Crowd Dynamics and Co-Creation Practices In Robotics Innovation: An Interpretive Study Of Facilities And Education Initiatives

ABSTRACT

This paper aims to investigate the characteristics and organizing forms of facilities where the design and testing of robotics innovation happen. In particular, the paper addresses a gap in the state-of-the-art literature, which has not fully investigated the connection between those facilities, the different types of crowds involved in the design and testing of robotics innovation, and the values embedded in their outputs. To this end, this article presents a qualitative research based on two interpretive case studies of facilities and education initiatives in Italy and Switzerland. The article aims to provide a further understanding of the role of crowds in innovation, especially focusing on robotics, and to contribute to the stream of research connecting open innovation and resource-based view (RBV), by questioning how facilities for co-creation, specifically in robotics, inform the values that make both the testing sites and their outputs valuable resources. Also, the article adds its results to the corpus of studies on the collaboration between universities and firms, by highlighting organizational factors and trajectories that may eventually lead to the creation of innovation ecosystems and infrastructures.

Keywords:

Co-creation, Robotics, Crowd-dynamics, Resource-based-view (RBV)

Introduction

Innovation through robotics is relevant both at the business and societal level, especially considering the role that robots have in healthcare and crises as well as their prospected diffusion in the future. Also, understanding the elements that allow firms to create and capture value from co-cocreation practices would be relevant to their research and development strategies. This paper aims to investigate the characteristics and organizing forms of facilities where the design and testing of robotics innovation happen. In particular, the paper addresses a gap in the state-of-the-art literature, which has not fully investigated the connection between those facilities, the different types of crowds involved in the design and testing of robotics innovation, and the values informing or rather forming their outputs. In this paper, the focus is on robotics innovation facilities and education initiatives for addressing the following research questions:

- *What are the key characteristics of innovation facilities for value creation and value capture?*
- *How crowd dynamics eventually shape collective co-creation activities in robotics innovation facilities, either enabling or bounding their capacity of scaling?*
- *What are the trajectories that enforce an innovation infrastructure or ecosystem from design and testing facilities?*

The paper is structured as follows. First, the theoretical background is discussed, and the methodology is outlined. Then the results are presented and discussed with regard to their contribution to scholarship and practice before concluding remarks end the paper.

Theoretical background

The study of users as innovators has been at the center of the interests of management scholars in the last two decades, where the role of users in innovation has been considered valuable in the high tech industry (Bogers et al., 2010, p. 869). Also, from a strategy point of view, the involvement of users as innovators and the co-creation of the outcomes (Prahalad & Ramaswamy, 2004; Ramaswamy, 2010; Storbacka et al., 2016; Tekic & Willoughby, 2019) are linked to value-creation in inter-organizational relationships framed by openness (Frow et al., 2015; Laursen & Salter, 2014; Prahalad & Ramaswamy, 2004). Those issues are particularly relevant considering the recent rush to fund and invest in facilities and initiatives for testing and promoting co-creation in innovation. Especially in robotics and artificial intelligence (Iansiti & Lakhani, 2020) facilities may scale to become infrastructures for the design and development of new systems having societal impacts (Barrett et al., 2011). However, the state of the art literature has not fully investigated the connection between the facilities, the different types of crowds of actors (users, scientists, managers, citizens, etc.) involved in the design and testing of robotics innovation, and the values informing or rather forming the outputs of co-creation

initiatives that may eventually lead to new ecosystems (Adner, 2017; Adner & Kapoor, 2010) or infrastructures (Monteiro et al., 2013; Star, 1999).

