particularly important for sales performance and growth (Ebersberger et al., 2021; Evangelista & Vezzani, 2010; Herstad & Sandven, 2020; Martin-Rios & Ciobanu, 2019), we compute predicted probabilities of combined service and supportive innovation with detailed marginal effects of experience variety, R&D and CSMs at different combinations of the variable. All other variables are then held constant at their mean effect. This innovation outcome is exhibited by 19% of firms in the sample (cf. Table 1). Note that the term "effect" here refers to statistical associations (e.g., marginal "effects") that do not necessarily reflect causal relationships.

4 | RESULTS

Table 3 below reports the baseline regression results. Rho is positive and significant in all three models, meaning that error terms of the two equations are correlated and outcomes interdependent as service innovation theory lead us to expect: Higher probabilities of SUPPINNO follows from higher probabilities of SERVINNO and vice versa. In model 1, total experience variety is positive and significant in both equations, as is CSM and R&D. Note the test provided at the bottom of the table showing that estimates for the two latter are not significantly different from each other. Once the distinction between experiences collected within and between domains is introduced in model 2, it is evident that both service innovation and supportive innovation is positively associated only with the component of total experience variety that is between-domain. In the final model 3, all interactions terms implied by the hypotheses are included. For all constitutive terms to be included (Brambor et al., 2006), also the two three-way interactions between knowledge management practices (R&D and CSMs) and collected worker experiences must be added to the model (Dawson & Richter, 2006; Haans et al., 2016). Doing so introduces a distinction between the different terms (i.e., baseline, two-way and three-way interaction terms) used to describe the focal variables, and the variables themselves, meaning that significance cannot be evaluated from the individual terms (Brambor et al., 2006). Therefore, supplementary Wald's tests of joint coefficient significance are included at the bottom of the table. These tests show that both within-domain and between-domain variety of experiences in interaction with R&D and CSMs have significant effects on both types of innovation.

Notably, employment churn and growth both yield significantly negative coefficients in Equation A in Table 3 estimating service innovation. Whereas the former underscores the importance of isolating noise of replacement from influences of new experiences brought in, the latter suggests that KIS become more eager to innovate when their growth is lagging and are less bothered when not. It is also notable that neither market presence nor firm size and education levels have significant effects on innovation when practices and experiences are accounted for as here.

Table 4 reports predicted probabilities and marginal effects from the interactions involving *within-domain* (aka "related") variety of collected experiences. All other variables including between-domain variety are here held constant at their mean effects. Significant negative marginal effect estimates for within-domain variety are obtained from low to moderately high levels when firms engage in R&D without implementing CSMs, and, similarly, when they engage in CSMs without R&D and within-domain variety is well above the full sample mean of 0.175. There is also strong indication of a positive effect when firms engage both practices, as the marginal effect of CSMs in the presence of R&D increases from 11.6 percentage points to 68.7 percentage points in the range of within-domain experience variety considered. Similarly, the effect of R&D in this range of experience variety increases from 19.5 percentage points to 67.2 when CSMs are implemented. Thus, whereas the statistical effect of within-domain variety per se on innovation largely is insignificant, such experience-variety strengthens dramatically the complementary of R&D and CSMs (cf. significant three-way interactions in Table 3). This suggests that firms need employees with relatively specialized *intra-industry* experiences in order to unleash the innovation potential of broad, and thereby complex, knowledge management efforts.

Table 5 reports predicted probabilities and marginal effects for the interactions involving *between-domain* (aka "unrelated") variety of collected experiences, with all other variables including within-domain variety held constant at their mean effects. When firms do not implement any knowledge management practices, variety affects the

TABLE 3 Results from bivariate probit regressions with supplementary tests for joint coefficient significance. N = 795

