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INTRODUCTION



Artificial intelligence, big data, algorithms and Industry 4.0 in firms and clusters

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ABSTRACT

This collection on 'Artificial intelligence, big data, algorithms and Industry 4.0 in firms and clusters' is introduced exploring the themes discussed by the nine papers and grouped into three categories to uncover new dynamics and identify future research opportunities for clusters and organizations in these transformative times. The first group explores theoretical aspects of AI and its evolution in social sciences, focusing on industry 4.0, smart cities, big data, and other related topics. The second group examines the role of industrial robots in employment, productivity, and knowledge absorption in industrial districts. The third group discusses innovation in the context of local production systems, AI ecosystems, and the growth and potential of the Metaverse.

KEYWORDS

Artificial Intelligence; big data; industry 4.0; firms; clusters

1. Introduction

The last years have seen a strong increase in interest and studies on artificial intelligence (AI) and robots and their potential to trigger a new industrial revolution. Several articles have been written to explore its paradigm fields of application and impact on research areas, while others have applied computational artificial intelligence tools such as machine learning, deep learning and neural networks to study specific industries or sectors (Furman and Seamans 2019, Floridi and Cows 2019; Acemoglu and Restrepo 2020). While the disruptiveness of AI is expanding exponentially in all fields of the economy, there are still some underdeveloped fields regarding the studies, particularly the studies regarding the role of AI for regional sciences and clusters seem to be underdeveloped (Lazzeretti 2023). In addition, little retrospective on this evolution has been made so far and thus, we still know little about the impact that this new paradigm is making in regional sciences and particularly looking at clusters and the firm level.

Artificial Intelligence (AI) refers to advanced technologies that exhibit human-like intelligence, including machine learning or autonomous robotics and vehicles, among

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others (see Furman and Seamans 2019; Lazzeretti et al. 2022). Along with AI, Industry 4.0 and all related digital technologies, such as the Internet of Things (IoT), 3D printing, Cloud Computing or Cyber-Physical systems, among others, are challenging existing business models, products and industries, offering new business opportunities and also altering existing value propositions (e.g. Porter and Heppelmann 2014, 2015). These enabling technologies are evidenced to improve firm performance, maximize efficiency, and decrease set-up costs, errors and machine downtime. Also, they enhance the quality of the products and the reduction of production waste, while increasing production capacity (see Büchi, Cugno, and Castagnoli 2020; Dalenogare et al. 2018).

Industrial and innovation policies are supporting digitization of the economy. The European Union, like many countries such as UK or USA, is facilitating the adoption of digital technologies in businesses, industries and even in regions (see the European Expert Group on Clusters 2021). A new paradigm for understanding the new phenomenon and its related policies and plans is ascribed to the Digital Single Market initiative by the European Commission,¹ concomitant with many national policy initiatives to stimulate the digital shift. At the regional level, The European Expert Group on Clusters (2021) points out the importance of clusters to the green and digital transitions. An example of the regional approach followed by the EU in the Smart Specialization Strategy (RIS3) is the initiative of the Digital Innovation Hubs,² targeting regions and allowing local businesses and organizations to follow a bottom-up process for setting up digital platforms for increasing Industry 4.0, especially targeting SMEs (see more in Hervas-Oliver et al. 2021).

Zooming into the regional setting, work is starting to audit Industry 4.0 in regions and districts/clusters (e.g. Bianchi, Durán, and Labory 2019; De Propriis and Bailey 2020; Bettiol, Di Maria, and Micelli 2020; Hervás-Oliver 2021; Hervas-Oliver 2022; Lazzeretti 2022; Balland and Boschma 2021; Doloreux and Turkina 2021), recognizing Artificial Intelligence as an emergent line of inquiry crossing many works of literature and positioning them in the regional realm (Lazzeretti et al. 2022).

In industrial districts and clusters, the literature has pointed out that collective initiatives, based on cooperation and open doors, might support the digitization of territories, by co-creating place-based innovation policies to digitize specific territories (Hervas-Oliver et al. 2021; Pagano et al. 2021). Cooperation and competition, therefore, constitute a powerful leverage to digitize districts and their SMEs.

Industry 4.0 and related technologies are also applied to SMEs, showing how business models are reshaped (Müller, Buliga, and Voigt 2018) and how these firms present less probability to adopt these new technologies due to their scarcity of resources (e.g. Mittal et al. 2018) their reliance on local networks (Hervas-Oliver 2022) and external sources of knowledge (Petruzzelli et al. 2022).