Taking these issues into account, crowdsourcing has received increasing attention from management scholars, especially interested in innovation (Afuah & Tucci, 2012; Felin et al., 2017; Majchrzak & Malhotra, 2020). Although not anymore purely considered a specific form of outsourcing, crowdsourcing is still mainly studied as a specific practice of open innovation (Bogers et al., 2017; West & Bogers, 2014, 2017) for attracting ideas or productive resources that are external to an organization (Boudreau et al., 2016; Boudreau & Lakhani, 2013; Lin et al., 2015; Majchrzak & Malhotra, 2016; Piezunka & Dahlander, 2018). However, the status of crowdsourcing as a practice fully belonging to open innovation may be nowadays questioned by the rising interest in internal crowdsourcing (Zuchowski et al., 2016) and the study of the performance of teams in crowd-based settings for problem-solving (Riedl & Woolley, 2016). Moreover, especially focusing on markets and features as information aggregation and matching, Felin & Zenger (2011, p. 169) have proposed a perspective on crowdsourcing-like efforts as unique market–hierarchy hybrids. Moreover, Zollo et al (2018, p. 1775) point out that "the involvement of representative members of stakeholder categories in strategic decisions is, in and of itself, an important venture for future work," also including crowdsourcing among the ways to opening the strategy-making process of the firm. Finally, Nickerson et al. (2016, p. 278) outlined key issues and constructs for early foundations of a theory of crowdsourced value creation

consistent “not only with transaction cost economics but also the resource-based and capabilities perspectives” (*Ibid.*, p. 279).

In line with that perspective, the arguments making up the background for this paper point out the potential theoretical and practical value of questioning the strategy implications of crowdsourcing under the lens of the resource-based-view (RBV) theory (Barney, 2001, 1991; Barney et al., 2011; Mata et al., 1995). This perspective has been recently explored in the area of management information systems for identifying the firm intentions to crowdsource (Ye & Kankanhalli, 2015) and in the literature on innovation by Cappa et al. (2019) to question how crowdsourcing may impact the future profits of a firm, leading to the identification of two contingency factors, brand value, and investment opportunities. However, the number of articles focused on the adoption of RBV for understanding crowdsourcing specifically oriented toward the theory and the practice of strategic management is still limited and this paper aims to contribute to increasing the corpus of strategy literature on those topics by considering the specific domain of robotics innovation.

Methodology

This article presents the early results from a qualitative research based on two interpretive case studies for the substantive domain of design and testing of robotics innovation. The research has been carried out as part of the SCALINGS project focused on

the study of co-creation practices in the design and testing of robotics and energy innovation, questioning their scalability and situatedness when adopted in context with different socio-economic characteristics. In this paper, the focus is on robotics innovation facilities and education.

The arguments are developed empirically through the analysis of two interpretive case studies (Walsham, 2006): a Robotics Innovation Facility (RIF) based in Italy, where an ethnography has been carried out in 2018-2019, and a set of initiatives on educational robotics by the EPFL Center for Learning Science (LEARN), in Vaud, Switzerland observed in 2019-2020. The research at the basis of the case study has included desk research on documents and websites providing information on the activities of the considered organizations. Besides desk research and fieldwork, 23 people have been interviewed. The interviews were semistructured, whose average length was 30 minutes, resulting in nearly seven hours for transcription. Memos and field notes taken during the fieldwork are part of the corpus of data that have been analyzed with the software ATLAS.ti, by following the sequence of open coding, selective coding, and theoretical coding of the classical or glaserian grounded theory (Glaser, 1978; Holton & Walsh, 2017). However, it is worth noting that in this paper the results are mainly descriptive and based on categories emerging from open coding and constant comparative analysis of data.

Results

The analysis of the two cases shows that a co-creation facility is not a single identifiable place, but an ecosystem including physical labs, *temporary assembly* in public school classrooms, and *exhibiting* the robots in industry and market events or expositions. This diversity of spaces and settings making up the facilities as part of an ecosystem is acknowledged by informants who see, for example, a RIF not only as validation spaces but also to connect research, territory, and businesses. Furthermore, the enactment of ecosystems from facilities for robotics innovation eventually leads to the involvement of different types of crowds of actors that, on the one hand, intervene in the design and testing of robotics innovation; on the other hands, the interaction of situated and diverse crowds of actors with testable robots *informates* (Zuboff, 1988) the resulting artifacts with specific effects on:

- the values embedded in the robotics products and services (through the value orientation and culture of groups and local communities sample of users) and
- the value (economic, public, and social) created or eventually captured through the testing and experiments on external crowds of actors (not necessarily including the same sample of users involved in the design phase but a larger population).

