Sinergie SIMA
Management Conference

Rediscovering local roots and interactions in management

Conference Proceedings

Short papers

Bari (Italy)

29-30 June 2023

Sinergie-SIMA Management Conference Proceedings
Rediscovering local roots and interactions in management
29-30 June 2023
Mercure Villa Romanazzi Carducci (Bari)

ISBN 978-88-94-7136-3-3

The Conference Proceedings are published online on *https://www.sijmsima.it*

Via Interrato dell'Acqua Morta, 26
37129 Verona - Italy

Rediscovering local roots and interactions in management

29-30 June 2023

Conference Proceedings

Short Papers

edited by

Arabella Mocciaro Li Destri, Marta Ugolini,
Angeloantonio Russo and Savino Santovito

What Open Innovation practices enhance SMEs' adoption of Big Data?

GIULIO FERRIGNO[*] SAVERIO BARABUFFI[•] ENRICO MARCAZZAN[♠] ANDREA PICCALUGA[**]

Framing of the research. *Nowadays, the world is overwhelmed by Big Data generated every second, with the growth rate increasing approximately 10 times every five years (Del Vecchio et al., 2018; Hendrickson, 2010; Hilbert and López, 2011). Big Data refers to any set of data that, with traditional systems, would require large capabilities in terms of storage space and time to be analysed (Kaisler et al., 2013; Ward and Barker, 2013). The ability to aggregate, elaborate and analyse Big Data is becoming a key competitive advantage and resource, especially for small- and medium-sized enterprises (SMEs) (Del Vecchio et al., 2018). However, SMEs struggle with the liability of smallness, facing resource constraints and scale limitations and having fewer technological assets to bargain with (Chesbrough 2011; Dahlander and Gann 2010; Narula 2004). Therefore, they have to open up more than their larger counterparts to access external knowledge and technology for innovative purposes (Mesquita and Lazzarini 2008).*

In order to adopt Big Data technologies, SMEs can leverage their external networks (Mittal et al., 2018; Spithoven et al., 2013). In fact, external partners can increase SMEs' awareness of the benefits and challenges of Big Data technologies and provide useful knowledge and support for their adoption, thereby reducing their reluctance to invest in them (Bourke and Roper, 2019). More specifically, Open Innovation (OI) practices (Chesbrough, 2003; Spithoven et al., 2013) can support the transformation of SMEs' processes and products provoked by the adoption of Big Data technologies, because the required resources can be made available through the cooperation with other organizations (Terjesen and Patel, 2017). Accordingly, SMEs become able to strategically adopt new technological solutions (Lichtenthaler, 2008). Although OI is commonly included in maturity models to assess a firm's readiness to Big Data technologies (e.g. Prause, 2015; Schumacher et al., 2016), its effect on the adoption of Big Data technologies has not been deeply analysed. Indeed, extant studies tend to focus on the obstacles that hamper their adoption without focusing on the strategy that they can adopt to overcome their problems (Horváth and Szabó, 2019). Actually, some scholars have recently investigated how OI can support SMEs in the adoption of I4.0 technologies (Messeni Petruzzelli et al., 2022). However, their analysis is not focused on Big Data and is limited by the regional context (Campania) used to test their hypotheses.

Purpose of the paper. *Our paper aims at covering this gap by investigating how SMEs can adopt a larger number of Big Data technologies by leveraging OI practices. To analyse OI practices, we consider the four dimensions proposed by Spithoven et al. (2013), namely (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. We discuss the relevance of the four OI practices for SMEs below.*

Albeit OI is a broad and multifaceted concept that involves a variety of innovation-related practices and processes in companies, the four dimensions highlight the main practices that can be articulated in the well-known categorization of inbound, outbound, and coupled OI processes (Gassmann et al., 2010). First, in OI literature it is acknowledged that firms heavily rely on external sources of information, subsequently combining these external sources with internal sources of innovation (Dahlander et al., 2021). Search strategies have thus been recognized as exerting an impact on the innovation activities of firms (Katila and Ahuja 2002; Laursen and Salter 2006). This OI practice is highly relevant for SMEs since they struggle with the liability of smallness, facing resource constraints such as fewer human resources to screen the external environment, scale limitations and having fewer technological assets to bargain with (Chesbrough 2011; Dahlander and Gann 2010; Narula 2004).

Second, previous research on OI has also emphasized that firms are no longer in a position to perform all R&D internally (Gassmann, 2006). Firms have to acquire-through licensing, venturing or buying-external knowledge. In this regard, SMEs not only lack financial resources but also the required number of skilled workers to perform R&D internally.

