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ICT OUTSOURCING, USER-DRIVEN AND OPEN INNOVATION STRATEGIES IN THE GENERATION OF NEW DATA_BASED SOLUTION

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Abstract: The reported empirical findings using survey data from 531 Finnish companies show that for digitalized data-based innovation generated for both firm's own and market needs, the firm's ICT-specific absorptive capacity matters more than its general absorptive capacity arising from the firms' investments in R&D and intangible assets. User-driven innovators differ from companies that do not produce new data-based solutions for their own use in three major dimensions: 1) they tend to use selective ICT outsourcing strategy, 2) they tend to involve more internal units closely to innovation activities and 3) they tend to use wider external knowledge search strategy. In other words, firms using data for producing innovative solutions for their own needs balance their relatively open innovation strategy with the close in-house innovation collaboration among different units, and further employ an ICT strategy that relies selectively on a firm's own ICT-specific absorptive capacity and external ICT expertise.

JEL Classification: D22, L20, O31

Key words: user-driven innovation, open innovation, data-based products and services, ICT strategy, outsourcing

Tiivistelmä: Kyselyaineisto 531 suomalaisesta yrityksestä osoittaa, että sekä yrityksen omaan käyttöön että markkinoille tuotettujen tietoperusteisten innovaatioiden syntymisessä merkityksellisempää on yrityksen tieto- ja viestintäteknologian (ICT) hyödyntämisestä syntyvä tieto ja osaaminen kuin yleisempi, T&K-investointien ja aineettoman pääoman kautta syntyvä osaaminen. Käyttäjälähtöisiä innovaatioita kehittävät yritykset eroavat yrityksistä, jotka eivät ole tuottaneet uusia tietoperusteisia ratkaisuja omaan käyttöönsä, kolmella keskeisellä tavalla: 1) Ne ovat tyypillisesti ulkoistaneet strategisesti osan tieto- ja viestintäteknologisesta osaamisesta, 2) yrityksen sisäinen yhteistyö innovaatiotoiminnassa on muita tiiviimpää, ja 3) ne hakevat muita laajemmin tietoa yrityksen ulkopuolelta. Toisin sanoen, käyttäjälähtöisiä innovaatioita tuottavien yritysten suhteellisen avoimeen innovaatiotoiminnan strategiaan liittyy tiivis yrityksen sisäinen innovaatioyhteistyö, ja sekä yrityksen sisäisen tieto- ja viestintäteknologisen osaamisen hyödyntäminen että ulkoisen asiantuntemuksen käyttö tarvittavilta osin.

Asiasanat: käyttäjälähtöinen innovaatiotoiminta, avoin innovaatiotoiminta, tietoperusteiset tuotteet ja palvelut, tieto- ja viestintäteknologia, ulkoistaminen,

1. Introduction

Various prior reports and studies have acknowledged the importance of data as an essential factor of production and an ingredient of new products and services, and further for the economy as a whole (see, e.g., Brynjolfsson et al., 2011; McKinsey Global Institute, 2011)[1]. Technological ICT-related innovation provides potential for firms to collect, manage and use different types of data in multiple ways to create value. Firms may not only use data for producing new data-based products and services for their customers but they may also generate data-based innovation for their own use, i.e. user-driven innovation (e.g. innovative ways to use data to improve decision-making within a firm). Though the literature covers case examples of user-driven innovation in various fields not any systematic research are reported on the emerging innovative applications of data in this context.

This empirically oriented study focuses on the determination of data-based user-driven innovation among 531 Finnish firms, and particularly the roles of a firm's ICT outsourcing and knowledge search strategies in it. The concept of *user-driven innovation* is here used both for describing *innovation generated by the users for their own needs* (see, e.g, Lettl et al., 2006) and for *innovation that involves systematic involvement of users* (see, e.g, Wise and Høgenhaven, 2008). Our empirical analysis tackles both types of user-driven innovation: i) data-based innovation developed for the firm's own needs, and ii) data-based innovation developed for the firm's customer's needs in close collaboration with the customers. As a comparison, we also consider a more "traditional" type of product and service innovation

[1] Potential for the generation of high-growth business and new markets via innovative data-based products and services are considered to be particularly high for spatial data (i.e. any data with a direct or indirect reference to a specific location or geographical area) used, e.g., for geographical information systems (GIS), navigation and location-based services (e.g. information on the local attractions and events) and geomarketing (e.g. real estate consulting).

developed for market needs: *data-based demand-driven innovation* comprises *new products and services the firm has developed using one or several types of data*.

