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Developing a competency model for open innovation

From the individual to the organisational level

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Abstract

Purpose – From the organisational perspective, the authors know that management, including innovation management, becomes less "organised" by bureaucracy and administrative tools, and much more impacted by organisational capabilities, competences and hidden, "soft" routines, bringing innovation and creativity to the core of organisation. The purpose of this paper is to focus on competency sets for open innovation (OI) and is to provide recommendations for OI competency development in companies, linked to the core OI processes.
Design/methodology/approach – The research is exploratory and aims at theory-based practical indication combining deductive identification of competency clusters and inductive model development. Thus, the authors apply quantitative methods to data collection and analysis. The authors conducted an extensive literature review on competence challenges with regard to execution of OI, and empirical data analysis based on a large-scale structured industrial survey in Europe ($N = 264$), leading to the development of competency sets for companies. SPSS tools are applied for empirical tests.
Findings – The authors develop a generic OI competency model applicable across industries, combined with organisational implications for sustaining OI management capabilities. The research clusters competencies based on the empirical analysis, which addresses the various challenges of OI, leading to recommendations for competency management in an OI context.
Research limitations/implications – The data were collected from one key informant per company. Although the authors made efforts to ensure that this was a senior manager responsible for innovation, the authors cannot exclude some bias in the way that OI activities and related competencies are perceived. Exploratory nature of the research, which calls for a more systematic investigation of the OI activity modes and the OI competencies resulting competency model. In particular, the competencies could be tested on an inter-professional sample of employees with involvement in and/or responsibility for innovation, development, and HR management, as well as on leaders of innovating companies. Third, although significant in size for the analyses undertaken, the sample is not large enough to enable a more fine-tuned analysis of regional differences across Europe in the way that OI is managed through the development and implementation of competencies.

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Practical implications – The research contributes to the OI management field with an outlined OI competency profile that can be implemented flexibly and tailored to individual firm's needs. It brings indications for both further theory building and practice of innovation organisation, especially with regard to human resource development and organisational capability building for OI.

Social implications – The social implications of the paper result from the contribution to innovation management competency development in OI regimes, which is an important tool for designing contemporary educational programmes, contributes to OI management sophistication in business which is especially important during the economy slowdown and search for new sources of growth and productivity, and supports firms productive engagement in OI ecosystems and collective technology upgrading towards higher societal benefits and stakeholder involvement.

Originality/value – An empirically grounded OI competency model is proposed with an implication to support human resource development for OI. To the best of the authors' knowledge, there has been no prior attempt to build such a model. The distinguished feature of the research is its extensive European coverage of 35 countries and multinational scope. The empirical validation strategy makes the research extremely relevant for management decisions related to human factors related OI capability development in organisations.

Keywords Management skills, Open innovation, Competency model, Organizational competency, Skills and abilities

Paper type Research paper

1. Introduction

Open innovation (OI), which can be defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model" (Chesbrough and Bogers, 2014, p. 17), poses a range of challenges for the management of human resources involved in innovation, R&D and boundary-spanning activities (West *et al.*, 2006; Du Chatenier *et al.*, 2010; Petroni *et al.*, 2012; Podmetina *et al.*, 2013; Vanhaverbeke *et al.*, 2014; West *et al.*, 2014). Relatively little is currently known about how the challenges of OI are handled at the individual level (Bogers *et al.*, 2017), even though "the effectiveness of firms' OI strategies strongly depends on the individuals tasked to bring those strategies to fruition" (Bogers *et al.*, 2017, p. 13). Reviewing the related literature, Du Chatenier *et al.* (2010) identified some of the most important issues, including building trustworthy mutual working relationships in innovation partnerships, collaborative knowledge creation across organisational boundaries, communication among different professional groups and striking a balance between individual (firm) and collective (innovation alliance) interests. This implies that OI professionals engaged in real OI teams and projects must possess, learn and develop competencies specific to this context (Du Chatenier *et al.*, 2010) in order to be motivated and able to deliver the fruits of OI (Bogers *et al.*, 2017). In similar vein, Hafkesbrink and Schroll (2014) developed a conceptual model of individual competencies for exploration, exploitation and ambidexterity in the OI process, responding to the OI-driven needs of combining different competencies and technological capabilities in all of those three "modes" of innovation (Chesbrough, 2003). While previous studies have laid an important foundation for the study of OI-related organisational competencies, their limitations in terms of empirical validation and/or study scope constrain their application at the organisational level. Building on these contributions, the aim here is to develop an OI competency model that organises individual competencies around organisational OI processes. Based on this formulation, the research question is as follows:

RQ. What individual competencies are essential for OI, and how can they be incorporated into a generic model of organisational competency?

Based on rigorous theoretical and empirical modelling, our contribution is twofold. First, we propose an original, evidence-based measurement scale for OI competencies. Development of the scale was based on primary data on the importance of OI skills as reported by managers in Europe. We further explore how these competencies relate to open and collaborative innovation activities at the organisational level, proposing an inductive approach to organisational

OI competency building based on individual skills and organisational OI processes. Second, we move beyond conceptual and case-based insights on competencies for OI, and augment empirical studies that focus only on discrete skills or organisational capabilities to develop a model incorporating distinct competency categories. The results reinforce conceptual linkages between competency management and innovation management and provide insights for managers of different levels and functions, concerning how individuals can contribute to realising the potential of OI (Bogers *et al.*, 2017) by articulating a model of the various competencies (i.e. skills and abilities) required for the execution of open and collaborative innovation activities. Although the research is exploratory, it uses quantitative data to build the evidence, based on an original European industrial survey ($N = 264$) conducted within the framework of the OI-NET Erasmus+ project.

The paper is organised as follows. A review of the fundamentals of OI in relation to organisational competencies is followed by a focused literature review of professional competencies, with an emphasis on OI competencies. We then discuss the methodology, research process and data collection, detailing the developed scales and operationalisation of variables. The results section reports the factor analysis and ANOVA for group comparison, grouping and relating OI activities and competencies as the empirical foundation for the proposed OI competency model. The paper concludes with theoretical and managerial implications, and we discuss the study's limitations and avenues for future research.

2. Innovation, OI and organisational competencies: literature background

From innovation to OI

Innovation research embraces a broad array of topics, including types, dimensions and determinants of innovation, which are studied at the macro, organisational and micro levels, using a range of theoretical lenses that include institutional and evolutionary economics, networks, the resource-based view, learning and change theories (Crossan and Apaydin, 2010). As a dynamic triptych of process, outcome and context (Crossan and Apaydin, 2010; Chesbrough and Bogers, 2014), the term "innovation" is broadly used by scholars and practitioners to denote new products and artefacts, new services, new manufacturing and business processes and new organisational structures, procedures, business models and strategies (Keupp *et al.*, 2012; Keely *et al.*, 2013). This broadening of conceptualisation and approach took root during the 1990s with the emergence of the innovation systems (IS) approach (e.g. Freeman, 1987; Lundvall, 1992; Nelson, 1993). Drawing primarily on evolutionary economics and a macro perspective, the IS approach has, however, been criticised for treating the firm as a black box, offering little guidance as to how companies, the innovation engines of an economy, might act in order to leverage the dynamics of such systems (Walrave and Raven, 2016). To address this issue, complementary approaches were developed, including innovation clusters (Porter, 2000), triple helix (Etzkowitz and Leydesdorff, 2000) and entrepreneurial ecosystems (Feld, 2012), emphasising the interactions and interplay among firms, institutions and market conditions in IS. Over the last decade, this has resulted in a shift of focus in firm-level innovation research from the product to the business model (Visnjic *et al.*, 2016).

In this context, OI has emerged as a model that bridges the macro and micro levels in innovation studies (Carayannis and Campbell, 2011; Huizingh, 2011), where companies strive for innovation partly by tapping into knowledge residing outside their boundaries and partly by allowing their own internally developed knowledge to flow outward for external use (Chesbrough, 2003). Environmental dynamism enhances the development of OI, but it is a complex process, requiring effective management of both external and internal knowledge (Martinez-Conesa *et al.*, 2017). The theoretical foundations of OI can therefore be seen as a firm-level mirroring of the IS literature. OI conceptualises innovation as occurring between companies and other relevant actors, who exchange knowledge and co-develop products and services in loosely coupled networks, including technology-enabled social networks

(Palacios-Marqués *et al.*, 2015), where business models are dynamically created, reshaped, dissolved and recreated to continuously enhance innovation competency, outcomes and performance (Chesbrough, 2003; Chesbrough, 2006; Chesbrough and Bogers, 2014).

OI encompasses a wide range of forms and degrees of openness in the innovation process (Laursen and Salter, 2006). Companies can engage in outbound OI (by revealing or selling ideas, knowledge, or technologies) or in inbound OI (by sourcing or acquiring innovation assets from outside) (Dahlander and Gann, 2010), or in both (by coupling external knowledge sources and outbound commercialisation activities) (Chesbrough and Bogers, 2014). A growing body of research on OI adoption shows that firms in various sectors use a range of different organisational modes (e.g. licensing agreements, alliances, purchase and supply of technical and scientific services) to enter into relationships with different types of partners (e.g. indirect and even direct competitors, suppliers, service and platform providers, technology brokers, universities, research organisations, crowds, lead users) with the aim of acquiring inbound OI and/or commercially exploiting outbound OI technologies and knowledge (e.g. Chiaroni *et al.*, 2011; Bianchi *et al.*, 2011; Spithoven *et al.*, 2013; Virlée *et al.*, 2015; Kortmann and Piller, 2016). The essential contribution of this body of research is to describe the content of change towards OI in terms of different OI activities and the context-specific industries/sectors in which it happens while less emphasis is placed on the process of change (Bianchi *et al.*, 2011; Virlée *et al.*, 2015). This corresponds to the call by Bogers *et al.* (2017) for research at the intra-organisational level of analysis "that help[s] to explain how individual-level attributes and behaviours as well as design elements of the organisation need to adapt as the organisation transitions to OI" (p. 22).

To link the "what" of OI activities to the "how" of individual attributes and behaviours in our analyses and competency model development, we compiled a list of OI activities based on Chesbrough and Brunswicker (2013, 2014). As in our own approach, that research relied on an original cross-country survey, anchored in innovation surveys such as the community innovation survey, which (among other things) provides systematic empirical evidence of OI activities. Their research confirmed that OI is a persistent and widespread phenomenon across industries and countries (Chesbrough and Brunswicker, 2014).

Professional competencies in support of OI

As noted above, the challenges of implementing and managing OI activities place new demands on the skills and abilities of the individuals involved. However, it is difficult for managers to define and source these skills and abilities in new recruits (Dabrowska and Podmetina, 2014). To identify the specific skills and behaviours for the successful execution and management of OI activities that must be found, developed and cultivated in the workforce, researchers have recently turned to the concept of professional competencies (Du Chatenier *et al.*, 2010; Mortara *et al.*, 2009; Hafkesbrink and Schroll, 2014). Before reviewing competency models for OI, it seems important to resolve the confusion around terms relating to individual competence and competency and to organisational capability.