	Equation A: SERVINNO			Equation B: SUPPINNO		
	Model 1 Coeff (SE)	Model 2 Coeff (SE)	Model 3 Coeff (SE)	Model 1 Coeff (SE)	Model 2 Coeff (SE)	Model 3 Coeff (SE)
CSM	0.521*** (0.144)	0.516*** (0.142)	−0.011 (0.465)	0.913*** (0.138)	0.905*** (0.137)	0.044 (0.439)
R&D	0.863*** (0.170)	0.869*** (0.169)	−0.026 (0.494)	0.666*** (0.155)	0.669*** (0.153)	0.848* (0.466)
SEARCH	0.122*** (0.022)	0.120*** (0.021)	0.125*** (0.021)	0.103*** (0.022)	0.101*** (0.022)	0.108*** (0.021)
R&D x CSM			1.461** (0.693)			0.642 (0.658)
Collected worker experiences						
VAR_TOT	0.495*** (0.160)			0.356*** (0.133)		
VAR_WITHIN		−0.215 (0.568)	0.233 (0.960)		−0.343 (0.413)	0.188 (0.550)
VAR_WITHIN x CSM			−0.976 (1.397)			−1.704* (1.011)
VAR_WITHIN x R&D			−2.283* (1.300)			−2.419** (1.084)
VAR_WITHIN x CSM x R&D			4.066** (1.916)			5.769*** (1.701)
VAR_BETWEEN		0.627*** (0.208)	0.431 (0.335)		0.494*** (0.160)	0.234 (0.224)
VAR_BETWEEN x CSM			0.492 (0.452)			1.069*** (0.392)
VAR_BETWEEN x R&D			0.916** (0.465)			0.223 (0.361)
VAR_BETWEEN x CSM x R&D			−1.554** (0.639)			−1.452*** (0.560)
Firm characteristics						
SIZE	−0.061 (0.063)	−0.050 (0.065)	−0.042 (0.064)	0.020 (0.057)	0.030 (0.058)	0.036 (0.059)
FORMAR	−0.259 (0.209)	−0.285 (0.209)	−0.255 (0.206)	0.074 (0.180)	0.052 (0.181)	0.057 (0.181)
EDULEVEL08	0.107 (0.094)	0.114 (0.093)	0.119 (0.092)	−0.021 (0.078)	−0.017 (0.077)	−0.026 (0.077)
CHURN0608	−1.336** (0.634)	−1.310** (0.627)	−1.323** (0.635)	−0.350 (0.505)	−0.348 (0.504)	−0.215 (0.510)
GROWTH0608	−0.284** (0.122)	−0.282** (0.121)	−0.329*** (0.124)	0.014 (0.095)	0.009 (0.094)	0.024 (0.095)
Urban locations						
OSLO C	Reference	Reference	Reference	Reference	Reference	Reference
OSLO W	−0.038 (0.181)	−0.014 (0.184)	−0.069 (0.182)	−0.049 (0.176)	−0.018 (0.180)	−0.061 (0.180)
OSLO C	−0.281 (0.320)	−0.320 (0.323)	−0.330 (0.328)	0.211 (0.336)	0.161 (0.331)	0.120 (0.324)

TABLE 3 (Continued)

	Equation A: SERVINNO			Equation B: SUPPINNO		
	Model 1 Coeff (SE)	Model 2 Coeff (SE)	Model 3 Coeff (SE)	Model 1 Coeff (SE)	Model 2 Coeff (SE)	Model 3 Coeff (SE)
BERGEN	0.063 (0.219)	0.041 (0.218)	0.069 (0.221)	−0.139 (0.209)	−0.160 (0.207)	−0.179 (0.207)
STAVANGER	−0.113 (0.260)	−0.185 (0.245)	−0.198 (0.245)	−0.231 (0.198)	−0.288 (0.192)	−0.253 (0.194)
TRONDHEIM	−0.120 (0.255)	−0.168 (0.245)	−0.133 (0.242)	0.314 (0.228)	0.269 (0.224)	0.345 (0.225)
NACE 2-digit industry groups	Included (14)	Included (14)	Included (14)	Included (14)	Included (14)	Included (14)
Constant	−1.912*** (0.581)	−1.994*** (0.591)	−1.820*** (0.588)	−1.361*** (0.484)	−1.406*** (0.485)	−1.006*** (0.368)
Walds Chi2 test of coefficient equality						
CSM = R&D	2.21	2.44	-	0.05	0.03	-
Walds Chi2 test of joint coefficient significance						
All terms involving CSM	-	-	25.38***	-	-	21.65**
All terms involving R&D	-	-	29.44***	-	-	26.95**
All terms involving VAR_WITHIN	-	-	14.65**	-	-	14.86**
All terms involving VAR_BETWEEN	-	-	21.39***	-	-	21.64**
Walds Model Chi2 (df)	3803.83(56)***	4251.5(58)***	3553.86(72)***			
Rho	0.567	0.564	0.552			
Walds Chi2 test of Rho = 0	47.588***	46.348***	44.851***			