Our current understanding of the creation of user-driven innovation is, by and large, based on the innovation and industry-level case studies concerning various different innovations of which development has been user-driven such as sports equipment (see, e.g., Franke and Shah, 2003; Lüthje et al, 2005; Raasch et al., 2008) and medical equipment (see, e.g, Lettl et al., 2006). There are only few exceptions using more extensive statistical data to shed light on the patterns of user-driven innovation. The study of de Jong and von Hippel (2009) using a survey data from 498 high tech SMEs in the Netherlands suggests that user-driven innovation is a rather common phenomenon (i.e. 54 percent of their sample firms were considered user-innovators). The descriptive analysis of Flowers et al. (2009) based on the Innobarometer survey data from over 4000 innovative firms in the EU finds, similarly, that in 2007, about 30 (28) percent of firms were user process (product) innovators and about 53 percent user involvers.[2]

The reported research contributes also to the thin empirical literature on the relationship between ICT outsourcing and innovation.[3] Arvanitis and Loukis (2012) using (in 2005 conducted) survey data from Swiss and Greek firms found that the outsourcing of ICT relates positively to process innovation but not to product innovation. Unlike their study, we use not only binary information on ICT outsourcing (i.e. whether or not the firm has its outsourced

[2] Flowers et al. (2009) define user process innovation as "innovations that are introduced by modifying process technologies first developed by others". User product innovation "refers to a situation where firms create new or improved products for sale to the wider market by customizing or modifying products originally produced by other companies". User involvement refers to firms drawing on the expertise of their user populations to better understand the needs of actual or potential users.

[3] Also, the empirical literature investigating the relationship between other (than ICT) outsourcing and innovation is scarce (see Hempel and Swick, 2008).

ICT) but also to what extent a firm has outsourced its ICT activities. Furthermore, we extend the empirical analysis to consider not only "traditional" customer-driven product/service innovation but also the relationship between ICT outsourcing and user-driven innovation.

Closely related to this study, there is also an emerging field of strategic management literature on the utilization of data in the firm's business activities, decision-making, innovation and performance (see, e.g., Brynjolfsson et al., 2011; Koski, 2012)[4]. Brynjolfsson et al. (2011) using survey data on the business practices and information technology investments of 179 large publicly traded firms finds that more extensive use of data in a firm's business practices and decision-making relates positively to the firm's output and productivity. Koski (2012) approaches data-based innovation from the strategic management perspective by using survey data from 531 Finnish firms for the empirical analysis focusing on the question how a firm's knowledge search strategy affect data-based innovation.[5] She finds that generally a firm's external information sources, and particularly customer involvement innovation process, play a more prominent role than internal information sources. Also, a too broad external search reduces the probability of the occurrence of data-based innovation, while external search depth does not have a statistically significant relationship with data-based innovation.

The rest of the paper is organized as follows. Section 2 introduces the data used in the empirical part of the paper. Section 3 reports the results of the empirical estimations. Section 4 summarizes the major findings and concludes with some policy implications.

[4] Firms' data utilization also – as the public sector is the single largest source of information in Europe - relates to the literature concerning the economics of public sector information (see, e.g., Newbery et al., 2008; Pollock, 2008; Koski, 2011).

[5] For instance, Laursen and Salter (2006) and Zhou and Li (2012) provide prior empirical studies exploring the relationship between firm knowledge search strategies and innovation performance.

2. Descriptive findings

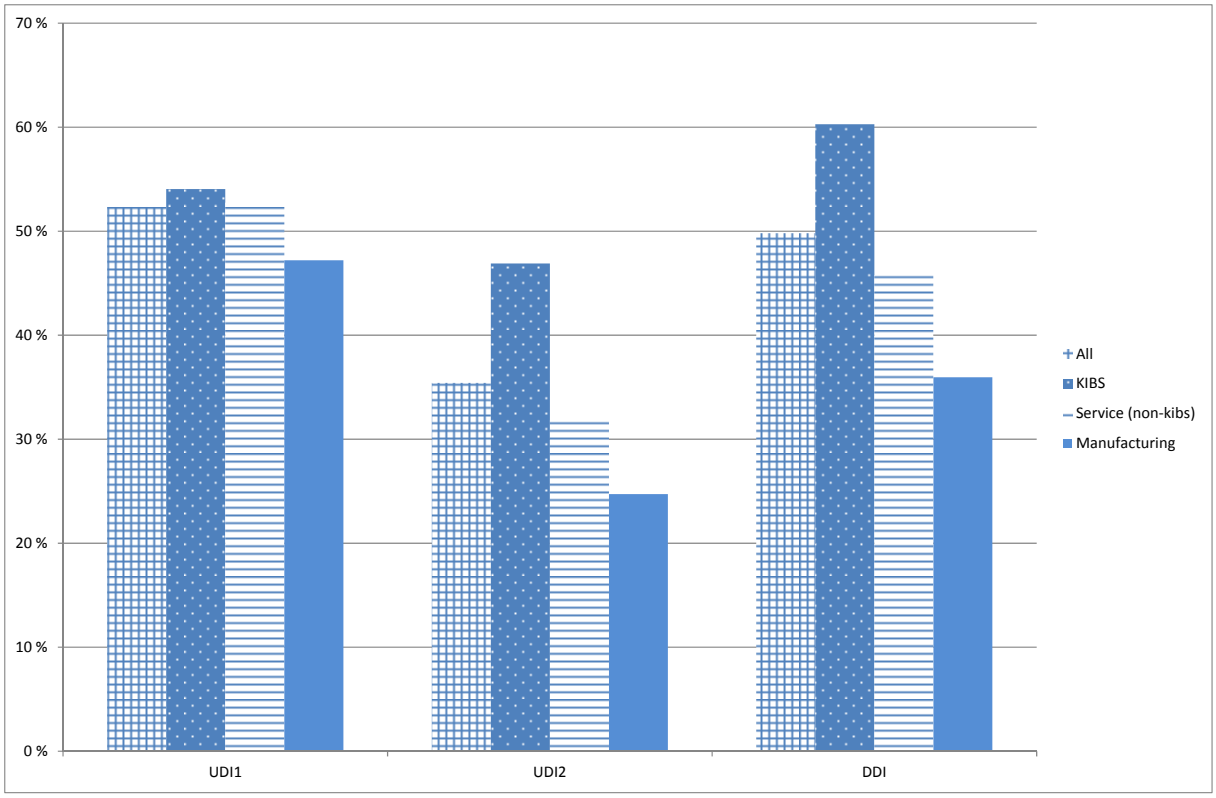
The dataset used in the empirical analysis was collected in the autumn 2011 via a web survey from the Finnish firms. One major aim of the survey was to obtain information on the firm's use of different types of data (particularly spatial, meteorological, demographic, business and traffic data[6]) in their innovation activities. Fonecta's[7] firm catalogue was used to identify the e-mail addresses of over 30,000 Finnish firms widely from different sectors of economy. An invitation and a web link to participate to the questionnaire were then sent to these companies. We obtained a response from 531 firms of which majority came from the service sector: 80 percent of the respondents were active in the service sector. The majority of the respondents firms – 93 percent of them - were either micro firms employing less than 10 people or small firms employing 10-49 people corresponding relatively well the size distribution of the Finnish firms in general.