Also, the different contextual logics at play from the academic side (ranging from *enacting acceptability* through user-centered design to the promotion of *computational thinking*) and

industrial partners (with an interest in the application and testing of their innovative robots) enact robots as "*black-boxed*" (Kline & Pinch, 1996) devices for at least one group of actors at a time, thus making co-creation unilateral (either guided by the users or the engineers, depending on the specific context of the design and testing).

In summary, different types of value for the robotics innovation emerge from the case studies analysis as informed by the crowd dynamics (Viscusi & Tucci, 2018), ranging from selected groups to communities, or crowds of users involved in the design and testing activities, and eventually exhibited by the final robotics artifacts, questioning their scalability and situatedness when adopted in context with different socio-economic characteristics, consequently impacting their capacity to lead to a sustainable competitive advantage. Also, the spaces or facilities where the design and testing of robotics innovation happen are in the two cases close to an *ecosystem as affiliation* (Adner, 2017, p. 41). However, it is worth noting that in the two cases the ecosystems are not oriented by value propositions, as in business ecosystems, but by missions of institutional configurations between state, academia, and industry, represented by, e.g., the Triple Helix Model (Etzkowitz & Leydesdorff, 2000). Nevertheless, value propositions orient the action of the startups operating in those robotics innovation ecosystems. Additionally, the strategy dissonance between the different actors is also reflected in the *heterarchy* (Stark, 2009) identified as characterizing the organizational structure for the two cases where hierarchical forms allow the co-existence of different groups developing in harmony different programs.

Finally, those ecosystems are providing the necessary installed base, standards, social arrangements, and links of the conventions of practices (Star, 1999) for moving from facilities to infrastructures for the co-creation of robotics innovation.

Discussion

The results presented in this paper are still preliminary and further interviews and observation on the two settings and similar initiatives would be required to obtain theoretical saturation for the initial set of categories identified (e.g., *temporary assembly*, *enacting acceptability,* or *computational thinking*), thus moving from a conceptual description to a theory (Eisenhardt, 2021; Eisenhardt & Graebner, 2007). However, the expected contribution of this paper is to provide a further understanding of the role of crowds in innovation, especially in robotics. Also, the research is expected to contribute to the stream of research that aims to connect open innovation and resource-based view (RBV), by questioning how *facilities* for co-creation, specifically in robotics, inform the values that make both the testing sites and their outputs valuable, rare, inimitable, and non-substitutable resources for companies (Barney, 1991; Barney et al., 2011). Also, the article contributes to the study of the collaboration between universities and firms, by highlighting some of the organizational factors and trajectories that may eventually lead to the creation of innovation infrastructures and ecosystems. Moreover, the research provides a potential contribution to practice through an increased understanding of the contextual factors of co-creation practices in robotics innovation. This is important for investing in facilities for

design and testing that take into account the situatedness of artifacts' embedded values. Those values may have an impact on value-capture when the products and services delivery scale to reach markets with different socio-economic characteristics.

Conclusion

Considering the increasing relevance of robots in society and business as well as their prospected diffusion in the future, understanding the elements that allow firms to create and capture value from co-cocreation practices would be relevant to their research and development strategies. This paper has presented the results of two interpretive case studies on robotics innovation facilities and education showing the dynamics of a crowd for design and testing and the emergent configuration of values eventually embedded in the resulting robotics artifact. Furthermore, this research aims to contribute to practice through an increased understanding of the contextual factors of co-creation practices in robotics innovation. This is important for companies investing in facilities for design and testing that consider the situatedness of artifacts' embedded values and their potential of scaling in different markets. In future work, the corpus of data from those studies will be further analyzed and enriched through further documents and interviews through theoretical sampling on further facilities and education testing sites to develop a grounded theory on the substantive domain of robotic innovation design and testing.

References

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, *43*(1), 39–58.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*(3), 306–333.

