Configuring HRM Practices for Open Innovation: But Can It Deliver?

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ABSTRACT

Though current scholarly interest generates a sustained growth of literature on open innovation, we need to learn more about human resource practices relating to open innovation. Building on the ability-motivation-opportunity (AMO) framework, we demonstrate the differential impact of human resources practice bundles on open innovation. We also find evidence that motivation-enhancing and competency-enhancing practices share a compensating effect on open innovation. Using firm-level data from 2540 Italian manufacturing firms, our study, if not first, contributes to the growing bodies of research on open innovation by bringing forth the human dimension to the forefront and offering a drilled-down practice-level view that needs to be addressed in the literature.

KEYWORDS

HR Practice Bundles, Open Innovation, Ability–Motivation–Opportunity (AMO) Framework, Knowledge Sharing

INTRODUCTION

Open innovation refers to a way of innovating where knowledge is intentionally shared among different organizations to create new ideas and solutions (Chesbrough et al., 2014). Although extant literature delved deep into open innovation (Ferrarini & Curzi, 2022; Naqshbandi et al., 2023), the role of human resource practices in open innovation still needs to be explored. The answer to this question is crucial because it can help explain the contribution of human resource function to the corporate strategy. Capturing organizational infrastructure that enables and facilitates open innovation - the new emergent form of innovation is important because "the ability to translate strategic rhetoric into workplace reality" remained a significant challenge hitherto (Marchington, 2015, p.176). In this article, using firm-level data from 2540 Italian manufacturing firms, we examine specific human resource practices that have potential explanatory power with regard to open innovation.

While presenting a review of the contributions of HRM (Human Resource Management) during the last 30 years, Beer et al., (2015) urged that "it is now time to go beyond …. and to acknowledge the role of multiple stakeholders that organizations deal with every day and bring our studies back into line with the reality faced by those involved" (p.428). Motivated by such a clarion call, we made an attempt to empirically demonstrate how active orchestration of HRM practices could be related to open innovation. Thus, our research aims at exploring the interplay of diverse stakeholders, open innovation, and human resource management practices. Building on the emergent literature on open innovation, our research contributes to bringing forth the human dimension of open innovation to the

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forefront. Though recently, a few research works examined the role of HR in open innovation (Ferrarini & Curzi, 2022; Naqshbandi et al., 2023), our research work demonstrates the differential impact of human resources practice bundles on open innovation. We also find evidence that motivation-enhancing and competency-enhancing practices share a compensating effect on open innovation. Our study contributes to the growing bodies of research on open innovation by bringing forth the human dimension to the forefront and offers a drilled-down practice-level view which has been neglected in the literature so far.

The growing literature on open innovation appears to be tilted towards the research on the effectiveness of open innovation rather than locating enabling dynamics (West & Bogers, 2014; Tucci et al., 2016). Extant research on open innovation reported that the researchers paid more attention to extracting the relationship between open innovation and performance facets (West et al., 2006; West & Bogers, 2014; Tucci et al., 2016). Our research explores human resource practice-based explanations that may be relevant for open innovation - thus, our research contributes to the relatively unserved domain related to open innovation.

We organized our research paper in the following manner. First, we explicate selective organizational constraints that need to be addressed while leveraging externally developed knowledge. Using the ability-motivation-opportunity framework and the too-much-of-a-good-thing (TMGT) effect, we argue that human resource managers utilize capacity-enhancing, motivation-enhancing, and opportunity-enhancing HR interventions to deal with these organizational constraints. We explore plausible relationships among these HR interventions with regard to open innovation and develop hypotheses. Subsequently, we defend and advance arguments to support the research method that we have adhered to execute our research. Then, followed by a detailed tabular presentation of our analysis, we present a graphical analysis of our non-linear models through a simulation-based technique in line with extant research (King et al., 2000; Brambor et al., 2006; Zelner, 2009). To rule out alternative interpretations of our results, we utilize a number of robustness tests. Finally, we present a brief discussion and managerial implication of our study before highlighting the limitations of our study and drawing a conclusion about our current research endeavour.

LITERATURE REVIEW

Human resource management practices promote a safe climate (Zacharatos et al., 2005), enhance organizational commitment (Gong et al., 2009), improve service performance (Chuang & Liao, 2010), contribute to sales growth (Batt, 2002), and contribute to innovative performance as well (Arvanitis et al., 2016). However, very few studies hitherto examined the relationship between human resource management and open innovation. For example, using a qualitative framework, Petroni et al., (2012) examined how the adoption of open innovation process orchestrated change in the organization structure of R&D. Likewise, using a mixed method strategy Lazzarotti et al., (2015) examined the mediating role of organization and social antecedents that governs the relationship between open innovation and performance. Using a case study-based approach, Ollila & Elmquist (2011) outlined various challenges associated with open innovation. Using a case-based approach, Yström et al., (2015) identified a few challenges in handling uncertainties (such as work identities, information sharing and knowledge transparency) which are often associated with open innovation processes. Using an inductive approach, Ollila & Yström (2016) identified three managerial roles such as facilitator, tactician, and sense giver, that are crucial for innovation in an open, collaborative setting. Using the observed pattern of project membership and code contribution, Belenzon and Schankerman (2015) explained the important role of intrinsic motivation, reputation, and labour market signaling in an open innovation context. None of these studies, however, addressed the questions that we raised in our research.

Innovation inefficiencies, shorter product life cycles and rising costs compel firms to engage in open innovation processes. Some of the pioneering firms, such as IBM, Procter and Gamble, Air Product and Chemicals, and Siemens, initiated programmes to deal with cultural bottlenecks that may prevent firms from open innovation (Chesbrough, 2007; Escher, 2003; Kline, 2003). In explaining the HRM-performance relation, literature increasingly draws upon the AMO framework (Paauwe et al., 2013). The AMO framework advances that some combination of an individual's ability (A), motivation (M) and opportunities (O) can give us a measure of an individual's performance. The underlying arguments revolve around the assumptions that employees need to have *abilities* (competencies) and *motivation* (incentives) to perform work in an organizational context that provides adequate support and *opportunity* to perform (Boxall & Purcell, 2011). Based on this framework, HR practices are designed to improve and strengthen each of these elements. When these practices are combined in the right way, they can have a positive impact on how well the organization performs. However, literature provides mixed guidance on AMO-based HR practices (capacity-enhancing, motivation-enhancing and empowerment-enhancing HR practices) for its effectiveness. Though capacity-enhancing practices contribute positively, over-trained employees may locate better market value for their talent elsewhere, thereby negatively affecting firms' performance. Similarly, empowerment-enhancing practices provide ample opportunity for the willing and able employees to perform, but too much empowerment can increase co-ordination costs. Therefore, AMO-based HR practices are indeed a necessary and good thing, but they can also potentially undermine the positive contribution when available in higher quantities. The "too-much-of-a-good-thing" (TMGT) effect signifies that if one HR practice is used too much, even though it is good at first, it can end up causing problems and have a curved, or nonlinear, relationship with the desired outcome (Pierce & Aguinis, 2013). This framework shows that there are limits to how much benefit one can get from using HR practices. Neglect of the curvilinearity possibilities makes a large amount of organizational outcome research 'seriously flawed' (Luft & Shields, 2003). Therefore, curvilinearity should be the rule rather than the exception (Pierce & Aguinis, 2013). Explicating the simultaneous interplay between the underlying weight of the contribution and erosion of HR practices over open innovation, we develop plausible hypotheses. We build arguments on how human resource functions deal with organizational constraints, outlined earlier, to unleash the power of open innovation in organizational contexts:

EMPOWERMENT-ENHANCING HR PRACTICES

Empowerment-enhancing practices are characterized by decentralized decision-making and self-managed teams designed to provide employees with opportunities and information to contribute to organizational innovation (Delery & Shaw, 2001; Gardner et al., 2011). Chained in bureaucratic rules and corporate rituals, employees often experience a sense of powerlessness, which prevents them from merit-based participation in organizational activities. This sense of powerlessness may be purely fictional and may or may not correspond to actual organizational realities. Human Resource managers create organizational infrastructure in terms of processes, systems, and practices to address these concerns. To enable open innovation, HR managers actively introduce employee diversity, especially educational diversity, in the organizational infrastructure (Bogers et al., 2018). The linkages between innovation and management teams (i.e., the middle management teams as well as the top management teams are positive, though their effects depend upon their configuration (Schubert & Tavassoli, 2020). HR managers encourage employee participation in innovation processes by supporting, enabling, and even driving open innovation, depending on the strategic intent of their implementation. (Tirabeni & Soderquist, 2019). As sharing of inventive experience across invention teams positively influences firm-level innovation output, HR managers could influence these team-level sharing by actively managing HR policies. With the use of panel data on new biotechnology

ventures, it is reported that concentrated structures are related to higher firm-level innovation quality, nourished by more equal contributions from their teams. Introducing self-managed teams, enabling employee participation in the organizational decision-making processes, and accommodating delegation in the main frame of organizational operation, HR Managers often try to offer psychological safety and a sense of collective ownership (Cogner & Kanungo, 1988) as well as the collective level of self-efficacy, leading to enhanced level of task meaningfulness and employee engagement. Thus, employees are motivated to exercise more discretionary choices whenever an opportunity arises; this kind of discretionary behaviour produces fruitful results in an open innovation context.