Supporting the prior survey studies (see Flowers et al., 2009; Jong and von Hippel, 2009), the data suggest that user-driven innovation practices are relatively often adopted also among the Finnish firms. We find that about 52 percent of all respondents have developed new data-based products and/or services for their own needs (i.e user-driven innovation type 1 or UDI1) during the past three years, while 35 percent have developed data-based innovation for their customer's need in close collaboration with the customers (i.e user-driven innovation type 2 or UDI2) during the past three years. About half of the respondents told that they have developed data-based innovation for their customer's needs (i.e. demand-driven innovation) during the past three years. Demand-driven innovation occurs clearly more often in the

[6] The respondents were also given three open lines to report other types of data they have used in new products and/or services.

[7] Fonecta is part of the European Directories Group, which has business operations in eight European Union countries. (http://www.fonecta.com)

Figure 1. User- and demand-driven innovation occurrence by different sectors



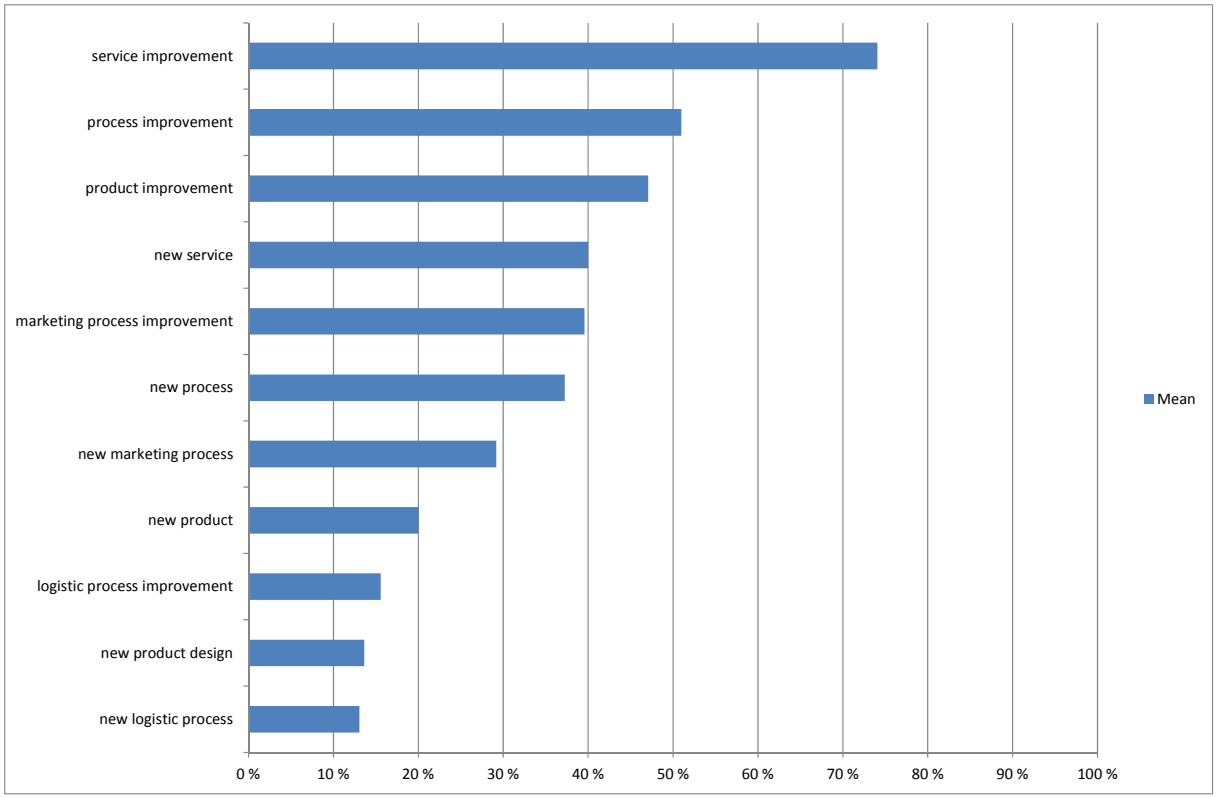
service sector, and particularly among knowledge-intensive business service (KIBS) firms[8]. Instead, differences in the emergence of user-driven data-based innovations among different sectors are not as dramatic.

