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A systematic literature review of business-to-business platforms for the digital transformation of the manufacturing industry: taking stock and advancing through research

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ABSTRACT

This systematic literature review aims to define the state of research on digital business-to-business platforms for manufacturing (DB2BPMs), by adopting a novel interdisciplinary approach. Previous studies have addressed this topic in a "compartmentalised" way, focusing either on the technical or on the economic domain, offering limited theoretical and practical insights into these platforms when creating value for the manufacturing industry. Current research gaps also concern the role of digital B2B platforms within the digital transformation of the manufacturing industry, and the conditions, innovations, and governance models that stimulate or hamper this transformation. Eighty-two articles, published between 1999 and March 31st' 2024, were scrutinized and systematised. A conceptualization of DB2BPMs is provided, based on our results, as well as an analysis of the barriers that hamper their adoption at firm, industry, and supply chain-level. All these levels involve a variety of actors and infrastructures, which may have multiple, or evolving roles. Innovation processes that DB2BPMs can stimulate are identified, in terms of: business model adoption (especially leveraging on the opportunities offered by digital servitisation), technological advancements and capabilities, and automation of tasks. The paper suggests further research on the following key categories: actors; value creation; trust and capabilities; governance; impact; and technological innovations. A selection of policy and practical implications is proposed, that seek to guide policymakers and practitioners when navigating the complexities of DB2BPMs.

1. Introduction

The emergence of the digital platform economy[1] has disrupted the way the society, firms and institutions, work, interact, and create value (Kenney and Zysman, 2016). The adoption of digital platforms has especially accelerated the digital transformation [2] of both large

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[1] "Digital platform economy" is neutral term which includes a growing number of digitally enabled activities in business, politics, and social interaction (Kenney and Zysman, 2016).

[2] Gong and Ribiere (2021, p. 12) developed a unified definition of digital transformation which is «A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity* and redefine its value proposition for its stakeholders». *An entity could be: an organization, a business network, an industry, or society.

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companies (Drewel et al., 2021; Pauli et al., 2021) and small and medium-sized enterprises (SMEs), redesigning the structure of whole industries (Hasler et al., 2022). However, digital business-to-business platforms for manufacturing (DB2BPMs) still represent «a major, untapped opportunity» (He and Zhang, 2022, p. 704; Pauli et al., 2021) for this industry[3] which is a key driver of employment, innovation and economic growth at the global level.[4] While supply chains have become more and more complex with growing sourcing costs (Marzi et al., 2023), manufacturing firms need to adapt their business models and implement technological innovations by taking advantage of the potential of these platforms (Björkdahl, 2020) which connect physical products to sensors, software, applications and services (Porter and Heppelmann, 2015). Manufacturing firms also need to understand the distinctive features, technologies, infrastructures, data, and the roles of actors involved in DB2BPMs. This serves to develop new modes of governance, to ease mass customization, to integrate autonomous systems into manufacturing environments, to foster servitisation,[5] to improve energy and resource efficiency, and to strenghthen upskilling and reskilling of human capital in synergy with technological assets (European Union, 2017).

While the literature has mainly investigated digital platforms in both business-to-consumer (B2C) and consumer-to-consumer (C2C) contexts by scrutinising, amongst other aspects, their governance, openness, effects and scalability (Hasler et al., 2022; Marzi et al., 2023), the business-to-business domain is still underexplored. There is, especially, a need to conceptualise the unique features of DB2BPMs, and to understand both the advantages and challenges behind their design, implementation and transformation, when creating value for the manufacturing industry (Hartner et al., 2021a, 2021b; Hasler et al., 2022; Hossain et al., 2022; Jovanovic et al., 2022; Pauli et al., 2021; Riemensperger and Falk, 2020; Shree et al., 2021). DB2BPMs are ideally placed « at the edge of the so-called platform economy» (Drewel et al., 2021, p. 412) since they could be strategically vital for manufacturing firms in the long-term for several reasons. Indeed, DB2BPMs enhance firms' networking capabilities, and strengthen flexibility and continuity of the sourcing processes (Marzi et al., 2023) both along supply chains, and within innovation ecosystems (Gawer, 2014). Furthermore, DB2BPMs could support firms in shifting to a business model which combines smart products, smart services and customer experiences within their mechanisms (Beverungen et al., 2021; Ghosh et al., 2022; Riemensperger and Falk, 2020).

Although recent studies have attempted to address the definition, characteristics (e.g., Hasler et al., 2020, 2022), and dynamics of DB2BPMs (e.g., Aaldering and Song, 2021; Kapoor et al., 2022; Marzi et al., 2023), most existing research has examined these platforms by focusing on one single scientific field. From the technical standpoint, the engineering disciplines do contribute to advancing the design of digital platforms in Industry 4.0 (Zeba et al., 2021). Whereas, from the business and managerial economics perspective, there is as yet little understanding of the modes of governance (Michel et al., 2023), and of the drivers that motivate, or hinder, manufacturing firms when adopting DB2BPMs (Arica and Oliveira, 2019; Marzi et al., 2023), and on how these companies create value by means of such platforms (Björkdahl, 2020; He and Zhang, 2022). Because DB2BPMs intertwine with information systems, business models, strategic management, markets and institutions (De Reuver et al., 2018; Hasler et al., 2020), a single discipline-driven approach does not fully capture the cross-disciplinary nature of a DB2BPM. Indeed, it would be particularly useful here to use the approach of information systems alongside industrial economics, in order to explore industry dynamics and value creation approaches while identifying the opportunities offered by DB2BPMs (Beverungen et al., 2021; European Union, 2017; Gawer, 2014; Kapoor et al., 2022; Pauli et al., 2021). This combination could help understand the emergence, governance and the paths of transformation, of DB2BPMs which are acting, more and more as innovation and transaction platforms in the manufacturing industry (Cusumano et al., 2020).

The aim of this study is to provide a systematic literature review (SLR) (Briner and Denyer, 2012; Tranfield et al., 2003) of the state of theoretical and empirical research on DB2BPMs by unveiling their role within the digital transformation of the manufacturing industry, and by understanding the conditions, innovations, and governance models that stimulate or hamper this transformation. We adopt a novel and interdisciplinary approach which combines applied economics and information engineering, to address the topic in a comprehensive manner by scrutinising 82 articles published between 1999 and March 31st, 2024. This review offers a threefold contribution. First, it brings clarity and synthesis to the literature on DB2BPMs which is growing as a multifaceted, complex, and interdisciplinary research area. Furthermore, the paper advances the conceptualization of DB2BPMs and the understanding of their theoretical implications. A definition of DB2BPM is offered. Second, drawing on the findings obtained from the review, a research agenda is proposed. Third, this paper also suggests a selection of practical insights relevant for policymakers and practitioners when navigating the complexities of DB2BPM.

The following research questions are addressed:

1. What are the main features and the roles of DB2BPMs in the digital transformation of the manufacturing industry?
2. What are firm-level, industry-specific and supply chain conditions that stimulate or hamper this transformation?
3. What are the modes of governance that enable the emergence or renewal of DB2BPMs?
4. What are the paths of transformation and, what is the required change in actor roles, over time?
5. What are the innovations, either technological or in the business model, that enable this transformation?

The paper is structured as follows. Section 2 describes the methodology adopted for conducting this review. Section 3 offers the descriptive analysis. Section 4 presents the thematic analysis. Conclusions, policy and practical implications, and a proposal for a future research agenda end the paper.

2. Methodology

A systematic literature review (SLR) was carried out to reveal the state of current knowledge (Tranfield et al., 2003) in the field of digital business-to-business platforms for the manufacturing (DB2BPMs). DB2BPMs have unique features which distinguish them from other digital platforms in the B2B and B2C domain. This especially concerns manufacturers' roles and actors' participation, modes of governance, value co-creation, scalability and available technologies. Furthermore, DB2BPMs represent a nascent, multifaceted, complex and interdisciplinary field of knowledge. Thus, SLR can be an appropriate method to obtain insights into, and to conceptualise, these platforms, as well as

[3] According to Eurostat – the statistical office of the European Union, the manufacturing industry refers to the production of goods on a large scale using various processes and technologies, including equipment, labor, machinery, tools, and chemical or biological processing, to transform raw materials into finished products. This industry includes, amongst the others, industrial manufacturing, automotive manufacturing, consumer electronics manufacturing, chemical manufacturing, and food and drink manufacturing. See https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Manufacturing.