Uncertainty is an inherent feature of the innovation processes and cannot be completely done away with. Unless actively managed, uncertainty may dampen innovation due to the fear of failure in a punitive climate (Danneels, 2008). Therefore, firms foster an egalitarian culture that offers psychological safety (Edmondson, 1999), enabling the breaking of existing scripts for deriving relatively more creative solutions (Keltner et al., 2003). In dealing with the NIH (Not-invented-here) syndrome, empowerment-enhancing practices facilitate generous information dissemination (Amabile, 1983; Deci & Ryan, 1985) and orchestrate social influence (Crano & Prislin, 2006). The empowerment-enhancing mechanism promotes non-routine and reciprocal information processing by overcoming differences, managing dominant interpretations, and building understanding among employees (Jansen et al., 2005). Without a cooperative organizational climate, firms may not be able to implement externally acquired knowledge for innovation (Hillebrand & Biemans, 2004). Whereas prevailing NSH (Not-shared-here) syndrome propagates a secluded organizational life for its employees, empowering employees to strengthen cross-functional interfaces and create a conducive environment for learning, sharing, and combining knowledge, leading to creativity (Huber, 1991). The empowerment mechanism, embedded in the organizational framework, potentially enhances the self-efficacy levels of individual employees. With an increased level of self-efficacy, employees holding a conservative attitude towards external knowledge may gain confidence to deal with external partners for knowledge and collaborative engagement. By introducing empowerment-enhancing bundles, firms attempt to build a culture that offers respect and dignity for failure (Buckler & Zien, 1996). Allowing smart failure, firms attempt to create a risk-free environment (Williams, 1998) that may encourage employees to develop an appreciation for external knowledge.

Second-order competencies involve disowning some part of current organizational practices, which may inherit legendary and romantic connotations for their fruitfulness over the years. Therefore, dismantling some parts of these legendary frameworks may create substantial political hurdles. Empowerment-enhancing bundles attempt to build a culture by allowing open debate in place of behind politicking (Eisenhardt & Bourgeois, 1988), facilitating safe human exchanges (George, 2007), discouraging dysfunctional conflict that distorts and withholds crucial information (Menon et al., 1996). By introducing empowerment-enhancing processes, firms make vigorous attempts to deal with a sense of powerlessness and resistance (Staw, 2009; Keltner et al., 2003) and focus on issues that people involved (Amason, 1996). So, instead of personal attacks and blame games as a means of personal safety, firms steer the dialogues on issues only (Jehn, 1995). This active nurture of human expression fosters a great diversity of ideas due to open exchanges (Kanter, 1988). It does not imply disowning conflict altogether but allows a sense of constructive conflict that offers a better decision and greater satisfaction (Tjosvold, 1985). Constructive conflict is better as it facilitates vigorous debate for second-order competence (Danneels, 2008) by enabling a richer range of ideas to emerge (Eisenhardt et al., 1997) without losing psychological safety (Edmondson, 1999). Thus, empowerment-enhancing bundles encourage risk-taking behaviour with adequate psychological safety, facilitate collective decision-making processes, and enable knowledge acquisition and validation through collective internal screening without retaliatory fear of failure or error of judgment. Thus, we argue that empowerment-enhancing bundles should share a positive relationship with open innovation.

Hypothesis 1: Empowerment-enhancing practice bundles share a positive relationship with open innovation. (H1).

MOTIVATION-ENHANCING HR PRACTICES

Motivation-enhancing practices are characterized by monetary incentives, merit-based pay, and non-monetary incentives that motivate discretionary employee effort and behaviour (Gardner et al., 2011). Employees participating in open innovation ecology enjoy privileged access to information and thereby enjoy unaccounted opportunities to add value to the focal organization. Many of these interactions offer unique exchanges of tacit knowledge, thereby remaining beyond the scrutiny of formal mechanisms. Thus, employees participating in an open innovation platform may exercise more discretionary power than in-role behaviour. During regular interactions with external knowledge search partners, employees may discover discretionary opportunities for radical contributions leading to serendipitous outcomes. Serendipity implies the sudden discovery of a product/process that was not the aim of the focal research project (Austin et al., 2012). Hoarding of such discovery for subsequent personal use may deprive the focal organization of the benefit of such discovery. In this regard, we notice empirical substantiation that rewards instituted for sharing knowledge within firms trigger autonomous motivation to share knowledge. Likewise, the enlightened HR system can evidently contribute to team-level knowledge sharing and control for knowledge hoarding (Chuang et al., 2016)

Contrary to this robust discourse, there have been alternative findings that monetary incentives share a negative relationship (Bock et al., 2005; Deci et al., 1999) with innovative behaviour and no relationship with radical innovation. Two major components of motivation-enhancing practices – extrinsic reward and intrinsic reward – behave differently with creativity and other relevant organizational outcomes. Where intrinsic reward has consistently exerted influences on organizational innovation, extrinsic reward shares an occasional positive relationship with innovation-related outcomes and even shares a negative relationship with innovation (Bock et al., 2005; Cabrera et al., 2006; Foss et al., 2009). To explain these unintended consequences, scholars argued that extrinsic reward undermines intrinsic motivation and diverts attention from autonomy, freedom and self-realization to economic gain and due formal compliance (Amabile & Conti, 1997). External rewards exert a negative effect on knowledge sharing by 'crowding out' the influence of intrinsic motivation (Osterloh & Frey, 2000).

Motivation-enhancing practices aim at reinforcing and rewarding certain pre-determined positive behaviour displayed and accomplished by employees. Thus, motivation-enhancing practices include monetary and non-monetary rewards. Though monetary reward, being hygienic, with limited latitude to steer employee behaviour toward the accomplishment of certain objectives, a comprehensive reward scheme is essential to drive motivational instinct among employees (Lawler, 1986). Literature uses broad classification rules to distinguish reward: extrinsic reward and intrinsic reward (Deci, 1975; Jeffery & Shaffer, 2007). A broad category of research generally converges to state that monetary incentives enhance innovative behaviour, compensating for risk-taking and creative behaviour (Eisenberger & Cameron, 1996; Laursen & Foss, 2003; Alexy & Leitner, 2011). Social exchange theory (Blau, 1964) predicts that employees' participation in knowledge-sharing activities is purely calculative in nature, derived from estimated costs and potential benefits; therefore, extrinsic rewards will have the potency to influence employees positively (Cabrera et al., 2006; Foss et al., 2009). A monetary reward does not have the potency to trigger inspired participation (Füller et al., 2008). Substantial research informs that non-monetary incentives promote an innovative organizational atmosphere, build commitment, and motivate to acquire new competencies. Non-monetary incentives enhance

employee involvement, which in turn encourages employees to seek out meaning and challenges at work.

Hypothesis 2: Motivation-enhancing practice bundles share a positive relationship with open innovation. (H2)

COMPETENCE-ENHANCING HR PRACTICES

Competency-enhancing practices are characterized by training that enhances the level of the knowledge, skills, and abilities of the organization's employees (Gardner et al., 2011). While under the intense grip of NIH, employees held a biased attitude, favoring only knowledge that had been produced internally. Likewise, NSH (Not Shared Here) syndrome prevents firms from sharing internally produced knowledge with external agencies, depriving firms of building a crucial relationship and monetizing internally produced knowledge. In an open innovation context, NIH (Not Invented Here) and NSH syndromes are grossly dysfunctional and undesirable. Therefore, human resource managers deploy a number of organizational processes to weaken the impact of these negative predispositions. For example, some of the leading firms such as Hewlett-Packard, Siemens, IBM, and Procter & Gamble launched intense training programs aimed at altering these dysfunctional predispositions prior to the introduction of open innovation strategies (Chesbrough, 2007; Escher, 2003; Kline, 2003; Houston & Sakkeab, 2006). Behavioural science informs that to modify employee attitudes, human resource managers use training as a useful and effective device (Ehrhardt et al., 2011). Training contributes to improvement in firms' performance by positively influencing the quality of customer service, organizational effectiveness, and job satisfaction (Tharenou et al., 2007). While training works as an effective device to modify dysfunctional employees' attitudes, it can also work to enhance competencies, enabling collaborative engagement with external partners.

Collaborative interactions require good interpersonal skills (Chung & Jackson, 2013), technical and teamwork skills (Jackson et al., 2006), and abilities to learn from others (Collins & Smith, 2006). With the increase in the degree of openness, managerial and organizational complexity also intensifies. To deal with this growing complexity, firms engage in 'context creating' functions that facilitate knowledge sharing within the firm (Cabrera & Cabrera, 2005; Yang & Lin, 2009) and among companies (Jolink & Dankbaar, 2010). Effective participation in open innovation is possible only when firms possess adequate domain-relevant skills. As open innovation involves sensing, seizing, and reconfiguring, firms build special know-how (Teece, 2007) by broadening skill repertoire (Amabile, 1983) by building common understanding among team members (Gilson & Shalley, 2004). With a view to reducing the impact of the NSH attitudinal syndrome, firms may introduce competence-building measures such as training (Burcharth et al., 2014). Training enables transformative learning (Lane et al., 2006), weakening the negative predisposition (Burcharth et al., 2014) by eliciting and reinforcing desirable attitudes and behaviour (Tharenou et al., 2007). With the help of persistent competency-building measures, firms acquire the aptitude to identify best industry practices for suitable application within the organization (Lawson et al., 2009). To deal with NSH, firms encourage employees to remain open to external ideas (Birdi, 2007) and build new resources and competence anchored on the individual and organizational level foundations (Felin & Foss, 2005; Rothaermel & Hess, 2007). Second-order competencies require enabling competence-building measures that bring fluidity for the immediate transfer of organizational knowledge (Nonaka, 2007), persuade employees by educating, and thereby reduce the intensity of resistance to change (Cummings & Worley, 2014). Effective training may contribute to the formation of desirable attitudes that may facilitate innovation training (Ehrhardt et al., 2011).