We further sent a follow-up question for the firms that had reported that they had developed innovation for their own use, and asked them to define more precisely the types of innovation they had developed for their own use.[9] We obtained a response from 54 user-driven

[8] KIBS firms are defined to be those functioning in one of the knowledge-intensive business service sectors: computer and related activities (i.e. NACE 72), research and development (i.e. NACE 73), or other business activities (i.e. NACE 74).

[9] The responded were given "yes"/"no" answering options for the following 11 non-exclusive user-driven innovation types: new product, product improvement, new product design, new service, service improvement, new process, process improvement, new marketing process, marketing process improvement, new logistic

Figure 2. The shares of firms developing different data-based user-driven innovation



innovators. Figure 2 illustrates the shares of firms in this sub-sample that had developed each type of data-based user-driven innovation.

The sample firms had most commonly used data for user-driven service improvements (i.e. over 70 percent of respondents). The reported examples of user-driven service improvements were, e.g., use of weather data for the evaluation of the heating costs of the firm's properties, the advanced use of data and information technology for the generation of a bid form that simultaneously functions as a contract and the use of verdicts to update bid contracts). Also, over half of the respondents told that they had user-driven process innovation such as more

process, and logistic process improvement. They were further asked to name or describe innovation or improvement for those cases they had replied "yes."

efficient collection and distribution of all relevant material and data for construction projects prior to the beginning of the project, and simplified and sharpened, less bureaucratic processes with in-time feedback and team work. Product improvements (e.g., on-line provision of data and a firm's internal electronic database concerning the firms' customers and the liabilities of the firm for them), new services (e.g., a distribution chain for digital products; new service facilitating internal data exchange between the databases of the firms in the consortium), marketing process improvements (e.g., use of demographic data for the planning of marketing and the use of new media platforms) as well as new processes (e.g., distribution chains via the Internet) were also relatively often mentioned as types of user-driven innovation generated within the firm. Only few firms had generated new data-based logistic processes or logistic process improvements for their own use. It seems credible that commercially available products improving the efficiency of firms' logistics processes such as navigators and other routing devices fulfill the needs of the majority of firms.

The firm's ICT resources form the base for digitalized, data-based innovation, and both the firm's ICT intensity and their ICT outsourcing strategy may matter for the firms' innovation performance (see Section 3 for a discussion). Almost quarter of the respondents reported that their ICT competence is based completely on the firm's internal expertise. Almost 70 percent of the firm strategically or selectively outsourced part of their ICT[10]: over one quarter (i.e. 24 percent) reported to use approximately equally the firm's ICT expertise and ICT outsourcing, while about 12 percent was relying primarily on their internal ICT expertise and about 12 had mainly outsourced their ICT activities. Only about 2 percent of the firms had outsourced ICT completely.

[10] Also Maliranta et al. (2008) using Finnish survey data find that IT outsourcing is widespread; their sample firms reported to outsource, on average, 40-66 percent of the IT activities in question.

The t-tests indicate that the sample firms' ICT-outsourcing strategies relate closely to their ICT intensiveness[11]. Firms that have totally internalized their ICT activities are using ICT for statistically significantly smaller number of business activities than others, while the firms using approximately equally internal and outsourced ICT are clearly more active users of ICT in their regular business activities measured by the variable ICT_use (see Table 1 for a description of the variable ICT_use).

3. User- and demand-driven innovators

Contemporary understanding of user-driven innovation is, by and large, based on various case examples (see, e.g. Wise and Høgenhaven, 2008). Prior empirical literature does not report any systematic empirical analysis on the characteristics of firms that develop innovation either for their own needs or for their customers in close collaboration with them. As there is no rigorous theoretical framework to explain data-based user-driven and demand-driven innovation, we base the empirical model on the state-of-the-art economics and strategic management literature on innovation generally.

ICT plays a central role in the generation of new data-based products and services: the acquisition, management and processing of different data as well the integration of data to the firm's regular business operations and innovation activities requires different types of information and communication technologies. Thus, the firms with greater ICT intensiveness are more apt to data-based activities, including the generation of both user- and demand-driven data-based innovation. We measure the order of magnitude of a firm's utilization of

[11] Similarly, Arvanitis and Loukis (2012) find that more intensive use of ICT (measured by the intensity of use of Internet and Intranet) was important for the outsourcing of ICT among Swiss firms. Their data from Greek firms didn't find statistically significant relationship between ICT use and outsourcing though.