[*] Senior Assistant Professor *of Management* – Sant'Anna School of Advanced Studies, Pisa
e-mail: giulio.ferrigno@santannapisa.it
[•] Research Fellow *of Management* – Sant'Anna School of Advanced Studies, Pisa
e-mail: saverio.barabuffi@santannapisa.it
[♠] Research Fellow *of Management* – Sant'Anna School of Advanced Studies, Pisa
e-mail: enrico.marcazzan@santannapisa.it
[**] Full Professor *of Management* – Sant'Anna School of Advanced Studies, Pisa
e-mail: andrea.piccaluga@santannapisa.it

Sinergie-SIMA 2023 Management Conference ***Conference Proceedings***
Rediscovering local roots and interactions in management **ISBN 978-88-94-7136-3-3**
29-30 June 2023 - LUM University and the University of Bari (Italy) **DOI 10.7433/SRECP.EA.2023.01**

Third, extant studies have also documented that firms can make use of a variety of collaborative innovation partners such as customers, suppliers, competitors, universities, public research organisations, consultants, professional and industrial associations, among others (Leiponen and Helfat 2010). Since the process of developing and introducing big data technologies is more complex for SMEs than before, the use of collaborative innovation partners to innovate can be important to improve or speed up innovation (Laursen and Salter 2006; Messeni Petruzzelli et al., 2022).

Fourth, existing OI studies pointed out that IP protection mechanisms are indispensable to stimulate the firm's propensity to engage in risky and uncertain R&D investments and innovation projects such as big data technologies. In this context, Lee et al. (2010) argue that exploitation of IP protection mechanisms is particularly important for SMEs.

In line with this theoretical approach, we will develop some hypotheses to analyse the effects of these OI dimensions on SMEs adoption of Big Data technologies. Exactly, we will hypothesize that some OI practices may provide a large variety of, potentially complementary, resources that may support SMEs in dealing with the uncertain and complex implementation of Big Data technologies (Messeni Petruzzelli et al., 2022). Conversely, we will assume that other OI practices may support the absorption of some resources, like tacit knowledge, that may improve the implementation of Big Data technologies (Terjesen and Patel, 2017).

Methodology. *To test our hypotheses, we will collect evidence on the adoption of Big Data from SMEs' perspective, at the individual firm level. To ensure internal validity, we will select the Italian context to control for normative environment, contextual munificence, and entrepreneurial opportunities (Beckman and Burton, 2008). Italy is characterized by a large prevalence of SMEs, since they employ more than 90% of the national workforce (ISTAT, 2022). In accordance with a study of the Italian Ministry of the Economic Development (MISE, 2020), Italy presents a high percentage of firms that are moving toward I4.0. As a matter of fact, in the last decade, the Italian Government has launched a number of plans and ad-hoc interventions to stimulate firms' digitalization and the adoption of I4.0 technologies, including Big Data. Consequently, considering the peculiar structure of the Italian economy mainly based on SMEs and the recent national policies aiming at accelerating digitalisation, Italy represents an interesting country to catch the complexity of SMEs behaviors toward the adoption of Big Data (Martinelli et al., 2021).*

To build our sample, we will access the Italian website "registroimprese" and search for the companies that develop Big Data technologies. A preliminary search on this website produced an initial sample of 3891 companies. Since we are mainly interested to analyze SMEs' adoption of Big Data technologies, we will restrict the sample by selecting those companies that employed less than 250 people and had a turnover lower than 50 millions of euros (Messeni Petruzzelli et al., 2022). After, we will use Orbis database to access the mail and main contacts of the companies. Moreover, we will manually search on companies' websites for data that we will not be able to download. We will contact the selected italian SMEs and send them an online structured questionnaire to be addressed by their CEOs or founders. We aim to collect more than 150 responses in order to perform a quantitative analysis of what OI practices enabled Italian SMEs' to adopt Big Data technologies.

As regards the operationalization of the variables, we will follow the measures used by previous studies on OI practices in SMEs (Spithoven et al., 2013), especially with regards to Big Data technologies (Messeni Petruzzelli et al., 2022). The explanatory variables of OI practices (namely (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) will be scaled between a minimum value of 0, implying that no use is made of them, and a maximum value of 10, implying that they are all used. Then, we will use composite indicators to examine the effects of OI practices by applying Factor Analysis to resume and to reduce the complexity of the questionnaire answers into the four dimensions proposed by Spithoven et al. (2013) since we cannot measure them directly. Factor Analysis models the observed variables (i.e., questionnaire's answers) as a linear function of a smaller number of underlying unobservable factors (i.e., dimensions of OI practices) as proposed by previous studies (Bigliardi and Galati, 2016), Sun et al., 2020). Each factor will capture a certain amount of the overall variance in the observed variables, and the factors will be listed according to how much variation they explain (Fabrigar and Wegener, 2011).