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Hypothesis 3: Competence-enhancing practice bundles have a positive relationship with open innovation. (H3)

COMPLEMENTARILY OR SUBSTITUTABILITY

Complementarity and substitutability occupy a central role in the innovation literature. Literature provides rich guidance on the application of complementarity (Cassiman & Valentini, 2006; Ebergerger & Herstad, 2011; Rothaermel & Hess, 2007) and substitutability (Ceccagnoli et al., 2014). Concurrently, diverse HR practices remain active in the organizational context, and their interactive effects could be complementary or substitutive. Following Rothaermel and Hess (2007), we define Complementarity or Substitutability. Two HR practices are complementary when the marginal benefit of deployment of one HR practice could be beneficial while used in conjunction with other practices. Two HR practices are considered substitutive when the marginal benefit of deployment of one HR practice decreases in the presence of the other (Rothaermel & Hess, 2007, p. 902). We explain it further with examples in the following paragraphs.

EMPOWERMENT-ENHANCING PRACTICES x MOTIVATION-ENHANCING PRACTICES

Motivation-enhancing and empowerment-enhancing practices jointly reinforce the perception of continued organizational commitment toward employee development. Employees value trust expressed through these two HR practices. With an increased level of perception congruence between organizational and employee fit, employees could identify with the company better (Meyer & Herscovitch, 2001). Empowerment-enhancing practices involve sharing valued information, allowing participation in decision-making processes, and treating employees with respect. This enhances the feelings of relatedness, commitment and autonomy and thereby influences employees to identify with the organization (Meyer & Herscovitch, 2001). Employees involved in open innovation activities require challenging the status quo and breaking down existing boundaries. Therefore, to voice up against existing organizational practices for the introduction of change, a trusting work environment is necessary (George, 2007). Empowerment-enhancing HR practices foster social cohesion among group members, leading to an enhanced experience of affective commitment (Osterman, 1995). By using a combination of reward and incentive, motivation-enhancing practices also steer to induce required attitudinal and behavioural outcomes. Motivation-enhancing practices are used to reinforce social cohesion and encourage practicing voice behaviour (Shin et al., 2012), that is essential for innovation.

Therefore, whereas empowerment-enhancing practices attempt to promote transparency by creating a shared perception of critical organizational issues, motivation-enhancing practices reinforce and encourage remaining committed to such transparent relational exchanges (Chang et al., 2014). Reward reflects an organizational intention (Rousseau & Wade-Benzori, 1994), communicating consistent messages of willingness to invest more resources for creative performance (Bowen & Ostroff, 2004). Empowering employees to achieve business outcomes and reinforcing it subsequently by a robust reward mechanism may work as complementary to each other and may potentially create a favourable context for open innovation. Therefore, we speculate a complementary relationship between empowerment-enhancing practices and motivation-enhancing practices with regard to open innovation.

Hypothesis 4: Motivation-enhancing HR practice bundles and empowerment-enhancing HR practice bundles are complementary to each other with reference to open innovation. (H4)

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EMPOWERMENT-ENHANCING PRACTICES AND CAPACITY-ENHANCING PRACTICES

HR practices attempt to influence performance by building employee capacity through training as well as empowering them to deploy newly learned skills. Continued investment through competency-enhancing practices works as an indication that the firm is concerned about the well-being of the employees and is committed to their career development (Snape & Redman, 2010), leading to discretionary positive organizational behaviour (Sun et al., 2007). Employees' perception that firms value their talent and contribution elicits a high degree of commitment (Marchington & Wilkinson, 2005). Whereas empowerment-enhancing practices provide autonomy and opportunity to perform to willing and competent employees, competency-enhancing practices enable the acquisition of skills for future assignments and promotions, thereby offering a feeling of competence (Lincoln & Kalleberg, 1996). Thus, competency-enhancing practices influence the employees' perception that they are a valued asset (Galunic & Anderson, 2000). Without empowerment, skilled employees will not be able to deploy all relevant resources and skills for obtaining business results. The potential simultaneity between these two practices appears to be complementary and may generate positive synergistic results.

> **Hypothesis 5:** Empowerment-enhancing practices and capacity-enhancing practices are complementary to each other with reference to open innovation. (H5)

MOTIVATION-ENHANCING PRACTICES AND CAPACITY-ENHANCING PRACTICES

Motivation-enhancing practices signal employees what is valued and expected out of the term of engagement (Appelbaum et al., 2000). Effective reward administration potentially carries messages of desirable behaviour that will be reinforced through reward. The meta-analytic review informs that role ambiguity may take away inner commitment (Mathieu & Zajac, 1990). Motivation-enhancing practices bring role clarity and transparency. Therefore, employees will have underlying reasons for developing adequate skills to achieve performance targets for reward. Motivation-enhancing practices enable competent performance and convey a sense of competence (Deci & Ryan, 1985). By incentivizing and rewarding desired behaviour, firms reduce ambiguity in the system and satisfy competence needs (Mowday et al., 1982). As both practices promote competent performance, i.e., 'the same organizationally relevant outcomes' (Wright, 1998), we argue that there might be some degree of substitution between motivation-enhancing and capacity-enhancing practices while influencing open innovation.

> **Hypothesis 6:** Empowerment-enhancing and capacity-enhancing practices are substitutes for each other with reference to open innovation. (H6)

RESEARCH METHOD

SAMPLE

On behalf of the Statistical Office of the European Communities (EUROSTAT), The Italian National Institute of Statistics carried out The Fifth Community Innovation Survey and reported in June 2013. The sample consists of 6265 Italian firms from the manufacturing and service industry from 2008-2010. It includes firms across industries (NACE classification). The current sample has 2979 firms with employees between 10-49, 1567 firms with 50-249 employees and 1627 firms above 250 employees. However, due to missing data, we can only use data from 2540 firms.

DEPENDENT VARIABLES

Our dependent variable is open innovation. We operationalize open innovation in line with existing literature (Laursen & Salter, 2014) and utilize two standard frames: external search breadth and collaborative search breadth.

EXTERNAL SEARCH BREADTH

External search breadth consists of knowledge search across different external sources, such as suppliers, competitors, consultants, customers, and other external sources such as research labs, universities, etc. Each of these channels brings in their unique insights and perspectives that are valuable to the recipient firms. External search breadth indicates firms' willingness to stretch beyond their organizational boundary for innovative ideas. These innovative ideas could be market, technology and process-related. Firms utilize this freshly acquired knowledge to link and enhance the effectiveness of internal R&D efforts.

Further, such acquired knowledge enables firms to create breakthrough opportunities by knowing, familiarizing, and exploiting emergent and novel forms of technology, market opportunities and process reengineering (Katila & Ahuja, 2002). We operationalize external search breadth equal to the number of relationships the firm maintained for knowledge search across stakeholders such as suppliers, competitors, clients, consultants, universities, and government agencies, divided by the upper bound (maximum number of stakeholders). Kuder-Richarson's coefficient of reliability for external search breadth is 0.94.

COLLABORATIVE SEARCH BREADTH

Collaborative breadth provides an opportunity for frequent interactions among representative employees from firms. This provides a durable frame of reference, "shared representations and systems of meaning among parties" (Nahapiet & Ghoshal, 1998, p.244), commonality in their respective shared visions (Lechner et al., 2010), collective resource for achieving strategic goals (Lovas & Ghoshal, 2000), and consistent linguistic expression for interactions (Bolino et al., 2002). "Brokerage benefits derived from bridging ties are not limited to timely access to information in the short-term but can also include the persistent effect of learning and knowledge redeployment" (McEvily et al., 2012: p.559). Fruitful interactions in the collaborative network create trust and shared understanding, replacing many rudimentary but formal control systems (Kirsch et al., 2010). For example, a cluster of suppliers in the automotive industry locate their firms in the supplier park where final assembly will be carried out (Miemczyk & Holweg, 2004). In this setup, firms under collaborative networks are structurally designed to share a common destiny and attempt collective survival. We operationalize collaborative breadth equal to the number of collaborative relationships with suppliers, competitors, clients, consultants, universities, government agencies, etc., divided by a maximum number of stakeholders (7). Since each scale item is dichotomous, we calculate the Kuder-Richarson reliability coefficient for collaborative breadth, and the scale appears to have a reasonable internal consistency (0.87).

