

5G is not just Another G: A Review of the Managerial Literature

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Abstract: Due to the higher range of markets and applications opportunities it brings, the fifth generation of mobile communications (5G) cannot be considered just a technological transition, as it was for earlier generations of cellular technology, rather it represents a revolutionary phenomenon which could deeply change the competitive landscape for wireless services. According to the literature, it is “one of the most complex technologies seen over the past decade both in terms of technical development and business implications”. However, on one hand, the 5G is a hotly discussed topic from a technical perspective, on the other the managerial literature appears ambiguous and fragmented in the way it is presented. Such absence recalls for a paper whose purpose is to position the 5G search thread also in the managerial literature. For this reason, the work aims to systematize previous knowledge and identify potential research directions related to the strategic adoption of 5G technology. To answer the underlying research question regarding the state of the art of the 5G in the strategy domain, a systematic search has been done, then, on the selected papers, a conceptual review has been carried out to identify (i) the “business reconfigurations” of 5G technology, (ii) the boundary conditions, intended as the conditions of existence of a 5G business case, (iii) the barriers, which instead hinder the development of cases. The research provides useful implications to both the theory and practice: from a theoretical perspective, it represents one of the first studies concerning 5G which is not strictly related to a specific industry or scenario. Secondly, the challenges and gaps identified generate research questions which can be traceable also to a general and more theoretical context, such as the business model innovation literature, where the strategic adoption of new technological paradigms entails further investigations. From a practitioner’s perspective, it provides useful insights regarding 5G adoption for increasing actors’ awareness of such technological innovation, especially concerning their attitude change which is needed to seize the business opportunities it embraces.

Keywords: 5G, Business Model, Business Model Innovation, Enabling Technology

1. Introduction

According to Chesbrough (2010), it is not just a matter of leveraging the best technologies available in today's digital world, rather being confident with the development of alternative businesses enabled by these allows firms to be more competitive. Furthermore, also from a more network perspective (Jocevski, Arvidsson, Ghezzi, 2020), the adoption of these technologies may entail in most cases the reshaping of market boundaries by highlighting new intersectional convergence within industries.

This is particularly true for what concerns the 5G technology since due to the higher range of markets and applications opportunities it brings, it cannot be considered just a technological transition, as it was for earlier generations of cellular technology, rather it represents a revolutionary phenomenon which could deeply change the competitive landscape for wireless services (Lehr, Queder, Haucap, 2021). It is more “a toolbox of capabilities than a one-size-fits-all technology” (Lehr et al, 2021; p.1), and for this reason, it not only constitutes a complex technology in terms of technical development, but it also requires a change in the actors’ attitude, especially of Mobile Network operators (MNOs) (Lehr et al, 2021), which have always played an important role in the telecommunication domains (Noh et al, 2021), characterized by high rates of volatility (Ghezzi, Cortimiglia, Frank, 2015).

However, even if it represents a very new technology with high potential, there is still ambiguity and fragmented knowledge about its strategic adoption. All these implications recall further investigations to address emerging challenges with great scientific and social relevance. Consistently, this work aims to trace the state of the art of the 5G literature in the managerial sciences field by defining a search protocol to systematically structure extant knowledge about the above-mentioned technological paradigm and identify potential directions.

The paper is structured as follows: after having outlined the research’s starting point and the overall objective in section 2, in section 3 the search protocol with the description of the eligibility criteria is presented. Afterwards, in section 4 a conceptual review about the state of the art of 5G literature in the business and management field is presented. Finally, the paper ends with a discussion about the methodologies used by scholars to try to investigate the gaps that emerged in literature and the identification of future avenues.