Notes: Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

TABLE 4 Predicted probabilities (PP) of combined service and supportive innovation with marginal effects (ME) of VAR_WITHIN, CSM and R&D for different combinations of the three variables. All other variables are held constant at their mean effect

		CSM constant at 0			CSM constant at 1			Marginal effects of CSM	
		PP	ME (VAR_)	SE	PP	ME (VAR_	SE	ME (CSM)	SE
R&D constant at 0 & VAR_WITHIN at:	0	0.028	0.015	0.051	0.101	−0.151	0.206	0.074	0.041*
	0.15	0.030	0.016	0.059	0.080	−0.131	0.149	0.050	0.023**
	0.3	0.032	0.017	0.067	0.062	−0.112	0.098	0.029	0.027
	0.45	0.035	0.018	0.075	0.046	−0.092	0.055*	0.011	0.038
	0.6	0.038	0.020	0.085	0.034	−0.074	0.026***	−0.004	0.048
	0.75	0.041	0.021	0.094	0.024	−0.058	0.021***	−0.017	0.058
	0.9	0.044	0.022	0.105	0.016	−0.043	0.030	−0.028	0.069
R&D constant at 1 & VAR_WITHIN at:	0	0.181	−0.578	0.340*	0.296	0.434	0.274	0.116	0.084
	0.15	0.107	−0.407	0.200**	0.363	0.454	0.336	0.256	0.052***
	0.3	0.057	−0.256	0.089***	0.431	0.459	0.370	0.374	0.071***
	0.45	0.028	−0.144	0.045***	0.500	0.452	0.371	0.472	0.116***
	0.6	0.012	−0.071	0.041*	0.566	0.434	0.340	0.554	0.165***
	0.75	0.005	−0.031	0.032	0.630	0.409	0.284	0.625	0.210***
	0.9	0.002	−0.012	0.019	0.689	0.377	0.209*	0.687	0.245***

		CSM constant at 0		CSM constant at 1	
		ME (R&D)	SE	ME (R&D)	SE
Marginal effects of R&D when VAR_WITHIN at:	0	0.153	0.063**	0.195	0.084***
	0.15	0.077	0.031**	0.283	0.056***
	0.3	0.025	0.024	0.370	0.074***
	0.45	−0.007	0.027	0.453	0.119***
	0.6	−0.026	0.035	0.533	0.168***
	0.75	−0.036	0.047	0.606	0.212***
	0.9	−0.042	0.062	0.672	0.247***

probability of innovation positively when it increases from low to moderately low levels; yet the estimate becomes insignificant well before the mean variety of 1.078 is reached. When firms *either* engage in R&D *or* implement CSMs, marginal effects of experience variety are positive and significant more or less throughout the range considered. Moreover, it can be seen from the column to the right that between-domain experiences of staff differentiate the marginal effect of implementing CMSs without R&D in the range from 0.5% to 37.9%. Similarly, the effect of R&D without CSMs range from an insignificant minus 0.6 percentage-points at zero between-domain variety to a positive and strongly significant 49.8 percentage-points at the maximum level of such variety observed. When both knowledge management practices are implemented, marginal effects of between-domain experience variety are insignificant across the range observed. Still, increasing between-domain variety substantially *weakens* the complementarity of R&D and CSMs that within-domain variety strengthened (cf. Table 4).

