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Open Innovation search strategies and Innovation performance: differential moderating effects of Big Data Characteristics

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Abstract

This extended abstract examines the relationship between open innovation search strategies (breadth and depth) and innovation performance in SMEs. Specifically, it invokes a big data perspective to propose the differential moderating effects of four dimensions of big data characteristics, namely big data volume, variety, velocity, and veracity. Based on a sample of Italian SMEs, our statistical analysis intends to show the positive combinative effects of some big data characteristics and open innovation breadth on radical innovation outcomes and those of other big data characteristics and open innovation depth on incremental innovation outcomes. The findings of differential moderating effects underscore the need to assess the boundary conditions within which OI positively impacts on innovation outcomes. Additionally, they provide valuable insights to managers regarding the significance of big data characteristics in enhancing innovation outcomes through OI strategies.

Key words: open innovation; incremental innovation; SMEs; big data; Italy

Framing of the research. Since Chesbrough's seminal work in 2003, open innovation has increasingly captured the interest of both scholars and practitioners (Bogers et al., 2017; Dahlander et al., 2021), particularly in the domain of R&D management (Ferrigno, Crupi, Di Minin, Ritala, 2023). Open innovation facilitates firms in sourcing external ideas and resources, collaborating on the development of new products and processes with external partners, and leveraging internal ideas that deviate from the firm's current business model (Enkel et al., 2009; Ferrigno, Del Sarto, Cucino, & Piccaluga, 2022; Messeni Petruzzelli et al., 2022: 617), thereby influencing both financial and non-financial performance (Carrasco-Carvajal et al., 2023; Martín-Peña et al., 2023).

A significant focus lies on firms' search strategies within open innovation (Greco et al., 2015; Sà et al., 2023), with established literature supporting the concept of two distinct open innovation search strategies: (1) open innovation breadth, which denotes the number of sources utilized for innovation; and (2) open innovation depth, indicating the level of involvement of these sources in the innovation process (Laursen and Salter, 2006; Messeni Petruzzelli et al., 2022). Both these strategies shape firms' propensity towards acquiring external knowledge (Garriga et al., 2013; Laursen and Salter, 2006) from various sources, including suppliers, customers, competitors, financial institutions, consulting firms, other private enterprises, universities, research centers, and public organizations (Messeni Petruzzelli et al., 2022).

Existing literature has shown that open innovation search strategies affect firms' innovation performance (Cruz-González et al., 2015; Del Sarto et al., 2023; Greco et al., 2016; Henttonen et al., 2011). However, within the contemporary landscape, the proliferation of big data inundates the global sphere incessantly, with its growth trajectory expanding approximately tenfold every quinquennium (Del Vecchio et al., 2018; Hendrickson, 2010; Hilbert & López, 2011). Characterized by datasets of vast proportions that would necessitate significant storage capacities and temporal investments for analysis under conventional systems (Kaisler et al., 2013; Ward & Barker, 2013), big data assumes paramount importance as a pivotal competitive advantage and strategic resource, particularly discernible within the milieu of SMEs (Del Vecchio et al., 2018). In this regard, research has shown that big data may affect open innovation search strategies (Del Vecchio et al., 2018; Ferrigno, Barabuffi, Marcazzan, Piccaluga, 2023). Other scholars found that big data can also bring firms to improve their innovation performance (Ferrigno, Marcazzan, Barabuffi, Piccaluga, 2024; Johnson et al., 2017). Taken together, these streams of literature suggest that big data might play a role in the relationship between open innovation and incremental innovation in SMEs. However, scant research has analyzed whether the relationship between open innovation and incremental innovation is moderated by big data.

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Purpose of the paper. *Our paper aims at covering this gap by unveiling what v of the big data can play a moderation effect on the relationship between open innovation and incremental innovation. Big data is a multifaceted concept (Cappa et al., 2021). Thus, this study we refer to the most used characteristics of the big data (also known as 4Vs, see Ghasemaghaei & Calic, 2019): volume (i.e., the amount of data collected); variety (i.e., the assortment of data collected per observation); velocity (i.e., the speed of generating and analyzing data), and veracity (i.e., the reliability and insightfulness of data) (Cappa et al., 2021). Adopting these dimensions, we explore the following research question: what is the moderating effect of the volume, the variety, the velocity, and the veracity of big data on the relationship between SMEs' open innovation and innovation performance?*

To address this research question, we will follow recent studies that have investigated moderating effects around the relationship between open innovation and firm's innovation performance (Cruz-González et al., 2015; Ovuakporie et al., 2021). More specifically, we will firstly hypothesize that the relationship between open innovation search strategies (breadth and depth) and innovation performance (radical and incremental) is positive. After we will assume that some big data characteristics can moderate positively this relationship while others moderate it negatively.