2. Research background and objective

The 5G represents an emerging digital infrastructure (Gooderham et al, 2022) that can revolutionize multiple sectors and it promises a significant economic impact on companies (Knieps & Bauer, 2022). The technical literature on 5G appears to be well-established, surpassing the number of publications concerning 5G in managerial literature. However, this is not surprising given that 5G is a cutting-edge technology that has required years of study and research. In the managerial literature, the publications on this topic range across various areas, such as environmental sustainability, emerging countries and political issues (e.g., Parcu, Innocenti, Carrozza, 2022). However, as already mentioned in the Introduction section, it is less common to find articles that deal with the strategic impact of 5G and all the opportunities it entails. Many papers focus on the description of the technology's adoption in specific fields (see Table 1), without then delving into the details of the strategic and entrepreneurial implications arising from a broader perspective. The work aims to position the theme of 5G also in the managerial literature, attempting to identify the current challenges for the main players and potential directions to take, which could foster the development of the 5G market. Despite having attained a certain level of technological maturity, it is currently grappling to gain momentum.

Table 1: 5G main application fields

Application Field	Authors
Smart city	Gooderham et al, 2022
Smart agriculture	Gooderham et al, 2022; Knieps and Bauer, 2022
Smart manufacturing	Forge and Vu, 2020; Vuojala et al, 2020; Dolgui and Ivanov, 2022;
Smart energy	Vuojala et al, 2020; Gooderham et al, 2022
Logistics	Vuojala et al, 2020; Dolgui and Ivanov, 2022
Smart hospital	Forge and Vu, 2020; Vuojala et al, 2020

3. Methodology

3.1 Inclusion criteria

First, The SciVerse Scopus online scientific articles database has been selected as the most appropriate source for the research. Regarding the selection of the keywords, the choice has been driven mainly by the necessity to draw a state of the art of 5G technology literature.

To do so, the identification of papers with “5G”; “Fifth generation technology”; “Fifth generation of mobile communication”; “Fifth generation of wireless networks” present in their title, abstract and keywords section has been carried out. Together with a keyword-based search, a backward approach to identify other related studies (n= 5) has been followed.

Other inclusion criteria regard the domain the papers selected belong to, which is Business, Management and Accounting. Furthermore, the subject areas of Social and Decision Sciences have been also considered to broaden the analysis.

Finally, only articles and reviews in English were considered due to their higher quality.

The output from The SciVerse Scopus database of the above-mentioned query was 977 papers, updated in July 2022.

3.2 Exclusion criteria

To maximize the specificity of the studies included in the research, several exclusion criteria have been defined.

- (i) Studies requiring technical competencies (n = 186): all the studies where technical competence or specific knowledge is required to deeply analyse technology-dominated sectors that have been excluded (e.g., Lee and Ko, 2021).
- (ii) No implications for strategy, entrepreneurship, or innovation (n = 87): this criterion has been used to confine the research objective to the strategic, entrepreneurial and innovation field. Every article concerning different application domains has been excluded unless there was clear evidence of implications for the above-mentioned area without being mentioned expressly (e.g., Cheng, Hu, Varga, 2022)
- (iii) Clear focus on Implications for sustainability, globalization, emerging countries and government issues (n=80): all topics about heterogeneous development at the global level, developing countries, and applications

to increase sustainability have been excluded because being highly relevant topics would need a separate literature review on its own (e.g., Parcu, Innocenti, Carrozza, 2022).

(iv) Scimago Journal Rank (n = 576): To guarantee both the inclusiveness of the Scopus database and the quality of the journal outlet considered, only articles published in journals whose rankings are Q1 have been included.

The last access on the above-mentioned list was done on the 15th of July 2022. After the text screening, other papers have been excluded (labelled in the prism below as “Out of scope”) because they only fit the exclusion criteria just described after reading the entire text, or because 5G was not the central theme. The final sample of papers considered for the conceptual review was 37.

In Figure 1 the screening process of the query above mentioned is reported.