Comparing the estimates in Table 4 and Table 5, it is evident that firms face a choice between operating complex internal processes for knowledge management (combined R&D and CSMs) to innovate based on variety of experience-knowledge collected by employees outside the firm yet inside the sector domain (high within-domain

TABLE 5 Predicted probabilities (PP) of combined service and supportive innovation with marginal effects (ME) of VAR_BETWEEN, CSM and R&D for different combinations of the three variables. All other variables are held constant at their mean effect

		CSM constant at 0			CSM constant at 1			Marginal effects of CSM	
		PP	ME (VAR_)	SE	PP	ME (VAR_)	SE	ME (CSM)	SE
R&D constant at 0 & VAR_BETWEEN at:	0	0.011	0.012	0.004***	0.006	0.020	0.015	−0.005	0.011
	0.4	0.017	0.017	0.007**	0.020	0.052	0.019***	0.003	0.016
	0.8	0.025	0.023	0.015	0.051	0.109	0.033***	0.026	0.020
	1.2	0.036	0.032	0.027	0.110	0.188	0.089***	0.074	0.029**
	1.6	0.050	0.041	0.043	0.202	0.274	0.161*	0.152	0.068**
	2	0.069	0.053	0.062	0.327	0.343	0.202*	0.258	0.135*
	2.4	0.093	0.066	0.083	0.472	0.373	0.174***	0.379	0.208*
R&D constant at 1 & VAR_BETWEEN at:	0	0.005	0.020	0.016	0.272	0.090	0.076	0.266	0.112***
	0.4	0.021	0.064	0.025**	0.309	0.094	0.088	0.288	0.084***
	0.8	0.062	0.154	0.042***	0.347	0.098	0.097	0.285	0.059***
	1.2	0.148	0.278	0.100***	0.387	0.101	0.103	0.239	0.055***
	1.6	0.282	0.380	0.149**	0.428	0.102	0.105	0.146	0.095
	2	0.441	0.400	0.142***	0.469	0.102	0.104	0.028	0.155
	2.4	0.590	0.336	0.112***	0.509	0.101	0.100	−0.081	0.208

		CSM constant at 0		CSM constant at 1	
		ME (R&D)	SE	ME (R&D)	SE
Marginal effects of R&D when CWE_BETWEN at:	0	−0.006	0.011	0.265	0.112**
	0.4	0.004	0.017	0.289	0.085***
	0.8	0.038	0.025	0.296	0.062***
	1.2	0.113	0.039***	0.277	0.059***
	1.6	0.232	0.079***	0.225	0.100**
	2	0.372	0.132***	0.142	0.173
	2.4	0.498	0.175***	0.038	0.254

and low between-domain variety); or less extensive internal efforts (either R&D or CSMs) for innovation based on knowledge bases that are themselves more diverse, and thereby complex (high between-domain and low within-domain variety).

4.1 | Supplementary estimations and robustness test

As a sensitivity test, Model 3 has been estimated only for firms larger than the median size of 36 employees. Due to the difficulty of directly comparing results from nonlinear regression estimated on different samples (Mood, 2009), predicted probabilities and marginal effects have been computed in the same way as from the main estimation. The results reported in Table A3 and A4 in the Appendix are structurally consistent with those obtained from the estimation for all firms. In line with the choice identified above, this includes strengthened complementary of R&D and CSMs when within-domain variety increases (Table A3) and between-domain decreases (Table A4); and weakened complementary of R&D and CSMs when between-domain variety increases and within-domain variety goes down. Particularly high innovation probabilities and significance of the positive estimates for within-domain variety in the joint presence of R&D and CSMs suggest that larger firms have the greater capacity for transforming sector-specific experience-knowledge into innovation by means of extensive internal knowledge processing. Moreover, outcome probabilities that are generally low in the absence of experiences collected outside the organization underscore that also larger firms depend on learning through external labour markets in order to innovate.

Supplementary regressions have also been estimated to consider interaction effects between variety of worker experiences and average education levels. Neither the joint effect of baseline education level and its interaction with VAR_WITHIN nor the joint effect of baseline education level and its interaction with VAR_BETWEEN come out as significant, in any of the two equations.