Competence can be defined as a combination of the nature of the work and the characteristics of the worker performing it (Sandberg, 2000). It is a professional's generic capability (Mulder, 2015), consisting of the integrated set of knowledge, skills and attitudes of a person (Mulder, 2007) or that an employee possesses (Rowe, 1995; Garavan and McGuire, 2001). It follows that a person or employee cannot have two or more sets of competences – in other words, a professional cannot have several competences (Mulder, 2015). A competency (plural competencies) is a part of competence (Mulder, 2015) – that is, the individual's array of discrete knowledge, skills and attitudes/abilities/behaviours that enable them to cope with the demands and responsibilities of their job (Boyatzis, 1982; Lathi, 1999). Competencies should be formulated as "can" expressions (Mulder, 2015); they are observable and measurable, and their application results in effective and/or superior job performance, enabling a distinction

between superior and average performance (Boyatzis, 1982; Catano, 1998). As the notion of organisational capability typically refers to distinctive strategic strengths at the organisational level (Athey and Orth, 1999; Luoma, 2000), organisational capabilities are distinct from competence and competency, both of which relate to the individual level and are therefore a human resource management issue.

Drawing on the above, the present research focuses on reviewing, identifying, measuring and empirically analysing competencies as the primary unit of analysis and as the building blocks of competences. Based on their review of the extant literature, Soderquist *et al.* (2010) synthesised three analytical perspectives that clarify the meaning and applicability of the various types of competency encountered in organisations. First, generic vs organisation-specific competencies, which are competencies characterizing a specific job, "either generically, i.e. common to all individuals occupying a specific job, or specific to the job in a particular organisation" (Soderquist *et al.*, 2010, p. 328). Second, managerial vs operational competencies, which refer to competencies needed to successfully perform in a managerial or operational role, respectively. Third, competencies as skills vs competencies as abilities/behaviours, "which refer to characteristics of individuals that are either *learned* and describe *what* an individual does, or fundamentally *inherent* and describe *how* people do their job" (Soderquist *et al.*, 2010, p. 328, emphasis added).

This typology of combinations of the three identified pairs has general applicability for competency management, as it suggests an analytical "scale" of competencies, ranging from the most specific "organisation-specific operational skills" to the most general "generic management abilities". For the purposes of the present research, we focus on the analysis of generic managerial competencies for OI across industries and countries while distinguishing between skills and abilities in the review and further operationalisation of competencies in the research instrument and subsequent data analysis.

As skills, competencies specify the sufficiency of skills needed to execute a specific job (Soderquist *et al.*, 2010), which is particularly important for the knowledge-intensive work (Lawler, 2005) that characterises innovation. Skills are developed through training, experience and knowledge transfer (Lauby, 2013). As behaviours, competencies are often referred to as abilities that are more innate than skills (which are more acquired) (Lauby, 2013), defining the desirable attributes for a specific job (e.g. creativity, initiative, persistence in problem solving, discipline, assertiveness, empathy and the ability to communicate and cooperate with others) (Nordhaug, 1998; Rowe, 1995). Abilities are particularly important in organisational contexts that are characterised by discontinuous change (Harvey *et al.*, 2000), as well as by innovation and, in particular, by OI. Rather than sufficiency, abilities can only be evaluated in terms of performance expectations, embracing the notion of excellence (Rowe, 1995).

Competency models for OI

Turning to studies that explicitly analyse OI competencies, Mortara *et al.* (2009) proposed four categories of relevant skills:

(1) introspective skills related to the organisation's assessment of opportunities from inside;

(2) extrospective skills related to the organisation's assessment of opportunities from outside;

(3) interactive skills that convey the value, internally and externally, of relations with the world outside the organisation; and

(4) technical skills, encompassing all the technical, management and business skills needed to support the first three categories.

These skill categories are complemented by a set of desirable personal attributes (i.e. abilities as defined above), including (among others) motivation, sociability, a techno-business mindset, systems thinking, adaptability and flexibility (Mortara *et al.*, 2009). Table I summarises indicative skills and abilities from the competency models reviewed here, which we use as inputs to the research instrument. The final complete list of variables retained and analysed is shown in Table III (see methodology section), which also details their operationalisation.

Based on an extensive literature review and qualitative validation through interviews and focus groups, Du Chatenier *et al.* (2010) identified four categories of OI competencies:

(1) self-management (seen as the basis for achieving the central tasks related to OI);

(2) interpersonal management (essential for managing inter-organisational collaboration);

(3) project management (essential for managing the overall innovation process); and

(4) content management (essential for creating new knowledge collaboratively).

Although it represents a great step forward in understanding the specificities of OI competencies, the work of Du Chatenier *et al.* suffers from generality (Mulder, 2015), as it fails to distinguish analytically between OI skills and abilities and further lacks clarity by conflating the concepts of competence and competency (Mulder, 2015). While the present study corrects for these imperfections, we nevertheless employed several of the competencies proposed by Du Chatenier *et al.* (2010) (indicatively listed in Table I) in building our research instrument.

	Indicative OI skills	Indicative OI abilities	Indicative competency clusters
Mortara *et al.* (2009)	Understand fit with internal strategies, understand IP implications, understand fit with partners' strategies, communication internally and to partners, resolve conflicts, building networks, evaluation of risk, problem solving	Ability to learn, sociability, techno-business mindset, systems thinking, vision, adaptability, flexibility	Introspective, extrospective, interactive, technical
Du Chatenier *et al.* (2010)	Negotiate, establish team goals, coordinates and synchronises team members, monitors, evaluates, and provides feedback on team and individual performance	Develops team spirit, feels responsible for the team, deals with flexible team composition, manages the inter-organisational collaboration process, possesses knowledge and perceptions of various professional areas and languages, shares information freely with others	Self-management, interpersonal management, project management, content management
Hafkesbrink and Schroll (2014)	Multi-tasking, entrepreneurial skills, knowledge concentration, knowledge brokerage	Ambiguity tolerance, dialectic thinking, synthesis thinking, strategic thinking, creativity, coping with complexity, mediation	Professional, methodic, social, personal
Dabrowska and Podmetina (2014)	Decision-making skills, business knowledge, leadership skills, virtual collaboration skills, trust management skills	Project management, new media literacy, cultural awareness, novel and adaptive thinking, ability to work in an interdisciplinary environment, ability to share knowledge and ideas externally, Risk awareness	Individual skills and abilities useful for OI professionals, OI-specific skills and abilities

Table I. Indicative individual open innovation competencies from the literature

Hafkesbrink and Schroll (2014) drew on the theoretical underpinnings of exploration, exploitation (March, 1991) and their simultaneous integration in ambidexterity (Raisch *et al.*, 2009; Blindenbach-Driessen and van den Ende, 2014) to elaborate a comprehensive catalogue of organisational and individual OI competencies. In innovation studies, exploration – associated, for example, with search, variation, risk taking, experimentation and discovery (March, 1991) – has become synonymous with radical innovation, while exploitation – associated, for example, with refinement, efficiency, selection, implementation and execution (March, 1991) – has become synonymous with incremental innovation (Jansen *et al.*, 2009). Ambidextrous organisations are "capable of simultaneously exploiting existing competencies and exploring new opportunities" (Raisch *et al.*, 2009, p. 685). In this way, exploration and exploitation can work together towards innovation that is simultaneously incremental and radical, referred to as innovation ambidexterity (Li *et al.*, 2008). External knowledge sourcing, which is central to inbound OI, was recently found to be positively associated with organisational ambidexterity, mediating the relationship between organisational ambidexterity and firm performance (Vrontis *et al.*, 2017). Based on empirical research in 189 Italian knowledge-intensive firms, Vrontis *et al.* proposed that greater use of external knowledge in pursuit of innovation helps in managing the internal tensions entailed by joint exploitation and exploration activities, identified by March (1991) as one of the main difficulties in developing ambidexterity. Firms that adopt OI can obtain greater benefits from ambidexterity; in turn, ambidexterity is central to innovation performance, especially in the OI context, which is characterised by intensive knowledge transfer and learning (Ferraris *et al.*, 2017).

In relation to the ambidextrous nature of OI, Hafkesbrink and Schroll (2014) identified four interdependent categories of key individual competencies for managers and employees: professional competencies, methodic competencies, social competencies and personal competencies. It should be noted that, such as Du Chatenier *et al.* (2010), Hafkesbrink and Schroll's model makes no distinction between skills and abilities but uses the words competencies, skills and abilities interchangeably for what we have defined here as either competencies as skills, or competencies as abilities. Hafkesbrink and Schroll emphasise the importance of knowledge and knowledge management for the effective implementation and execution of OI, as further analysed and confirmed in recent empirical studies (Ferraris *et al.*, 2017; Scuotto *et al.*, 2017), and indicative competencies from Hafkesbrink and Schroll (2014) used in our instrument-building and analysis are listed in Table I.

Finally, Dabrowska and Podmetina (2014) conducted an extensive literature review (keywords: "open innovation" and "capability*" or "competence*" or "skill*") and collected data on job offers (keyword: "OI" (in the job title or job description)). In addition to the competencies identified in the above studies, we also used items from Dabrowska and Podmetina (2014) as indicatively listed in Table I.

3. Methodology

Questionnaire development and validation by experts

With a view to conducting the first empirical study of requisite competencies for OI in a European industrial context, we developed a structured questionnaire covering "the following broad topic areas: 1) the current state of open innovation adoption in industry; 2) the perceived importance of open innovation at present and in the near future; and 3) the employee competencies currently considered important for open innovation" (Podmetina, Equey, Kleer, Lopez Vega, Dabrowska, Albats, Petraite, Soderquist, Rethi and Hafkesbrink, 2017; Podmetina, Soderquist, Dabrowska, Hafkesbrink and Lopez-Vega, 2017, p. 45). To assess the level of OI adoption, we applied the list of OI and collaborative activities adopted from Chesbrough and Brunswicker (2013, 2014) for inbound and outbound OI, indicatively

comprising customer/consumer co-creation, crowdsourcing, collaborative innovation with external partners (suppliers, universities, competitors, etc.), participation in standardisation and IP in- and out-licensing (see Table AI).

The initial list of questionnaire items was reduced the following evaluation by 15 business and academic experts in OI. Next, the questionnaire was piloted in 52 organisations (both business and academic) from 24 European countries. Based on that feedback, the original questionnaire was edited, and the large-scale online survey was subsequently launched. For the purposes of this paper, we addressed only those variables related to OI competencies: skills, abilities and OI activities. In addition, we controlled for firm size, industry and location. The final list of variables and their operationalisation is presented in Table AI.