ICT by the variable ICT_use that is a sum of six likert-scale[12] variables measuring the importance of different forms of ICT for a firm's business: i) Internet, ii) E-commerce, iii) Customer Relationship Management (CRM), iv) Business Intelligence (BI), v) Supply Chain Management (SCM), and vi) Enterprise Resource Planning (ERP).

Another important strategic decision for a firm is to what extent it relies on a firm's internal expertise in its ICT functions and whether or to what extent it uses ICT outsourcing to perform ICT-related activities. The economic and strategic management literature concerning the ICT outsourcing suggests that though the outsourcing of a firm's ICT activities may provide various benefits for the firm such as concentration on the firm's core competencies, cost-efficiency and higher technological quality due to the economies of scale and technical expertise of ICT service providers, it also involves potential risks for the firm's innovation performance (see, e.g., Mahnke et al., 2005). The outsourcing of a firm's ICT activities completely is likely to reduce the firm's absorptive capacity (i.e. "ability to recognize the value of new information, assimilate it, and apply it to commercial ends", Cohen and Levinthal, 1990) needed for ICT-based innovation and hinder its capabilities to produce new data-based products and services. A commonly used outsourcing strategy is to strategically outsource only part of a firm's ICT functions (typically infrastructure management and support), while keeping the relevant ICT experience for the firm's business inside the boundaries of the company.

It is an interesting question that prior empirical research has not tackled how different ICT outsourcing strategies relate to data-based user- and demand-driven innovation. Based on the

[12] The variables get value 1 for "not important at all", 2 for "slightly important", 3 for "quite important", 4 for "very important", 5 for "essentially important" for a firm's business. If all six forms of ICT use are not important at all for a firm's business, the variable gets value 6 and if all six forms of ICT use are of essential importance, the variable gets value 30, otherwise some value between the lower and upper bound.

above discussion, it seems credible that complete ICT outsourcing relates negatively to the firm's innovative performance and generates an adynamic environment for digitalized data use for both internal and customer needs based innovation. The relationship between totally in-house ICT and data-based innovation is less clear. On the one hand, for many SMEs, keeping ICT completely in-house may force a firm to use its scarce resources for ICT at the cost of innovation and also result in less innovation. On the other hand, a strong internal ICT focus and expertise of a firm may mean that the firm's ICT-specific absorptive capacity is large and thus facilitates digital data use for innovation.

It is also less obvious whether partial ICT outsourcing or different degrees of ICT outsourcing relate negatively of positively to a firm's innovation performance. On the one hand, prior empirical findings suggest that the primary reason for ICT sourcing among SMEs – which the majority of the sample firms are - is the lack of required internal ICT resources (see, Dibbern and Heinzl, 2006). Thus, also the selective outsourcers may lack ICT expertise needed for data-based innovation and be less likely to generate new data-based solutions for both their own and their customers use. On the other hand, selective ICT outsourcing may generate cost savings that can be used for innovation activities and thus increase the likelihood of the generation of new data-based products and services. This question is left to be determined empirically.

We measure the firm's ICT outsourcing strategy by the four dummy variables (using the firms that perform their ICT activities *completely internally* as a reference group): i) ICT_MOST_INHOUSE that takes value 1 if the firm is relying mainly on intra-house ICT expertise, ii) ICT_EQUAL that takes value 1 if the firm approximately equally relies on intra-house ICT expertise and ICT outsourcing, iii) ICT_MOST_OUTSOURCE that takes value 1 if the firm has outsourced most of its ICT expertise, and iv) ICT_OUTSOURCE that takes

value 1 if the firm has entirely outsourced its ICT expertise. The first three dummy variables capture different degrees of *strategic* or *selective outsourcing of ICT*, while the last dummy variable measures "*outsourcing ICT completely*" strategy.

A firm's ICT intensity and ICT outsourcing strategy determine the order of magnitude of its "specialized" absorptive capacity particularly important for ICT-based innovation. More general absorptive capacity of a firm that is essential for innovation is generated largely by the firm's R&D investments and accumulated intellectual capital (Cohen and Levinthal, 1990). It seems credible that firms with greater absorptive capacity are more likely to generate both user- and demand-driven innovation. We measure a firm's "general" absorptive capacity by two variables. First, the role of a firm's R&D in its innovation process are captured by the dummy variable OWN_RD that gets value 1 if the respondent reports that the firm's own R&D section is either important or very important source of information for the firm's innovation process, and 0 otherwise. Second, the variable INTANGIBLE – that is the order of magnitude of a firm's intangible assets (i.e. intangible rights, other capitalized expenses, and advances paid) in relation to the order of magnitude of its all assets, both tangible and intangible – controls for the firm's absorptive capacity arising from its intellectual capital.