All in all, different research questions are starting to be considered, such as how does Industry 4.0 shape industrial clusters and regions? What policy initiatives foster digitization in clusters and regions? What advantages or disadvantages have clustered SMEs for Industry 4.0? Other questions are still unanswered and this special issue brings them to this emerging conversation within the realm of the geography of innovation literature.

Given these considerations, the Special Issue wants to enlarge this debate to offer a wide discussion on the interrelation among AI, algorithms, big data and Industry 4.0 using a local perspective to understand the importance of these new paradigms for the development of firms, districts, clusters, city, regions and innovation (Cooke 2017;

Götz and Jankowska 2017; Cooke 2019; Cséfalvay 2020; Zukin 2020; Scherrer 2021; Lazzeretti 2022).

In particular, the special issue has a twofold objective. Firstly, understanding the new dynamics generated by the advent of these technologies and how they may affect regions, cities, clusters, industries and organizations. Secondly, identifying avenues for future research in the development of new trajectories for clusters and firms in these challenging times.

2. Contents of the special issue

The present special issue departs from a solid base of papers that were presented during the third and fourth editions of the Rethinking Cluster Conference that were held in Valencia and Florence in the 2020 and 2021 respectively. This special issue is composed of nine papers that were strongly connected with the themes of ‘Artificial Intelligence, Big data, Algorithms and Industry 4.0 in firms and clusters’ in the actual challenging times that see the increasing importance of digital transformation. However, throughout the special issue, we may distinguish several different perspectives, approaches and trajectories of the papers that compose the collection.

It is possible to identify a first group, composed of three papers that cover theoretical aspects of the issues related to the evolution of the studies of artificial intelligence in social sciences and the role of learning and machine learning.

The first paper by Lazzeretti et al. (2022) represents a deep reflection and a theoretical discussion regarding the artificial intelligence topic in social sciences and more deeply in regional sciences. After a first discussion on the definition of AI, it develops a bibliometric analysis to follow the evolution of this literature over 1986–2020 identifying the main authors, journals and topics covered by this literature. Then, developing an in-depth review of the most recent papers, it identifies five main groups of topics, the one related to ‘Industry 4.0’, a group related to ‘Smart cities’, those connected with ‘Big data and social media’, obviously an entire group related to ‘Artificial intelligence’ and finally a group including the remaining technologies related to AI ‘Robotization, IoT, augmented and virtual reality’.

The second paper, authored by Nannelli, Capone, and Lazzeretti (2023) deals with the recent strong transformation brought by information and communication technologies (ICT) and AI technologies to the tourism and hospitality industry. The article, based on papers published until 2021, firstly develops a bibliometric analysis also using network analysis to map the intellectual structure of the AI tools in tourism and then, based on the most relevant publications retrieved, develops a critical literature review to identify the main themes and trends of the literature. The main research themes identified relate to ‘Big data’, ‘Augmented reality’, ‘Virtual reality’, ‘Smart tourism’ and ‘Covid-19 pandemic’.

While the last paper of this first group by Cooke (2022) explores a new idea regarding the role of ‘learning’ and its evolution in the last decades, relating this evolution also with the recent introduction of new information technology and machine learning. The development of the paper leads to some relevant conclusions, regarding the ‘knowledge economy’ of the 1980s, which caused concern that ‘lifelong learning’ was needed to cope with the economic change and the following neoliberal politics avoiding planning and learning. And the most recent digital economy and ‘spontaneous’ markets as the sole

origin of rational change show many problems and dark sides. It suggested that it is important to review and re-regulate the 'learning' arena.

Then the second group of papers focus on Industry 4.0 and the role of industrial robots in employment and productivity. The first paper, authored by Hervás-Oliver et al. (2022) presents a qualitative analysis based on 24 interviews and a review of the literature on the adoption of I.4.0 in three different Marshallian Industrial Districts (MID; one on footwear, one on toys and one on ceramic tiles) of the Valencian region in Spain. In this article, the purpose is to compare different innovation policies aimed at facilitating awareness and the adoption of I.4.0 in those three MIDs considered. The results clearly show that one-size-fits-all Industry 4.0 policies can't be identified for all the different MIDs. Rather, what works better are collective actors leading place-based collective actions that are bottom-up and co-designed with public and private local actors.