5 | DISCUSSION AND CONCLUSION

This paper aimed to address the question of whether experience-knowledge collected by workers and accessed by KIS in the labour markets of large-city regions interact with firms' knowledge management practices (R&D and CSMs) to shape their innovation capacities and outcomes. As baseline result, we found strong support for Hypotheses H1 and H2 that predicted positive statistical effects of the two practices, and found the positive estimates for CSMs not statistically different from the positive estimate for R&D. This is highly notable in light of service innovation theorizing (Engen & Magnusson, 2018; Witell et al., 2017). Hypothesis H3 predicted interaction effects between the two knowledge management practices R&D and CSMs. At low between-domain experience (aka "unrelated") variety, marginal effects of R&D were only found significantly positive in the presence of CSMs, and vice versa. Thus, a complementary relationship exists specific to firms were variety of staff experiences from outside the (NACE 2-digit) sector in question is low to moderately high. This complementary of CSMs and R&D becomes even more pronounced as within-domain (aka "related") variety increases. At the higher levels of between-domain experience variety observed, by contrast, adding the absent practice to that implemented does not significantly increase the outcome probability considered here. Thus, we have found conditional (on experience variety) support for Hypothesis H3 that reflects the more clear-cut support provided for Hypothesis H4 on the role of experience-variety in innovation and Hypothesis H5 on its interaction with practices. In the absence of dedicated practices, experience-variety does little to differentiate innovation probabilities. In the presence of either one practice, between-domain variety of experiences collected by staff *strongly* does. For firms that only implement CSMs, the probability of combined service and support innovation increases significantly from practically zero to 47% from the lowest to the highest level of variety observed; the parallel to which when firms only engage in R&D is an increase from zero to almost 59%.

This holds even though market orientation, education levels and the use by firms of different external information sources is accounted for separately—the "usual suspects" in research on the geography of KIS innovation (Doloreux & Shearmur, 2012; Herstad & Ebersberger, 2015; Torres & Godinho, 2020). Taken together, the results show that firms engaging extensively in knowledge management for innovation, as evidenced by the co-existence of R&D with CSMS, depend for the productivity of these efforts on tapping the specialized labour pools of KIS clusters in cities and thereby build knowledge bases characterized by high within-domain (aka "related") variety. Firms that engage more selectively in knowledge management, by contrast, exhibit declining innovation propensities from tapping such pools and need instead the more diverse external impulses of between-domain (aka "unrelated") experience variety. The two correspond to capturing Marshallian advantages of specialization and Jacobian advantages of diversity, respectively; and specifically through the mechanism that is recruitment with requisite knowledge management.

To ongoing theoretical and methodological debates in economic geography, these results demonstrate that experience-knowledge traditionally defined as "unrelated" can be highly complementary when combined in certain industries and certain locations, in certain ways. This and conditional (on absence of complementary practices) negative effects of within-domain variety resonates well with the firm-level results of Timmermans and Boschma (2014) for the capital labour market region in Denmark where "related variety" of inflows gave negative productivity estimates, and the region-level results of Firgo and Mayerhofer (2018) who found employment growth in services facilitated by "unrelated variety" in the surrounding economy. In turn, this is consistent with the suggestion made that KIS often depend on diverse cognitive resources and broad contact points to the surrounding economy for cross-domain innovation (Bugge, 2011; Herstad, 2018). The conditions also revealed under which more specialized "related variety" is beneficial demonstrate that cities are not like sunny beaches where the tan comes from merely "being there": Whether or not firms are able to exploit urban density and diversity for innovation depend strongly on their positions in labour flows and efforts made to process knowledge.

Implications can also be drawn for the service research field that for quite some time has theorized the need for mobilizing employees' individual and collective expertise. The argument goes that learning and innovation have distinct distributed and informal dimensions (Engen & Magnusson, 2015; Gallouj, 2002; Karlsson & Skålén, 2015; Sørensen et al., 2013; Tuominen & Toivonen, 2011) where interactions and problem solving between employees and with clients constitute processes of idea generation, learning and knowledge integration that shape the services provided (Amara et al., 2009; Leiponen, 2006; Witell et al., 2017). Our results on the role of CSMs and their conditional (on experience-knowledge) capacity to substitute for R&D are fully in line with this. At the same time, they also underscore the importance of looking beyond organizational boundaries and the service encounter itself in search of the resources that, through these practices, are integrated into (new) services.