The literature further suggests that an increasing utilization of ICT, globalization and competition have changed firms' business practices towards more open approach[13] enhancing the importance of the firm's both internal and external sources of knowledge in their innovation activities (see, e.g., Berry, 2006; Vega-Jurado et al., 2008). The strategic management literature finds that the firm's external knowledge search strategy (i.e. breadth and depth of external knowledge search) affects is innovative performance (see, e.g., Katila

[13] This is also stressed by Chesbrough (2006): "*Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology*."

and Ahuja, 2002; Laursen and Salter, 2006; Leiponen, 2012; Zhou and Li, 2012). Firms with more open knowledge search strategy having access to larger number of information sources tend to be more innovative. The empirical analysis of Koski (2012) further indicates that also a firm's *internal* knowledge search strategy may affect data-based innovation: larger number of a firm's internal functioning units participating intensely to innovation activities provides enhances the creation of data-based innovation. The depth of a firm's internal knowledge search strategy may be important particularly for user-driven innovation aimed at producing innovative solutions for the use of a firm's internal units.

We measure the breadth of external search by the number of external sources of knowledge a firm uses in its innovation process[14]. The variable EXT_BREADTH is calculated as the sum of five dummy variables, CUSTOMER, COMPETITOR, SUPPLIER, RESEARCH, and PUBLIC, getting each value 1, if the respondent reports that the firm's customers, competitors, suppliers/subcontractors, universities and/or other research institutes (i.e. public or private research organizations or consulting companies) or public sector agencies – respectively – are used as a source of information for the firm's innovation process, and 0 otherwise. The variable EXT_DEPTH, the measure of external search depth, is calculated as a sum of five variables getting each value 1 if the external knowledge source is regarded to be either important or very important source of knowledge in a firm's innovation process.

A firm's internal search depth, variable INT_DEPTH, is calculated as a sum of four dummy variables, PRODUCTION, MARKETING, MANAGEMENT, MULTI-PLANT getting each value 1, if the respondent reports that the firm's production unit, marketing unit or

[14] We follow Laursen and Salter (2006) in the construction of the breadth and depth variable. See their study on further details, motivation and justification of the chosen measures.'

Table 1. Description of variables

Description of variable	**Variable name**	**Mean (S.D.)**
Dependent variables:		
Dummy variable that gets value 1 if a firm has during the past three years produced data-based innovation for a) firm's own needs, b) its customer's needs in close collaboration with the customers, c) it's customer's needs, and 0 otherwise.	a) UDI1 b) UDI2 c) DDI	
Independent and control variables:		
Variable that is a sum of six likert-scale variables measuring the importance of different forms of ICT for a firm's business: i) Internet, ii) E-commerce, iii) Customer Relationship Management (CRM), iv) Business Intelligence (BI), v) Supply Chain Management (SCM), and vi) Enterprise Resource Planning (ERP).	ICT_USE	15.10 (5.78)
Dummy variable that gets value 1 if a firm is relying mainly on its in-house ICT experience and 0 otherwise.	ICT_MOST_INHOUSE	0.30 (0.46)
Dummy variable that gets value 1 if a firm approximately equally relies on intra-house ICT expertise and ICT outsourcing and 0 otherwise.	ICT_EQUAL	0.27 (0.44)
Dummy variable that gets value 1 if a firm has outsourced most of its ICT experience, and 0 otherwise.	ICT_MOST_OUTSOURCE	0.12 (0.32)
Dummy variable that gets value 1 if a firm has entirely outsourced its ICT experience, and 0 otherwise.	ICT_OUTSOURCE	0.02 (0.14)
Dummy variable that gets value 1 if a firm's own R&D is a source of information in the firm's innovation process and 0 otherwise.	OWN_RD	0.71 (0.46)
Number of internal information sources (i.e. production, marketing, management and other firm(s) in the same corporate group) a firm reports to be an important or very important source of information in its innovation process.	IN_DEPTH	0.71 (0.46)
The order of magnitude of a firm's intangible assets in relation to the order of magnitude of its total assets.	INTANGIBLE	0.13 (0.25)
Number of external information sources (firm's customers, competitors, suppliers/subcontractors, research institutes (i.e. consulting companies, public or private research institutes or universities) or public sector agencies) a firm has used as a source of information in its innovation	EXT_BREADTH	3.51 (2.01)

process. Number of external information sources a firm reports to be an important or very important source of information in its innovation process.	EXT_DEPTH	1.75 (1.60)
Dummy variable that gets value 1 if a firm has 10-49 employees, and 0 otherwise.	SMALL	0.21 (0.40)
Dummy variable that gets value 1 if a firm has 50-249 employees, and 0 otherwise.	MEDIUM	0.04 (0.19)
Dummy variable that gets value 1 if a firm has at least 250 employees, and 0 otherwise.	LARGE	0.01 (0.09)
Firm's age.	AGE	16.46 (12.77)
Return on total assets.	PROFITABILITY	0.12 (0.37)
Dummy variable that takes value 1 if a firm is active in one of the knowledge-intensive business service sectors: computer and related activities (i.e. NACE Rev. 1. 72), research and development (i.e. NACE Rev. 1. 73), or other business activities (i.e. NACE Rev. 1. 74), and 0 otherwise.	KIBS	0.39 (0.49)
Dummy variable that takes value 1 if the firm is functioning in the service sector, but not in the one of the KIBS sectors, and 0 otherwise.	SERVICE (non-kibs)	0.38 (0.49)
+location dummies		

management or other firm(s) in the same corporate group – respectively – is used as a source of information for the firm's innovation process, and 0 otherwise.