INDEPENDENT VARIABLES

We have three HR practice bundles: empowerment-enhancing, motivation-enhancing, and capacity-enhancing practices. We have two dichotomous scale items representing each of these practices. Two dichotomous scale items, 'Financial incentives for employees to develop new ideas' and 'non-financial

incentives for employees to develop new ideas, such as free time, public recognition, more interesting work, etc.', have been used to represent motivation-enhancing practices with 1= representing the existence of the practice and zero = representing the absence of the practice. Since our scale items are dichotomous, we calculate the Kuder-Richarson coefficient of reliability for the motivation-enhancing scale, which appears to have an excellent internal consistency (0.84). Likewise, we use two dichotomous scale items, 'training employees on how to develop new ideas or creativity' and 'job rotation of staff to different departments or other parts of your enterprise group', to represent capacity-enhancing practices. Kuder-Richarson's coefficient of reliability for capacity-enhancing practice is 0.72.

Similarly, we use two dichotomous scale items, ' Brainstorming sessions' and 'multidisciplinary or cross-functional work teams', to represent empowerment-enhancing practices, with '1' indicative of the practice's presence and '0' indicative of the absence of the practice. Kuder-Richarson's coefficient of reliability for empowerment-enhancing practices is 0.87. We normalize each HR practice score by dividing the upper bound figure. Thus, all the scale remains within the 0 (minimum) and 1 (maximum).

CONTROL VARIABLES

To control heterogeneity in external knowledge exploitation across industries, we use 51 industry dummies as *industry fixed effect* (Grindley & Teece, 1997). Larger firms possess better organizational resources (Beckman et al., 2004), oligopolistic position over R&D (Rosenberg, 1990) and are also often reflective of organizational inertia (Hannan & Freeman, 1984). Studies conducted on knowledge ecology usually use a firm's size as a control variable (Van Wijk et al., 2008). We operationalized *firm size* using the log of employee strength as used in most of the studies in open innovation research (Ebersberger & Herstad, 2011; Spencer & Gomez, 2014). Based on existing literature on open innovation, which shows *R&D intensity* as a reflector of a firm's absorptive capacity, we also control firm-level R&D intensity and derive by dividing R&D expenditure by sales (Laursen & Salter, 2014). By being a part of a business group, a subsidiary takes advantage of inter-firm knowledge spillovers, internal access to finance, multi-site presence, enlightened management practices and may be better in innovation performance than a non-subsidiary firm (Deeds & Hill, 1996). On the contrary, a subsidiary firm may not enjoy the privilege of engaging in knowledge-creation activities (Veugelers & Vanden Houte, 1990). Therefore, to control whether the firm is a part of a larger set-up, we include a dummy variable if the firm is *part of a larger firm* set up. As *market size* potentially influences a firm's innovation behaviour (Kafouros et al., 2008; Filippetti et al., 2011), while modelling, we control market size by measuring whether the focal firm is predominantly local, domestic, Other European Union (EU), EFTA, or EU candidate countries or all other countries (Laursen & Salter, 2014). Educated employees enhance the assimilation and application of external knowledge and facilitate knowledge sharing within firms (Schmidt, 2010; Xia & Roper, 2016). We control *employee education* level by capturing the strength of current employees possessing a university degree. We operationalized *employee education* by coding 0% current employee having a university degree =0, 1% to 4% current employee possessing a university degree=1, 5% to 9%=2, 10% to 24%=3, 25% to 49%=4, 50% to 74%=5, 75% to 100% =6. We also control *governmental support* and assistance given to the firms to promote innovation. Literature states that government support positively relates to open innovation (Etzkowitz & Leydesdorff, 2010). We operationalized by measuring whether focal firms receive any public financial support for innovation activities from the following levels of government: Local or regional authorities, Central government (including central government agencies or ministries), and the European Union (EU).

ANALYTICAL STRATEGY

Our dependent variables are average scores derived from count scores with non-negative integers. Usually, for modelling count data where no upper bound is there in the observed count, Poisson regression is often recommended. Otherwise, to accommodate over-dispersed count data, where dispersion is more than the mean, Negative binomial regression can be used. However, as discussed earlier, our dependent variables, i.e., external search breadth and collaborative breadth, are expressed as a fraction (all values stay between 0 and 1).

Therefore, neither Poisson regression nor negative binomial regression could be applied. Following Wooldridge (2002) and Laursen& Salter (2014), we implement fractional logit modelling. It is useful when the dependent variable comprises a fraction derived by "dividing a count variable by an upper bound." This technique utilizes GLM methods "to estimate nonlinear, non-additive effects on the mean of a variable distributed continuously over a bounded range." It always provides 'in range' predictions without requiring special treatment of boundary values. "It does not invoke strong assumptions about the error term distribution" (Fossett et al., 2012, p.1).

TESTING A U-SHAPE RELATIONSHIP

We develop a graphical representation of our model using a simulation-based approach, suggested by King et al., (2000), introduced to the political science by Brambor et al., (2006) and later in corporate strategy literature by Zelner (2009). We adhered to the principles of this approach over the margin-based model because it produces "more accurate results," "intuitive," and "practical" (Zelner, 2009). Under this method, the coefficient estimated is simulated by drawing new values from the normal distribution. Thus, sourcing the information from the estimated nonlinear model (from our fractional response model) forms simulated vectors converging to the original nonlinear vector estimated in the primary model. We subsequently model the nonlinear relationship between HR practices and open innovation using these simulated coefficient vectors and variance-covariance matrix. We followed Laursen and Salter (2014), who used a modified formulation initially developed by Brambor et al., (2006). Our simulation is based upon 10,000 draws from the estimated co-efficient vector and variance–covariance matrix. We implement Brambor et al., (2006), where we simulate a dataset that draws a vector from a multivariate normal distribution closer to the estimated coefficient vector. With the help of 10,000 draws, we graph the model.

SELF-REPORT AND COMMON METHOD BIAS

Our research relies upon a self-report data collection system and attempts to capture various human resources practices and knowledge search behaviour. Human resource practices relevant to open innovation are predominantly not readily available for public scrutiny. In such a context, self-reporting is considered an effective mechanism which can be used in similar knowledge search contexts (Reinholt et al., 2011). We also argue that perceptual measures correlate with objective innovation measures (Frishammar & Åke Hörte, 2005), thus providing good proxies for objective data. We also examined if our analysis suffers from common method bias. In order to reduce the risk of common method bias, we placed the dependent variable earlier than the independent variable while designing the questionnaire items (Podsakoff et al., 2003). Though an independent third party does data collection and primarily remains beyond our control, dependent variables are measured prior to independent variables, and there has been a substantial gap between these two sets of variables. Following Podsakoff et al., (2003), we also carried out Harman's single-factor test that involves running an unrotated factor analysis using all critical variables in the model. As the first unrotated

factor shares less than 50% of the total variance, we argue that the common method bias does not necessarily affect our study (Evans, 1985; Siemsen et al., 2010; Reinholt et al., 2011).

RESULTS

Table 1 presents the correlation matrix and descriptive statistics. Multicollinearity is not an issue as the Variance Inflation Factors (VIF) are all within the acceptable level i.e., below 10 (Neter et al., 1985). Table 2 presents our main models. Our base model results indicate that empowerment-enhancing practice bundles as well as capacity-enhancing bundles share positive relationships with open innovation; however, motivation-enhancing practices share negative relationship (Table 2: Model 1-2). It implies that human resource managers must nurture suitable interventions that provide a sense of empowerment and competency among its employees for productive participation in open innovation.

In line with our hypothesis, we notice that empowerment enhancing bundles share linear relationship with external search breadth as well as collaboration breadth (Table 2: Model 1-2). It implies that in order to encourage open innovation, firms need to invest substantial organizational resources consistently that provide a sense of psychological safety and empowerment to its employees.

Contrary to our Hypothesis 2, our primary results indicate that motivation enhancing HR practices shares a negative relationship with open innovation. Should we conclude that to encourage open innovation, motivation-enhancing practices are not only redundant – rather may trigger negative results (Table 2: Model 1-2). This result almost appears to be surprising, given our available understanding and literature of the power of motivation-enhancing bundles on innovation. In line with hypothesis 2, we investigate it further whether motivation-enhancing bundles have an absolute negative influence on open innovation or it is an indication of non-linear functional relationship. Therefore, we introduce the linear and squared term of motivation-enhancing bundles in the equation. Now we notice a mixed result. We find that the relationship between motivation-enhancing bundles and open innovation is indeed non-linear only for collaborative breadth (Table 2: Model 6), these relationships are not statistically significant for external search breadth (Table 2: Model 5). Whereas the linear term of motivation-enhancing bundles is positive but not statistically significant, the squared term of it is negative and statistically significant with external search breadth ($p<0.05$) (Table 2: Model 5). The linear form of motivation-enhancing practices is positive and statistically significant ($p<0.01$), and the squared term of it is negative and statistically significant with collaboration breadth ($p<0.001$) (Table 2: Model 6). It implies that motivation-enhancing practices share a linearly negative relationship with external search breadth, but this relationship becomes quadratic for collaborative breadth. Based upon a simulation technique (Brambor et al., 2006; Laursen & Salter, 2014) with 10000 draws that proximate our equation, the curve indicates a concave relationship between motivation-enhancing practices and collaborative breadth – thus reinforced our findings (Figure 1). The curve reflects the ultimate limit of the motivation-enhancing practices with regard to open innovation.