Afuah, A., & Tucci, C. L. (2012). Crowdsourcing As a Solution to Distant Search. *Academy of Management Review*, *37*(3), 355–375. https://doi.org/10.5465/amr.2010.0146

Barney, J. B. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Barney, J. B. (2001). Is the Resource-Based "View" a Useful Perspective for Strategic Management Research? Yes. *Academy of Management Review*, *26*(1), 41–56. https://doi.org/10.5465/amr.2001.4011938

Barney, J. B., Ketchen Jr, D. J., & Wright, M. (2011). The future of resource-based theory: Revitalization or decline? *Journal of Management*, *37*(5), 1299–1315.

Barrett, M., Oborn, E., Orlikowski, W. J., & Yates, J. (2011). Reconfiguring Boundary Relations: Robotic Innovations in Pharmacy Work. *Organization Science*, *23*(5), 1448–1466. https://doi.org/10.1287/orsc.1100.0639

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as Innovators: A Review, Critique, and Future Research Directions. *Journal of Management*, *36*(4), 857–875. https://doi.org/10.1177/0149206309353944

Bogers, M., Zobel, A.-K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, L., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M. G., Majchrzak, A., McCarthy, I. P., Moeslein, K. M., Nambisan, S., Piller, F. T., … Ter Wal, A. L. J. (2017). The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation*, *24*(1), 8–40. https://doi.org/10.1080/13662716.2016.1240068

Boudreau, K. J., Guinan, E. C., Lakhani, K. R., & Riedl, C. (2016). Looking Across and Looking Beyond the Knowledge Frontier: Intellectual Distance, Novelty, and Resource Allocation in Science. *Management Science*, *62*(10), 2765–2783. https://doi.org/10.1287/mnsc.2015.2285

Boudreau, K. J., & Lakhani, K. R. (2013). Using the crowd as an innovation partner. *Harvard Business Review*, *91*(April).

Cappa, F., Oriani, R., Pinelli, M., & De Massis, A. (2019). When does crowdsourcing benefit firm stock market performance? *Research Policy*, *48*(9), 103825. https://doi.org/10.1016/j.respol.2019.103825

Eisenhardt, Kathleen 2021. "What Is the Eisenhardt Method, Really?" *Strategic Organization* 19 (1): 147–60. doi:10.1177/1476127020982866.

Eisenhardt, K. M., & Graebner, M. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–37. https://doi.org/10.2307/20159839

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4

Felin, T., Lakhani, K. R., & Tushman, M. L. (2017). Firms, crowds, and innovation. *Strategic Organization*, *15*(2), 119–140. https://doi.org/10.1177/1476127017706610

Felin, T., & Zenger, T. R. (2011). Information aggregation, matching and radical market–hierarchy hybrids: Implications for the theory of the firm. *Strategic Organization*, *9*(2), 163–173. https://doi.org/10.1177/1476127011408250

Frow, P., Nenonen, S., Payne, A., & Storbacka, K. (2015). Managing Co-creation Design: A Strategic Approach to Innovation. *British Journal of Management*, *26*(3), 463–483. https://doi.org/10.1111/1467-8551.12087

Glaser, B. G. (1978). *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory*. The Sociology Press.

Holton, J. A., & Walsh, I. (2017). *Classic Grounded Theory: Applications With Qualitative and Quantitative Data*. SAGE Publications.

Iansiti, M., & Lakhani, K. R. (2020). *Competing in the age of AI : strategy and leadership when algorithms and networks run the world*. Harvard Business Review Press.

Kline, R., & Pinch, T. (1996). Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States. *Technology and Culture*, *37*(4), 763. https://doi.org/10.2307/3107097

Laursen, K., & Salter, A. J. (2014). The paradox of openness: Appropriability, external search and collaboration. *Research Policy*, *43*(5), 867–878. https://doi.org/10.1016/j.respol.2013.10.004

Lin, Y., Trattner, C., Brusilovsky, P., & He, D. (2015). The impact of image descriptions on user tagging behavior: A study of the nature and functionality of crowdsourced tags. *Journal of the Association for Information Science & Technology*, *66*(9), 1785–1798. http://10.0.3.234/asi.23292

Majchrzak, A., & Malhotra, A. (2016). Effect of Knowledge-Sharing Trajectories on Innovative Outcomes in Temporary Online Crowds. *Information Systems Research*, 20.