As any empirical analysis, ours has limitations that translate into implications for future research. For one, going back only to 2004 falls short of capturing the actual career paths of firms' employees in 2008. Although we have been constrained here by changing industry classifications, the option to observe careers over longer periods should be exploited in future research focusing on performance implications of what actually occurs 'on the ground' in different locations, through on-the-job learning and labour market mobility. Preferably, such research should implement an explicit sector focus to nuance sweeping arguments made for "relatedness" (Boschma, 2017) in the evolutionary economic geography literature (cf. the critique in Herstad, 2018), yet look beyond the KIS domain considered here. Second, by way of estimation strategy, we assumed that education, type and levels of experience variety, and the implementation by firms of practices, are determined independently. Actual causal relationships are likely more complex, differentiated and dynamic, involving indirect effects and feedback-loops that play out over time in organizations, through the career paths of individuals, and at their intersections. In particular, and third, the interplay between educations and experiences demand attention beyond what has been awarded here, as the former provide individuals with keys that open doors to career paths and affect their capacities for learning, and unlearning, as they subsequently progress.

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ENDNOTES

[1] SUPPINNOV = 1 (yes) if INPSPD (new production method) = 1 (yes) or INPSLG (new logistics, delivery, or distribution method) = 1 (yes) or INPSSU (new method in supporting activities) = 1 (yes) or ORGBUP (new business practice for

organizing procedures) = 1 (yes) or ORGWKP (new method for organising responsibilities or decision-making) = 1 or ORGEXR (new method for organising external relations) = 1 (yes) or MKTDES (new or significantly improved design) = 1 (yes) or MKTPROM (new forms of media or communication) = 1 (yes) or MKTPRDU (new forms of product placement or sales channels) = 1 (yes) or MKTPRIS (new pricing strategies) = 1 (yes).

[2] Capturing worker experiences collected over longer periods would have been preferable. When using CIS2010 as point of departure and going further back than we do here, one inherently encounters the problem of changing industry classifications that can only be solved by recoding all data to earlier and substantially less fine-grained versions of industry classifications in which sectors present today might be absent. Working back from later rounds of the CIS is possible on a general basis; however, later versions do not include the information on CSMs that is essential to analyse services as here.

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TABLE A1 Description of sample

NACE 2-digit industry groups			Innovation output and activities				Average education and collected worker experiences		
Description		Share	SERVINNO	SUPPINNO	R&D	CSM	EDULEVEL08	VAR_WITHIN	VAR_BETWEEN
58	Publishing activities including software	0.169	0.269	0.582	0.515	0.500	5.269	0.169	1.036
59	Motion picture, video and television programme production, sound recording and music publishing activities	0.033	-	0.269	0.038	0.192	4.277	0.180	1.164
60	Programming and broadcasting activities	0.014	-	0.182	-	0.273	4.713	0.157	1.076
61	Telecommunications	0.063	0.280	0.360	0.340	0.380	4.739	0.188	1.063
62	Computer programming, consultancy and related activities	0.164	0.277	0.523	0.577	0.492	5.483	0.216	1.090
63	Information service activities	0.050	0.475	0.650	0.425	0.550	4.887	0.162	1.380
64	Financial service activities, except insurance and pension funding	0.054	0.209	0.605	0.163	0.442	4.853	0.209	0.964
65	Insurance, reinsurance and pension funding, except compulsory social security	0.040	0.156	0.563	0.125	0.344	5.089	0.184	0.985
66	Activities auxiliary to financial services and insurance activities	0.058	0.152	0.370	0.065	0.304	5.244	0.260	1.034
70	Activities of head offices; management consultancy activities	0.035	0.321	0.536	0.214	0.393	5.716	0.163	1.432
71	Architectural and engineering activities; technical testing and analysis	0.189	0.200	0.453	0.433	0.433	5.465	0.148	1.018
72	Scientific Research and Development	0.029	0.261	0.435	0.696	0.478	6.240	0.114	1.160
74	Other professional, scientific and technical activities	0.035	0.357	0.500	0.607	0.464	5.592	0.101	1.168
79	Travel agency, tour operator and other reservation service and related activities	0.029	0.174	0.391	0.043	0.174	4.329	0.129	0.670
82	Office administrative, office support and other business support activities	0.039	0.097	0.226	0.129	0.323	4.568	0.154	1.240
	All (N = 795)	1	0.236	0.481	0.380	0.425	5.217	0.175	1.078