Likewise, in line with our Hypothesis 3, our base model shows that capacity-enhancing practices shares a positive relationship with open innovation (Table 2: Model 1-2). Looking into the behaviour of motivation-enhancing practice with reference to open innovation, we also introduce a quadratic form of capacity-enhancing practices into our base model. We notice that capacity-enhancing practices share a quadratic relationship with open innovation. Whereas the linear form of capacity-enhancing practice is positive and significant with external search breadth ($p<0.001$) and collaboration breadth ($p<0.01$); the squared term of capacity-enhancing is negative and statistically significant with external search breadth ($p<0.10$) and collaboration breadth ($p<0.05$). It implies that firms need to invest a limited amount of resources to enhance employee capacity to participate in open innovation context

Table 1. Descriptive Statistics and Simple Correlations (n=2540)

SL No	Variables	Mean	SD	Variance	Min	Max	1	2	3	4	5	6	7	8	9	10
1	External Search Breadth	0.25	0.35	0.12	0	1										
2	Collaboration Breadth	0.05	0.16	0.03	0	1	0.494***									
3	Part of a Larger Firm	0.36	0.48	0.23	0	1	0.323***	0.251***								
4	Firm Size (Employee Log)	1.78	0.84	0.70	1	3	0.407***	0.294***	0.566***							
5	R&D Intensity	0.02	0.09	0.01	0	5.40	0.210***	0.180***	0.0381*	0.0331*						
6	Government Assistance	0.04	0.13	0.02	0	1	0.445***	0.508***	0.172***	0.228***	0.223***					
7	Employee Education (Absorptive Capacity)	1.75	1.69	2.87	0	6	0.333***	0.246***	0.455***	0.440***	0.0998***	0.176***				
8	Market Size	1.55	0.79	0.62	1	4	0.307***	0.215***	0.362***	0.373***	0.0621***	0.203***	0.298***			
9	Empowerment-enhancing Practices	0.11	0.29	0.09	0	1	0.352***	0.271***	0.288***	0.313***	0.121***	0.199***	0.302***	0.186***		
10	Motivation-enhancing Practices	0.07	0.23	0.05	0	1	0.205***	0.142***	0.177***	0.182***	0.0544***	0.114***	0.149***	0.154***	0.562***	
11	Capacity-enhancing Practices	0.10	0.27	0.07	0	1	0.333***	0.251***	0.226***	0.250***	0.0927***	0.189***	0.214***	0.167***	0.722***	0.672***

Note: * p<0.05, ** p<0.01, *** p<0.001

Table 2. Fractional Logit Modeling: The Relationship Between HRM Practice Bundles and Open Innovation

	External Search Breadth Co-efficient Robust S.E. Model 1	Collaboration Breadth Co-efficient Robust S.E. Model 2	External Search Breadth Co-efficient Robust S.E. Model 3	Collaboration Breadth Co-efficient Robust S.E. Model 4	External Search Breadth Co-efficient Robust S.E. Model 5	Collaboration Breadth Co-efficient Robust S.E. Model 6	External Search Breadth Co-efficient Robust S.E. Model 7	Collaboration Breadth Co-efficient Robust S.E. Model 8
Industry Effect (51)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Part of a Larger Firm	0.290*	0.0152	0.294*	0.0153	0.282*	-0.0657	0.298*	0.0286
	-0.124	-0.36	-0.124	-0.36	-0.123	-0.364	-0.124	-0.364
Firm Size (Employee Log)	0.379***	0.735***	0.380***	0.735***	0.375***	0.757***	0.379***	0.731***
	-0.0879	-0.215	-0.088	-0.215	-0.0881	-0.204	-0.0881	-0.206
R&D Intensity	19.75***	2.056	19.85***	2.054	19.79***	1.64	19.79***	2.409
	-4.98	-3.347	-4.984	-3.35	-5.008	-3.348	-4.956	-3.22
Governmental Assistance	6.017***	6.401***	6.033***	6.402***	6.053***	6.690***	5.900***	6.443***
	-0.574	-0.854	-0.576	-0.857	-0.573	-0.863	-0.573	-0.877
Market Size	0.330***	0.436*	0.333***	0.436*	0.342***	0.482*	0.322***	0.441*
	-0.0709	-0.197	-0.0707	-0.196	-0.0711	-0.191	-0.0716	-0.196
Employee Education (Absorptive Capacity)	0.0418	0.171	0.0408	0.171	0.0407	0.188	0.0434	0.167
	-0.0374	-0.101	-0.0374	-0.101	-0.0374	-0.1	-0.0374	-0.103
Empowerment-enhancing Practices	0.853***	0.865*	-0.279	0.941	0.883***	0.986*	0.830***	0.685
	-0.249	-0.43	-1.042	-1.729	-0.245	-0.426	-0.246	-0.392
Motivation-enhancing Practices	-0.898**	-0.843†	-0.963**	-0.842	1.484	4.123**	-0.660*	-0.412
	-0.327	-0.537	-0.339	-0.545	-1.095	-1.575	-0.331	-0.484
Capacity-enhancing Practices	1.189***	1.043*	1.198***	1.042*	1.117***	0.712	2.406***	3.493**
	-0.306	-0.501	-0.309	-0.503	-0.304	-0.49	-0.664	-1.215

Table 2. Continued

	External Search Breadth Co-efficient Robust S.E. Model 1	Collaboration Breadth Co-efficient Robust S.E. Model 2	External Search Breadth Co-efficient Robust S.E. Model 3	Collaboration Breadth Co-efficient Robust S.E. Model 4	External Search Breadth Co-efficient Robust S.E. Model 5	Collaboration Breadth Co-efficient Robust S.E. Model 6	External Search Breadth Co-efficient Robust S.E. Model 7	Collaboration Breadth Co-efficient Robust S.E. Model 8
Empowerment-enhancing Practices² (H1)			1.198 -1.069	-0.077 -1.703				
Motivation-enhancing Practices² (H2)					-2.498* -1.137	-5.326*** -1.587		
Capacity-enhancing Practices² (H3)							-1.506† -0.773	-2.696* -1.318
_cons	-4.619*** -0.51	-21.59*** -0.556	-4.570*** -0.487	-21.51*** -0.258	-4.933*** -0.653	-22.33*** -0.641	-4.740*** -0.542	-21.97*** -0.755
N	2540	2540	2540	2540	2540	2540	2540	2540

Note: †< 0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 3. Fractional Logit Model: Inter-Bundle Interactions with Open Innovation

	External Search Depth Co-efficient Robust S.E. Model 9	Collaboration Breadth Co-efficient Robust S.E. Model 10
Industry Effect (51)	*Yes*	*Yes*
Part of a Larger Firm	*0.296***	*0.032*
	-0.125	*-0.37*
Firm Size (Employee Log)	*0.376****	*0.688***
	-0.0881	*-0.223*
R&D Intensity	*19.87****	*2.304*
	-5.028	*-3.546*
Governmental Assistance	*5.921****	*6.347****
	-0.572	*-0.845*
Market Size	*0.328****	*0.466**
	-0.0715	*-0.191*
Employee Education (Absorptive Capacity)	*0.044*	*0.189*
	-0.0376	*-0.103*
Empowerment-enhancing Practices	*0.763**	*0.313*
	-0.344	*-0.663*
Motivation-enhancing Practices	*0.633*	*0.542*
	-0.449	*-1.532*
Skill-enhancing Practices	*1.607****	*1.156*
	-0.361	*-0.728*
Empowerment-enhancing Practices x Motivation-enhancing Practices (H4)	*0.987*	*2.568*
	-0.737	*-1.894*
Empowerment-enhancing Practices x Capacity-enhancing Practices (H5)	*-0.0878*	*0.774*
	-0.61	*-1.147*
Motivation-enhancing Practices x Capacity-enhancing Practices (H6)	*-3.047****	*-4.542***
	-0.903	*-1.504*
_cons	*-5.047****	*-22.12****
	-0.693	*-0.453*
N	*2540*	*2540*

Note: †< 0.10, * p<0.05, ** p<0.01, *** p<0.001

– after a threshold point, any additional investment may share a negative marginal relationship with open innovation (Table 2: Model 7-8). Likewise, based upon a simulation technique, the curve indicates a concave relationship between competency-enhancing practices and open innovation (external search breadth and collaboration breadth) – thus curvilinearity is supported, though the curve is not found to be very pronounced in its shape (Figure 2 & 3).