[4] The global manufacturing market is projected to expand at a compound annual growth rate (CAGR) of 4.6 % in the period 2023–2030, reaching a value of USD 22.56 trillion by 2030 (Future Data Stats, 2023).

[5] «Servitisation is the transformation of a firm from taking a product-to taking a service-centric approach. It represents a significant change in the business model and mission of the firm, whereby the service business serves as a growth engine of the firm» (Raddats et al., 2019).

defining their practical implications for the manufacturing industry.

Systematic reviews emphasise the principles of rigour, reliability, transparency, reproducibility and updatability to reduce both subjective bias and the risk of omitting relevant literature. Moreover, this approach is better able to overcome some limitations of traditional methods of review, as it both advances academic research and informs practice (Briner and Denyer, 2012), which is especially important in the field scrutinized here. An SLR process has also proved to be appropriate for our investigation since this methodology has recently been adopted to explore both digital platforms (Hasler et al., 2020, 2022) and the digital transformation of the manufacturing industry (Paschou et al., 2021). The methodology used for this SLR was based on the six-stage procedure outlined below.

Stage 1. Preliminary exploration. To define the boundaries of the subject, the review began by interviewing two academics and two international experts with long experience in the field of digital platforms and manufacturing. Interviews were conducted in-person or via videoconferencing and were held either in English or in Italian. Each interview lasted, on average, 45 min. This preliminary step made it possible to obtain some insights both into the general framework of DB2BPMs, and into the perspective and roles of the diverse actors involved in the emergence, development, adoption and transformation of these platforms. The interviews made it possible to identify a set of recurrent key words: "Artificial Intelligence", "AI", "automation", "Business-to-Business", "B2B", "business model". "digital platform", "digitalization", "digital transformation", "governance", "innovation", "Internet of Things", "manufacturing", "servitisation", and "supply chain".

Stage 2. Database and search terms. Elsevier's Scopus was the source used for bibliometric data. This search system is among the most widely used databases of peer-reviewed research literature because it is both extensive and multidisciplinary (Gusenbauer and Haddaway, 2020; Paul et al., 2021). The search was restricted to journal papers and articles in conference proceedings, in order to ensure the most representative scientific outputs in the field of analysis were collected, and included both open, and non-open, access texts. Furthermore, the search was refined to articles published in English so as to ensure that we had a thorough understanding of each eligible item. We refined the keywords obtained from the first stage, to fit with the research questions of this review and to exclude potentially less relevant topics. The following search string was used: "B2B" OR "business to business" AND "platform*" AND "manufactur*". These terms were sought in the titles, abstracts and keywords of publication records. To maximize the recovery of relevant studies and get the broadest possible overview of the emergence and evolution of DB2BPMs, no criteria of minimum citations was adopted for inclusion of items. Furthermore, no specific initial time frame for the publication dates of articles was set. The search was refined to March 31st, 2024: this first search yielded a total of 99 records.

Stage 3. Article download and selection. All the papers listed were downloaded from Scopus. When this was not possible, publications were downloaded from either Google Scholar or ResearchGate. In some cases, the authors were contacted directly, via e-mail and asked for the article. At this point we had 92 papers because it was not possible to retrieve 7 items as either the journal was no longer available or the authors did not have any digital or printed copy of the publication. Inclusion criteria were defined, to address the research questions, and the 92 papers were then manually checked by reading the titles, abstracts and keywords. Only those items that met the following inclusion criteria were included in the sample:

- the papers' core research theme should be: (1) "digital business-to-business platforms", or "digital B2B platforms"; and (2) "manufacturing sector", "manufacturing industry", "manufacturer", "industry", or "supply chain";
- the research objective of the papers should be related to factors which stimulate, or hamper, the design, adoption and transformation, of DB2BPMs; the technological and business model innovations introduced by DB2BPMs; the modes of governance of DB2BPMs; and, lastly, the roles of actors in DB2BPMs.

This procedure made it possible to exclude a further 16 articles because 13 out of 16 were not relevant to the objectives of this review since they did not focus on DB2BPMs at all, neither did they deal with the factors which stimulate, or hamper, the adoption, and transformation, of DB2BPMs, nor did they deal with topics related to the research questions outlined in the Introduction. Furthermore, two articles were excluded because they were in Chinese and the other one was excluded because it was in German. We now had 76 articles and adopted the snowballing technique (e.g., Jalali and Wohlin, 2012), to avoid missing essential contributions. In particular, we identified further eligible items cited in the papers already included in the sample. First, the title, keywords and abstract of each eligible paper was manually checked in order to select only those articles relevant to the scope of the research. Second, the selection was further refined by drawing on the citation tracking provided by Google Scholar (Greenhalgh and Peacock, 2005; Vassar et al., 2016). Following recent SLRs (e.g., Compagnucci and Spigarelli, 2024), we focused on the most impactful papers only by setting a lower cut-off point of 60 citations for inclusion in the sample. This resulted in a further 6 eligible studies. Thus, the final sample used in this analysis was made up of 82 texts: 42 journal papers and 40 articles in conference proceedings.

Stage 4. Data extraction and coding. These 82 articles were fully read, scrutinized and coded. Throughout the process, inter-coder reliability was assured by comparison between researchers coding the same material as a measure of objectivity (Leitão et al., 2024; Mayring, 2014). In particular, four researchers participated in coding all the articles, in two rounds. All disagreements were discussed, and agreements reached. To further address potential biases or subjectivity, a third coding round was arranged, and an external researcher was invited to code a subset of the articles that had presented differences in the first two rounds of coding. This external researcher contributed to resolving any remaining disagreements (Cooper, 2010), especially during the article's revision. Drawing on Brekke (2021), Compagnucci and Spigarelli (2020, 2024), the content of each text was systematised using a protocol that was based on assigning the following codes to each article and recording them in a table: (1) author(S); (2) title; (3) year published; (4) journal; (5) Citations (Scopus); (6) abstract; (7) keywords; (8) research question (S); (9) research gap(S); (10) theoretical framework; (11) methodology; (12) geographical area considered in the study; (13) data collection, sample and analysis period; (14) main results obtained on the basis of the research questions addressed in this review; (15) section for further comments. The protocol resulted in a final document 226 pages long.

Stage 5. Categorization and descriptive analysis. The articles selected were descriptively analysed by adapting the scheme elaborated by previous systematic reviews in the field of Social Sciences (e.g., Compagnucci and Spigarelli, 2020, 2024) and on the topic of digital transformation (Paschou et al., 2021). For each article, along with scrutinising the year of publication, journal and keywords, we first identified the geographical area considered in the studies (category 1). To do so, we involved the codes A-K to identify the location where the analysis was performed. Second, we coded the methodological approach used in the paper (category 2). To do this, we involved the codes A-F to distinguish theoretical-conceptual papers; qualitative studies; quantitative papers; quali-quantitative analysis; and use cases. Third, we identified the timeframe of analysis considered in the article (category 3) by using the codes A-E. Table 1 shows the categorization and coding scheme adopted for the descriptive analysis of the 82 articles.

Stage 6. Thematic analysis. A manual inductive review process (Gioia et al., 2013) was adopted for examining each of the 82 papers, their keywords, titles of sections, and content. We then clustered the results into thematic areas by applying a concept mapping approach (Rosas and Kane, 2012). To this end, we considered the aspects related

Table 1
Categorization and coding criteria.