Moreover, in line 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 and Amburgey, 1991), (3) the SME's size (Arbore and Ordanini, 2006; Horváth and Szabó, 2019), (4-5) the SME's potential and realised 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 and George, 2002), (6) the digital skills of the SME's human resources (measured as the percentage of employees with a STEM degree; see Agostini and Filippelli, 2019, Eller et al., 2020, Giotopoulos et al., 2017, Horváth and Szabó, 2019), and (7-8-9) the CEO's education, age and tenure (Datta et al., 2003; Li et al., 2018; Wiersema and Bantel, 1992).

We will test the hypotheses by running several probit regressions to estimate the effect of OI practices on the probability of adopting Big Data technologies. Probit models have been widely used to quantitatively assess the role of open innovation in firms (Spithoven et al., 2013; Triguero and Fernandez, 2016) and the link between Big Data and innovation (Niebel et al., 2018).

Results. *In general, we expect that OI practices will lead to an increased propension of adopting Big Data technologies in SMEs. However, taking into account the different OI practices, we also expect that the magnitude and the path that leads to this enhancing adoption could be different. In particular, we anticipate that the degree of breadth of the OI is more important than the degree of depth in SMEs' Big Data technologies adoption.*

Research limitations. *Although this extended abstract may contribute to our understanding of OI practices affecting SMEs' propension to adopt Big Data technologies, several limitations must be taken into account. First, the*

OI practices on which we base our study were identified though the work written by Spithoven et al. (2013). However, we are aware that other studies recognize other OI practices that we do not consider in our questionnaire. For instance, Gassmann et al. (2010) take a 'process perspective' by discussing these practices in terms of inbound, outbound and coupled OI processes. Future studies may replicate our approach by also considering alternative OI practices.

Second, we have examined the effects of OI practices on the adoption of Big Data technologies in a very specific context: Italian SMEs that are registered at the Italian website "registroimprese". We recognize that the generalizability of our results is limited to this type of organization operating in this specific country. Future studies could investigate what are the effects of OI practices in SMEs operating in other countries. Likewise, this study focuses on SMEs. Future research may examine the impact of OI practices in other types of firms, such as older firms, large firms, or start-ups.

Third, in this study we do not analyze the characteristics of the potential partners and collaboration in the OI practices. Future studies may investigate if these characteristics moderate the effects of OI practices on SMEs' adoption of Big Data technologies.

Fourth, OI practices may affect every type of I4.0 technology (Messeni Petruzzelli et al., 2022). In this study, we have focused our attention on Big Data. It might be interesting to study whether the impact of OI practices on Industry 4.0 technologies differ by considering the technological features that epitomize a specific technology. For instance, future studies may explore whether OI practices impact differently on Industry 4.0 base technologies and front-end technologies (Frank et al. 2019).

Last but not least, in this study we will analyze what OI practices affect SMEs' propensity to adopt Big Data technologies. However, we will not investigate whether the adoption of these technologies can be reflected in SME's innovation performance. Future studies may conduct econometric analysis that can assess the mediation effects of OI practices on the relationship between the adoption of Big Data technologies and SMEs' innovation performance.

Managerial implications. *Our research has implications for practitioners such as SMEs owners-managers. More specifically, we emphasize that a more cooperative and collaborative relationship between SMEs and other organizations may facilitate their propensity to adopt Big Data technologies, which is fundamental for those companies that are facing organizational and business challenges that contain their future growth. In general, we expect that OI practices may allow SMEs towards an increased propension of adopting Big Data technologies. More specifically, we highlight that the magnitude and the path that leads to this enhancing adoption could be different, depending on the type of OI practices. As a matter of fact, this study suggests that the degree of breadth of the OI is more important than the degree of depth in SMEs' Big Data technologies adoption.*

Moreover, our expected findings may point out that OI practices may allow SMEs' managers to make up for the lack of financial resources sources and knowledge that can be accessed by forming open and collaborative relationships with external partners. On this basis, SMEs' CEOs must overcome the well-known "not invented here" syndrome and dedicate their resources to the relationship with external partners in order to develop big data technologies.

Our study may also be considered useful for policy makers. More specifically, in this study we will show that policy makers should support interactions between firms to facilitate the exchange of knowledge that is necessary to develop breakthrough technologies such as Big Data technologies.