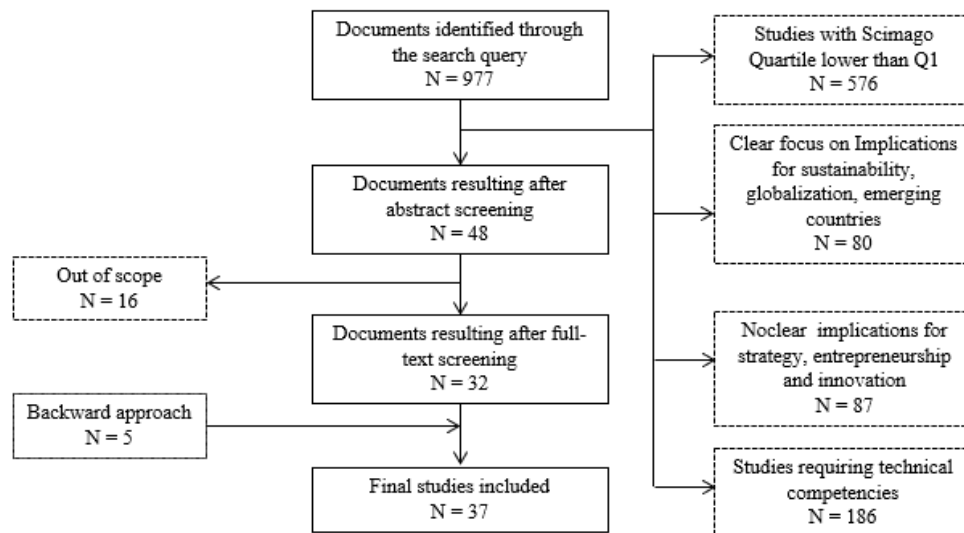


Figure 1: The document screening process

4. Findings

Looking at the papers' typologies, several works are conceptual reviews. However, among them, it is possible to find different perspectives adopted. For instance, most of these refer to spectrum policies and regulations, especially taking into consideration different countries (e.g., Teece, 2021; Blind and Niebel, 2022). Other conceptual reviews refer to specific application fields (e.g., Dolgui and Ivanov, 2021) or 5G implications in the digital innovation process of small and medium enterprises (Olokundun et al, 2022). Furthermore, two bibliometric reviews have been found (Mendonça et al, 2022; Buggenhagen and Blind, 2022).

Several papers are based on case study methodology where a specific business case, industry or country has been described (e.g., Gooderham et al, 2022; Lee and Yu, 2022; Schneir et al, 2022; Massaro and Kim, 2021).

In the sample of papers considered, also quantitative studies are present. The usage of predictive analytics and scenario-based assessment exemplifies the aim of such works, which try to measure quantitatively the effect of the factors considered, such as regulations, technological standards and 5G mobile broadband coverage (e.g., Wen, Forman, Jarvenpaa, 2022; Rathje and Katila 2021; Schneir et al, 2019; Oughton et al, 2018).

4.1 5G Managerial reconfigurations

According to the European Commission and the 5G Infrastructure Association, 5G refers to the fifth generation of broadband data-networking digital communications technology (5G-PPP; 2016). From a more managerial perspective, in the literature considered it is possible to find several 5G definitions which appear as attempts to reconfigure the technological one in a business domain. In Table 2 the main 5G business reconfigurations explicit in the analysed papers are synthesized. Generally, due to its pervasiveness, 5G is envisioned to become the base for future services, and almost infinite applicability which may change the development trajectory of the telecommunication industry and beyond. Due to these characteristics, several authors classify it as an “enabling technology” or “Junior General-purpose technology” (Teece, 2018; Schneir et al, 2019; Rathje and Katila, 2021).

Enabling technologies are upgradable, adaptable technologies with improvement potential that have broad applicability (Gambardella et al., 2021). Even though they share part of the general-purpose technology's definition (Bresnahan and Trajtenberg, 1995), their economic impact is uncertain (Teece, 2018a).

4.2 5G Boundary Conditions

Table 2: 5G Managerial reconfigurations

5G Managerial reconfigurations	Authors
Game changer	Deng et al, 2020; Knipes & Bauer, 2022
General Purpose Technology (GPT)	Knipes & Bauer, 2022; Mendonça et al, 2022
Junior GPT or Enabling technology	Teece, 2018; Schneir et al, 2019; Rathje and Katila, 2021
Connectivity/Enabling platform	Ahokangas, 2021, Bauer and Bohlin, 2022;
Emerging digital infrastructure	Gooderman et al, 2022
Toolbox of capabilities	Lehr et al, 2021
Paradigm shift	Lehr et al, 2021; Teece, 2021

In this paragraph, the boundary conditions (Busse et al, 2017) intended as the conditions of existence of 5G technology have been figured out. In other terms, based on the managerial literature, the aim has been to identify which are the “building blocks” for the development of 5G business cases. The four categories identified are (i) promised value, (ii) ecosystem, (iii) regulation and (iv) infrastructural requirements.