Category	Significance	Code	Significance
1	*Geographical area considered in the study*	A	USA and Canada
		B	Europe
		C	China
		D	Japan, South Korea, Taiwan and Singapore
		E	Rest of Asia
		F	Africa
		G	South America
		H	Australia and New Zealand
		I	Rest of the world
		J	Multiple[a]
		K	Not applicable
2	*Methodological approach*	A	Theoretical-conceptual study/ model building
		B	Qualitative analysis
		C	Quantitative analysis
		D	Quali-quantitative analysis
		E	Use case
3	*Time frame of data analysis*	A	Cross sectional
		B	Longitudinal: two years
		C	Longitudinal: three years
		D	Longitudinal: more than three years
		E	Not applicable

** Some papers analyse two or more types of sample.
[a] Some studies consider two or more geographical areas.
Source: Authors' elaboration.

to the research questions addressed in this review. Thus, this review established the state of current knowledge in the field of DB2BPMs, and suggests an agenda for future research. Fig. 1 shows the flowchart of this systematic literature review.

Section 3 offers the descriptive analysis of the 82 articles. Section 4 presents the thematic analysis.

3. Descriptive analysis

The 82 studies selected using the methodology described in the previous section were divided, by year, as shown in Fig. 2. The very first article dealing with the concept of a digital business-to-business platform for manufacturing (DB2BPM) and retrieved for this review is the work by Fellner and Turowski (1999). In a world that was seeing the rise of the Internet as a means of conducting business electronically, they took up the challenge of standardizing the electronic data interchange for B2B communications. Until 2016, the number of papers per year remained quite low, with one, two or three articles per year, except for 2008 when there were five papers about DB2BPMs. Then, key enabling technologies for real time monitoring (Internet of Things), data and communication management (cloud computing and infrastructure), and data analytics (Artificial Intelligence), made further effective developments possible, as reflected in the increasing number of studies from 2017 on. The year with most studies (13) in the sample used for this review was 2022. Over the period studied, the 82 articles appeared in 70 different international journals or conference proceedings. According to the search criteria, the journals with the highest number of articles about DB2BPMs were "Technovation", the "International Journal of Production Economics", and the "Journal of Business and Industrial Marketing", with three articles in each.

Fig. 3 shows the word cloud of the words appearing in the abstracts of the articles examined. Aside from the obvious mentions of the words "platform" (206 hits, which rises to 278 when one includes the plural "platforms"), "business" (156), "B2B" (110), and "manufacturing" (82), excluded from the visualization as they were used for the search, the words which appeared most often in the article abstracts were "services" or "service" (107 hits) and "data" (73), highlighting the importance of offering services based on information processing and data-driven analysis to enable decision-making (Sjödin et al., 2023) and greater competitiveness (Riemensperger and Falk, 2020). Other words appearing 50 or more times in the abstracts were "study" (64 hits), "digital" (62), "value" (62), and "innovation" (57).

As regards the research methodologies used in the 82 studies of the sample, Fig. 4 shows that the most commonly adopted was empirical, with 36.59 % (30 out of 82) of the articles describing some platform (or platform component) developments, such as e-commerce platforms (Xu, 2009), virtual cloud technologies (Biibosunov et al., 2020), monitoring

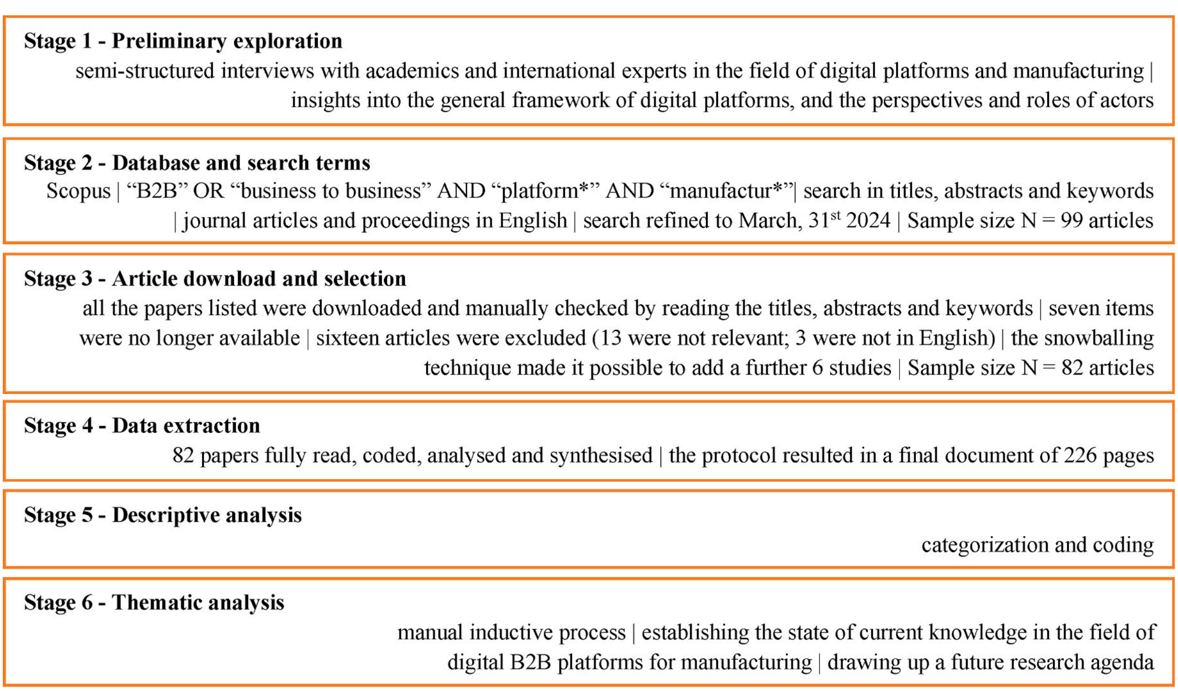

Fig. 1. Flowchart of the systematic literature review.
Source: Authors' elaboration.

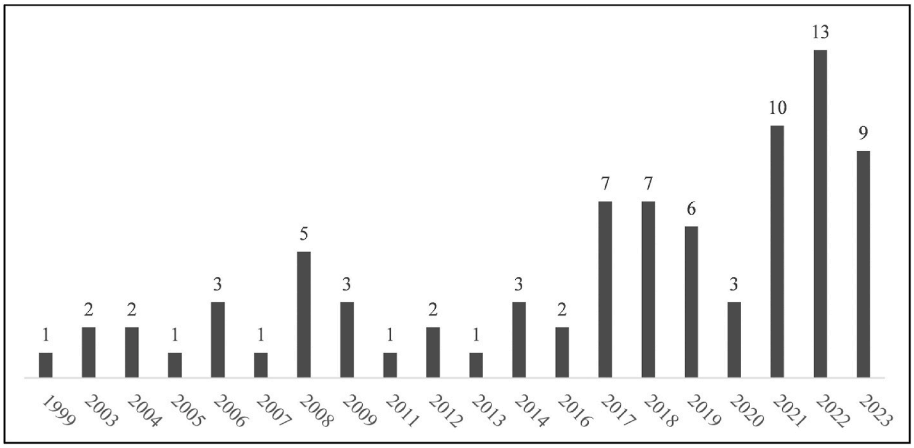

Fig. 2. Number of articles examined per year.
Source: Authors' elaboration.

Fig. 3. Word cloud of the words in the abstracts of the articles examined.
Source: Authors' elaboration.