Originality of the paper. *The main originality of the paper relies on its focus on the underestimated relationship between the setting (i.e., SMEs) and the particular Industry 4.0 technology (i.e., Big Data) analysed, covering a research gap in the literature that should be studied for both theoretical and practical reasons. Theoretically speaking, moving away from the view that considers (only) the SMEs' limitations in adopting I4.0 technologies, our study could suggest important and peculiar factors that SMEs could implement for the adoption of Big Data technologies (compared to their larger counterpart). 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.*

Keywords: *Big Data; Open Innovation; SME; Industry 4.0*

References

AGOSTINI L., FILIPPINI, R. (2019), "Organizational and managerial challenges in the path toward Industry 4.0", *European Journal of Innovation Management*, vol. 22, n. 3, pp. 406-421.

ARBORE A., ORDANINI A. (2006), "Broadband divide among SMEs: the role of size, location and outsourcing strategies", *International Small Business Journal*, vol. 24, n. 1, pp. 83-99.

BECKMAN C.M., BURTON M.D. (2008), "Founding the future: path dependence in the evolution of top management teams from founding to IPO", *Organization Science*, vol. 19, n. 1, pp. 3-24.

BIGLIARDI B., GALATI F. (2016), "Which factors hinder the adoption of open innovation in SMEs?", *Technology Analysis & Strategic Management*, vol. 28, n. 8, pp. 869-885.

CASSETTA E., MONARCA U., DILEO I., DI BERARDINO C., PINI M. (2020), "The relationship between digital technologies and internationalisation. Evidence from Italian SMEs", *Industry and Innovation*, vol. 27, n. 4, pp. 311-339.