Data collection process and sample description

The online survey was launched in September 2014 on Webropol. While the main language was English, the survey was also translated into 12 other languages. In total, 528 respondents answered the survey, providing data from 38 countries across Northern, Southern, Eastern and Western Europe. Using stratified sampling, companies were selected on the basis of their industry's economic significance (five to ten leading industries per country). To collect the data, we contacted one respondent per company by e-mail; those targeted included top management, innovation and R&D managers and HR specialists. The cover letter described the survey objective, supplying Chesbrough's (2003, p. xxiv) definition of OI to avoid possible bias due to different understandings of the concept. The average response rate was 10 per cent, but this varied between countries. After cleaning the sample and removing incomplete questionnaires, the final number of responses accepted for further analysis was 264.

The sample consisted mainly of SMEs and large firms (41 and 38 per cent, respectively). Micro enterprises (i.e. those with fewer than ten members of staff) were relatively under-represented (21 per cent). The majority of respondents were located in Southern and Eastern Europe, with slightly fewer from Northern and Western Europe (see Table II). The industrial classification was based on the Global Industry Classification System (www.msci.com/gics). A majority of respondents (28.4 per cent) came from industries that included capital goods, professional and commercial services and transportation (see Table II). Information technology, grouping software and services, technology hardware and equipment, and semiconductors and semiconductor equipment, accounted for 17 per cent of the sample, and consumer discretionary firms such as automobile and components, consumer durables and apparel, hotels, restaurants and leisure, media and retail accounted for 14.4 per cent, with other industries achieving a lower share. Overall, 37 per cent of our respondents represented the manufacturing companies. The proportion of high-tech firms was small at just 18 per cent; the high-tech classification was based on Kile and Phillips (2009).

Region	Western Europe (12.9%), Southern Europe (36.4%), Northern Europe (19.7%), Eastern Europe (21.1%)
Industry	Consulting (4.5%); consumer discretionary (14.4%); consumer staples (7.6%); energy (4.9%); financials (6.1%); health care (4.2%); industrials (28.4%); information technology (17.0%); materials (10.6%); telecommunication services (1.1%); utilities (1.1%)
High tech	High tech (18.2%); other (low and medium tech) (81.8%)
Manufacturing vs service	Manufacturing (37.1%) Service (62.9%)
Size	Large (more than 250 people, 38.3%); SMEs (10-250 people, 40.5%); micro-enterprises (1-9 people, 21.2%)

Table II. Descriptive sample statistics

To control for possible common method bias, we implemented Harman's single factor test (Podsakoff and Organ, 1986). We conducted a principal component analysis for all the studied variables, which resulted in 14 factors with eigenvalues greater than 1. While the overall percentage of explained variance was 66.5 per cent, the variance accounted for by a single factor was only 19.8 per cent, indicating that bias due to cross-sectional data is unlikely.

OI activities and competency measurement scales

Because the measurement scales used for data collection were new in part (see Table AI), we checked for scale reliability in addition to the expert evaluation and pilot test (Tables III and IV) to ensure the quality of the instrument and data. Cronbach's α was high for OI activities (i.e. higher than 0.8), and all items fit well, so validating the scale (see Table III).

Cronbach's α for OI competencies was also high (i.e. higher than 0.8). All items on the scale fit well, with the exception of IP management skills, indicating a higher α for the whole scale if these items were removed (Table IV). However, given the study's exploratory nature, we decided to retain the item at this stage.

4. Research findings

To identify the individual competencies essential for OI and to build a generic organisational competency model, we applied several analytical procedures, which can be described in stages. First, to identify the most important competencies for OI, we compared the means of competencies that are important for the OI professional and determined the percentage of respondents who acknowledged the importance of specific competencies. Next, we compared the importance of different competencies for OI in companies of different sizes and from different industries in order to evaluate the generic applicability of the measurement scale. Then, to group and reduce the number of OI and collaborative activities and OI competencies, we conducted a factor analysis to define the groups that were later used in the competency model. Finally, we analysed the grouped OI competencies identified as important for open and collaborative innovation adoption.

Variable	Item-total correlation	α if item deleted
Open innovation activities ($\alpha = 0.863$, No. of items = 13)		
1. Customer and consumer co-creation in R&D projects	0.494	0.856
2. Crowdsourcing	0.484	0.856
3. Scanning for external ideas	0.507	0.855
4. Collaborative innovation with external partners (i.e. suppliers, universities, competitors, etc.)	0.560	0.852
5. Subcontracting R&D	0.505	0.855
6. Idea and start-up competitions	0.573	0.851
7. Using external networks (e.g. associations, intermediaries, knowledge brokers)	0.521	0.854
8. Participation in standardisation (public standards)/influencing industry standards	0.425	0.860
9. Free revealing (e.g. ideas, IP) to external parties	0.566	0.852
10. IP in-licensing	0.568	0.851
11. IP out-licensing	0.676	0.846
12. External technologies acquisition	0.554	0.852
13. Selling unutilised/unused technologies	0.473	0.857

Table III.
Scale reliability analysis – open innovation activities

Source: Adopted from operationalisation of variables in Podmetina, Equey, Kleer, Lopez Vega, Dabrowska, Albats, Petraite, Soderquist, Rethi and Hafkesbrink (2017, pp. 8-10) and Podmetina, Soderquist, Dabrowska, Hafkesbrink and Lopez-Vega (2017, pp. 8-10)

Variable	Item-total correlation	α if item deleted
Open innovation competencies (Cronbach's $\alpha = 0.912$, No. of items = 28)		
Skills 1: IP management skills	0.300	0.914
Skills 2: negotiation skills	0.475	0.910
Skills 3: entrepreneurial skills	0.457	0.910
Skills 4: leadership skills	0.449	0.910
Skills 5: team-working skills	0.528	0.909
Skills 6: multi-tasking skills	0.471	0.910
Skills 7: problem-solving skills	0.477	0.910
Skills 8: virtual collaboration skills	0.485	0.910
Skills 9: internal collaboration skills	0.547	0.909
Skills 10: external collaboration skills	0.605	0.908
Skills 11: trust skills	0.555	0.908
Skills 12: communication skills	0.549	0.909
Skills 13: networking skills	0.545	0.909
Abilities 1: technology and business mindset	0.399	0.911
Abilities 2: project management	0.422	0.911
Abilities 3: adaptability and flexibility	0.570	0.908
Abilities 4: managing inter-organisational collaboration processes	0.549	0.908
Abilities 5: ability to work in an interdisciplinary environment	0.595	0.908
Abilities 6: ability to work in internal cross-functional teams	0.619	0.908
Abilities 7: strategic thinking	0.497	0.909
Abilities 8: creativity	0.410	0.911
Abilities 9: new media literacy	0.483	0.910
Abilities 10: cultural awareness	0.555	0.908
Abilities 11: ability to work with different professional communities	0.629	0.907
Abilities 12: ability to share knowledge and ideas internally/within an organisation	0.564	0.908
Abilities 13: ability to share knowledge and ideas externally	0.534	0.909
Abilities 14: risk awareness	0.497	0.909
Abilities 15: failure tolerance	0.382	0.912

Source: Adopted from operationalisation of variables in Podmetina, Equey, Kleer, Lopez Vega, Dabrowska, Albats, Petraite, Soderquist, Rethi and Hafkesbrink (2017, pp. 8-10) and Podmetina, Soderquist, Dabrowska, Hafkesbrink and Lopez-Vega (2017, pp. 8-10)

Table IV. Scale reliability analysis – open innovation competencies

OI competency descriptive statistics

OI competencies (divided into skills and abilities) were evaluated using a Likert-type attitude scale, ranging from 1 (not important) to 7 (very important) (see Table AI). Respondents identified networking, communication, team-working and problem-solving skills as the most important for OI specialists (Figure 1). All the skills were considered important, with scores ranging from 5.261 to 6.163 and an average importance (for the whole sample) of 5.676. The abilities of OI specialists were also mainly considered important or very important, with average importance ranging from 4.992 to 6.023 and an average for the whole sample of 5.684 (Figure 2). Respondents emphasised that technology and business mindset, the ability to share knowledge within the organisation, creativity, adaptability and strategic thinking is most important for OI adoption.

To develop the OI competency model, we selected only those questionnaire responses indicating high importance of an OI skill or ability – that is, scores of 5, 6 or 7 on the Likert scale. The percentage of respondents assigning this level of importance to OI skills and abilities (5, 6 and 7) is shown in Figure 3.

The importance of OI competencies does not vary significantly for companies of different sizes (Table V) and from different industries. A Welch's ANOVA test revealed no significant differences between most competencies in relation to company size; the notable exceptions

Figure 1.
Importance of open innovation skills

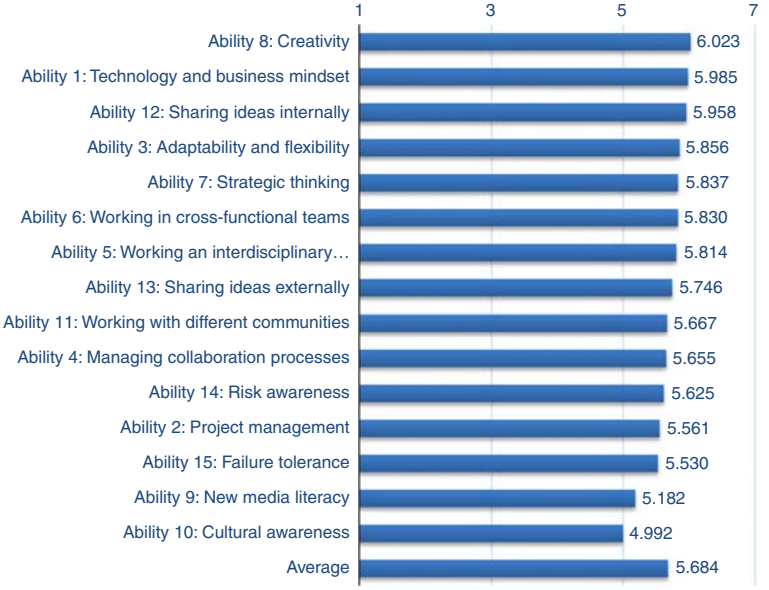

Figure 2.
Importance of open innovation abilities

were negotiation skills, the ability to manage inter-organisational collaboration processes and cultural awareness. Similarly, *t*-tests comparing service and manufacturing firms and high-tech companies and others (low and medium tech) showed that OI competencies were considered equally important by companies from different industries. It is notable, however, that entrepreneurial skills seem more important for service firms than for those from manufacturing. This suggests that the proposed scale is generic for companies of different sizes and from different industries.