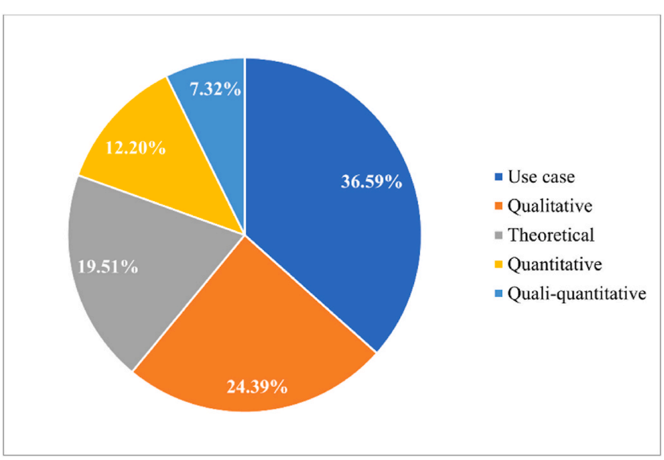

Fig. 4. Research methodologies in the articles examined.
Source: Authors' elaboration.

services (Pieterkosky et al., 2017), apps (Di Pasquale and Roósz, 2016) and many others. Fewer, 24.39 % of the articles (20 out of 82) adopted qualitative evaluations, for example of case studies, such as Sjödin et al. (2023), Galvani et al. (2022), and Hui (2013). Slightly less, 19.51 % of the articles (16 in total) adopted a theoretical approach, such as Drewel et al. (2021), in which a methodology of platform development was outlined or Beverungen et al. (2021), which tried to create a taxonomy of platforms. Around 12.20 % of the papers (10) sought to perform some kind of statistical quantitative analysis about DB2BPMs, such as Marzi et al. (2023) who analysed the adoption of platforms, or He and Zhang (2022) who performed surveys on the value created by DB2BPMs in China. The rest of the papers, i.e., 7.32 % (6 articles), combined qualitative and quantitative analyses for example, as in the work by Verbivska et al. (2023), where the development of platforms was examined using both statistical metrics and qualitative considerations.

A further interesting aspect of the studies reviewed is the geographical distribution of their findings. A significant portion — 60.98 % (50 out of 82 articles) — does not report findings tied to a specific geographical area, suggesting that many studies either adopt a global perspective or focus on conceptual and methodological advancements with cross-regional implications. This reflects the inherently digital and borderless nature of DB2BPMs, which are often designed to operate across multiple markets and industries. Among the studies that do focus on specific locations, half examine platforms for manufacturing implemented in Asia, with an overwhelming majority (91.67 %) centered on China. This is consistent with China's rapid digital transformation of manufacturing, and the prevalence of large-scale industrial ecosystems driven by digital platforms. The remaining regional studies primarily focus on European experiences, probably reflecting the continent's strong research tradition in digital transformation and industrial policy supporting platform-based business models. Notably, only one study addresses a case from the America — Espinosa-Garza et al. (2017)

— which describes a Google Docs-based platform prototype developed in Mexico to streamline real-time B2B interactions, demonstrating cost reductions and productivity improvements. The limited presence of American case studies, particularly from North America, is surprising given the prominence of digital platforms in U.S. and Canadian industries. A plausible explanation is that most of those data are in the papers that provide a global perspective. Moreover, Latin America, including Mexico, may have a lower research output on DB2BPMs due to fewer large-scale initiatives in digital manufacturing compared to Asia and Europe. The dominance of cross-regional studies further suggests that DB2BPM research is often conducted from a global perspective, reflecting the interconnected nature of digital ecosystems and the growing role of international collaborations in advancing manufacturing platforms.

Overall, these preliminary descriptive results show not only the increasing importance, over time, of the DB2BPMs and related topics, but also the need to delve more deeply into the crucial contribution of key enabling technologies and data for the digital transformation of manufacturing firms. Along with the need for advancing the theoretical conceptualization of DB2BPMs and their unique features, future research should advance the understanding of both the relations among actors, and the role of technological and business innovations in the design, implementation and transformation of these platforms.

4. Thematic analysis

The following sections presents the thematic analysis. Fig. 5 shows the key categories of the thematic analysis which was performed by addressing the research questions outlined in the Introduction. As for research question *1) What are the main features and the roles of DB2BPMs in the digital transformation of the manufacturing industry?*, the conceptualization of both the features and the roles of DB2BPMs is provided in Section 4.1. Regarding research question *2) What are firm-level, industry-specific and supply chain conditions that stimulate or hamper this transformation?*, Section 4.2 illustrates how DB2BPMs are put in place, to understand conditions that could enable or hinder their emergence and transformation. Results are presented according to firm-level, industry-specific-level, and supply chain-level. Research question *3) What are the modes of governance that enable the emergence or renewal of DB2BPMs?*, i.e. how DB2BPMs are managed, is addressed in Section 4.3. Then, Section 4.4 deals with research question *4) What are the paths of transformation and, what is the required change in actor roles, over time?*, presenting the findings about the roles of key actors behind the functioning of a DB2BPM for the digital transformation of the manufacturing industry. The last research question *5) What are the innovations, either technological or in the business model, that enable this transformation?*, is addressed in Section 4.5. Based on the findings obtained from the SLR, three main kinds of innovation DB2BPMs offer in terms of new business models, technological advancement and automation of tasks.

4.1. Conceptualizing the features and roles of digital B2B platforms for manufacturing

From a general point of view, a «digital platform is characterized by strong network effects, links two or more different and interdependent groups of participants and enables value-added interactions through the exchange of products, services, information and/or currencies (e.g. money or data)» (Drewel et al., 2021, p. 413). Such characteristics acquire a distinctive connotation in the manufacturing industry, also determining diverse considerations at both the technical and economic

Fig. 5. Key categories of the thematic analysis.
Source: Authors' elaboration.

level. DB2BPMs permit the creation of a multi-sided market which facilitates interactions and transactions among and between a plurality of diverse actors operating in the manufacturing industry. Indeed, DB2BPMs connect two or more distinct and interdependent groups of users, such as suppliers and purchasers (Michel et al., 2023), buyers and sellers (Choi et al., 2023), and producers and consumers (Barni et al., 2018). They also support the conditions that foster value-added interactions through the exchange of products, information, currencies, and data (Drewel et al., 2021), DB2BPMs especially enhance innovative service delivery through available digital technologies (Wortmann et al., 2019).

This means that a DB2BPM can stimulate the digital servitisation[6] of manufacturers, shifting from a product and service-oriented strategy to a service-centric strategy. This path of transformation offers a number of opportunities and challenges for the manufacturing industry. On the one hand, DB2BPMs are perceived as being useful because they enable manufacturers to complement their advantages and to strengthen competitiveness by connecting trading partners in a more trustworthy manner (Hui L., 2011). However, the realm of DB2BPMs is very heterogeneous, with many differences in terms of modes of governance, openness, impact and scalability (Marzi et al., 2023). As a result, most authors do not provide a specific definition of the concept of a DB2BPM. Nevertheless, some common categories of DB2BPMs can be intuited from the way authors use this expression. As presented in Fig. 6, three main categories can be identified:

(a) marketplaces along the supply chain;
(b) information technology/computer infrastructures;
(c) collaborative environments/means of communication within the supply chain.

(a) DB2BPMs often function as marketplaces, providing venues for interaction and transaction between multiple parties. According to Beverungen et al. (2021), these platforms operate in both two-sided and multi-sided markets, using the internet to enable direct interactions between distinct but interdependent user groups, such as buyers and sellers, in order to generate value for at least one of these groups. Platforms extend beyond mere matchmaking, as they facilitate extensive interactions and transactions that support the co-creation of value-in-use with platform actors. Similarly, Pauli et al. (2021) describe DB2BPMs as manufacturing ecosystems that collect and integrate data from various industrial assets and provide marketplaces to facilitate interactions between platform owners, third parties, and business customers. Hui (2013) further define B2B e-marketplaces in manufacturing environments as internet-based markets involving buyers, suppliers, and agents, forming the basis for strategic partnerships among and between enterprises.

(b) DB2BPMs also serve as sophisticated IT infrastructures. Indeed, Tiwana (2014) describes digital platforms as software-based systems with extensible codebases that provide core functionalities shared by interoperating applications. These infrastructures are inseparably intertwined with strategies for the manufacturing industry. This infrastructural role of DB2BPMs is further emphasised by Li (2019), who describes digital B2B platforms as e-commerce systems designed using Service-Oriented Architecture (SOA) to facilitate interoperability and integration among and between heterogeneous enterprise systems. These platforms act as technological backbones, supporting various business functions and interactions in industrial settings. Additionally, digital platforms provide technological support for third-party organizations seeking to develop complementary solutions, enhancing the overall functionality and efficiency of industrial assets and devices.