Methodology. *To test our hypotheses, we will gather evidence on the adoption of Big Data from the perspective of SMEs at the individual firm level. To ensure internal validity, we have chosen the Italian context, aiming to control for normative environment, contextual munificence, and entrepreneurial opportunities (Beckman & Burton, 2008). Italy is characterized by a significant prevalence of SMEs, employing over 90% of the national workforce (Cucino et al., 2024; ISTAT, 2022). According to a study by the Italian Ministry of Economic Development (MISE, 2020), Italy demonstrates a notable percentage of firms transitioning towards Industry 4.0. Over the last decade, the Italian Government has initiated numerous plans and interventions to stimulate firms' digitalization and the adoption of Industry 4.0 technologies, including Big Data. Therefore, given Italy's distinctive economic structure primarily based on SMEs and recent national policies aimed at accelerating digitalization, Italy provides an intriguing setting to explore SMEs' behaviors concerning the adoption of Big Data (Martinelli et al., 2021).*

To construct our sample, we will utilize the Italian website "registroimprese" to identify companies involved in developing Big Data technologies. A preliminary search on this website yielded an initial sample of 4357 companies. Since our focus is primarily on analyzing the moderating effects of big data characteristics on the relationship between open innovation search strategies and SMEs' innovation performance, we will narrow down the sample by selecting companies with fewer than 250 employees and a turnover below €50 million (Messeni Petruzzelli et al., 2022). Subsequently, we will employ the Orbis database to access the email addresses and main contacts of these companies. Additionally, we will manually search companies' websites for data that cannot be downloaded. We intend to reach out to the selected Italian SMEs and distribute an online structured questionnaire to be completed by their CEOs or founders. Our objective is to gather more than 150 responses to facilitate a quantitative analysis of the moderating effects of big data characteristics on the relationship between open innovation search strategies and SMEs' innovation performance.

We will test the hypotheses by running several OLS regressions in which the dependent variable is represented by incremental and radical innovation, while the main independent variables are represented by open innovation breadth, open innovation depth and 4Vs of big data. Moreover, the main focus of our analysis is understanding the moderating effect of big data characteristics on open innovation strategies, hence we introduce interaction terms among our main independent variables.

As regards the dependent variables (radical and incremental innovation performance), we will follow the methodologies outlined by Subramanian & Youdt (2005) and Mikalef et al. (2019) and assess radical and incremental innovation using a three-item, 7-point Likert scale through elaborating specific questions that capture these concepts. For the regression analysis, we consider the average score of the multiple responses.

Regarding the operationalization of variables, we will follow the measures used in previous studies on Open innovation search strategies (Messeni Petruzzelli et al., 2022, based on Laursen and Salter, 2006). The explanatory variables of open innovation search strategies (namely (1) open innovation breadth, which denotes the number of sources utilized for innovation; and (2) open innovation depth, indicating the level of involvement of these sources in the innovation process (Laursen and Salter, 2006; Messeni Petruzzelli et al., 2022)) will be computed as it follows. Firstly, we will operationalize open innovation breadth as the count of sources (including suppliers, customers, competitors, financial companies, consulting companies, other private companies, universities, research centers, and other public organizations) collaborating with the SMEs to foster innovative activities. Secondly, open innovation depth will be operationalized as the count of sources with which the firm collaborates "very often" (Messeni Petruzzelli et al., 2022). The variables are computed by summing the number of sources and the number of sources with which a firm collaborates "very often". Consequently, their value ranges between zero (indicating no collaboration, minimum) and eight (maximum), and we will treat Open innovation search strategies as categorical variables.

To gauge the "4Vs" of big data, we draw upon insights from prior research on big data characteristics. Consistent with the approach outlined by Johnson et al. (2017) and Ghasemaghaei & Calic (2020), we evaluate "big data volume," "big data velocity," and "big data variety" using a 7-point Likert scale, ranging from 1 ("strongly disagree") to 7 ("strongly agree"). Conversely, to operationalize "big data veracity," we rely on the work of Ghasemghaei (2021). The Likert scale allows us to assess the extent of data collected ("big data volume") (Cappa et al., 2021), the diversity of data per observation ("big data variety") (Cappa et al., 2021), the pace of data collection and analysis ("big data velocity") (Ghasemaghaei & Calic, 2020), and the reliability of data collection and analysis ("big data veracity") (Ghasemaghaei, 2021). The measures of "big data volume" and "big data velocity" comprise 4 items each, while those of "big data

variety” and “big data veracity” consist of 3 items. Specifically, for the regression analysis, we consider the average score of the multiple responses.