We find support for Hypothesis 6 that motivation-enhancing and capacity-enhancing practices are substitutes for one another concerning open innovation because the interaction between them is negative and statistically significant (Table 3: Model 9-10). It implies that while influencing open innovation, firms, at their discretion, interchange some of the motivation-enhancing and capacity-
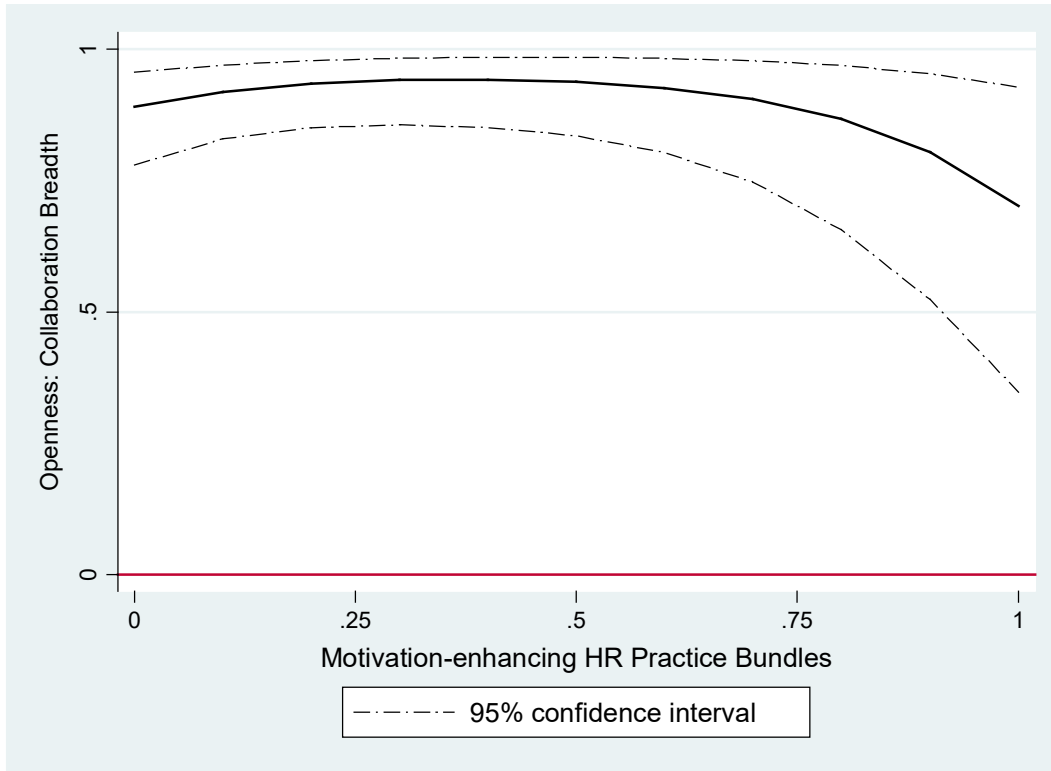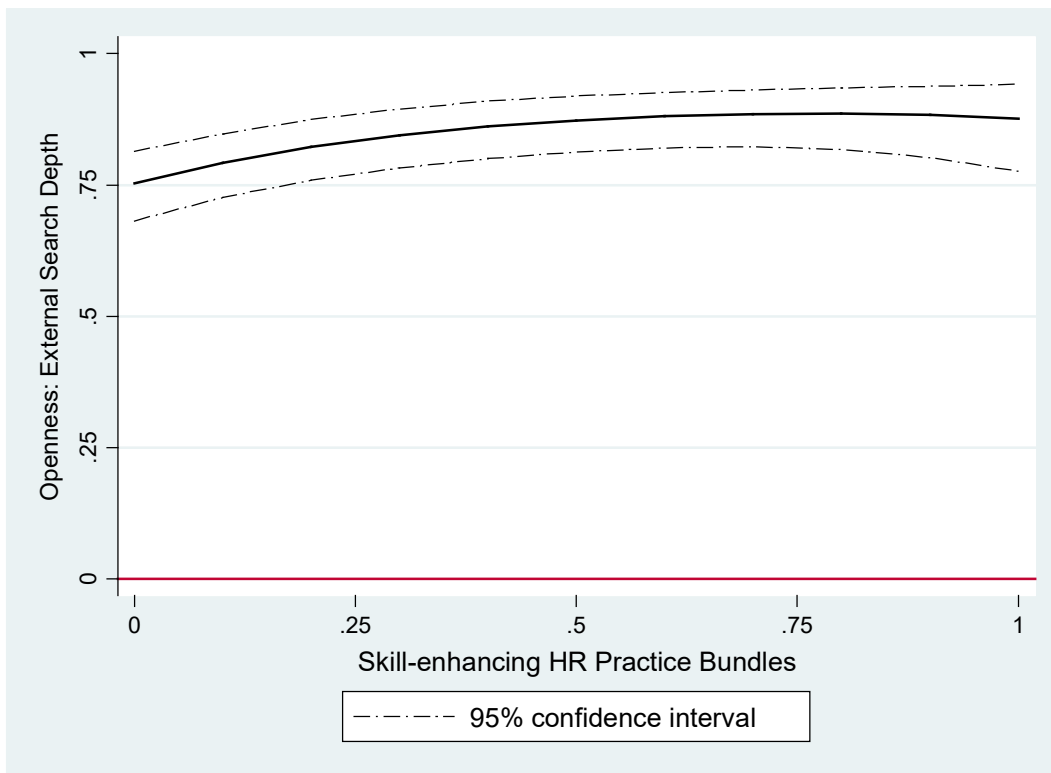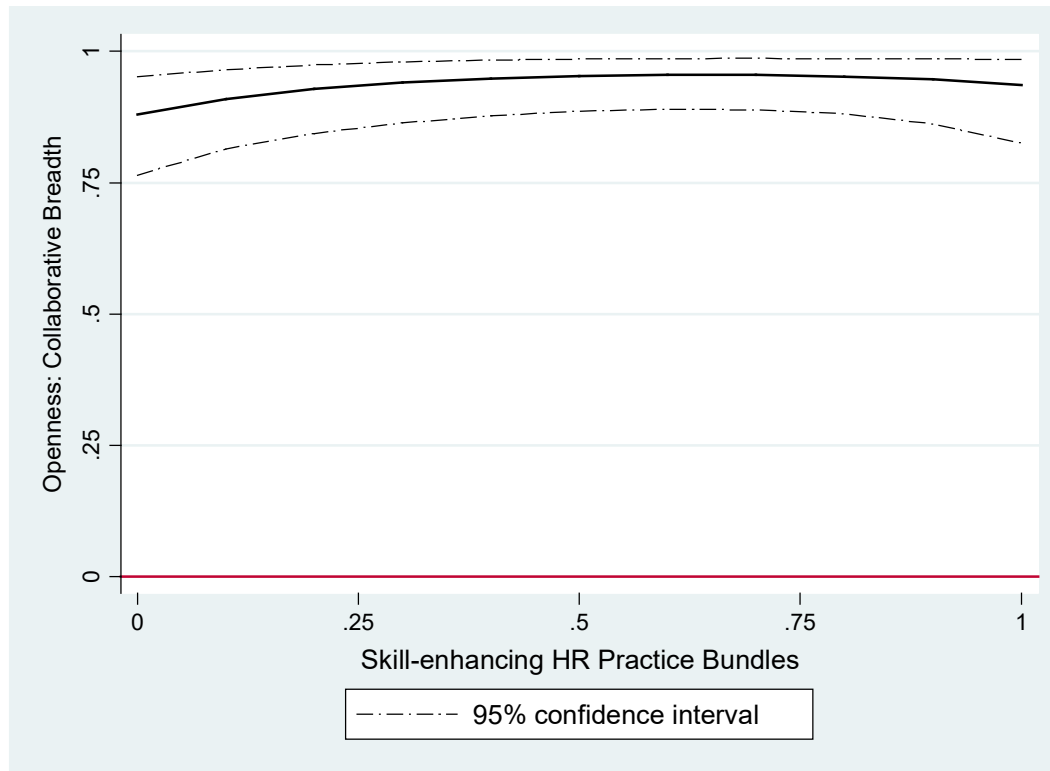
Figure 1

Figure 2.

Figure 3.

enhancing practices without losing their effectiveness. We do not find any support for Hypothesis 4 and Hypothesis 5. Hypothesis 4 argues for the plausible synergistic relationship between empowerment-enhancing and motivation-enhancing practices; however, the interaction term is not statistically significant. We also do not support Hypothesis 5, which suggested a synergistic relationship between empowerment-enhancing and capacity-enhancing practices, as their interaction is not statistically significant (Table 3: Model 9-10).

ROBUSTNESS CHECK AND ALTERNATIVE MODEL EVALUATIONS

To check the robustness of our analysis, we develop a number of alternative econometric models to deal with the various concerns around our models.

ROBUSTNESS CHECK FOR QUADRATIC RELATIONSHIP

Firstly, one of the potential concerns is that inter-industry differences might have influenced our findings in HR practice bundles. Literature acknowledges the inter-industry differences across HR practices (Subramony, 2013). For example, some industries may need help to introduce empowerment-enhancing HR practices. In healthcare industries, due to asymmetric power distribution at the core of medicine practices, the introduction of empowerment-enhancing practices may face more difficulties than others (Kramer et al., 2008). We must examine whether these inter-industry differences in HR practice bundles drive our results. We have already used industry-fixed effect in all our models to accommodate inter-industry idiosyncrasies. Therefore, including additional industry-level HR practice bundles (motivation-enhancing and capability-enhancing bundles) into our existing models creates an identification problem; we cannot run our models. Therefore, we solve this

Table 4. Fractional Logit Modeling: The Relationship Between HRM Practice Bundles and Open Innovation: Robustness Tests