4.2.1 Promised Value

According to Oughton and colleagues (2018), mobile network operators (MNOs), who have always played a key role in the telecommunications industry, must be aware of the advantages and the threats coming from such a technology paradigm shift (Lehr et al, 2021). Already with earlier technologies, MNOs have adjusted their business models, however, with the fifth generation, it seems that the development trajectory has changed strongly due to the high expected value such technology is promising (Lehr et al, 2022; Gooderham, 2022). Guo and colleagues (2022, p.52) affirm explicitly that MNOs must shift from “the business-to-individual-customers model to the business-to-business model”. The same scholars put emphasis also on the fact that shifting from customized network structures could play a crucial role in terms of business model development. However, such reasoning is extended by Bauer and Bohlin (2022) by affirming that if one hand the 5G customized applications are promising higher revenues, on the other 5G networks infrastructure might be very expensive, for this reason, all the stakeholders involved must be aware of such risk, especially MNOs.

4.2.2 Ecosystem

According to Blind and Niebel (2022), the 5G ecosystem include a large variety of stakeholders with different goals and interests. The emergence of this technological paradigm will be not only related to the telecommunications industry, but rather other vertical industries will also exploit wireless communication (Vuojoala et al, 2020; Dolgui and Ivanov, 2021). In these terms, greater attention must be given to all those opportunities which are not strictly connected to the MNOs, especially by considering that if they do not rejuvenate their business models, the risk is that specialized players are in some way sabotaged by them (Bauer and Bohlin, 2022). On the other hand, if MNOs continue to pursue the same role as suppliers of connectivity, they will risk losing competitiveness. What emerges is the importance of collaborations between the different players with heterogeneous competencies to reduce costs and gather all the opportunities the 5G offers (Hutajulu et al, 2021). More in general, Rathje and Katila (2021) demonstrated through their quantitative study the importance of collaboration between governments and private companies to shape the new ecosystem. This is the reason why in the following section the third boundary condition identified for the development of 5G business cases is the so-called “Government policy”.

Similarly, Massaro and Kim (2020) state that 5G technology cannot be considered just as a technical artefact, rather, it is socially constructed. The authors distinguish between non-private actors, which are government, research institutes and universities and users, private actors, which are MNOs, equipment manufacturers, service providers and also “new actors”, intended as additional players who join the ecosystem due to new opportunities the technology could bring.

From another perspective, Bauer and Bohlin (2022) distinguish between four different layers and place the different players depending on their core competencies and business strategy. In the lower part, it is possible to find passive and active infrastructure layers which constitute the physical network layer. In the upper find, it is

possible to find the enablers on the so-called enablement, the development layer and the application service layer. On the top, there is the end user, while on each layer an orchestrator provider is present.

4.2.3 Regulation

According to Knieps and Bauer (2022), the 5G technology has introduced governance and management challenges never seen before.

If on one hand, MNOs need government support to face the uncertainty arising from 5G adoption (Forge and Vu, 2020); on the other hand, a stable standards roadmap in terms of spectrum bands is necessary to foster the development of private 5G network deployments (Forge and Blackman, 2017). The fifth generation of mobile communications allows the development of deployments on a wider spectrum range, from 450 MHz to 24,25-52,6 GHz (Bauer and Bohlin, 2022). Vuojala and colleagues (2020) in their works analysed several “spectrum scenarios” to understand all the possible configurations in terms of licences and 5G private deployments for vertical industries. Knieps and Bauer (2022) summarized the spectrum policy to distinguish between principal deployment options and all the possible spectrum licence’s configurations, both in terms of the licence and unlicensed spectrum and the national and local. The scholars also summarized the spectrum allocation by nation from 2017 to nowadays, distinguishing between the licenced and unlicensed spectra.