Different industrial sectors have different propensity to innovate. It seems credible - as service improvements play a significant role in data-based innovation – that service firms may be more likely to produce data-based innovation both for their own use and for their customers than manufacturing firms. Particularly, the knowledge intensive service firms or KIBS firms relying heavily on knowledge and data in their business activities are likely candidates to originate data-based user- and demand-driven innovation. We control these two service firm groups as follows (keeping the manufacturing firms as the reference group of comparison): The dummy variable KIBS takes value 1 if the firm is active in one of the knowledge-

intensive business service sectors: computer and related activities (i.e. NACE Rev. 1. 72), research and development (i.e. NACE Rev. 1. 73), or other business activities (i.e. NACE Rev. 1. 74). The dummy variable SERVICE(non-kibs) takes value 1 if the firm is functioning in the service sector, but not in the one of the KIBS sectors, and 0 otherwise.

The prior empirical studies report also that various firm-level factors such as firm size, age, profitability and location affect innovation (see, e.g., Cohen and Klepper, 1996; Martinez-Ros and Labeage, 2002). Firm size is controlled by a set of dummy variables SMALL (i.e. firms with 10-49 employees), MEDIUM (i.e. firms with 50-249 employees) and LARGE (i.e. firms with at least 250 employees), while the group of firms with less than 10 employees is used as a reference group in the estimations. The variable AGE measures the number of years elapsed since the establishment of the firm. The variable PROFITABILITY is, quite typically used measure of a firm's profitability, return on its total assets. The estimations also include 17 province dummies to capture inter-regional variation in the generation of data-based products.

4. Empirical results

We estimated the probit models explaining the following three dependent dummy variables: i) UDI1 that gets value 1 if a firm had developed new data-based products and/or services for their own needs during the past three years, ii) UDI2 that gets value 1 if a firm had developed data-based innovation for their customer's need in close collaboration with the customers during the past three years, and iii) DDI that gets value 1 if a firm had developed innovation for their customer's needs during the past three years.

Table 2. The estimation results of the Probit models for data-based user-driven and demand-driven innovation

	Dependent variable		
Variable	**UDI1**	**UDI2**	**DDI**
ICT_USE	0.01 (0.01)	0.02 (0.02)	0.01 (0.01)
ICT_MOST_INHOUSE	0.08 (0.20)	0.39* (0.21)	0.29 (0.20)
ICT_EQUAL	0.65*** (0.20)	0.65** (0.23)	0.46** (0.22)
ICT_MOST_OUTSOURCE	-0.11 (0.27)	0.11 (0.29)	0.15 (0.28)
ICT_OUTSOURCE	0.79 (0.51)	0.30 (0.47)	-0.01 (0.68)
OWN_RD	0.13 (0.27)	0.22 (0.29)	0.37 (0.26)
INTANGIBLE	-0.35 (0.27)	0.08 (0.27)	0.23 (0.27)
INT_DEPTH	0.21*** (0.06)	0.08 (0.07)	0.06 (0.06)
EXT_BREADTH	0.17** (0.07)	0.30*** (0.09)	0.30*** (0.08)
EXT_DEPTH	0.04 (0.06)	0.26*** (0.06)	0.05 (0.06)
SMALL	-0.07 (0.21)	0.13 (0.21)	-0.12 (0.21)
MEDIUM	-0.01 (0.38)	-0.91** (0.41)	-0.57 (0.36)
LARGE	0.79 (0.68)	1.11 (0.67)	0.91 (0.74)
AGE	0.00 (0.01)	-0.01 (0.01)	0.00 (0.01)
PROFITABILITY	-0.10 (0.20)	-0.15 (0.20)	-0.04 (0.18)
KIBS	0.32 (0.22)	0.65*** (0.24)	0.70*** (0.23)
SERVICE (non-kibs)	0.28 (0.21)	0.29 (0.23)	0.33 (0.22)

Constant	-2.41*** (0.61)	-3.26*** (0.71)	-2.96*** (0.63)
	+ location dummies	+ location dummies	+ location dummies
Observations	369	366	369
Log pseudo likelihood	-202.80	-179.13	-197.55

The heteroscedastic robust standard errors are reported in the parentheses. Significance levels are reported on superscripts, where *** denotes significance level of 1%, ** significance level of 5% and * significance level of 10%.