	Inter-Industry Difference				Ordered Logit Modeling				Endogeneity Test			
	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.	External Search Breadth Co-efficient Robust S.E.	Collab. Breadth Co-efficient Robust S.E.
	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21	Model 22
Industry Effect (45)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Part of a Larger Firm	0.282* -0.123	-0.058 -0.367	0.298* -0.124	0.0309 -0.367	0.323* -0.138	-0.0718 -0.323	0.338* -0.138	0.00822 -0.32	0.271* -0.127	-0.0922 -0.348	0.287* -0.127	-0.0154 -0.346
Firm Size (Employee Log)	0.375*** -0.0881	0.759*** -0.207	0.379*** -0.0881	0.734*** -0.208	0.384*** -0.0945	0.739** -0.227	0.384*** -0.0945	0.727** -0.224	0.301** -0.0944	0.704*** -0.206	0.305** -0.0943	0.673** -0.206
R&D Intensity	19.79*** -4.935	1.53 -3.29	19.81*** -4.886	2.315 -3.177	21.81*** -2.136	2.927 -2.775	21.83*** -2.126	3.561 -2.767	15.57*** -4.453	-0.435 -2.62	15.65*** -4.41	0.436 -2.589
Governmental Assistance	6.053*** -0.571	6.693*** -0.863	5.899*** -0.572	6.448*** -0.877	6.835*** -0.559	8.048*** -0.892	6.685*** -0.561	7.648*** -0.879	3.398*** -0.644	4.615*** -0.746	3.260*** -0.643	4.326*** -0.766
Market Size	0.342*** -0.0711	0.485* -0.191	0.322*** -0.0716	0.443* -0.196	0.313*** -0.0786	0.655*** -0.168	0.296*** -0.0788	0.611*** -0.17	0.249*** -0.0714	0.355 -0.184	0.230** -0.0719	0.32 -0.194
Employee Education (Absorptive Capacity)	0.0407 -0.0374	0.184 -0.1	0.0434 -0.0374	0.165 -0.103	0.0636 -0.0437	0.204* -0.0966	0.0637 -0.0437	0.186 -0.0965	0.0251 -0.0403	0.188* -0.0935	0.0298 -0.0399	0.183 -0.101
indus_eff	48.34** -15.81	-43.29 -36.98	48.04** -15.84	-46 -38.35								
indus_eff2	-368.7*** -104.1	289.6 -240.3	-365.9*** -105.1	312.5 -248.5								

Table 4. Continued

	Inter-Industry Difference				Ordered Logit Modeling				Endogeneity Test			
	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.	External Search Breadth Coefficient Robust S.E.	Collab. Breadth Coefficient Robust S.E.
	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21	Model 22
INONG									1.881***	2.011***	1.875***	1.956***
									-0.121	-0.34	-0.122	-0.338
Empowerment-enhancing Practices	0.883***	0.979*	0.830***	0.673	0.822**	0.637	0.778**	0.423	0.783**	0.74	0.726**	0.438
	-0.245	-0.427	-0.246	-0.391	-0.258	-0.487	-0.256	-0.483	-0.246	-0.421	-0.253	-0.39
Capacity-enhancing Practices	1.117***	0.728	2.405***	3.554**	1.413***	0.961	2.874***	4.146**	0.958**	0.27	2.186**	2.915*
	-0.303	-0.492	-0.663	-1.207	-0.316	-0.593	-0.731	-1.318	-0.305	-0.498	-0.755	-1.235
Motivation-enhancing Practices	1.484	4.105**	-0.659*	-0.413	2.043	4.998**	-0.624	-0.225	1.693	4.850***	-0.711*	-0.172
	-1.095	-1.577	-0.331	-0.483	-1.246	-1.895	-0.353	-0.594	-1.15	-1.426	-0.306	-0.441
Motivation-enhancing Practices² (H2)	-2.498*	-5.314***			-3.103*	-6.010**			-2.713*	-5.642***		
	-1.137	-1.589			-1.28	-1.945			-1.156	-1.427		
Capacity-enhancing Practices² (H3)			-1.504†	-2.742*			-1.762*	-3.315*			-1.393	-2.414
			-0.772	-1.312			-0.84	-1.384			-0.798	-1.289
_cons	-4.389***	-6.827***	-4.411***	-6.847***					-4.532***	-24.32	-4.326***	-22.19***
	-0.552	-1.059	-0.55	-1.111					-0.8	(.)	-0.675	-0.839
N	2540	2540	2540	2540	2540	2540	2540	2540	2540	2540	2540	2540

Note: †< 0.10, * p<0.05, ** p<0.01, *** p<0.001

identification problem by reconfiguring the industry fixed effect by reducing 6 industries representing at most 2% of the sample. Then, we compute industry-level capacity-enhancing and motivation-enhancing bundles and include them in the model. After accommodating industry-level motivation-enhancing practices, our main results remained unchanged. The linear relationship between motivation-enhancing practices and external search breadth remains intact. In line with our main model, the linear form of motivation-enhancing practices is not significant, though the squared term of it is significant (Table 4: Model 11). However, motivation-enhancing practices share a quadratic relationship with collaboration breadth (Table 4: Model 12). The linear and squared forms of motivation-enhancing practices are statistically significant and follow the statistical sign as in the main model. Simultaneous inclusion of industry-level motivation-enhancing practice bundles may generate a multi-collinearity problem in the model. However, it implies that industry-level motivational factors are not driving our results in the current context.

Similarly, after accommodating industry-level capacity-enhancing practices into our models, we notice the non-linear relationship remains intact. We notice that the linear and squared form of capacity-enhancing practices are statistically significant and follows the statistical sign as the main models (Table 4: Model 13-14). It implies that industry-level capacity-enhancing practices are not driving our results.

Our results may be the product of our specific method (i.e., fractional logit response modelling) and how we have treated our variables. Therefore, we use an alternative ordered logit estimator to examine if it produces similar results. We notice similar parameter estimates and statistical significance for motivation-enhancing practice bundles and capacity-enhancing practices like our earlier results (Table 4; Model 15-18). As parameter estimates behave similarly to those results obtained from the fractional logit response models, we argue that any specific method is not driving our results.

Another concern is that our results might have been influenced by the endogeneity effect. This concern stands for a unique situation where the third factor governs the relationship between dependent and independent variables. In the absence of an instrumental variable, it is difficult to deal with the endogeneity problem. We also have a limited number of variables available in the given dataset – we are unable to locate a variable that can statistically qualify as an instrument. In our current case, the self-selection of innovative firms and different HR practice bundles (capability-enhancing and motivation-enhancing practice bundles) are the characteristics of high-technology firms. Continued innovation efforts are often practiced in high-technology industries. High-technology firms are often associated with continued innovative performance (Oh et al., 2012; Shrader, 2001). We introduce one additional variable that represents the firm's current innovation status. We notice that the linear relationship between motivation-enhancing practices and external search breadth remains intact. The quadratic relationship between motivation-enhancing practices and collaborative breadth also remains the same (Table 4: 19-20). However, in the case of collaborative breadth, whereas the linear form of capacity-enhancing practices is positive and statistically significant as in our main model, the quadratic form of capacity-enhancing practices now holds statistical significance only at p<0.10 (Table 4: Model 21-22). These tests attempt to deal with firm-specific heterogeneity that may arise due to the self-selection of high/low technology firms in the sample. As robustness checks hold the overall direction of the models intact – we arguably state that firm-specific technology characteristics are not necessarily driving our results. A similar level of statistical treatment has been accepted elsewhere as an alternative to 2SLS with instrumental variables (Laursen & Salter, 2014).

INTERACTION MODEL AND ITS ROBUSTNESS TEST

We do not find support for Hypothesis 4 and 5 (Table 3: Model 9 - 10). We find that empowerment-enhancing and motivation-enhancing practices do not share a complementary relationship concerning

Table 5. Robustness Tests: Interaction Model (Ordered Logit Model)

	Ordered Logit Estimation	
	External Search Depth Co-efficient Robust S.E. Model 23	Collaboration Breadth Co-efficient Robust S.E. Model 24
Industry Effect (51)	Yes	Yes
Part of a Larger Firm	0.342* -0.138	0.0255 -0.323
Firm Size (Employee Log)	0.377*** -0.0947	0.689** -0.227
R&D Intensity	21.99*** -2.144	3.913 -2.757
Governmental Assistance	6.672*** -0.561	7.690*** -0.88
Market Size	0.300*** -0.0788	0.626*** -0.169
Employee Education (Absorptive Capacity)	0.0656 -0.0438	0.202* -0.0973
Empowerment-enhancing Practices	0.537 -0.348	-0.262 -0.766
Motivation-enhancing Practices	0.99 -0.605	0.628 -1.822
Capacity-enhancing Practices	1.858*** -0.409	1.603* -0.812
Empowerment-enhancing Practices x Motivation-enhancing Practices (H4)	1.056 -0.931	3.674 -2.151
Empowerment-enhancing Practices x Capacity-enhancing Practices (H5)	0.381 -0.688	0.849 -1.323
Motivation-enhancing Practices x Capacity-enhancing Practices (H6)	-3.841*** -1.046	-5.698** -2.069
_cons	-0.104* -0.0456	-0.0389** -0.0134
N	2540	2540

Note: †< 0.10, * p<0.05, ** p<0.01, *** p<0.001

open innovation (H4). Though their relationships are mixed, it is not statistically significant. This indicates that firms may use both practices without synergistic benefits regarding open innovation. In contrast to Hypothesis 5, we do not find support suggesting that empowerment-enhancing and capacity-enhancing practices complement each other. Though this relationship is positive, it is not statistically significant. This finding indicates that overlap advantages between these two practices are not available, and each of these practices exerts influences on open innovation, independent of each other. Therefore, firms need to use both practices to influence open innovation positively.