(c) DB2BPMs offer a new paradigm for collaborative environments by enabling cooperation, coordination, and resource sharing among diverse actors along the manufacturing supply chain. Jovanovic et al. (2022) highlights that platform ecosystems can be viewed as evolving meta-organizational forms which offer platform architectures and governance mechanisms that are able to facilitate cooperation and integration. These platforms enhance the digital transformation of manufacturing firms by providing unified places for purchasing products, services, and software, and for accessing online training sessions and events (Galvani et al., 2022). Choi et al. (2023) also note that cloud-based manufacturing platforms, classified as service-oriented manufacturing models, primarily aim to facilitate resource sharing and cooperation among and between various participants, to further promote a collaborative environment. Moreover, Michel et al. (2023) describe DB2BPMs as facilitators that centralize offers and requests, recruit carriers, and define pricing by using algorithms, thereby improving regulatory compliance and resource matching also in manufacturing environments. He and Zhang (2022) emphasise the role of digitalized interactive platforms in aggregating consumers and integrating business resources, creating platform value through both positive network effects and enhanced customer relationship management. Furthermore, Kapoor et al. (2022) define platforms as foundations for products, services, or technologies that support the development of complementary offers by external firms within a business ecosystem, highlighting the importance of aligning platform operations with their ecosystems to create broader understanding and effectiveness. Overall, these platforms support the conditions that foster collaborative servitisation in the manufacturing industry.

4.2. *Conditions enabling or hindering a DB2BPM*

The diffusion of Industry 4.0 digital technologies and the consequences of recent health and geo-political crises have increasingly encouraged manufacturing firms to go beyond their core business, and to build, or adopt, a DB2BPM in order to remain competitive and to benefit from the opportunities of servitisation (Drewel et al., 2021; Jovanovic et al., 2022; Struwe and Slepniov, 2023; Tian et al., 2022).

As the foundations for DB2BPMs are already in place in a variety of manufacturing sectors (Drewel et al., 2021), both large leading companies, and small and medium-sized enterprises (SMEs), especially start-ups (Cenamor et al., 2017; Corti et al., 2021; Drewel et al., 2021; Hartner et al., 2021a, 2021b), have started to provide for, and implement, solutions for redesigning the way physical products and services are offered in the manufacturing environment. Within the framework of the smart factory (Butollo and Schneidemesser, 2021; Choi, 2018), DB2BPMs may well enable manufacturers to address the service paradox, namely, «the challenge of simultaneously enriching the value proposition by adding services while maintaining cost levels» (Cenamor et al., 2017, p. 54). Nevertheless, the success of a DB2BPM also requires firms to shift from product thinking to platform thinking, as well as having to reshape their own organization (Riemensperger and Falk, 2020).

The following subsections synthetize the most frequently recurring conditions, found in the literature, which are likely to stimulate, or hamper, the emergence, implementation and transformation of DB2BPMs. Findings are categorised according to firm-level, industry-specific-level, and supply chain-level.

[6] According to Paschou et al. (2020) digital servitisation is «the development of new services and/or the improvement of existing ones through the use of digital technologies. These can be exploited to enable new (digital) business models, to find novel ways of (co)creating value, as well as to generate knowledge from data, improve the firm's operational and environmental performance, and gain a competitive advantage».

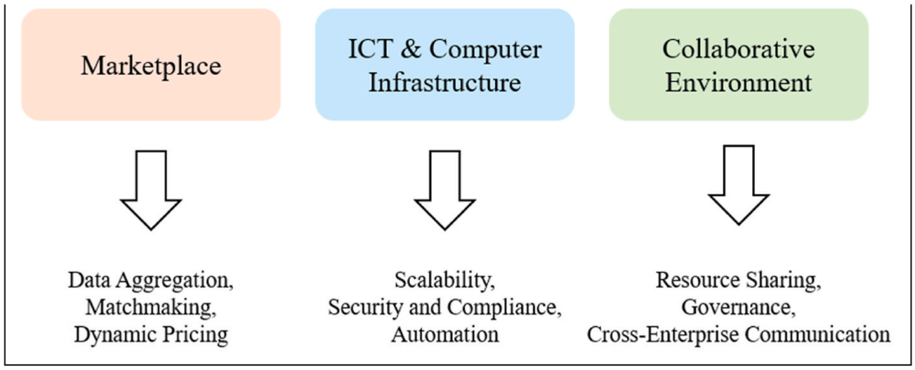

Fig. 6. The features supported by each category of DB2BPMs.
Source: Authors' elaboration.

4.2.1. *Firm-level conditions*

The emergence, adoption and transformation of a DB2BPM is associated with several opportunities that manufacturing firms seek to develop, in particular, increasing sales (Drewel et al., 2021; Espinosa-Garza et al., 2017; Verbivska et al., 2023), improving mass customization (Fellner and Turowski, 1999), increasing efficiency, reducing production costs (Tang and Wang, 2008; Verbivska et al., 2023; Wang et al., 2022), lowering transaction costs (Butollo and Schneidemesser, 2021; Espinosa-Garza et al., 2017), setting prices (Espinosa-Garza et al., 2017), augmenting client loyalty and satisfaction (Drewel et al., 2021; Espinosa-Garza et al., 2017) and, targeting new market segments (Tang and Wang, 2008). Furthermore, manufacturing firms are stimulated to build, or implement, DB2BPMs in order to create added-value by coordinating technologies, buyer and supplier networks and their resources (Butollo and Schneidemesser, 2021), which can, in turn, lead to the development of new advanced services (Jovanovic et al., 2022; Tian et al., 2022).

Although manufacturing firms, which leverage on DB2BPMs, have usually grown in size and scale (Tian et al., 2022), the successful operation of these platforms should not be taken for granted by all manufacturing companies. Indeed, firms should be aware of a number of factors that may hamper, or even interrupt, the implementation of a DB2BPM (Drewel et al., 2021). Since manufacturing SMEs usually have few resources and digital competencies when entering the platform economy (Bazaz et al., 2021; Drewel et al., 2021; Liu et al., 2023; Hui, 2013; Palová and Weinaug, 2009), they have to address three main challenges. First, firms should understand whether implementing a B2B digital platform will enable the company to create added valued and. Second, manufacturers should comprehend to what extent a DB2BPM could be adapted to pre-existing products, processes and organization. Third, firms should manage the initial costs for designing and/or adopting a DB2BPM (Drewel et al., 2021). Fourth, most manufacturing SMEs have to deal with their lack of knowledge of the advanced data usage and monitoring that are required in order to successfully operate such platforms (Hossain et al., 2022).

Furthermore, the introduction of a DB2BPM may be being hampered by the difficulty of combining flexible customization with efficient standardization, even when simultaneously dealing with new demand in an efficient manner (Hui, 2013; Nguyen and Savio, 2008). To overcome these challenges, manufacturing firms should exchange information, be integrated, establish a common IT network (Fraga et al., 2003; Palová and Weinaug, 2009), and, most importantly, be able to engage their stakeholders in value co-creation processes (Struwe and Slepniov, 2023) that need suitable capabilities. As regards platform providers, it might be helpful to offer user-friendly, secure, and trustworthy digital infrastructures which are more attractive to SMEs given their low digital capabilities (Palová and Weinaug, 2009). Platform providers are also encouraged to take into account the distinctive features of manufacturing industries where actors often operate in volatile, uncertain and ambiguous environments, and will be forced to, periodically, redesign their supply and internal processes due to rapid changes in both physical, and online, markets (Verbivska et al., 2023).