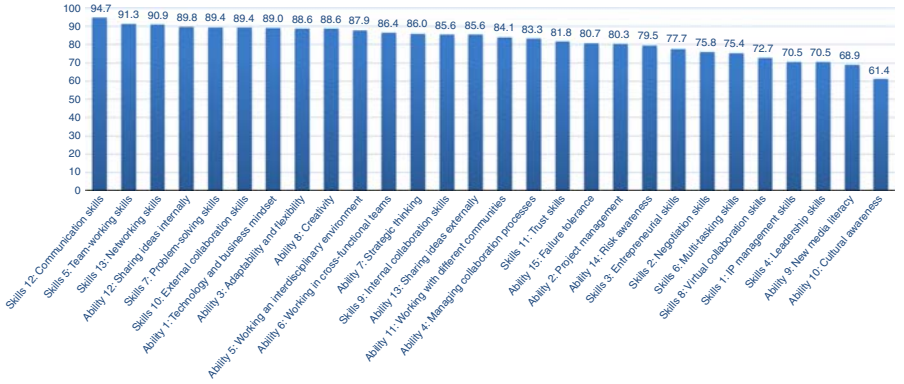

Figure 3.
Percentage of respondents indicating the high importance of open innovation competencies

Variable	Large > 250	SMEs, 10-249	Micro, 1-9	Full sample	Welch's ANOVA
Skills 1: IP management skills	5.178	5.346	5.804	5.379	2.984
Skills 2: negotiation skills	5.238	5.224	6.054	5.405	8.374*
Skills 3: entrepreneurial skills	5.515	5.383	5.821	5.527	1.823
Skills 4: leadership skills	5.218	5.290	5.321	5.269	0.130
Skills 5: team-working skills	6.069	6.047	6.143	6.076	0.128
Skills 6: multi-tasking skills	5.267	5.495	5.536	5.417	0.933
Skills 7: problem-solving skills	5.812	5.916	6.143	5.924	1.210
Skills 8: virtual collaboration skills	5.277	5.234	5.286	5.261	0.041
Skills 9: internal collaboration skills	5.644	5.738	5.982	5.754	1.647
Skills 10: external collaboration skills	5.891	5.841	6.143	5.924	1.653
Skills 11: trust skills	5.653	5.766	5.804	5.731	0.389
Skills 12: communication skills	6.129	6.150	6.250	6.163	0.300
Skills 13: networking skills	5.970	5.822	6.196	5.958	2.263
Abilities 1: technology and business mindset	5.950	5.916	6.179	5.985	0.987
Abilities 2: project management	5.446	5.636	5.625	5.561	0.745
Abilities 3: adaptability and flexibility	5.960	5.682	6.000	5.856	2.128
Abilities 4: managing inter-organisational collaboration processes	5.762	5.439	5.875	5.655	3.123*
Abilities 5: ability to work in an interdisciplinary environment	5.762	5.748	6.036	5.814	1.477
Abilities 6: ability to work in internal cross-functional teams	5.891	5.682	6.000	5.830	1.784
Abilities 7: strategic thinking	5.782	5.841	5.929	5.837	0.296
Abilities 8: creativity	5.980	6.047	6.054	6.023	0.131
Abilities 9: new media literacy	5.129	5.065	5.500	5.182	1.744
Abilities 10: cultural awareness	5.257	4.692	5.089	4.992	4.884*
Abilities 11: ability to work with different professional communities	5.713	5.551	5.804	5.667	0.970
Abilities 12: ability to share knowledge and ideas internally/ within an organisation	5.911	5.907	6.143	5.958	1.144
Abilities 13: ability to share knowledge and ideas externally	5.693	5.710	5.911	5.746	0.722
Abilities 14: risk awareness	5.535	5.701	5.643	5.625	0.561
Abilities 15: failure tolerance	5.594	5.514	5.446	5.530	0.239

Note: *$p < 0.05$

Table V.
Importance of open innovation competencies for companies of different sizes (means)

Conversely, companies located in different European regions were more heterogeneous in their perceptions of the importance of various competencies. In particular, significant differences were found for entrepreneurial and networking skills, technology and business mindset, ability to work in internal cross-functional teams, new media literacy, cultural

awareness and failure tolerance. Therefore, although it appears that industry and company size exert no particular influence on the set of required competencies, regional features (such as cultural characteristics) may play a significant role in shaping the profile of OI professional competencies.

Factor analysis of OI activities and competencies

Factor analysis of open and collaborative innovation activities confirmed the possibility of reducing the number of activities to three groups. The rotated component matrix (rotation converged in five iterations) is presented in Table VI. The selected extraction method was principal component analysis, and varimax with Kaiser normalisation was chosen as the rotation method. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy returned a value of 0.867, which is much higher than the threshold value of 0.5. Bartlett's test of sphericity was significant ($p < 0.001$), indicating that the data were suitable for factor analysis. To include only those factors that explained more variance than a single variable, we limited the minimum eigenvalue to 1. The factor analysis explained around 55 per cent of the sample variance. It is notable that all items other than idea and start-up competitions exhibited good loadings without sufficient cross-loadings while that item (idea and start-up competitions) had significant cross-loadings, with commonality below 0.5, leading to the exclusion of that variable from further analysis.

Interestingly, all "traditional" inbound and outbound monetary (pecuniary) OI activities (such as external technology acquisition, technology commercialisation, in- and out-licensing and participation in industry standardisation) appeared in the first group (see Table VI, Factor 1). We subsequently refer to this group as open technology (in and out) sourcing. These monetary activities represent technology acquisition and commercialisation across organisational borders, which are well-established OI practices. These practices differed in average intensity of adoption, while companies reported high intensity of adoption of external

	Factor name			
Open innovation activities within firms	Open technology sourcing 1	Open mass innovation 2	Open collaborative innovation 3	Mean of intensity of adoption of the activity
10. IP in-licensing	*0.731*	0.243	0.116	*2.909*
12. External technologies acquisition	*0.717*	0.196	0.127	*4.311*
13. Selling unutilized/unused technologies	*0.671*	0.051	0.182	*2.693*
11. IP out-licensing	*0.654*	0.322	0.301	*2.660*
8. Participation in standardisation (public standards)/influencing industry standards	*0.560*	0.078	0.196	*3.947*
6. Idea and start-up competitions	0.426	0.303	0.421	*3.163*
9. Free revealing (e.g. ideas, IP) to external parties	0.265	*0.759*	0.135	*2.943*
2. Crowdsourcing	0.155	*0.743*	0.139	*2.898*
7. Using external networks (e.g. associations, intermediaries, knowledge brokers)	0.243	*0.632*	0.202	*4.167*
4. Collaborative innovation with external partners (i.e. suppliers, universities, competitors, etc.)	0.212	0.146	*0.782*	*5.570*
5. Subcontracting R&D	0.331	−0.019	*0.717*	*4.053*
3. Scanning for external ideas	0.145	0.300	*0.621*	*5.405*
1. Customer and consumer co-creation in R&D projects	0.022	0.427	*0.610*	*4.792*
Cronbach's α	0.766	0.685	0.727	
Mean	*3.304*	*3.336*	*4.955*	

Table VI.
Factor analysis of open innovation activities

technology acquisition (mean 4.311) and participation in standardisation (mean 3.947), in- and out-licensing (mean 2.909 and 2.660 respectively) and technology commercialisation (mean 2.693) were not very intensively adopted. Average intensity of adoption for this group was 3.303.

The second group (Table VI, Factor 2) includes activities that involve non-monetary (non-pecuniary) inbound and outbound activities that open the innovation process to a wide range of partners, such as free revealing (ideas, IP, etc.) to external partners, crowdsourcing and use of external networks (e.g. associations, intermediaries, knowledge brokers). We describe these practices as open mass innovation, characterised by less formal, non-contractual collaboration and involving a broader range of partners as compared to the OI practices in the first group. Most companies use external networks intensively (mean 4.167), but crowdsourcing (mean 2.898) and free revealing (mean 2.943) are very specific activities that are intensively adopted in a smaller number of firms. Average intensity of adoption for this group was 3.336.

Finally, the group we characterised as open collaborative innovation included practices most intensively (group mean 4.955) adopted by companies (Table VI, Factor 3): collaborative innovation with external partners (i.e. suppliers, universities, competitors), R&D subcontracting, scanning for external ideas and customer co-creation in R&D projects. Even the least adopted activity in this group – subcontracting R&D – exhibited a high level of adoption (mean: 4.053), and the most adopted activity – collaborative innovation with external partners – was the most adopted of all OI activities in this study (mean: 5.570). In the academic literature, these inbound collaborative practices are often analysed as OI practices, but they are in effect a source of critique, as many companies adopted them before the emergence of the OI paradigm.

Next, we performed a factor analysis for OI competencies, which yielded seven factors. The rotated component matrix (rotation converged in 8 iterations) is presented in Table VII. Principal component analysis was applied as an extraction method, and varimax with Kaiser normalisation was chosen as a rotation method. KMO was high at 0.886, and Bartlett's test for sphericity was significant at $p < 0.001$, indicating that the data were suitable for factor analysis. The number of factors was based on eigenvalues (where the factor eigenvalue should exceed 1). The factor analysis explained around 59 per cent of the sample variance. Although all variables demonstrated quite good commonalities (i.e. above 0.5), we had to remove several items because of significant cross-loadings between several factors. In particular, we removed virtual collaboration skills from Factor 3 and strategic thinking ability from Factor 4.

This factor analysis served as the background for development of our competency model, which is discussed in the next section. OI management competency, which defines the distinct core OI management competency, included ten items (Table VII, Factor 1): networking skills, communication skills, ability to work with different professional communities, ability to share knowledge and ideas internally, ability to share knowledge and ideas externally, ability to work in internal cross-functional teams, ability to work in an interdisciplinary environment, managing inter-organisational collaboration processes, adaptability and flexibility and cultural awareness. This competency reflects the specialist's ability to manage both the inter-organisational collaboration process (collaborating with different stakeholders, sharing knowledge externally) and intra-organisational collaboration (sharing knowledge internally, working in internal cross-functional teams), as well as using communication and networking skills. Working in a holistic collaboration process (internal and external) requires adaptability and flexibility, along with networking and communication skills and the ability to work in an interdisciplinary, cross-cultural, cross-functional environment.