TABLE A2 Descriptive statistics and bivariate correlations

		Mean	SD	Min	Max	1	2	3	4	5	6
1	SERVINNO	0.236	0.425	0	1	1					
2	SUPPINNO	0.482	0.500	0	1	0.370	1				
3	R&D	0.380	0.486	0	1	0.370	0.340	1			
4	CSM	0.425	0.495	0	1	0.300	0.398	0.328	1		
5	SEARCH	3.548	3.287	0	10	0.318	0.382	0.437	0.387	1	
6	SIZE (log)	3.792	1.112	2.303	8.88	0.052	0.078	0.041	0.076	0.086	1
7	FORMAR	0.162	0.369	0	1	0.012	0.095	0.260	0.063	0.151	−0.025
8	EDULEVEL08	5.218	0.868	2.333	7.5	0.121	0.105	0.303	0.170	0.179	−0.002
9	CHURN0608	0.221	0.149	0	1	−0.051	−0.041	−0.153	−0.072	−0.064	0.054
10	GROWTH0608	1.506	0.785	0.035	4	0.008	0.067	0.124	0.054	0.043	0.010
11	OSLO C	0.550	0.498	0	1	0.010	0.002	−0.099	−0.025	−0.051	0.054
12	OSLO W	0.126	0.332	0	1	0.030	−0.001	0.094	0.019	0.057	0.089
13	OSLO N	0.035	0.184	0	1	−0.058	−0.048	−0.093	−0.082	−0.078	−0.043
14	BERGEN	0.102	0.303	0	1	0.028	−0.034	−0.024	−0.088	−0.039	−0.052
15	STAVANGER	0.111	0.314	0	1	−0.045	−0.011	0.046	0.062	−0.003	−0.038
16	TRONDHEIM	0.092	0.289	0	1	−0.023	0.068	0.056	0.053	0.058	−0.101
17	VAR_TOT	1.254	0.540	0	2.985	0.065	0.087	0.039	0.025	0.034	0.113
18	VAR_WITHIN	0.176	0.157	0	0.919	−0.013	0.009	−0.055	−0.021	−0.047	0.232
19	VAR_BETWEEN	1.079	0.469	0	2.488	0.080	0.098	0.064	0.036	0.056	0.053

TABLE A2 Continued

	7	8	9	10	11	12	13	14	15	16	17	18
1												
2												
3												
4												
5												

TABLE A2 (Continued)

	7	8	9	10	11	12	13	14	15	16	17	18
6												
7	1											
8	0.236	1										
9	−0.073	−0.212	1									
10	0.041	0.062	−0.405	1								
11	−0.027	0.040	0.094	−0.087	1							
12	0.101	0.122	−0.036	−0.005	−0.404	1						
13	−0.029	−0.098	−0.043	0.020	−0.184	−0.011	1					
14	−0.092	−0.070	0.007	−0.017	−0.355	−0.103	−0.019	1				
15	−0.025	−0.095	−0.026	0.091	−0.374	−0.110	−0.024	−0.092	1			
16	0.049	0.015	−0.056	0.041	−0.325	−0.094	−0.014	−0.078	−0.084	1		
17	−0.015	−0.034	0.274	0.356	0.040	−0.046	−0.049	−0.027	0.089	−0.037	1	
18	−0.068	−0.009	0.164	0.195	0.112	0.057	−0.047	−0.064	−0.061	−0.092	0.572	1
19	0.006	−0.036	0.261	0.345	0.008	−0.073	−0.041	−0.010	0.123	−0.011	0.962	0.326

TABLE A3 Robustness test. Predicted probabilities (PP) of combined service and supportive innovation with marginal effects (ME) of VAR_WITHIN, CSM and R&D for different combinations of the three variables. Computed from Model 3 estimated only for firms larger than the median size of 36 employees. N = 389