Majchrzak, A., & Malhotra, A. (2020). *Unleashing The Crowd—Collaborative Solutions to Wicked Business and Societal Problems*. Palgrave Macmillan/Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-25557-2

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information technology and sustained competitive advantage: A resource-based analysis. *MISQ Quarterly*, *19*, 487-505 ST-Information technology and sustained.

Monteiro, E., Pollock, N., Hanseth, O., & Williams, R. (2013). From Artefacts to Infrastructures. *Computer Supported Cooperative Work (CSCW)*, *22*(4–6), 575–607. https://doi.org/10.1007/s10606-012-9167-1

Nickerson, J. A., Wuebker, R., & Zenger, T. (2016). Problems, theories, and governing the crowd. *Strategic Organization*, *15*(2), 275–288. https://doi.org/10.1177/1476127016649943

Piezunka, H., & Dahlander, L. (2018). Idea Rejected, Tie Formed: Organizations' Feedback on Crowdsourced Ideas. *Academy of Management Journal*. https://doi.org/10.5465/amj.2016.0703

Prahalad, C. K., & Ramaswamy, V. (2004). Co-Creaction Experiences: The Next Practice in Value Creation. *Journal of Interactive Marketing*, *18*(3), 5–14. https://doi.org/10.1002/dir.20015

Ramaswamy, V. (2010). Competing through co-creation: Innovation at two companies. *Strategy & Leadership*, *38*(2), 22–29. https://doi.org/10.1108/10878571011029028

Riedl, C., & Woolley, A. W. (2016). Teams vs. Crowds: A Field Test of the Relative Contribution of Incentives, Member Ability, and Emergent Collaboration to Crowd-Based Problem Solving Performance. *Academy of Management Discoveries*, *3*(4), 382–403. https://doi.org/10.5465/amd.2015.0097

Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist*, *43*(3), 377–391. https://doi.org/10.1177/00027649921955326

Stark, D. (2009). *The Sense of Dissonance—Accounts of Worth in Economic Life*. Princeton University Press. https://doi.org/10.1017/CBO9781107415324.004

Storbacka, K., Brodie, R. J., Böhmann, T., Maglio, P. P., & Nenonen, S. (2016). Actor engagement as a microfoundation for value co-creation. *Journal of Business Research*, 10.

Tekic, A., & Willoughby, K. (2019). Co-creation – child, sibling or adopted cousin of open innovation? *Innovation*, *21*(2), 274–297. https://doi.org/10.1080/14479338.2018.1530565

Viscusi, G., & Tucci, C. L. (2018). Three's a crowd? In C. L. Tucci, A. Afuah, & G. Viscusi (Eds.), *Creating and Capturing Value through Crowdsourcing* (pp. 39–57). Oxford University Press. https://doi.org/10.1093/oso/9780198816225.003.0003

Walsham, G. (2006). Doing interpretive research. *European Journal of Information Systems*, *15*(3), 320–330. https://doi.org/10.1057/palgrave.ejis.3000589

West, J., & Bogers, M. (2014). Leveraging External Sources of Innovation: A Review of Research on Open Innovation. *Journal of Product Innovation Management*, *31*(4), 814–831. https://doi.org/10.1111/jpim.12125

West, J., & Bogers, M. (2017). Open innovation: Current status and research opportunities. *Innovation*, *19*(1), 43–50. https://doi.org/10.1080/14479338.2016.1258995

Ye, H. (Jonathan), & Kankanhalli, A. (2015). Investigating the antecedents of organizational task crowdsourcing. *Information & Management*, *52*(1), 98–110.

Zollo, M., Minoja, M., & Coda, V. (2018). Toward an integrated theory of strategy. *Strategic Management Journal*, *39*(6), 1753–1778. https://doi.org/10.1002/smj.2712

Zuboff, S. (1988). *In the Age of the Smart Machine—The Future of Work and Power*. Heinemann Professional Publishing Ltd.

Zuchowski, O., Posegga, O., Schlagwein, D., & Fischbach, K. (2016). Internal crowdsourcing: Conceptual framework, structured review, and research agenda. *Journal of Information Technology*, *31*(2, SI), 166–184. https://doi.org/10.1057/jit.2016.14