Other groups of competencies comprised smaller sets of skills and abilities reflecting the specific competencies of OI management. In fact, respondents evaluated all items included in

Table VII.
Factor analysis of open innovation skills and abilities in firms, determining the competency clusters

Open innovation skills and abilities in firms	Component						
	OI management competency 1	Entrepreneurial leadership competency 2	Innovative team work competency 3	Creative work competency 4	Innovation process competency 5	Inter and intra-organisational collaboration competency 6	Failure tolerance 7
Abilities 11: ability to work with different professional communities	*0.724*	0.049	0.043	0.250	0.030	0.199	0.141
Abilities 12: ability to share knowledge and ideas internally/within an organisation	*0.667*	−0.098	0.002	0.350	0.010	0.290	0.095
Abilities 13: ability to share knowledge and ideas externally	*0.664*	−0.054	0.051	0.249	0.066	0.019	0.231
Abilities 6: ability to work in internal cross-functional teams	*0.639*	0.171	0.217	0.310	0.076	0.099	−0.133
Abilities 5: ability to work in an interdisciplinary environment	*0.587*	0.252	0.176	0.199	0.199	0.050	−0.111
Skills 13: networking skills	*0.581*	0.202	0.029	−0.059	0.138	0.302	0.153
Abilities 4: managing inter-organisational collaboration processes	*0.572*	0.142	0.153	−0.103	0.256	0.073	0.259
Abilities 3: adaptability and flexibility	*0.564*	0.189	0.224	0.011	0.095	−0.019	0.372
Skills 12: communication skills	*0.525*	0.341	0.165	−0.151	0.294	0.246	−0.126
Abilities 10: cultural awareness	*0.515*	0.259	0.230	0.127	−0.134	0.096	0.310
Skills 3: entrepreneurial skills	0.033	*0.711*	0.129	0.230	0.023	0.142	0.252
Skills 4: leadership skills	0.180	*0.640*	0.290	0.153	0.067	−0.055	−0.038
Skills 11: trust skills	0.382	*0.469*	0.136	−0.014	0.207	0.361	−0.065
Skills 7: problem-solving skills	0.042	0.157	*0.704*	0.181	0.159	0.223	0.073
Skills 6: multi-tasking skills	0.158	0.205	*0.665*	0.148	0.105	0.082	0.027
Skills 8: virtual collaboration skills	0.225	−0.085	0.476	0.147	−0.054	0.408	0.431
Skills 5: team-working skills	0.398	0.332	*0.470*	−0.012	−0.032	0.139	0.039
Abilities 8: creativity	0.081	0.185	0.172	*0.675*	0.046	0.146	0.002
Abilities 9: new media literacy	0.222	0.008	0.311	*0.589*	0.033	0.109	0.166
Abilities 14: risk awareness	0.256	0.135	0.053	*0.505*	0.398	−0.097	0.218
Abilities 7: strategic thinking	0.363	0.411	−0.046	0.446	0.178	−0.031	−0.045
Skills 1: IP management skills	0.044	−0.023	0.085	0.117	*0.770*	0.133	−0.078
Skills 2: negotiation skills	0.153	0.415	0.109	−0.050	*0.575*	0.144	0.159
Abilities 2: project management	0.296	−0.057	0.393	0.139	*0.563*	−0.322	0.138
Abilities 1: technology and business mindset	0.091	0.275	−0.214	0.321	*0.447*	0.224	0.255
Skills 9: internal collaboration skills	0.218	0.134	0.300	0.219	0.065	*0.738*	0.003
Skills 10: external collaboration skills	0.426	0.074	0.150	0.064	0.170	*0.684*	0.134
Abilities 15: failure tolerance	0.207	0.078	0.052	0.114	0.094	0.042	*0.762*
Cronbach's α	0.871	0.632	0.662	0.612	0.626	0.787	na
Mean	5.764	5.509	5.806	5.610	5.582	5.839	5.530

the identified competencies as important, indicating that although the competencies clearly relate to different tasks, they all play an important role in the OI process. For example, entrepreneurial leadership competency (Table VII, Factor 2) combines entrepreneurial, leadership and trust skills. Although entrepreneurial and leadership skills are essential for any successful innovation project manager, the addition of trust becomes especially critical in the context of external collaboration. In contrast to how the first group brought together the broader set of skills required for OI specialists at various levels, this competency is essential for taking on a high-level management role in an OI context.

Innovative team work competency includes problem solving, multi-tasking and team-working skills (Table VII, Factor 3), contributing to effective and efficient teamwork in an OI context. In isolation, this competency may be considered important for any project team member and for in-house (internal) innovation. However, in combination with other competencies, it becomes an important factor in the overall competence of OI specialists and team members in such projects.

Creative work competency (Table VII, Factor 4) combines creativity, new media literacy and risk awareness, which are critical for transforming creative ideas into innovations that are likely to succeed in a dynamic and uncertain environment. Indeed, while this competency *per se* should not be considered as a unique requirement for OI specialists, it contributes to search, evaluation and integration of external knowledge in innovation projects and to external exploitation.

Innovation process competency consists of negotiation and IP management skills, technology and business mindset, and project management ability (Table VII, Factor 5). This competency is critical for those in an OI project management role, combining technical skills with the ability to manage trade-offs between technical concerns and business imperatives.

Inter- and intra-organisational collaboration competency combines internal and external collaboration skills (Table VII, Factor 6). This competency is important for all OI professionals, but it is especially crucial for the OI manager, where this role is defined and exists within the organisation. Internal and external collaboration skills are the essence of any boundary-spanning activity.

Failure tolerance competency (Table VII, Factor 7) is of equal importance across all professions and employee levels in an innovation-intensive environment. Given the high levels of uncertainty in innovation activities and the high failure rates of such projects, this competency is essential for innovation managers. Although OI is thought to have the potential to reduce the costs and associated risks of internal R&D activities, it creates additional challenges for relationships with external partners, making this an essential competency for OI managers.

Descriptive statistics, correlation matrix and reliability assessment are presented in Table VIII. While some factors (2, 3, 4 and 5) have Cronbach's α values below the

					Correlation matrix						
Factor	n	Mean score	SD	Cronbach's α	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Factor 1	264	5.764	0.765	0.871	1						
Factor 2	264	5.509	0.971	0.632	0.528*	1					
Factor 3	264	5.806	0.924	0.662	0.508*	0.514*	1				
Factor 4	264	5.610	0.914	0.612	0.514*	0.409*	0.413*	1			
Factor 5	264	5.582	0.923	0.626	0.457*	0.422*	0.351*	0.428*	1		
Factor 6	264	5.839	0.988	0.787	0.576*	0.446*	0.472*	0.372*	0.318*	1	
Factor 7	264	5.530	1.319	na	0.368*	0.196*	0.241*	0.303*	0.227*	0.232*	1

Note: *$p < 0.01$

Table VIII. Descriptive statistics, reliabilities, and correlation matrix for open innovation skills and abilities, factor solution

commonly accepted cut-off point of 0.7, the coefficients are still relatively high (greater than 0.6), making them suitable for exploratory study. At the same time, all the factors correlate with each other, indicating the appropriateness of joint application for the evaluation of OI competencies.

To bring together OI activities and competencies in the competency model, a final step analysed the relationship between the three identified OI activities modes – open technology (in and out) sourcing, open mass innovation and open collaborative innovation – and the seven identified OI competencies (see Table IX).

This leads to several interesting observations. First, although Welch's ANOVA revealed significant differences in the perceived importance of several competencies for different degrees of engagement in open technology sourcing and open mass innovation activities, it revealed no such differences with regard to degrees of engagement in open collaborative innovation activities. In other words, companies tend to evaluate the importance of OI competencies evenly, irrespective of their current degree of engagement in collaborative innovation activities. Second, companies that are intensively involved in open technology sourcing – that is, the most traditional OI activities – consider all competencies (except Factor 4 creative work competence, Factor 6 inter- and intra-organisational collaboration competency and Factor 7 failure tolerance) as more important than do those who adopt this OI activity mode less intensively. As the same can be said of companies that intensively adopt (non-monetary) open mass innovation, the only exceptions in this case are Factors 4 and 7.

Competency clusters open innovation activity mode	OI management competency 1	Entrepreneurial leadership competency 2	Innovative team work competency 3	Creative work competency 4	Innovation process competency 5	Inter and intra-organisational collaboration competency 6	Failure tolerance 7
Open technology sourcing	5.764	5.509	5.806	5.610	5.582	5.839	5.530
N	264	264	264	264	264	264	264
Low (0-2)	5.643	5.385	5.646	5.578	5.439	5.723	5.414
N	128	128	128	128	128	128	128
Medium (3-4)	5.838	5.547	5.957	5.663	5.682	5.935	5.598
N	92	92	92	92	92	92	92
High (5-7)	5.961	5.788	5.955	5.591	5.790	5.977	5.727
N	44	44	44	44	44	44	44
Welch's ANOVA	3.681*	3.286*	3.727*	0.252	3.309*	1.806	1.082
Open mass innovation	*5.764*	*5.509*	*5.806*	*5.610*	*5.582*	*5.839*	*5.530*
N	264	264	264	264	264	264	264
Low (0-2)	5.650	5.356	5.617	5.570	5.535	5.685	5.519
N	135	135	135	135	135	135	135
Medium (3-4)	5.780	5.542	5.958	5.644	5.503	5.938	5.580
N	88	88	88	88	88	88	88
High (5-7)	6.105	5.943	6.098	5.667	5.909	6.134	5.463
N	41	41	41	41	41	41	41
Welch's ANOVA	6.700*	8.670*	6.578*	0.255	4.232*	4.073*	0.102
Open collaborative innovation	*5.764*	*5.509*	*5.806*	*5.610*	*5.582*	*5.839*	*5.530*
N	264	264	264	264	264	264	264
Low (0-2)	5.843	5.424	5.750	5.515	5.563	5.909	5.591
N	44	44	44	44	44	44	44
Medium (3-4)	5.641	5.378	5.704	5.622	5.478	5.711	5.533
N	90	90	90	90	90	90	90
High (5-7)	5.822	5.628	5.895	5.633	5.662	5.904	5.508
N	130	130	130	130	130	130	130
Welch's ANOVA	1.668	1.950	1.206	0.289	1.120	1.027	0.064

Note: *$p < 0.05$

Table IX.
Importance of open innovation skills and abilities (OI competency clusters) for the intensity of adoption of open innovation activities

Notably, in the majority of cases, companies with a low degree of engagement in OI activities differ more from those with medium and high degrees of engagement while the difference between those with medium and high degrees of engagement is often negligible.

The most important competencies for all three groups of OI activities are OI management competency (Factor 1), innovative teamwork competency (Factor 3) and inter- and intra-organisational collaborative competency. Interestingly, the importance of these competencies is higher for companies that adopt open mass innovation more intensively than for other corresponding groups. Notably, companies with a high degree of engagement in open collaborative innovation activities place less importance on OI competencies than firms with a high degree of engagement in other groups of activities. At the same time, low adoption of collaborative innovation indicates higher importance of competencies than in the case of low adoption of open technology sourcing and open mass innovation. For that reason, the gap in competencies evaluation between active adopters of open collaborative innovation and those who are not actively involved in such activities is narrower than for other types of OI activity.

5. Development of an OI management competency model

In building an organisational competency model for OI, we sought to address the challenge of linking OI activities with supporting competency sets. The results led to the extraction of OI activity groups (or OI modes) that require specific competencies for their execution – that is, open technology sourcing (in and out), open mass innovation and open collaborative innovation. These extracted OI activity modes correspond to previous findings concerning inbound, outbound and coupled innovation (Vanhaverbeke *et al.*, 2014) and the monetary and non-monetary OI framework (Dahlander and Gann, 2010; Chesbrough and Brunswicker, 2013). We detected a changing landscape of OI, in which new crowd-driven innovation activities are adopted as intensively as more traditional activities such as technology sourcing. However, firms still adopt collaborative innovation activities most intensively.