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

CHESBROUGH H.W. (2011), "Bringing open innovation to services", *MIT Sloan Management Review*, vol. 52, n. 2, p. 85.
DAHLANDER L., GANN D.M. (2010), "How open is innovation?", *Research Policy*, vol. 39, pp. 699-709.
DAHLANDER L., GANN D.M., WALLIN M.W. (2021), "How open is innovation? A retrospective and ideas forward". *Research Policy*, vol. 50, n. 4, 104218.
DATTA D.K., RAJAGOPALAN N., ZHANG Y. (2003), "New CEO openness to change and strategic persistence: the moderating role of industry characteristics", *British Journal of Management*, vol. 14, n. 2, pp. 101-114.
DEL VECCHIO P., DI MININ A., PETRUZZELLI A.M., PANNIELLO U., PIRRI S. (2018), "Big data for open innovation in SMEs and large corporations: Trends, opportunities, and challenges", *Creativity and Innovation Management*, vol. 27, n. 1, pp. 6-22.
ELLER R., ALFORD P., KALLMÜNZER A., PETERS M. (2020), "Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization", *Journal of Business Research*, vol. 112, pp. 119-127.
FABRIGAR L.R., WEGENER D.T. (2011), *Exploratory factor analysis*, Oxford University Press.
FRANK A. G., DALENOGARE L.S., AYALA N.F. (2019), "Industry 4.0 technologies: Implementation patterns in manufacturing companies". *International Journal of Production Economics*, vol. 210, pp. 15-26.
GASSMANN O. (2006), "Opening up the innovation process: Towards an agenda", *R&D Management*, vol. 36, n.3, pp. 223-228.
GASSMANN O., ENKEL E., CHESBROUGH H. (2010), "The future of open innovation", *R&D Management*, vol. 40, n. 3, pp. 213-221.
GIOTOPOULOS I., KONTOLAIMOU A., KORRA E., TSAKANIKAS A. (2017), "What drives ICT adoption by SMEs? Evidence from a large-scale survey in Greece", *Journal of Business Research*, vol. 81, pp. 60-69.
HENDRICKSON S. (2010), *Getting Started with Hadoop with Amazon's Elastic MapReduce*, EMR-Hadoop Meetup, Boulder/Denver.
HILBERT M., LÓPEZ P. (2011), "The world's technological capacity to store, communicate, and compute information", *Science*, vol. 332, pp. 60-65.
HORVÁTH D., SZABÓ R.Z. (2019), "Driving forces and barriers of Industry 4.0: do multinational and small and medium-sized companies have equal opportunities?", *Technological Forecasting and Social Change*, vol. 146, pp. 119-132.
ISTAT (2022), "*Annuario statistico italiano 2022*", Roma: Istituto nazionale di statistica.
KAISLER S., ARMOUR F., ESPINOSA J.A., MONEY W. (2013), "Big data: Issues and challenges moving forward", *46th Hawaii International Conference on System Sciences*, Wailea, USA, pp. 995-1004.
KATILA R., AHUJA, G. (2002), "Something old, something new: A longitudinal study of search behavior and new product introduction", *Academy of Management Journal*, vol. 45, n. 6, pp. 1183-1194.
KELLY D., AMBURGEY T.L. (1991), "Organizational inertia and momentum: a dynamic model of strategic change", *Academy of Management Journal*, vol. 34, n. 3, pp. 591-612.
LAURSEN K., SALTER A. (2006), "Open for innovation: The role of openness in explaining innovative performance among UK manufacturing firms", *Strategic Management Journal*, vol. 27, n. 2, pp. 131-150.
LEE S., PARK G., YOON B., PARK J. (2010), "Open innovation in SMEs-an intermediated network model", *Research Policy*, vol. 39, n. 2, pp. 290-300.
LEIPONEN A., HELFAT C.E. (2010), "Innovation objectives, knowledge sources, and the benefits of breadth", *Strategic Management Journal*, vol. 31, pp. 224-236.
LI L., SU F., ZHANG W., MAO J.Y. (2018), "Digital transformation by SME entrepreneurs: a capability perspective", *Information Systems Journal*, vol. 28, n. 6, pp. 1129-1157.
LICHTENTHALER U. (2008), "Open innovation in practice: an analysis of strategic approaches to technology transactions", *IEEE Transactions on Engineering Management*, vol. 55, n. 1, pp. 148-157.
MARTINELLI A., MINA A., MOGGI M. (2021), "The enabling technologies of industry 4.0: examining the seeds of the fourth industrial revolution", *Industrial and Corporate Change*, vol. 30, n. 1, pp. 161-188.
MESQUITA L.F., LAZZARINI S.G. (2008), "Horizontal and Vertical Relationships in Developing Economies: Implications for SMEs' Access to Global Markets", *Academy of Management Journal*, vol. 51, n. 2, pp. 359-380.
MESSENI PETRUZZELLI A., MURGIA G., PARMENTOLA A. (2022), "How can open innovation support SMEs in the adoption of I4.0 technologies? An empirical analysis", *R&D Management*, vol. 52, n. 4, pp. 615-632.
MISE (2020), "*Relazione sugli investimenti di sostegno alle attività economiche e produttive 2020*", Roma: Ministero dello Sviluppo Economico.
MITTAL S., KHAN M.A., ROMERO D., WUEST T. (2018), "A critical review of smart manufacturing & Industry 4.0 maturity models: implications for small and medium-sized enterprises (SMEs)", *Journal of Manufacturing Systems*, vol. 49, pp. 194-214.
NARULA R. (2004), "R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation", *Technovation*, vol. 25, pp. 153-161.
NIEBEL T., RASEL F., VIETE, S. (2019). "BIG data–BIG gains? Understanding the link between big data analytics and innovation.", *Economics of Innovation and New Technology*, vol. 28, n. 3, pp. 296-316.
PRAUSE G. (2015), "Sustainable business models and structures for Industry 4.0", *Journal of Security & Sustainability Issues*, vol. 5, n. 2, pp. 159-169.
SCHUMACHER A., EROL S., SIHN W. (2016), "A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises", *Procedia CIRP*, vol. 52, n. 1, pp. 161-166.
SPITHOVEN A., VANHAVERBEKE W., ROIJAKKERS N. (2013), "Open innovation practices in SMEs and large enterprises", *Small Business Economics*, vol. 41, pp. 537-562.
SUN Y., LIU J., DING Y. (2020), "Analysis of the relationship between open innovation, knowledge management capability and dual innovation", *Technology Analysis & Strategic Management*, vol. 32, pp.15-28.
TERJESEN S., PATEL P.C. (2017), "In search of process innovations: the role of search depth, search breadth, and the industry environment", *Journal of Management*, vol. 43, n. 5, pp. 1421-1446.
TRIGUERO A., FERNANDEZ S. (2018), "Determining the effects of open innovation: the role of knowledge and geographical spillovers", *Regional Studies*, vol. 52, n. 5, pp. 632-644.
WARD J.S., BARKER A. (2013), "Undefined by data: A survey of big data definitions", *arXiv preprint*, arXiv:1309.5821.

WIERSEMA M.F., BANTEL K.A. (1992), "Top management team demography and corporate strategic change", *Academy of Management Journal*, vol. 35, n. 1, pp. 91-121.
ZAHRA S.A., GEORGE G. (2002), "Absorptive capacity: a review, reconceptualization, and extension", *Academy of Management Review*, vol. 27, n. 2, pp. 185-203.