4.2.2. *Industry-specific conditions*

DB2BPMs have been being adopted because they permit a degree of flexibility which seems to be more viable for manufacturing industries than «the engineering-heavy approach associated with Industry 4.0» would be (Butollo and Schneidemesser, 2021, p. 550). These platforms seem particularly suitable for manufacturers as they permit agile trans-company collaboration when managing and improving product design, demand prediction, outsourcing, purchasing, manufacturing, distribution, storage, transportation and after sales services (Hui, 2013). Furthermore, the introduction of new information and communication technologies has made it possible for manufacturing industries to develop DB2BPMs for producing and testing products by connecting the original manufacturer to its clients, or by facilitating interaction among clients (Hu et al., 2022; Pauli et al., 2021). Because the manufacturing industry has become more and more reliant on social media platforms, this industry has also adopted, or built, its own B2B platforms for co-creating products and for sharing research and development (R&D) information (Sun et al., 2023).

Since the manufacturing industry is digitalizing rapidly (Bazaz et al., 2021), DB2BPMs offer further, as yet untapped, opportunities for manufacturing firms (He and Zhang, 2022) which should act swifltly to manage the challenges and seize the opportunities offered by the evolving platform economy (Drewel et al., 2021). On the one hand, the manufacturing industry is one of the largest that generates value by transforming data, obtained from the product and process life cycle, into manufacturing intelligence. On the other hand, big data is still used less in this industry than in some other sectors, for example, in finance (Cakir et al., 2022).

Unlike consumer industries, where successful B2C platforms, such as Amazon and Alibaba, have built monopolies through controlling contact with customers, the manufacturing industry does not have the «same winner-takes-all effect » since competitiveness relies on data-driven operations in the physical world (Riemensperger and Falk, 2020, p. 1). This means manufacturers have to combine smart products, smart services and customer experience, since B2B products may well be niche, and targeted to specific purposes (Riemensperger and Falk, 2020). Thus, the manufacturing industry needs to adopt an integrated perspective on DB2BPMs, focusing especially on the co-evolution of the architectures, services, and forms of governance of these platforms (Jovanovic et al., 2022).

It is worth noting that DB2BPMs have been implemented, with different degrees of intensity and success, in diverse manufacturing sub industries. These platforms have mainly been adopted within the manufacture of motor vehicles, trailers, semi-trailers and other transport equipment (Cenamor et al., 2017; Cisneros-Cabrera et al., 2018; Di

Pasquale and Roósz, 2016; Ghosh and Morita, 2006; Hartner et al., 2021a; Plapper et al., 2018; Sjödin et al., 2023), industrial machinery and equipment (Barni et al., 2018; Bazaz et al., 2021; Butollo and Schneidemesser, 2021; Cenamor et al., 2017; Ferreira and Pinto Ferreira, 2004; Hartner et al., 2021b; Singh, 2003; Vuolasto and Smolander, 2021) and for computer, electronic and optical products (Cenamor et al., 2017; Hartner et al., 2021a, 2021b; Hung et al., 2012; Kiuchi et al., 2012; Innerbichler and Damjanovic-Behrendt, 2018). DB2BPMs have also been introduced, but less often, in the following sectors: in the manufacture of machine tools for working both metals and other materials (Cenamor et al., 2017; Galvani et al., 2022), of food products (Espinosa-Garza et al., 2017; Pieterkosky et al., 2017; Verdouw et al., 2014), of textiles (Choi et al., 2023; Tian et al., 2022), and in furniture manufacturing (Jardim-Goncalves et al., 2008).

It is generally more effective to promote a DB2BPM in the manufacturing of electrical equipment (Kwon et al., 2021; Yang et al., 2017), since this sector is appropriate for multiple applications of the same platform to diverse contexts and environments. A further condition that favours the implementation of DB2BPMs in this sector, is the opportunity to develop servitisation in such a way that it can ensure integrated non-stop service from design to construction and to post-sales assistance (Kwon et al., 2021). As regards the manufacture of leather and related products, the emergence of DB2BPMs among and between firms operating in the same regional cluster, has been facilitated by existing, long-standing, collaboration between the diverse actors of the ecosystem, which already addresses a variety of common and shared targets. The role played by professional schools, training centres, technological centres and academic partners has been crucial here. Such actors have contributed to co-creating knowledge, offering technological support and, to training human capital for the leather industry (Ribeiro et al., 2017). In particular, both industrial and academic actors have cooperated by sharing and developing specific competences in the areas of data gathering systems, cameras, sensors and algorithms. As a result, these DB2BPMs permit exosystem actors to address the quality specifications not only of leather products, but also of commodities made from other raw materials, e.g. wood, glass and steel (Flores et al., 2004). This has determined the creation of further business opportunities along the whole supply chain.

As regards the textile sector, large firms and their suppliers have been developing DB2BPMs for product co-innovation (Butollo and Schneidemesser, 2021; Hossain et al., 2022; Shen et al., 2021). In this case, the emergence of DB2BPMs has mainly been determined by a firm's need to encourage technological collaboration and, in turn, to create customer value in a design driven sector (Shen et al., 2021). Regarding the manufacture of rubber and plastic products, this sector usually relies on well-defined technologies for injection moulding. Initially manufacturing firms have been particularly cautious in introducing DB2BPMs which would have required companies to redesign their own organization and processes. However, firms have started introducing DB2BPMs when they have recognized the need to move towards smart manufacturing processes, in order to be competitive and, to cope with the dynamics of market demand in an increasingly turbulent environment (Cakir et al., 2022).

4.2.3. Supply chain-level conditions

Both the recent and unexpected changes in the dynamics of globalization and the volatility of business environments have dramatically transformed supply chains (Hui, 2013), hence stimulated the emergence and transformation of DB2BPMs, so as to ensure information sharing, by strengthening or creating collaborative networks, and by permitting effective management of both complementary knowledge and expertise (Plapper et al., 2018; Ribeiro et al., 2017; Xu, 2009), which otherwise would have remained unexploited along the chain (Butollo and Schneidemesser, 2021). DB2BPMs facilitate streamlined operations and data sharing (Hartner et al. 2021), foster pre-competitive collaboration (Vuolasto and Smolander, 2021; Barni et al., 2018), and promote alliances (Xu, 2009) along the supply-chain. Furthermore, a DB2BPM can become a source of cooperation among and between various actors throughout the value chain. Indeed, new nodes can be attracted to the platform network, thus increasing opportunities for collaboration (Verbivska et al., 2023).

On the one hand, DB2BPMs usually do not require manufacturing suppliers to engage that much in upgrading their technologies and processes, and the actors along the chain are generally willing to participate in such platforms in order to increase their market reach and, consequently, their economic growth (Butollo and Schneidemesser, 2021). On the other hand, the adoption of a DB2BPM is not only a matter of information exchange and sharing along the supply chain. Indeed, a common understanding of information interoperability and access to standardized information technologies should also be ensured (Jardim-Goncalves et al., 2008; Wang et al., 2016). Also, actors in the chain usually do not have any real integration of standards, business processes and management models (Wang et al., 2016). Moreover, most manufacturing firms still rely on IT solutions which only focus on supporting internal activities and, interactions along the chain are mainly managed with manual interventions. To ensure seamless B2B collaboration within digital platforms, supply chains and their actors need to overcome these technical limitations (Hui, 2013), and to develop a flexible approach (Wang et al., 2016) based on trust, integration and communication (Hui, 2013). Information asymmetries, divergent interests, and lack of trust between actors along the supply chain, could generate both pre-transaction costs for negotiating and contract drafting, and post-transaction costs for monitoring and enforcing agreements (Michel et al., 2023).

These risks are especially clear in the automotive supply chain. Although DB2BPMs could play a strategic role in tackling the increasing challenges, mainly related to the supply of electric vehicle components, to lack of resilience traceability, logistic issues, traceability, provenance, and to data integrity (Mishra et al., 2025), the introduction of a DB2BPM might be hampered because the product passes through several actors within the chain, managing hundreds of processes and thousands components. Indeed, there are many B2B interactions which imply cross-firm transactions, cross-border communications, cross-industry trading, and, even, potential inefficiencies, errors and misunderstandings due to cultural barriers (Plapper et al., 2018). Similarly, in the footwear supply chain, the implementation of a DB2BPMs may be hindered by a lack of integration in technological solutions and by the heterogeneity of the interests at stake (Ribeiro et al., 2017).