Based on the factor analysis, each of the three OI modes requires a specific set of individual competencies. Open technology sourcing includes such monetary activities as the acquisition of external technologies, selling unutilised and unused technologies, intellectual property in- and out-licensing and, in particular, participation in industry standardisation, which requires specific search, commercialisation and negotiation skills at a high level. Companies that intensively adopt open technology (in and out) sourcing strategies (i.e. monetary OI activities) claim that the most important competencies are communication, technology and business mindset (> 6.3) and team working (> 6.2). The inbound and outbound OI processes are supported here by the high importance of external collaboration and internal knowledge sharing, networking, adaptability, ability to work in interdisciplinary environments and cross-functional teams (> 6.0).

The second OI mode, open mass innovation, includes such non-monetary activities as free revealing of ideas and intellectual property to external parties, crowdsourcing, use of external networks and idea and start-up competitions for innovation generation, with competency requirements related to collaboration and the transformation of broad sets of ideas. Team-working, communication (> 6.3) and networking (> 6.2) are most important for open mass innovation. Within the open mass innovation activity mode, ability to apply crowdsourcing to OI was identified as a critical skill for improvement. The adoption of activities involving a number of partners, crowds and networks also requires effective problem solving, strategic thinking, creativity and technology and business mindset, as well as external collaboration, trust and adaptability, the ability to work in interdisciplinary environments and cross-functional teams and the ability to work with external professional communities (> 6.0).

The third identified mode, open collaborative innovation, is based on both non-monetary and monetary activities, including collaborative innovation with external partners, subcontracting R&D, customer and consumer co-creation in R&D projects and scanning for external ideas. In terms of competency requirements, in anticipation of change towards OI management, collaboration for innovation with external partners and networking were identified as critical. However, along with external collaboration competency, collaborative innovation requires creativity, technology and business mindset and strategic thinking, as well as the ability to work in cross-functional teams, internal knowledge sharing and team-working. It should be noted here that the average importance of competencies in this group (5.9-6.1) was slightly lower than in the other two.

Based on these findings, an empirically grounded competency model for open innovation (CMOI) was developed (see Table X), relying for its structure principally on professional competencies modelling (Hafkesbrink and Schroll, 2014; Mulder, 2015), in that distinct and transferable sets of skills and abilities were used to construct the model.

The distinct OI competency reflects the need for companies to shape and manage innovation across ecosystem boundaries, combining multiple inbound and outbound knowledge sources within diverse and dynamic innovation processes. Referring to the vital need to tap into available knowledge across organisational boundaries and for effective internal and external knowledge flow management as identified in the literature (e.g. Carayannis and Campbell, 2011; Martinez-Conesa *et al.*, 2017; Palacios-Marqués *et al.*, 2015), firms must rely on distinct sets of competencies to manage "openness" as one way of handling the challenges of OI at the individual level (Bogers *et al.*, 2017). This "openness" is reflected in complex and dynamic exchanges of knowledge across internal and external networks and ecosystems, where effectiveness is defined by a set of explicit and implicit behaviours and micro decisions rather than as a single well-defined process. It follows that a distinct OI management competency requires the right combination of cultural awareness, ability to work with different professional communities, ability to share knowledge and ideas internally and externally, ability to work in an interdisciplinary environment and ability to work in internal cross-functional teams, complemented by communication and networking skills, adaptability and flexibility and management of inter-organisational collaboration processes.

The distinct OI management competency is complemented by specific transferable interpersonal and intrapersonal competencies that correspond quite closely to the competency categories formulated by Du Chatenier *et al.* (2010): self-management, interpersonal management, project management, and content management. We refer here to interpersonal competencies as those that manifest and are applied within interpersonal and organisational contexts. They are organisation specific (Soderquist *et al.*, 2010) and correspond in part to "interpersonal management" (Du Chatenier *et al.*, 2010). Intrapersonal competencies manifest at the individual level and are independent of any specific organisational context – that is, they are generic (Soderquist *et al.*, 2010), and correspond in part to Du Chatenier *et al.*'s (2010) self-management.

In the CMOI, interpersonal OI management competencies include innovative teamwork, inter- and intra- organisational collaboration and innovative project management. These competencies reflect specific sets of skills and abilities needed for successful exploration, combination and exploitation of innovation at the organisational/group level. Intrapersonal competencies encompass creative work, entrepreneurial leadership and failure tolerance. These are independent of the work context and fully transferable and are approached at the individual intrapersonal level, regardless of organisation and work profile.

The CMOI also embodies Mortara *et al.*'s (2009) introspective, extrospective and interactive competencies. In particular, the distinct OI management competency captures Mortara *et al.*'s interactive competencies by emphasising the value (both internally and externally) of relations with the world external to the organisation and the technical skills

Execution/Roles	Open innovation manager		
	Network and partnership manager		
	Knowledge manager		
	Intellectual capital manager		
	R&D manager/chief technology officer		
	Product marketing manager		
	Technology scouting manager		
Areas of expertise/ processes	Open technology (in and out) sourcing		
	External technologies acquisition		
	Selling unutilised/unused technologies		
	Intellectual property in- and out-licensing		
	Participation in standardisation		
	Open mass innovation		
	Free revealing of ideas and intellectual property to external parties		
	Crowdsourcing		
	Using external networks		
	Idea and start-up competitions		
	Open collaborative innovation		
	Collaborative innovation with external partners		
	Subcontracting R&D		
	Customer and consumer co-creation in R&D projects		
	Scanning for external ideas		
Professional competencies	OI management distinct competency		
	Cultural awareness		
	Ability to work with different professional communities		
	Ability to share knowledge and ideas internally/within an organisation		
	Ability to share knowledge and ideas externally		
	Ability to work in an interdisciplinary environment		
	Ability to work in internal cross-functional teams		
	Communication skills		
	Networking skills		
	Adaptability and flexibility		
	Managing inter-organisational collaboration processes		
Interpersonal competencies	Innovative team work competency	Inter- and intra-organisational collaboration competency	Innovation process competency
	Team-working skills	Internal collaboration skills	IP management skills
	Multi-tasking skills	External collaboration skills	Negotiation skills
	Problem-solving skills		Technology and business mindset
			Project management
Intrapersonal competencies	Creative work competency	Failure tolerance	Entrepreneurial leadership competency
	Creativity	Failure tolerance	Entrepreneurial skills
	New media literacy		Leadership skills
	Risk awareness		Trust skills

Table X. Open innovation management competency model

that support these relations. However, the CMOI focuses on integration rather than differentiation of skills and abilities to ensure effective OI management within the organisation and across the ecosystem. In relation to Hafkesbrink and Schroll (2014), while the distinct OI management competency captures both professional and personal competency categories, our interpersonal and intrapersonal competency categories correspond to their social and methodic competencies, respectively. Additionally, our competency model affords OI ambidexterity by building on data that explicitly integrate OI exploitation and exploration activities.

The proposed competency model contributes to the professionalisation of OI management (Chesbrough and Brunswicker, 2014) by identifying a distinct competency

associated with OI activity, as well as supporting interpersonal and intrapersonal competencies. These competencies support the job functions identified in companies searching for OI professionals as listed by Dabrowska and Podmetina (2014). As a whole, the proposed competency model answers the research question concerning the essential individual competencies for OI management and how these can be incorporated into a generic organisational competency model for OI. In so doing, the model complements and lends empirical validation to the competency frameworks proposed in earlier studies. The empirical grounding of the model enabled the integration of different theoretical approaches into a single construct and the construction of a model that represents actual competency development needs and perceptions based on the core activities of OI management. The model comprises three levels: OI roles, areas of expertise and individual competencies. Looking beyond the analysis of individual competencies, this wider perspective contributes to an understanding of how organisational capabilities can be based on individual competencies, and how both contribute to OI processes according to organisational needs and core areas of expertise. The competencies analysed here reflect industry's need for OI skills and abilities that can be clearly defined, measured and developed on the job and/or through training whenever possible.

The model's empirical base has two components: OI activities and OI competencies. It is particularly interesting that analysis of these parts reveals OI to be a holistic integrated process in respect of inbound and outbound activities and their related competencies (Chesbrough, 2003, 2006) while also a distinct process with regard to pecuniary and non-pecuniary OI activities (Dahlander and Gann, 2010). As a result, we have open technology in and out sourcing, group-only pecuniary and open mass innovation-only non-pecuniary processes. Similarly, the competency analysis revealed groups of competencies, two of which (inter- and intra-organisational collaboration competency and OI distinct management competency) were clearly associated with OI professional competencies, entailing mixed competencies associated with inbound and outbound OI, as well as with internal collaboration. This phenomenon points to the process of managing OI not only at intra- and extra-organisational levels (West *et al.*, 2014; Bogers *et al.*, 2010) but also at inter-organisational levels as well (Rohrbeck *et al.*, 2009). Here, the OI management process is expanded to include operation and management at the ecosystem level, requiring professional competencies in internal innovation, intra-organisational collaboration and cross-functional cooperation, external collaboration with various stakeholders, the ability to see the organisation as part of an ecosystem and the competency to manage collaboration at all levels.

6. Conclusions and further exploration

Contributing to the growing literature on human resource and competency management in an OI context, this paper identifies the individual competencies needed for adoption of OI and develops a generic CMOI management. These results contribute to the theory and practice of OI and HR management through the development of an original measurement instrument, presentation of original empirical results and development of the CMOI, with implications for both theory and practice. More precisely, our contributions can be summarised as follows.

Theoretical contributions

OI is a developing concept that still lacks theoretical grounding, widely accepted measurement instruments and quantitative empirical studies (Bogers *et al.*, 2017). The present study contributes to theory building by proposing and validating measurement scales for OI activities and professional competencies. This measurement tool is generic and can be used for OI competencies analysis in firms that differ in size, industry and

geographical location. Using these validated measurement scales, constructs related to open and collaborative innovation activities and their relation to competencies were validated and analysed, contributing to the growing though still limited body of research on the interconnections between HRM and OI (Vanhaverbeke *et al.*, 2014; West *et al.*, 2014).

The proposed CMOI builds on the existing literature (e.g. Du Chatenier *et al.*, 2010; Hafkesbrink and Schroll, 2014; Podmetina *et al.*, 2015) while moving beyond the conceptual, case-based or discrete empirical insights of those studies by proposing an integrated view of critical OI management competencies across all areas of OI expertise. This, in turn, facilitates construction of a dynamic model and links competency categories to particular managerial roles in OI. The core of the model is the distinct OI management competency, supported by professional, interpersonal and intrapersonal competencies, so reinforcing the conceptual links between competencies and innovation management (Mulder, 2015; Petroni *et al.*, 2012).

We found empirical evidence that, rather than focusing separately on inbound/outbound or internal/external collaboration processes, many companies instead consider OI as a holistic process and treat the organisation as part of an ecosystem, involving collaboration at different levels. This view informs recent calls for a more integrated approach to the different areas and levels of analysis in OI studies (Bogers *et al.*, 2017).

Practical implications

The results of this study build linkages between HR, competency and innovation management and provide insights for managers of different levels and functions. These results show how individual competencies can help to realise the potential of OI by articulating a model of the requisite competencies for executing OI and collaborative activities and constructing the organisational competencies for OI (Bogers *et al.*, 2017).