However, we find that interactional model between motivation-enhancing and capacity-enhancing practices may be substitutes for each other with reference to open innovation as their relationship is

found to be statistically significant (Table 3: Model 9-10). Motivation-enhancing and capacity-enhancing practices may be substitutes for each other, at least at the margin, about open innovation (H6). We find support for this argument. Firms desiring to trigger open innovation may use their discretion while choosing these two practices without losing effectiveness.

Likewise, there is a scope of argument that the result in our interaction model is the product of the method used in this study. Therefore, we used an alternative estimator, i.e., an ordered logit model and found the results remain the same (Table 5: 23-24) that Hypothesis 6 remains statistically significant.

RESULT OF CONTROL VARIABLES

Several control variables provide exciting insights. We consider the base model while interpreting the role of control variables concerning open innovation (Table 2: Model 1-4). We find that *Firm Size* (measured as employee strength), *Governmental Assistance*, and *Market Size* consistently share a positive and statistically significant relationship with open innovation. This finding suggests that larger firms receiving subsidies from governmental agencies with more extensive market reach will likely engage in open innovation. It implies that financial assistance holds a crucial explanation for open innovation. To our surprise, we notice that *Employee Education,* a reflector of absorptive capacity, is not significant with open innovation. *R&D intensity* is positive and statistically significant with external search breadth. However, this statistical significance gets eroded with collaborative breadth, and this is another unexpected outcome we encountered in our study (Table 2: Model 1-4)

DISCUSSION

In line with our Hypothesis (H1), we found that empowerment-enhancing practices share a linearly positive relationship with open innovation. Sharing information with employees and participatory management practices provides a sense of enhanced feelings of empowerment (Spreitzer, 1996). Empowered employees are prone to perform beyond the formal job requirements (Seibert et al., 2004; Thomas & Velthouse, 1990). Empowerment-enhancing practices are associated with job satisfaction and organizational citizenship behavior. Empowerment-enhancing practices are essential to motivate discretionary employee effort and behaviour, which are crucial for open innovation. Our research provides a macro view and demonstrates the usefulness of empowerment-enhancing practices with open innovation.

However, contrary to Hypothesis 2, motivation-enhancing practices share a linearly negative relationship with external search breadth – one component of open innovation. It implies that firms should refrain from using motivation-enhancing practices to trigger external knowledge search behaviour. This relationship reflects a diminishing marginal return (i.e., quadratic relationship) only for collaboration breadth– another component of open innovation. It suggests that motivation-enhancing practices may produce a positive result after reaching some theoretical threshold point. However, any additional allocation of resources for motivation-enhancing practices may be counterproductive concerning collaboration breadth. To explain this unexpected finding, we attempt to find corresponding results from the other parts of organizational psychology. We locate civic virtue, a component of organizational citizenship behaviour that resembles the external search behaviour of individual employees. Civic virtue, a kind of prosocial behaviour, is associated with gathering information and exerting influence to contribute positively to organizational progress (Graham & Van Dyne, 2006; Organ, 1988). Unlike our findings, corresponding literature indicates that reward (contingent upon performance) is positively related to civic virtues (Podsakoff et al., 1996; Podsakoff et al., 2003). Therefore, our finding that demonstrated a negative relationship between motivation-

enhancing performance and external knowledge search behaviour perhaps reflects an overpowering influence of self-determination theory and needs further investigation.

We notice a quadratic relationship between capacity-enhancing practices and open innovation, and this relationship is characterized by an inverted U-shaped curve, reflecting a relationship affected by a diminishing marginal return. Though initially, capacity-enhancing practices may produce some degree of a positive result by some margin, after reaching some theoretical inflexion point, additional investment through capacity-enhancing practices will produce negative results. This result may not be surprising if we blend employee marketability literature into our research. Hence, we support the argument that enhanced marketability of employees in the labour market negatively impacts open innovation. With greater use of capacity-enhancing practices, employees may discover lucrative employment options elsewhere, resulting in less bonding and commitment towards the existing workplace. Using the data from the National Longitudinal Study of Youth, Lowenstein and Spletzer (1999) reported that the learning from the formal training received at work will be helpful to at other firms. Providing purely firm-specific skills to employees is rare, unlikely, and difficult (Lepak & Snell, 1999). Skill sets developed in-house are also valued outside the market (Almeida & Kogut, 1999; Rao & Drazin, 2002). Therefore, skill levels and commitment share a negative relationship (Cappelli, 1999). Our research captures and integrates these competing positive and negative effects on open innovation by an inverted U-shaped curve.

THEORETICAL CONTRIBUTIONS

Extant literature on *dynamic capabilities* is often concerned with locating internal processes such as alliancing for improved network position as well as firm growth (Powell et al., 1996), resource reconfiguration across business units for firm growth (Galunic & Eisenhardt, 2001). We contribute to the dynamic capability literature by demonstrating how human resource policy-level interventions enable sensing, seizing, and reconfiguring to address rapidly changing environments (Teece et al., 1997). Sensing refers to 'the ability to spot, interpret and pursue opportunities in the environment' (Pavlou & El Sawy, 2011, p.26). Seizing implies responding to opportunities spotted in the external environment. Reconfiguring involves the identification of complementarities and synergies among resources and processes to deploy processes to orchestrate collective actions (Eisenhardt & Brown, 1999). We demonstrate disproportionate utilities of HRM practice bundles on external knowledge search ('scanning') and collaborative search ('seizing' and 'reconfiguring'). Matched with the needs of the environment, we demonstrate how orchestrating appropriate HR measures enables employees' qualified participation in open innovation.

Jiang et al., (2012) argued about the significance of research on the degree of overlap across HR practices. They recommended examining substitutive and synergistic relationships among HR practice bundles. Building on these arguments that redundancy and overlap may affect HRM practice bundles, our empirical findings have further supported the idea of fit between human resource management practice bundles. Only a few studies hitherto have empirically made a selective demonstration of complementary substitutive relationships. Our study presents empirical evidence that motivation-enhancing practices and competency-enhancing practices are substitutes for each other at a margin and thus fills a critical literature gap, opening up the possibilities for future research.

Growing literature on strategic human resource management demonstrated the contribution of selective HRM practice to open innovation. Most of these studies rely upon a small sample size (213 in Burcharth et al., 2014; 136-152 firms in Lichtenthaler, 2010; 162 teams from 34 firms in Chuang et al., 2016). Nevertheless, their works did not address a) three prime HRM bundles and their inter bundle relationships, b) their interaction effects on open innovation, which we accommodate in our model.

The current research addresses these concerns by contributing and extending AMO theoretical frameworks to an open innovation context. Specifically, we used a large sample of 2540 Italian firms of 51 industries in our models. We also considered the substitutive and complementary arguments and examined their effect on open innovation. We successfully demonstrate the differential impact of HRM practices bundles on different degrees of open innovation. For example, whereas empowerment practice bundles share a linear relationship, capacity-enhancing practices share a quadratic relationship with different types of open innovation. Our drilled-down view offers more profound insights into HRM practice bundles and their influences on different types of open innovations.

MANAGERIAL IMPLICATIONS

Our findings are significant in light of a growing interest in locating redundant and effective combinations of HR practices that may foster open innovation. Our research presents a comprehensive outlook on the three genres of HR practice bundles in a knowledge-sharing context and the impact of their interactions among these HR practices on open innovation. We demonstrate the role of HR practice bundles that promote open innovation in an organization.

HR practitioners may need to use empowerment-enhancing practices generously to trigger open innovation in an organizational context, as it shares a linear relationship with open innovation. However, caution is needed while utilizing capacity-enhancing practices to stimulate employees for open innovation as their relationship with open innovation remains non-linear. It implies that although firms will receive some positive results with the initial usage of capacity-enhancing practices to encourage open innovation, higher usage may produce negative results. Motivation-enhancing practices state cautionary tales regarding their usefulness with regard to open innovation. Motivation-enhancing practices share a negative relationship with external search breadth – hence, HR professionals must refrain from using motivation-enhancing practices to encourage employees to participate in knowledge search. Though we may expect positive results regarding collaborative breadth, it also starts providing a negative marginal return after a theoretical threshold point. Thus, HR personnel must monitor closely and derive the appropriate usage level of these two practices while attempting to stimulate the workforce for open innovation. Substitutive relationships between HR practice bundles may persuade HR managers to select either of the two practices to steer open innovation activities without losing effectiveness. Though there are a few documented case examples, such as HP, IBM, and Cisco, where open innovation appears to be successful, our research offers a more drilled-down practice-level view required for stimulating open innovation.

LIMITATION

Our research has certain limitations, as mentioned below.

First, in this research, we have used perceptual measures to capture our variables of interest. Collecting objective data on internal collaboration arrangements and external search behaviour is challenging. Future research may look into objective metrics to operationalize the variables.

Second, we have only two (question) items representing each HR practice bundle. Future researchers may look into this and expand to accommodate other non-redundant scale items.

Third, our data is cross-sectional; hence, we refrain from claiming causal relationships among variables of interest.

Fourth, elements such as organization structure, hierarchy, performance metrics, and monitoring may punctuate open innovation context. Future researchers may look into these organizational operators that significantly affect open innovation.

CONCLUSION

We proposed and empirically demonstrated the relationship between human resource practices and open innovation. We evaluate our findings using multiple robustness tests. Our research provides actionable knowledge and guidance to HRM professionals while operating in an open innovation context. We hope our findings will create additional research opportunities in knowledge sharing context.

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