4.3. Modes of governance

The governance model chosen for the DB2BPM is crucial to ensure the transparency, quality and efficiency of both transactions (Michel et al., 2023) and relations with intermediaries (Yin et al., 2023) for the digital transformation of the manufacturing industry. Indeed, trust between service providers, manufacturers and clients can be nurtured while creating an environment for inter-company transactions (Giuliano et al., 2009).

To achieve such goals, Biibosunov et al. (2020) suggest that public-private governance could be one solution. Regulations and framework conditions, *i.e.* the governance setting, should be clearly defined when designing the platform. Furthermore, interdependence and interaction between all platform actors should be considered (Wang et al., 2022). It is also essential to ensure collaborative governance through standardization (Hung et al., 2012) in order to create a digital ecosystem where all participants actively contribute to its success (Wang, 2017).

4.3.1. Decentralized organization and administration

The governance model of the platform is usually based on a decentralized organization (Ferreira and Pinto Ferreira, 2004) where any decision must be reached through consultation and between independent entities (Flores et al., 2004). Decentralized administration should also allow each participant to manage their own data, ensuring that sensitive information remains under the direct control of the data provider (Kemper and Wiesner, 2005). Here, the governance of a DB2BPM should be data-driven, with a transparent decision-making process supported by the technology itself: big data analysis can guide decisions and, in turn, contribute to optimizing the overall performance of the actors on the platform (Ge and Han, 2022), while blockchain technology can guaratee transparency (Corti et al., 2021).

4.3.2. Clear rules of the game

The good functioning of the DB2BPM also depends on the enforcement of community-based regulation, with rules and reputation mechanisms administering the interactions between platform participants (Hartner et al., 2021a, 2021b), ensuring trust (Li, 2019; Wu et al., 2019), information transparency (Cisneros-Cabrera et al., 2018), security and privacy (Mourtzis et al., 2021), as well as defining mechanisms for resolving disputes (Barni et al., 2018). Furthermore, user engagement protocols are required in order to maintain data integrity and operational efficiency (Hadi et al., 2018), while mutual supervision contributes to ensuring both risk control and cost reduction (Yin et al., 2023).

Governance rules should also include clearly defined decision-making structures and service level agreements to ensure consistent service quality and alignment among and between platform participants (Vuolasto and Smolander, 2021). In particular, integrating robust contractual agreements with manufacturing suppliers is considered to be of utmost importance to manage quality and delivery terms, to mitigate legal and compliance risks, and to enforce privacy and security protocols for safeguarding customer data (Dutta et al., 2019). Fairness and ethics commitments are essential too (Arica and Oliveira, 2019). As regards electronics manufacturing, patent co-development is another tool that can reinforce the governance of the platform community since it implies joint development of patents, sharing patent rights and the use of patent pools for managing intellectual property (Yang et al., 2017).

4.3.3. Democratic, trustworthiness and open context

The governance model should also establish democratic processes based on trust among actors within the DB2BPM. Jovanovic et al. (2022, p. 3) raise awareness regarding the risks that, in the B2B context, «actors actively shape the platform ecosystem through bilateral governance mechanisms between the platform sponsor and prospective members». To this end, advanced data management can promote transparency and improve the trustworthiness of transactions between manufacturing firms (Mourtzis et al., 2021; Corti et al., 2021). Further tools to support smooth relations within the DB2BPM are decentralized service management (Innerbichler and Damjanovic-Behrendt, 2018) and continuous real-time monitoring which latter ensures transparent information exchange and measurement of quality (Giuliano et al., 2009). The literature also emphasizes that the governance model should be "open", i.e. provide technical infrastructure and governance frameworks that facilitate stakeholder participation in the platform and thus, in turn, foster innovation (Hartner et al., 2021a; 2021b). However, the openness of the DB2BPM may encourage opportunistic behaviour from leading firms who exploit their position along the supply chain.

4.4. The roles of actors and paths of transformation

From a more general point of view, research on digital platforms usually refers to a «platform ecosystem» (Jacobides et al., 2018, p. 2257) as a broad array of diverse actors who participate in a given platform by adopting different roles and contributing to the operationalization of the platform (Gawer and Cusumano, 2008). Although this heterogeneity of agents, and their roles, is difficult to capture and systematize, the literature usually identifies three general typologies of actors: the platform owner, complementors and end-users (Heimburg and Wiesche, 2022). The platform owner will ensure the viability of the digital infrastructure, define and enforce the conditions to participate in it, and will continue to develop the platform (Hein et al., 2020; Schreieck et al., 2022). Complementors are placed on the supply side and co-create value which is then offered to end-users via the platform. End-users operate on the demand side and consume the offerings made available on the platform by the complementors (Hein et al., 2019; Schreieck et al., 2016).

Within the framework of a digital business-to-business platform for manufacturing (DB2BPM), the distinction between actors and their roles becomes even more blurred as it is influenced by a number of factors, including the distinctive features of the DB2BPM, the business model and the modes of governance adopted, the characteristics of the manufacturing industries involved, and the relations established between actors. A DB2BPM may involve platform owners, manufacturers, suppliers, logistic providers, service providers and other emerging figures, including industrial associations and, also, institutions, such as governments and universities, research centres and training centres (Flores et al., 2004; Innerbichler and Damjanovic-Behrendt, 2018; Innerbichler et al., 2017; Jardim-Goncalves et al., 2008; Kwon et al., 2021; Verbivska et al., 2023).

It is worth noting that, unlike in traditional C2C and B2C digital platforms, actors in a DB2BPM are not assumed to play one fixed role. They can have multiple roles simultaneously, roles that may even evolve over time (Bazaz et al., 2021; Gawer, 2014): complementors can also be called producers (e.g., Choi et al., 2023), sellers (e.g., Chakravarty et al., 2014), or suppliers, and end-users, may be known as buyers (e.g., Gawer, 2014; Vuolasto and Smolander, 2021) or demanders (e.g., Choi et al., 2023). However, it is crucial to build, strengthen and manage a value creation network, in which each actor benefits from participating on the platform (Riemensperger and Falk, 2020).

4.4.1. Manufacturers

Both manufacturing SMEs and large firms participate in DB2BPMs. Since these companies, due to their size and distinctive characteristics, have different interests at stake they will usually play diverse roles. Indeed, SMEs seek to increase exchanges and develop new networks with suppliers to extend their collaborations and to target new markets. Whereas large manufacturers adopt DB2BPMs to improve efficiency and security along the supply chain, thus reducing transaction costs (Marzi et al., 2023) and enhance the capabilities needed. In addition, they are more likely to encourage intrapreneurship among their employees because DB2BPMs provide collaborators both with easier access to resources and with more possibilities, opportunities, to identify business and innovation opportunities (Liu et al., 2023).

Nevertheless, manufacturers do need to adopt a path of transformation so as to exploit the potential of digital platforms better and to become key players (Yin et al., 2023) in the evolution from providers of physical products to more service-oriented roles (Hartner et al., 2021b; Kiuchi et al., 2012). First, manufacturers should make digital platforms more effective by managing any internal and external tensions related to governance of the infrastructure. Second, manufacturers should accelerate their transition from manual data processing and communication with suppliers, to more strategic roles focused on analysing real-time production data obtained from the platform, thus making more informed decisions (Hung et al., 2012). Third, manufacturers should move from isolated firm-based product platforms towards more participative roles (Arica and Oliveira, 2019; Corti et al., 2021; Ferreira and Pinto Ferreira, 2004; Mourtzis et al., 2021) in platform ecosystems (Jovanovic et al., 2022), where they can develop advanced and flexible systems (Barni et al., 2018).

4.4.2. Suppliers

Suppliers could be the original equipment manufacturers, the owners of manufacturing equipment, or both. These actors offer their wares to a manufacturing service pool via the platform (Hu et al., 2022), where they interact with logistics providers to improve tracking and monitoring of physical items and to optimize the use of resources (Innerbichler et al., 2017; Li et al., 2018). Furthermore, suppliers and logistics providers will also cooperate to ensure a more integrated delivery process (Dutta et al., 2019).