For practitioners, the following implications support the implementation, development and management of OI in organisations. Based on the CMOI model, we can trace the OI professional's profile, which includes specific knowledge of the ecosystem, a holistic approach to company operations and knowledge of inbound, outbound, internal and external collaboration processes. Additionally, the OI professional should possess a number of intrapersonal competencies, including creativity, leadership and entrepreneurial skills, as well as risk awareness and failure tolerance.

The linking of individual OI competencies and organisational level expertise, processes and managerial roles contributes to the discussion about how companies can build and structure an OI function. To date, the cross-functionality of OI has been neglected, and our results support managers in organising OI and clarifying linkages between OI and internal, cross-functional collaboration. The inventory of internal processes and competencies can help companies to establish distinct competitive advantages through innovation. The competency model for OI described here provides a general framework for OI competency analysis and development in organisations of different sizes across industries and countries. We believe that successful development of an organisational competency in OI is highly dependent on general characteristics such as company aims and ambition, management capability and maturity rather than just on the choice of OI mode. However, further success within each of the OI modes will depend on acquiring a set of skills to pursue particular activities. For example, while expertise in open technology in and out sourcing requires competencies in industry standardisation, the success of open mass innovation will rely heavily on the ability to apply crowdsourcing to OI, and improvement in open collaborative innovation requires a focus on collaboration for innovation with external partners. On the other hand, each of the identified OI processes requires the full set of skills for OI management competencies within organisations. It is also important to note that although OI activity modes were extracted for analytical

purposes, firms in reality combine various OI modes, resulting in coupled OI. In this regard, skill and competency combinations remain to be further elaborated in relation to OI management maturity, engagement level and other variables.

Limitations and future research

The present study has some limitations that should be addressed in future research. First, the data were collected from just one key informant per company. Although we sought to ensure that the respondent was a senior manager responsible for innovation, we cannot rule out the possibility of some bias in terms of how OI activities and related competencies are perceived. Future studies should therefore be designed to capture more opinions from each company, especially those of HR managers, CEOs and project managers in addition to innovation managers. This leads to a second limitation, as the exploratory nature of the research invites more systematic investigation of OI activity modes and competencies that inform the resulting competency model. In particular, competencies should be evaluated by an inter-professional sample of employees who are involved in and/or responsible for innovation, development and HR management, along with leaders of innovating companies.

Third, although the sample was of sufficient size for the analyses undertaken, it was too small to enable more fine-tuned analysis of regional differences across Europe in terms of how OI is managed through the development and implementation of competencies. Further analysis of these differences (which we assume reflect cultural variations) would be an interesting research direction that could be realised by introducing variables measuring cultural characteristics such as leadership style, strength of hierarchy, team dynamics and relational trust, and linking these to the most important OI competencies. Fourth, the present study did not control for familiarity with competency management and the possible use (or not) of a competency management system in the responding organisations. As our aim was to include companies of all sizes across most European countries, no such control was introduced because of the potential for definitional confusion and possible misinterpretation. In more focused samples, future research should introduce such controls and should analyse the interplay between more or less advanced HR practices and OI implementation and outcomes.

In conclusion, this paper makes a significant contribution to the study of OI by proposing measurement tools for OI activities and competencies, and by developing the OI management competency model. This research invites discussion of required and desired employee skills in firms implementing OI. It also proposes an interdisciplinary approach by seeking to integrate OI and HRM research streams, which can contribute to the development of practices related to OI human resource management, including training, reward systems, recruitment and an understanding of the role of OI managers. Additionally, the questionnaire and validated scales provide a unique tool for evaluating current and desired OI-related skills. We believe that the present findings will be of great value to a wide range of innovation professionals in academia, industry and consulting and will stimulate debate around the crucial common competencies for OI, as well as competencies related to local industrial needs.

References

Athey, T.R. and Orth, M.S. (1999), "Emerging competency methods for the future", *Human Resource Management*, Vol. 38 No. 3, pp. 215-225.

Bianchi, M., Cavaliere, A., Chiaroni, D., Frattini, F. and Chiesa, V. (2011), "Organisational modes for open innovation in the bio-pharmaceutical industry: an exploratory analysis", *Technovation*, Vol. 31 No. 1, pp. 22-33.

Blindenbach-Driessen, F. and van den Ende, J. (2014), "The locus of innovation: the effect of a separate innovation unit on exploration, exploitation, and ambidexterity in manufacturing and service firms", *Journal of Product Innovation Management*, Vol. 31 No. 5, pp. 1089-1105.

Bogers, M., Afuah, A. and Bastian, B. (2010), "Users as innovators: a review, critique, and future research directions", *Journal of Management*, Vol. 36 No. 4, pp. 857-875.

Bogers, M., Zobel, A.-K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, L., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M.G., Majchrzak, A., McCarthy, I.P., Moeslein, K.M., Nambisan, S., Piller, F.T., Radziwon, A., Rossi-Lamastra, C., Sims, J. and Ter Wal, A.L.J. (2017), "The open innovation research landscape: established perspectives and emerging themes across different levels of analysis", *Industry and Innovation*, Vol. 24 No. 1, pp. 8-40.

Boyatzis, R.E. (1982), *The Competent Manager: A Model of Effective Performance*, John Wiley and Sons, New York, NY.

Carayannis, E.G. and Campbell, D.F. (2011), "Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation concepts and the 'mode 3' knowledge production system", *Journal of the Knowledge Economy*, Vol. 2 No. 3, pp. 327-372.

Catano, V.M. (1998), *Competencies: A Review of the Literature*, Canadian Council of Human Resources Associations and Saint Mary's University, Halifax.

Chesbrough, H. (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, Boston, MA.

Chesbrough, H. (2006), *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press, Boston, MA.

Chesbrough, H. and Bogers, M. (2014), "Explicating open innovation: clarifying an emerging paradigm for understanding innovation", in Chesbrough, H., Vanhaverbeke, W. and West, J. (Eds), *New Frontiers in Open Innovation*, Oxford University Press, Oxford, pp. 3-28.

Chesbrough, H. and Brunswicker, S. (2013), "Managing open innovation in large firms", Survey Report: Executive Survey on Open Innovation 2013, Fraunhofer Verlag, Stuttgart.

Chesbrough, H. and Brunswicker, S. (2014), "A fad or a phenomenon? The adoption of open innovation practices in large firms", *Research-Technology Management*, Vol. 57 No. 2, pp. 16-25.

Chiaroni, D., Chiesa, V. and Frattini, F. (2011), "The open innovation journey: how firms dynamically implement the emerging innovation management paradigm", *Technovation*, Vol. 31 No. 1, pp. 34-43.

Crossan, M.M. and Apaydin, M. (2010), "A multi-dimensional framework of organizational innovation: a systematic review of the literature", *Journal of Management Studies*, Vol. 47 No. 6, pp. 1154-1191.

Dabrowska, J. and Podmetina, D. (2014), "Identification of competences for open innovation", *XXV ISPIM Conference – Innovation for Sustainable Economy and Society*, *Dublin*, *8-11 June*.

Dahlander, L. and Gann, D.M. (2010), "How open is innovation?", *Research Policy*, Vol. 39 No. 6, pp. 699-709.

Du Chatenier, E., Verstegen, J.A., Biemans, H.J., Mulder, M. and Omta, O.S. (2010), "Identification of competencies for professionals in open innovation teams", *R&D Management*, Vol. 40 No. 3, pp. 271-280.

Etzkowitz, H. and Leydesdorff, L. (2000), "The dynamics of innovation: from national systems and 'mode 2' to a triple helix of university-industry-government relations", *Research Policy*, Vol. 29 No. 2, pp. 109-123.

Feld, B. (2012), *Startup Communities: Building an Entrepreneurial Ecosystem in Your City*, Wiley, Hoboken, NJ.

Ferraris, A., Erhardt, N. and Bresciani, S. (2017), "Ambidextrous work in smart city project alliances: unpacking the role of human resource management systems", *The International Journal of Human Resource Management*, available at: www.tandfonline.com/action/showCitFormats?doi=10.1080%2F09585192.2017.1291530

Ferraris, A., Santoro, G. and Dezi, L. (2017), "How MNC's subsidiaries may improve their innovative performance? The role of external sources and knowledge management capabilities", *Journal of Knowledge Management*, Vol. 21 No. 3, pp. 540-552.

Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, Pinter Publishers, London.

Garavan, T.N. and McGuire, D. (2001), "Competencies and workplace learning: some reflections on the rhetoric and the reality", *Journal of Workplace Learning*, Vol. 13 No. 4, pp. 144-163.

Hafkesbrink, J. and Schroll, M. (2014), "Ambidextrous organizational and individual competencies in open innovation: the dawn of a new research agenda", *Journal of Innovation Management*, Vol. 2 No. 1, pp. 9-46.

Harvey, M.G., Novicevic, M.M. and Speier, C. (2000), "An innovative global management staffing system: a competency-based perspective", *Human Resource Management*, Vol. 39 No. 4, pp. 381-394.

Huizingh, E.K.R.E. (2011), "Open innovation: state of the art and future perspectives", *Technovation*, Vol. 31 No. 1, pp. 2-9.

Jansen, J.J.P., Tempelaar, M., Van den Bosch, F.A.J. and Volberda, H.W. (2009), "Structural differentiation and ambidexterity: the mediating role of integration mechanisms", *Organization Science*, Vol. 20 No. 4, pp. 797-811.

Keely, L., Pikkel, R., Quinn, B. and Walters, H. (2013), *Ten Types of Innovation: The Discipline of Building Breakthroughs*, Wiley, Hoboken, NJ.

Keupp, M.M., Palmié, M. and Gassmann, O. (2012), "The strategic management of innovation: a systematic review and paths for future research", *International Journal of Management Reviews*, Vol. 14 No. 4, pp. 367-390.

Kile, C.O. and Phillips, M.E. (2009), "Using industry classification codes to sample high-technology firms: analysis and recommendations", *Journal of Accounting, Auditing & Finance*, Vol. 24 No. 1, pp. 35-58.

Kortmann, S. and Piller, F.T. (2016), "Open business models and closed-loop value chains: redefining the firm-consumer relationship", *California Management Review*, Vol. 58 No. 3, pp. 1-12.

Lathi, R.K. (1999), "Identifying and integrating individual level and organizational level core competencies", *Journal of Business and Psychology*, Vol. 14 No. 1, pp. 59-75.

Lauby, S. (2013), "The difference between knowledge, skills and abilities", blog, available at: www.hrbartender.com/2013/recruiting/the-difference-between-knowledge-skills-and-abilities/ (accessed 24 April 2017).

Laursen, K. and Salter, A. (2006), "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms", *Strategic Management Journal*, Vol. 27 No. 2, pp. 131-150.

Lawler, E.E. (2005), "From human resource management to organizational effectiveness", *Human Resource Management*, Vol. 44 No. 2, pp. 165-169.