		CSM constant at 0			CSM constant at 1			Marginal effects of CSM	
		PP	ME (VAR_)	SE	PP	ME (VAR_)	SE	ME (CSM)	SE
R&D constant at 0 & VAR_WITHIN at:	0	0.006	0.035	0.016***	0.105	−0.126	0.219	0.098	0.050**
	0.15	0.014	0.069	0.034**	0.086	−0.126	0.176	0.072	0.029**
	0.3	0.028	0.125	0.083	0.068	−0.116	0.126	0.039	0.029
	0.45	0.053	0.208	0.171	0.051	−0.101	0.078	−0.002	0.044
	0.6	0.092	0.317	0.294	0.037	−0.083	0.039**	−0.055	0.072
	0.75	0.149	0.445	0.429	0.026	−0.065	0.024***	−0.123	0.121
	0.9	0.226	0.575	0.532	0.018	−0.048	0.034	−0.208	0.190
R&D constant at 1 & VAR_WITHIN at:	0	0.113	−0.158	0.255	0.154	0.601	0.177***	0.040	0.085
	0.15	0.091	−0.138	0.197	0.260	0.806	0.365***	0.169	0.061***
	0.3	0.072	−0.117	0.143	0.392	0.936	0.490*	0.320	0.085***
	0.45	0.056	−0.098	0.095	0.535	0.950	0.456**	0.479	0.145***
	0.6	0.043	−0.080	0.056	0.671	0.850	0.271***	0.628	0.194***
	0.75	0.032	−0.064	0.030**	0.786	0.675	0.099***	0.754	0.210***
	0.9	0.024	−0.050	0.024**	0.872	0.479	0.235**	0.849	0.191***

		CSM constant at 0		CSM constant at 1	
		ME (R&D)	SE	ME (R&D)	SE
Marginal effects of R&D when VAR_WITHIN at:	0	0.107	0.064*	0.049	0.078
	0.15	0.077	0.039*	0.174	0.061***
	0.3	0.044	0.032	0.324	0.086***
	0.45	0.003	0.042	0.484	0.145***
	0.6	−0.049	0.070	0.634	0.193***
	0.75	−0.117	0.118	0.760	0.208***
	0.9	−0.202	0.187	0.855	0.188***

TABLE A4 Robustness test. Predicted probabilities (PP) of combined service and supportive innovation with marginal effects (ME) of VAR_BETWEEN, CSM and R&D for different combinations of the three variables. Computed from Model 3 estimated only for firms larger than the median size of 36 employees. N = 389

		CSM constant at 0			CSM constant at 1			Marginal effects of CSM	
		PP	ME (VAR_)	SE	PP	ME (VAR_)	SE	ME	SE
R&D constant at 0 & VAR_BETWEEN at:	0	0.018	0.001	0.021	0.000	0.001	0.002	−0.018	0.027
	0.4	0.018	0.001	0.022	0.002	0.014	0.016	−0.016	0.019
	0.8	0.019	0.001	0.023	0.020	0.097	0.039**	0.001	0.017
	1.2	0.019	0.001	0.023	0.103	0.348	0.118***	0.084	0.031***
	1.6	0.020	0.001	0.024	0.307	0.652	0.227***	0.287	0.089***
	2	0.020	0.001	0.025	0.583	0.661	0.131***	0.563	0.148***
	2.4	0.021	0.001	0.025	0.798	0.397	0.176**	0.777	0.139***
R&D constant at 1 & VAR_BETWEEN at:	0	0.000	0.002	0.005	0.231	0.069	0.103	0.231	0.150
	0.4	0.004	0.021	0.021	0.260	0.073	0.120	0.256	0.110**
	0.8	0.026	0.106	0.045**	0.290	0.077	0.135	0.264	0.073***
	1.2	0.105	0.308	0.105***	0.321	0.081	0.148	0.216	0.067***
	1.6	0.275	0.526	0.210**	0.354	0.083	0.157	0.079	0.120
	2	0.499	0.547	0.214**	0.388	0.086	0.164	−0.111	0.207
	2.4	0.687	0.380	0.172**	0.423	0.088	0.166	−0.264	0.286

		CSM constant at 0		CSM constant at 1	
		ME R&D	SE	ME R&D	SE
Marginal effects of R&D when VAR_BETWEEN at:	0	−0.018	0.027	0.265	0.112**
	0.4	−0.014	0.019	0.231	0.150
	0.8	0.007	0.021	0.258	0.111**
	1.2	0.086	0.038**	0.270	0.073***
	1.6	0.256	0.084***	0.218	0.068***
	2	0.478	0.155***	0.047	0.129
	2.4	0.666	0.204***	−0.195	0.208