Unexpectedly, the ICT_USE variable doesn't get statistically significant coefficient in any of the estimated equations.[15] Instead, a firm's outsourcing strategy seems to matter for the likelihood of occurrence of both user- and demand-driven innovation. The most fruitful environment for data-based innovation seems to be in organizations that have selectively outsourced their ICT activities such that approximately a half of a firm's ICT activities are kept in-house and another half outsourced. Also, the variable ICT_MOST_INHOUSE gets a positive and weakly statistically significant coefficient in the estimation of the equation for the probability of data-based innovation developed for the firm's customers needs in collaboration with them. In other words, user-driven innovation type 2 developed for customers seems to benefit from selective ICT outsourcing at least half (but not all) of the firm's ICT activities in-house. Outsourcing most or all ICT activities does not seem to have statistically significantly different relationship between user- and demand-driven data-based innovation than ICT kept completely in-house (i.e. the reference group).

[15] However, this finding is not so surprising in the light of observation that the variable ICT_EQUAL, which is closely and positively related to the firm's ICT intensity (see Section 2), is statistically significant in all of the estimated equations, apparently capturing also variation related to the firm's ICT intensity.

We also included to the equations two variables measuring the role of general absorptive capacity of firm in user- and demand-driven data-based innovation. The estimation results show that the variables OWN_RD and INTANGIBLE do not get statistically significant coefficients in any of the estimated equations. Based on these two measures, we cannot thus conclude that those firms that have generally higher absorptive capacity would be more likely to generate data-based innovation either for their own needs or to provide new innovative data-based solutions to satisfy market demand.

We find that the internal knowledge search and external knowledge search breadth, but not depth, matters for user-driven innovation type 1: firms using a greater number of important internal knowledge sources and a greater number of external knowledge sources in their innovation activities are more likely to generate data-based innovation for their own use. Instead, the probability of occurrence of innovation developed for a firm's customers in close collaboration with them (i.e. UDI2) relates positively to the firm's external knowledge search and depth, while demand-driven innovation has a positively relationship only with the external search breadth. These results concerning the differences in the importance of internal and external knowledge sources for user- and demand-driven innovation seem rather logical. New products and services needed by the firm itself require more internal knowledge exchange and collaboration, while information needed for satisfying market needs is more likely to be obtained outside the firm boundaries.

The data suggest that firm size does not relate to the probability of a firm to develop new data-based products and services for its own use. However, the relationship between firm size and the variable UDI2 is negative and statistically significant. Thus it seems that the medium-sized companies are less likely to generate new data-based innovation for their customers in close collaboration with them than other firms.

Knowledge intensive business service firms do not tend to generate more innovation for their own use but they, instead, clearly more likely than manufacturing firms are the originators of data-based innovation developed in close collaboration with the firm's customers (i.e. UDI2) and data-based demand-driven innovation (i.e. DDI). This empirical finding is linked to the prior observations that KIBS generally work in close collaboration with their customers. Some researchers have called the relationship between KIBS and their customers even symbiotic (see, e.g., Hertog, 2000). This is an interesting finding though as, though the literature suggests that KIBS play a notable role in innovation processes, there exist not much prior empirical evidence on the types of innovation that KIBS are sources of.

5. Conclusions

The reported empirical findings indicate that a combination of a firm's in-house ICT and selective outsourcing of ICT activities provides the most fruitful environment for innovative activities aimed at generating new data-based solutions for both the firm's own use and for market needs. It seems credible that to maintain a sufficient absorptive capacity required for data-based innovation, a firm needs a certain level of internal ICT expertise but outsourcing part of ICT activities may help it to better focus on its competences on related fields of innovation. Our empirical findings further hint that for digitalized data-based innovation generated for both firm's own and market needs, the firm's ICT-specific absorptive capacity matters more than its general absorptive capacity arising from the firm's investments in R&D and intangible assets.

We find that user-driven innovators (type 1, i.e. firms producing innovation for their own needs) differ from companies that do not produce new data-based solutions for their own use

in three major dimensions: 1) they tend to use selective ICT outsourcing strategy, 2) they tend to involve more internal units closely to innovation activities and 3) they tend to use wider external knowledge search strategy. In other words, firms using data for producing innovative solutions for their own needs balance the open innovation strategy with the close in-house innovation collaboration among different units, and further employ an ICT strategy that relies selectively on a firm's own ICT-specific absorptive capacity and external ICT expertise.

The differences in the probability of generation of user- and demand-driven data-based innovation between different industrial sectors are also interesting. We find that while KIBS are more likely the originators of data-based innovation developed for their customers, the generation of data-based innovation for the firm's own needs does not statistically significant differ between KIBS and other service firms and manufacturing companies. This finding hints that possibilities to utilize different data to add value to a firm's internal functioning and regular business activities are not limited to the certain industrial sectors but the benefits of new data-based solutions can be reaped by industrial companies as well as service sector firms.

As the amount and importance of digitalized data that can be utilized both in firms' regular business activities and for their innovation purposes constantly increases, and the markets for data products and services expands, there is an increasing need to understand the patterns and best practices of data use in companies. Further systematic empirical research is needed both on the determination of user-driven innovation in different contexts as well as on the data-based innovation practices. Another interesting, under-explored question is whether and how the new data-based solutions affect firm performance. Is data used rather for increasing the firm's efficiency or decision-making processes and/or does it rather generate firm growth via the sales of new data-based products and services?

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