Li, Y., Vanhaverbeke, W. and Schoenmakers, W. (2008), "Exploration and exploitation in innovation: reframing the interpretation", *Creativity and Innovation Management*, Vol. 17 No. 2, pp. 107-126.

Lundvall, B.A. (1992), *National Systems of Innovations: Towards a Theory of Innovation and Interactive Learning*, Pinter Publishers, London.

Luoma, M. (2000), "Developing people for business success: capability-driven HRD in practice", *Management Decision*, Vol. 38 No. 3, pp. 145-153.

March, J.G. (1991), "Exploration and exploitation in organizational learning", *Organization Science*, Vol. 2 No. 1, pp. 71-87.

Martinez-Conesa, I., Soto-Acosta, P. and Carayannis, E.G. (2017), "On the path towards open innovation: assessing the role of knowledge management capability and environmental dynamism in SMEs", *Journal of Knowledge Management*, Vol. 21 No. 3, pp. 553-570.

Mortara, L., Napp, J.J., Slacik and Minshall, T. (2009), *How to Implement Open Innovation: Lessons from Studying Large Multinational Companies*, University of Cambridge Institute for Manufacturing, Cambridge.

Mulder, M. (2007), "Competence: the essence and use of the concept in ICVT", *European Journal of Vocational Training*, Vol. 40, pp. 5-22.

Mulder, M. (2015), *Professional Competence in Context – A Conceptual Study*, American Educational Research Association, Chicago, IL, 19 April.

Nelson, R.R. (1993), *National Innovation Systems: A Comparative Analysis*, Oxford University Press, Oxford.

Nordhaug, O. (1998), "Competencies specificities in organisations", *International Studies of Management and Organisation*, Vol. 28 No. 1, pp. 8-29.

Palacios-Marqués, D., Merigó, J.M. and Soto-Acosta, P. (2015), "Online social networks as an enabler of innovation in organizations", *Management Decision*, Vol. 53 No. 9, pp. 1906-1920.

Petroni, G., Venturini, K. and Verbano, C. (2012), "Open innovation and new issues in R&D organization and personnel management", *International Journal of Human Resource Management*, Vol. 23 No. 1, pp. 147-174.

Podmetina, D., Volchek, D., Dąbrowska, J. and Fiegenbaum, I. (2013), "Human resource practices and open innovation", *International Journal of Innovation Management*, Vol. 17 No. 6, p. 1340019, available at: www.worldscientific.com/doi/abs/10.1142/S1363919613400197

Podmetina, D., Hafkesbrink, J., Teplov, R., Dąbrowska, J. and Petraite, M. (2015), "What skills and competences are required to implement open innovation?", *XXVI ISPIM Conference – Shaping the Frontiers of Innovation Management, Budapest, 14-17 June*.

Podmetina, D., Soderquist, K.E., Dabrowska, J., Hafkesbrink, J. and Lopez-Vega, H. (2017), "Industrial needs for open innovation education", in Mention, A.L., Nagel, A., Hafkesbrink, J. and Dabrowska, J. (Eds), *Innovation Education Reloaded: Nurturing Skills for the Future*, The Open Innovation Handbook, LUT.

Podmetina, D., Equey, C., Kleer, R., Lopez Vega, H., Dabrowska, J., Albats, E., Petraite, M., Soderquist, K.E., Rethi, G. and Hafkesbrink, J. (2017), "Report on industrial needs for open innovation education", OI-Net project deliverable, available at: http://oi-net.eu/m-oinet-network/m-oinet-key-topics/m-wp2-industrial-needs (accessed 30 October 2017).

Podsakoff, P.M. and Organ, D.W. (1986), "Self-reports in organizational research: problems and prospects", *Journal of Management*, Vol. 12 No. 4, pp. 531-544.

Porter, M.E. (2000), "Location, competition, and economic development: local clusters in a global economy", *Economic Development Quarterly*, Vol. 14 No. 1, pp. 15-34.

Raisch, S., Birkinshaw, J., Probst, G. and Tushman, M.L. (2009), "Organizational ambidexterity: balancing exploitation and exploration for sustained performance", *Organization Science*, Vol. 20 No. 4, pp. 685-695.

Rohrbeck, R., Hölzle, K. and Gemünden, H.G. (2009), "Opening up for competitive advantage – how Deutsche Telekom creates an open innovation ecosystem", *R&D Management*, Vol. 39 No. 4, pp. 420-430.

Rowe, C. (1995), "Clarifying the use of competence and competency models in recruitment, assessment and staff development", *Industrial and Commercial Training*, Vol. 27 No. 11, pp. 12-17.

Sandberg, J. (2000), "Understanding human competence at work: an interpretative approach", *Academy of Management Journal*, Vol. 43 No. 1, pp. 9-25.

Scuotto, V., del Giudice, M., Bresciani, S. and Meissner, D. (2017), "Knowledge-driven preferences in informal inbound open innovation modes: an explorative view on small to medium enterprises", *Journal of Knowledge Management*, Vol. 21 No. 3, pp. 640-655.

Soderquist, K.E., Papalexandris, A., Ioannou, G. and Prastacos, G. (2010), "From task-based to competency-based: a typology and process supporting a critical HRM transition", *Personnel Review*, Vol. 39 No. 3, pp. 325-346.

Spithoven, A., Vanhaverbeke, W. and Roijakkers, N. (2013), "Open innovation practices in SMEs and large enterprises", *Small Business Economics*, Vol. 41 No. 3, pp. 537-562.

Vanhaverbeke, W., Chesbrough, H. and West, J. (2014), "Surfing the new wave of open innovation research", in Chesbrough, H., Vanhaverbeke, W. and West, J. (Eds), *New Frontiers in Open Innovation*, Oxford University Press, Oxford, pp. 281-294.

Virlée, J., Hammedi, W. and Parida, V. (2015), "Open innovation implementation in the service industry: exploring practices, sub-practices and contextual factors", *Journal of Innovation Management*, Vol. 3 No. 2, pp. 106-130.

Visnjic, I., Wiengarten, F. and Neely, A. (2016), "Only the brave: product innovation, service business model innovation, and their impact on performance", *Journal of Product Innovation Management*, Vol. 33 No. 1, pp. 36-52.

Vrontis, D., Thrassou, A., Santoro, G. and Papa, A. (2017), "Ambidexterity, external knowledge and performance in knowledge-intensive firms", *The Journal of Technology Transfer*, Vol. 42 No. 2, pp. 374-388.

Walrave, B. and Raven, B. (2016), "Modelling the dynamics of technological innovation systems", *Research Policy*, Vol. 45 No. 9, pp. 1833-1844.

West, J., Vanhaverbeke, W. and Chesbrough, H. (2006), "Open innovation: a research agenda", in Chesbrough, H., Vanhaverbeke, W. and West, J. (Eds), *Open Innovation: Researching a New Paradigm*, Oxford University Press, Oxford, pp. 285-307.

West, J., Salter, A., Vanhaverbeke, W. and Chesbrough, H. (2014), "Open innovation: the next decade", *Research Policy*, Vol. 43 No. 5, pp. 805-811.

Further reading

Mention, A.L., Nagel, A., Hafkesbrink, J. and Dabrowska, J. (2017), *Innovation Education Reloaded: Nurturing Skills for the Future*, The Open Innovation Handbook, LUT, Lappeenranta.

Appendix

Retained variables (in brackets […] the aggregated or other integrated variables)	Measurement	Sources
What skills should an open innovation specialist have? Please evaluate the importance of the following items IP management skills, negotiation skills, entrepreneurial skills, leadership skills [decision-making skills, evaluation of risks], team-working skills, multi-tasking skills, problem-solving skills [knowledge concentration, knowledge brokerage], virtual collaboration skills, internal collaboration skills, external collaboration skills [understand the fit with partners' strategies, resolve conflicts, business knowledge], trust skills, communication skills, networking skills	1 not important, 7 very important	Mortara *et al.* (2009), Du Chatenier *et al.* (2010), Hafkesbrink and Schroll (2014), Dabrowska and Podmetina (2014) and interpreted by authors
What abilities should an open innovation specialist have? Please evaluate the importance of the following items Technology and business mindset, project management, adaptability and flexibility, managing the inter-organisational collaboration process, ability to work in an interdisciplinary environment, ability to work in internal cross-functional teams [develops team spirit, feels responsible for the team, deals with flexible team composition], strategic thinking [vision, coping with complexity, novel and adaptive thinking], creativity, new media literacy, cultural awareness, ability to work with different professional communities [possesses knowledge and perceptions of various professional areas and languages, systems thinking, synthesis thinking], ability to share knowledge and ideas internally/within the organisation [ability to learn, sociability, shares information freely with others], ability to share knowledge and ideas externally [ability to learn, sociability, shares information freely with others], risk awareness, failure tolerance [ambiguity tolerance, dialectic thinking, mediation]	1 not important, 7 very important	
Open innovation activities – measurement of actual level of open innovation adoption Do you adopt the following activities in your company? 1. Customer and consumer co-creation in R&D projects 2. Crowdsourcing 3. Scanning for external ideas 4. Collaborative innovation with external partners (i.e. suppliers, universities, competitors, etc.) 5. Subcontracting R&D 6. Idea and start-up competitions 7. Using external networks (e.g. associations, intermediaries, knowledge brokers) 8. Participation in standardisation (public standards)/influencing industry standards 9. Free revealing (e.g. ideas, IP) to external parties 10. IP in-licensing	Intensity of adoption: 1 – no, we do not (adopt), 2 – very seldom, 9 – very	Chesbrough and Brunswicker (2013, 2014) and interpreted by authors

(*continued*)

Table AI. Operationalisation of variables

Retained variables (in brackets […] the aggregated or other integrated variables)	Measurement	Sources
11. IP out-licensing 12. External technologies acquisition 13. Selling unutilised/unused technologies		
Size	Large > 250, small and medium-sized 10-250, micro 1-9	The European Union classification
Industry	Nominal variable	Global Industry Classification System (GICS) (www.msci.com/gics)
High tech	1 – high tech 0 – low and medium tech	Global Industry Classification System (GICS). Kile and Phillips (2009)
Region Northern Europe: Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Norway, Sweden, UK Southern Europe: Bosnia and Herzegovina, Croatia, Cyprus, Greece, Italy, Macedonia, Malta, Portugal, Serbia, Slovenia, Spain Western Europe: Austria, Belgium, France, Germany, Luxembourg, Switzerland, the Netherlands Eastern Europe: Czech Republic, Hungary, Poland, Romania, Slovak Republic	Nominal variable	

Source: Adopted from Podmetina, Equey, Kleer, Lopez Vega, Dabrowska, Albats, Petraite, Soderquist, Rethi and Hafkesbrink (2017, pp. 8-10) and Podmetina, Soderquist, Dabrowska, Hafkesbrink and Lopez-Vega (2017, pp. 8-10)

Table AI.

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