Furthermore, consistent with previous studies, our model will include the following control variables: (1) whether the SME operates in a high-tech industry or not (Messeni Petruzzelli et al., 2022), (2) the SME's age (Kelly & Amburgey, 1991), (3) the SME's size (Arbore & Ordanini, 2006; Horváth & Szabó, 2019), (4-5) the SME's potential and realized absorptive capacity (i.e., the R&D expenses on total revenue and the number of patents in the last 10 years; see Cassetta et al., 2020; Zahra & George, 2002), and (6) the digital skills of the SME's human resources (measured as the percentage of employees with a STEM degree; see Agostini & Filippini, 2019; Eller et al., 2020; Giotopoulos et al., 2017; Horváth & Szabó, 2019).

Results. In general, we expect that big data characteristics will moderate the relationship between open innovation search strategies and innovation performance. However, taking into consideration the different v of big data (volume, variety, velocity, and veracity) and also the open innovation search strategies (breadth and depth) we also expect that the magnitude of these moderating effects could be different. In particular, we anticipate that some big data characteristics are more important than others in enhancing/downgrading the impact of open innovation breadth/depth on SMEs' incremental/radical innovation.

Research limitations. Although this extended abstract may contribute to our understanding of big data characteristics as moderating variables that affect open innovation search strategies and SMEs' innovation performance, many limitations should be taken into consideration. First, we identified the open innovation search strategies for our study based on the framework established by Messeni Petruzzelli et al. (2021; which is based on Laursen and Salter, 2006). However, we recognize the existence of other open innovation conceptualizations such as those highlighted in different studies that we have not included in our questionnaire. For example, Gassmann et al. (2010) adopt a 'process perspective,' categorizing these practices into inbound, outbound, and coupled OI processes; while Spithoven et al. (2013) suggest four open innovation practices, such as (1) search for external sources of innovation, (2) the acquisition of external R&D, (3) the use of collaborative innovation partners and (4) the exploitation of available IP protection mechanisms. Future research could replicate our methodology while also considering alternative open innovation conceptualizations identified in other studies.

Second, we have scrutinized the relationship between open innovation search strategies and innovation performance and the moderating role of Big Data characteristics within a highly specific setting: Italian (SMEs) listed on the Italian website “registroimprese”. We acknowledge the limited generalizability of our findings to this particular organizational category operating within the confines of this specific national context. Future investigations could explore the moderating effects of big data on open innovation impact on SMEs innovation performance across diverse geographical locations. Moreover, while our study primarily focuses on SMEs, forthcoming research could also examine these relationships on a broader spectrum of enterprises, encompassing established firms, larger corporations, and startups alike.

Third, in this study we analyzed the moderating role played by the most explored v of big data. However, other unexplored dimensions of interest in big data involve variability in data flow, acknowledging the inconsistencies within datasets (Katal et al., 2013), and the realm of big data visualization, which concerns organizations' ability to formulate pertinent inquiries to extract meaningful value from their big data initiatives (Simon, 2014). Future research endeavors could delve into these dimensions of big data to gain a more comprehensive understanding of how they influence open innovation impact on SMEs' innovation performance.

Managerial implications. The expected findings might have implications for managerial practices. More specifically, we emphasize that a more cooperative and collaborative relationship between SMEs and other organizations may facilitate their innovation performance, which is fundamental for those companies that are facing organizational and business challenges that contain their future growth. In general, we expect that open innovation search strategies may allow SMEs to increase their radical and incremental innovation performance. More specifically, we highlight that the magnitude and the path that explain this relationship could be different, depending on the v of big data.

Our research holds potential significance for policymakers as well. Specifically, we aim to demonstrate the importance of policymakers supporting firms in developing tools for analyzing big data. These tools offer valuable insights that facilitate interactions among firms, enabling the exchange of knowledge crucial for enhancing their innovation performance. Therefore, our study underscores the importance of policymakers fostering an environment conducive to the development and utilization of big data analysis tools, ultimately contributing to improved innovation outcomes within firms.

Originality of the paper. The main originality of the paper relies on its focus on the moderating effects of big data characteristics on the relationship between open innovation search strategies and innovation performance. Theoretically speaking, our study could suggest important and peculiar dimensions of big data that may increase or decrease the effect of open innovation search and breadth strategies on SMEs' radical and incremental innovation. Practically speaking, our study can be used not only by SMEs' owner-managers, but also by policymakers in order to promote policies in favor of more cooperative and collaborative behavior in the SMEs' ecosystem by leveraging Big Data.

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