4.2.4 Infrastructural requirements

As previously mentioned, one of the exclusion criteria of the search protocol was related to the exclusion of studies requiring extensive technical competencies. The information is gathered just from the managerial literature due to the aim of the works, for this reason, some limitations may emerge in this paragraph. However, it is fundamental to consider it in terms of boundary conditions since without adequate technological infrastructures it is not possible to develop 5G business cases.

According to Henriquez and colleagues (2022), the main investments regard the ICT physical infrastructure, and it will foster also IoT use cases. In these terms, Bauer and Bohlin (2022) specify that inputs that might be considered necessary resources are antennas, routing of cables and backhaul. ICT infrastructures allow reaching the 5G requirements.

Accordingly, Lehr and colleagues (2021) underline the necessity to deploy more cellular base stations. In addition, they mention the re-architecting of the radio-access networks (RANs) which constitute a greater opportunity also in terms of cost management. Another element the scholars introduce is the necessity of expanding the use of radio-frequency spectrum resources, especially with private and dedicated network deployments.

Furthermore, the paradigm shift represented by 5G requires further improvement of the internet, such as network slicing (Kim, 2020). Vuojala and colleagues (2020) mention also Mobile-Edge computing (MEC) together with the network slicing function, to indicate which are the elements to guarantee adequate communication between different users.

4.3 5G Barriers and Literature’s Gap

Together with the boundary conditions presented so far, it is important to mention that there are also barriers which slow down the diffusion of the technology. Furthermore, there are still several gaps which have emerged from the literature, and they refer both to the boundary conditions described and the barriers just mentioned.

4.3.1 Technological and Institutional Failure

Starting from the first barriers identified, both infrastructural or, in other terms, technological, and institutional failure may emerge in the development of 5G business cases. According to Hutajulu and colleagues (2021), From an institutional perspective, several scholars mention the necessity to deepen the mechanisms for developing technological standards, but also to allow companies which are not directly involved in the standards definition to have access to it since it represents an input for complementary innovations (Wen et al, 2022). Other uncertainties regard intellectual property rights and health and safety regulations (Blind and Niebel, 2022). Also considering the business-to-business sector, as already mentioned before, the necessity to regulate the spectrum’s availability and accessibility, especially for what concerns 5G private network deployments, constitutes a boundary condition. Every kind of uncertainty and worse choice related to this could constitute another important barrier to 5G adoption.

4.3.2 Uncertain Costs and Benefits

Granted that scholars agree to the fact that 5G promises a great expected value and the possibility of sustainable and profitable business models, as proposed in the previous section about 5G business cases' boundary conditions, it is likewise true that the uncertainties related to costs and revenues influence negatively such dynamic (Dolgui and Ivanov, 2021). 5G technology is costly and more technologically complex than previous technologies (Forge and Vu, 2020), and due to its characteristics of being a junior GPT (Teece, 2018), it is cross-sectorial, and it involved a large portfolio of stakeholders, which complicate even more the situation.

Apart from choices regarding technicalities, each stakeholder involved must understand how to overcome the infrastructure's capex and the R&D investment costs (Forge and Vu, 2020; Blind and Niebel, 2022), and this aspect is particularly relevant for MNOs, which roles are fundamental. If on one hand there is still a gap regarding the value creation mechanism of private companies adopting 5G in a specific field (Dolgui and Ivanov, 2021), on the other hand, mobile network operators must rejuvenate their business models, especially for what concerns their value propositions and their networks architecture (Moqaddamerad, 2020; Lehr et al, 2021; Gooderham et al, 2022). Similarly, Rendon and Schneir (2019) reinforce these reasonings by explicitly saying that until now few authors have discussed 5G revenues and costs streams and how to build a sustainable business model. Schneir and colleagues (2022) tried to investigate it by looking at the possible business cases a mobile network operator could realize in a seaport area.