The second paper, by Fiorini et al. (2022), deals with the effect of I.4.0 in industrial districts, showing that industrial districts may be a relevant field for the empirical investigation to understand how the knowledge linked to the I.4.0 technological paradigm can be absorbed and disseminated. The analysis is based on more than 100 interviews with firms based in four Tuscan IDs: Prato (textile), Arezzo (jewellery), Florence (leather) and Santa Croce (tanning). The interviews gathered information on the two main dimensions considered (absorption and dissemination) and identified different behaviours of the four considered IDs. The results show what can lead to District 4.0 is not the size or the technologies adoption alone, but the presence of competencies 4.0, culture 4.0 and the absorption and dissemination through collaboration.

The paper that closes this group is authored by Antonietti, Cattani, and Pedrini (2023). The paper departs from the growing literature that connects industrial robots with employment and productivity following the worrying idea that robots could substitute a part of human jobs shortly. The analysis is based on one of the main manufacturing regions in Europe (Emilia-Romagna) and encompasses 15 manufacturing industries and 39 local labour systems from 2008 to 2017. The results show that higher robots adoption led to a decline in high routine employment while it does not increase labour productivity or manufacturing value-added. However, the negative effect of robotization on employment decreases in the presence of high cross-industry occupational similarity and within industrial districts.

A third group of papers dealing with innovation and composed of both quantitative and qualitative contributions is provided by three papers. The first paper, authored by Boix-Domenech et al. (2022) is based on the idea that local communities are the real unit of generation of innovation and that they are constantly changing their boundaries and specializations, behaving like 'living innovation machines'. The authors use dynamic territorial units (local production systems that modify their geographical boundaries and specialization over time) and machine learning methods to explain the change in the innovative intensity of local production systems (LPSs) in Spain between 1991 and 2014. The results suggest that the type of LPS of origin continues to be relevant in explaining their innovation processes and the transformation to a different type of LPS does not necessarily implies changes or improvements in innovative intensity.

The second paper of this group by Sultana, Turkina, and Cohendet (2023) is based on the study of the AI ecosystem in Montreal, looking at the mechanisms that favour the emergence of innovation ecosystems. The study is based on the abductive approach, which uses qualitative content analysis and social network analysis. The data used are

partly from primary sources (semi-structured interviews) and partly from secondary sources (data on 19 key actors and 102 organizations). The results show a bottom-up approach in the emergence of the AI ecosystem in Montreal and show that the essential mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of a series of innovation by key actors.

Finally, the paper that closes the special issue was authored by Parcu et al. (2023) and deals with the growth of the expectations related to the advent of the Metaverse during the last years and which suddenly showed also a decline in attention, investments and financial performances. The aim of the paper is to go beyond the hype looking at several aspects of the Metaverse and investigating the firms, industries and the spatial effects that may represent the advent of the Metaverse in two possible scenarios. If the Metaverse will remain in its evolution as a fashion label, applications will be limited to replicating existing human activities in an immersive virtual environment and it will be a physical reality to drive and shape the Metaverse. While if the Metaverse will maintain its expectations enabling new forms of social interaction, and substantially altering key economic concepts and institutions we will have a Metaverse shaping reality view.

We hope the nine articles in this special issue will draw attention to these new technologies which may be considered potential breakthroughs and particularly when analyzed at the regional, city, cluster or firm level, leading to a new wave of innovation across a range of industries and also can stimulate further research. Following this, in concluding this introduction we aim to indicate some possible developments of the outlined debate. We firstly refer to the research agenda that arises from the papers that compose this issue and to the various risks and opportunities mentioned that concern the evolution of these new technologies that are already changing the competitive environment for companies and clusters and that are expected to bring additional challenges in the coming years (Lazzeretti 2023).

Of course, some of the results achieved cannot be generalized without due caution, as they are tested for certain countries, regions or specific technologies. For this reason, it appears clear that these topics need further analysis to confirm some of the achieved results for different areas or prove that the effects are context-specific. These create opportunities for additional research, and this is even more important considering the continuous and rapid evolution of these technologies. Think for instance of the Metaverse as discussed in the last paper of this selection and the uncertainty of its evolution, or the possibly disruptive effect of the use of AI recently evolved in an unexpectedly rapid use and adoption of ChatGPT, which will possibly lead to a revolution from an economic, social and regulatory perspective. Like the already mentioned I.4.0 and robotization, which, of course, will call for additional planning and policies aimed at dealing with the changes in the business models of firms and the industrialization of territories.

Notes

1. <https://ec.europa.eu/info/strategy/priorities-2019-2024>
2. <https://digital-strategy.ec.europa.eu/en/activities/edihs>

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