More in general, Noh and colleagues (2021) mention the challenge regarding the connection between technology resources and business objectives by underlining the importance of considering technology as a fundamental asset for strategic planning and by introducing the need for a "technology-driven strategy".

4.3.3 Actors' Reluctance

According to Hutajulu and colleagues (2021), several stakeholders are hesitant in adopting 5G technology. Actors involved perceive several risks in adopting the new technology, and they are also characterized by heterogeneous interests. On one hand, equipment suppliers foster the 5G roll-out, on the other, mobile networks operators need to understand how (i) to innovate their business model, especially considering new revenue streams, and (ii) how to face the rise of Over The Top (OTT) services, which pose a dangerous threat (Blind and Niebel, 2022). More in general, the private sector's reluctance in adopting 5G may emerge from a lack of a precise risk assessment (Forge and Vu, 2020), or maybe from the uncertainty driven by the lack of a clear definition of what the technology could bring to the society and business (Blind and Niebel, 2022). Such digital transition caused by 5G introduces many questions which need further investigation (Lee and Yu, 2022).

Finally, the debate regarding 5G's social impact (Mansell, 2021) as well as health implications (Bruns et al, 2020) is still open, and this negatively influences the 5G's social acceptance, further complicating the work of the actors involved. However, as mentioned in the exclusion criteria, papers regarding these matters, together with the ones describing the environmental impact and implications for sustainability have been excluded from the search protocol because, being extremely highly relevant topics, they would need a separate literature review on their own.

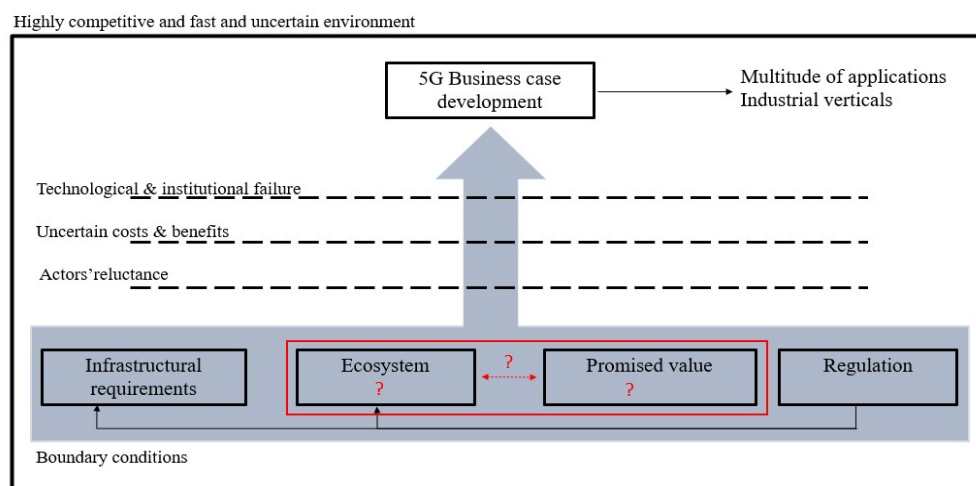


Figure 2. Boundary conditions and barriers for 5G adoption

5. Discussion

After an interpretation about which are the possible boundary conditions and barriers for the development of the 5G business case, in this section, the principal ways of investigations used by scholars to investigate the above-mentioned gaps are discussed. Finally, the limitations and further avenues are described.

In general, the techniques used in this context to close the gaps presented so far are future-oriented methods. For instance, the scenario-planning approach has been applied by Moqaddamerad (2020) and Jeong and colleagues (2016) studies, to forecast respectively how business models' innovation happens during the adoption of emerging technology and the feasibility of a specific application.

Furthermore, Hutajulu and colleagues (2021) mention simulation as an optimal method to gain the approval of the actors involved regarding infrastructure sharing. In a similar way, Ahokangas (2021) writes about the analysis of a future-oriented-case to deepen such complexity in terms of stakeholders involved, as it could be the case of a seaport developing a 5G private network. Such an approach is emphasized also by Noh and colleagues (2021) in mentioning the development of a value proposition map based on future circumstances defined by a depth-analysis of trends, predictions, and eventual relationships among them. For instance, the road mapping approach is a solution proposed by these scholars, especially they propose an integrated approach called "technology road mapping" which considers both the technology-push strategies with the market-driven one.

By analysing the 5G management literature, the need for greater structuring to intercept relevant phenomena emerged. As a matter of fact, it seems that the strategic impact of new technological paradigms, which may hold idiosyncratic implications in the strategy implementation dynamics, is still largely unstructured and there is still ambiguity and fragmented knowledge about it.

The gap just described emerged also through a non-systematic search regarding the literature about BMI and technology. As mentioned by Foss and Saebi (2016), several studies describe BMI in a retrospective way when considering the adoption of specific technologies, however, it is not the same way common to find predictive and theoretical perspectives. Accordingly, Baden-fuller and Heaflinger (2013) and Tongur and Engwall (2014) address the fact that often the impact of technology adoption is restricted to performance measurements, however, such a link with technology requires further investigation at a BM architecture level by understanding the mechanism to innovate BM through its components to create value.

6. Conclusions

6.1 Theoretical Implications and Future Avenues

The research aims to position the 5G search thread in the business and management literature by systematizing previous knowledge and identifying potential directions related to 5G technology in the above-mentioned stream of research. After having presented a search protocol to make the research falsifiable, reproducible, and scalable over time and to continuously update it, a conceptual review has been presented to figure out which are the managerial reconfigurations, the boundary conditions, the barriers, and the literature gaps of such very relevant and recent technological paradigm. By following the search protocol presented so far it will be possible to include also other papers to improve the framework presented and to reason about other boundary conditions and barriers, as well as enriching the existing ones.

According to the literature, due to its pervasiveness and the number of application fields which can be enabled, 5G is defined as an enabling technology (Teece, 2018; Schneir et al, 2019; Rathje and Katila; 2021). This nature is also confirmed when looking at the promised value resulting from the adoption of this technology (section 4.2.1), especially for MNOs which must rejuvenate their business models (Lehr et al, 2022; Gooderham, 2022), and the number of actors involved in different application areas (section 4.2.2). As a matter of fact, the emergence of this technological paradigm will be not only related to the telecommunications industry, but rather other industries will also exploit wireless communication (Vuojala et al, 2020; Dolgui and Ivanov, 2021). The promised value and the necessity of building an ecosystem represent two boundary conditions for the 5G business case development. Furthermore, for completeness other two boundary conditions have been outlined: (i) the necessity of infrastructural resources such as ICT physical infrastructure (Henriquez et al, 2022; Bauer and Bohlin, 2022) and (ii) regulation, since 5G technology has introduced governance and management challenges never seen before (Knieps and Bauer, 2022). All these boundary conditions have been described in the Findings section together with barriers, which slow down the diffusion of the technology, such as the actors' reluctance to adopt and the uncertainty concerning costs and benefits, as well as infrastructural and institutional failures.

Furthermore, as deepened in the Discussion section, while this work contributes to the positioning of this technology trend in the management literature, it has also shown that the strategic adoption of enabling technologies, including 5G, is not yet fully investigated by scholars. Some authors have attempted to analyse this topic, however, there are still few studies (e.g., Moqaddamerad, 2020).

From a theoretical standpoint, conducting research on the potential evolution of MNOs' business models could be highly intriguing. Furthermore, from what emerges from this analysis, an in-depth investigation of the ecosystem revolving around this technology and the competencies of the various actors is still lacking. Therefore, this work aims to generate research questions which can be traceable to the general and more theoretical contexts such as the ones of Business Model Innovation (Foss and Saebi, 2016) and Ecosystem (Adner, 2017).

6.2 Practical Implications

The research emphasises that it is the right moment for stakeholders to brainstorm and develop sustainable business models to capture the value that 5G technology promises. Furthermore, the necessity to create an active ecosystem in the telecommunication industry and beyond has emerged as well.

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