Leveraging on a DB2BPM, suppliers progressively adapt to roles which offer both products and services, focusing on management of the whole lifecycle (Mourtzis et al., 2021). Indeed, suppliers increasingly act as the providers of physical products combined with added value services (Barni et al., 2018), by delivering real-time data (Hung et al., 2012; Kemper and Wiesner, 2005) and by influencing the way in which data is processed and presented (Kemper and Wiesner, 2005). This, in turn, helps platform users, including manufacturers, to become more engaged participants (Hadi et al., 2018) and to offer suggestions for improvement (Sun et al., 2023).

4.4.3. Platforms and platform owners

DB2BPMs are intermediaries since they neither manufacture or service, nor do they directly influence product pricing or quality decisions (Chakravarty et al., 2014). These platforms enable users to find required partners (Kazantsev et al., 2022) and customized services (Wang, 2017), to access new markets, and to seize business opportunities, by reducing effort and risk-related costs (Cisneros-Cabrera et al., 2018). Furthermore, DB2BPMs ensure both standardized interfaces (Singh, 2003) for communication flows between manufacturers and suppliers (Hung et al., 2012), thus contributing to managing transaction information and controlling risks (Yin et al., 2023). These features reduce communication costs (Ghosh and Morita, 2006), enhance both the efficiency of procurement processes and the integration of the supply chain, even while further stimulating collaboration and competition among users in the digital marketplace (Ghosh and Morita, 2006).

However, DB2BPMs are much more than merely a technology which facilitates the interactions between manufacturers and diverse actors (Cenamor et al., 2019). Indeed, platforms ensure that both manufacturers and suppliers are considered in terms of value distribution across the digital ecosystem. The diversity of users involved in platforms also increases the heterogeneity of their roles and interests (Pauli et al., 2021), determining even conflicting demands (Chakravarty et al., 2014). Thus, platform owners have to address the critical issue of setting and managing the platform in a sustainable manner which will permit every user to benefit from their participation (Pauli et al., 2021).

During a DB2BPM itinerary of transformation, platform owners and their intermediaries should improve process optimization and governance mechanisms by using key performance indicators for monitoring and evaluation extensively (Giuliano et al., 2009). Furthermore, platforms should further extend the participation of users, by increasing reliance on technology and data analytics (Dutta et al., 2019; Li, 2019), and by facilitating real-time interactions and decision-making among and between peers in a given manufacturing sector (Bazaz et al., 2021; Cisneros-Cabrera et al., 2018; Ferreira and Pinto Ferreira, 2004; Hadi et al., 2018; Hartner et al., 2021b; Kazantsev et al., 2022), or in different industries (Hartner et al., 2021b).

In addition, DB2BPMs should strengthen service-oriented approaches among manufacturing users (Mourtzis et al., 2021), shifting to more open ecosystem strategies for promoting innovation (Vuolasto and Smolander, 2021). To do this, platforms should be designed by considering some key aspects such as user experience, personalization, and responsive service delivery (Wu et al., 2019). Furthermore, platform owners should further strengthen trust in relationships between users in order to consolidate the network, attract new actors and provide new business opportunities (Innerbichler and Damjanovic-Behrendt, 2018). This means that control and data governance should be enforced (Biibosunov et al., 2020), by complying with legal aspects especially those related to data sharing (European Union, 2017).

4.4.4. Emerging actors

A number of further actors have recently emerged within the framework of DB2BPMs. In particular, service providers include application servers, content providers and trading communities (Hui, 2013). Moreover, integrators collaborate closely with the platform owner in order to facilitate the adoption, and implementation, of new technologies within customer projects (Barni et al., 2018), contributing to the platform's adaptability and functionality (Choi, 2018). Integrators should also offer system integration technologies and assistance for reconstructing business flows (Hui, 2013). These may help speed up the transition from in-house systems to cloud services and, also, enhance communication and collaboration among platform users (Kiuchi et al., 2012). To do this, integrators should offer both comprehensive digital tools and personalized services (Barni et al., 2018; Hartner et al., 2021a), as well as ensuring access to standardized information (Hartner et al., 2021a).

Further agents are required for the new service roles on DB2BPMs: system administrators who supervise real-time data collection and device management, ensuring smooth platform operations (Choi, 2018); data analysts who collect, explore and model data to help inform supply chain decisions and to optimize a firm's performance (Choi, 2018; Ge and Han, 2022); security personnel dedicated to the implementation and maintenance of the platform's security measures for protecting data integrity and device communication (Choi, 2018); innovation managers who facilitate the innovation process within the platform (Corti et al., 2021); and supply chain managers who assist users to integrate platforms within the supply chain (Ge and Han, 2022).

There is also growing contribution made by industry associations (Wang et al., 2016), academic institutions (Flores et al., 2004) technological centres, professional schools and training centres (Ribeiro et al., 2017) to the development, implementation and transformation of a DB2BPM. Indeed, these actors participate in defining technological standards, the design of a platform's components, the creation of new business service models, and also contribute to increasing the confidence of manufacturers in technology adoption by conducting applied research and providing mentoring.

4.5. Key domains of innovation

DB2BPMs introduce three main kinds of innovation: the first is attached to the business model (BM), the second concerns the tecnological capabilities of manufacturing firms, and the third is related to the automation of tasks within the manufacturing industry.

4.5.1. Business models

The literature highlights the fact that successful digitalization, and then digital transformation, will only be achieved by manufacturing firms if novel ways of creating, delivering, and capturing value are established (Sjödin et a., 2022). In this context, sustainable data-centric digital business models (BMs) are required (Riemensperger and Falk, 2020). Indeed, in the new digital context, a business without data is unimaginable (Hossain et al., 2022), even within different scenarios of digital innovation (Bootz et al., 2023). Taking full advantage of production technologies requires digitalized support systems in diverse areas of a manufacturing company's business and often puts some pressure on well-established BMs (Bazaz et al., 2021).

Advances in technology can help to evolve traditional e-market places into integrated platforms that are able to facilitate both community services and e-commerce, thus enhancing long-term customer relationships (Mourtzis et al., 2021). Furthermore, BM platforms, that focus on a multi-sided platform model and make transactions between multiple users (suppliers and buyers) possible, thus optimizing unused capacity and fostering innovation (Corti et al., 2021). Continuous collection of large volumes of data (Choi, 2018) is encouraged, as is enhanced real-time interaction between businesses, with no central authority involved (Ferreira and Pinto Ferreira, 2004).

BM innovations include the possibility to ensure personalized recommendations in manufacturing platforms to address the complexity of

B2B supply chains and improve user experience by reducing information overload and optimizing search processes. This is done also by leveraging on the use of social network information (Hadi et al., 2018). Some authors recommend the design of federated services managed by peer-to-peer networks, including open membership (Wang, 2017) and contractual relationships. "Open" means that the DB2BPM allows new organizations with modest resources to join, to extend their businesses to new communities, and to create innovative BMs. Contractual relationships between all participants and their services affiliated with the platform ensure clear and formal agreements and obligations (Innerbichler et al., 2017). Modularity in system design is also crucial for easier adaptation to evolving business needs (Li et al., 2018; Wu et al., 2019). Also, AI technology capacities (perceptive, predictive, and prescriptive) could support new BM applications that promote circularity and sustainability within the digital servitisation of the manufacturing industry (Sjödin et al., 2023).

Different BMs are described in the literature. In response to the diffusion of DB2BPMS, Beverungen et al. (2021) define three options for manufacturing companies with reference to a BM. The first is for firms which only have a limited number of customers and choose not to engage in any platform, thus continuing to address a single-sided B2B market. The second option is for firms which have developed some capabilities in smart service provision and decide to offer services on another platform provider's smart service platform. Firms thus become better acquainted with platform business models, with reduced investments and risks (Hui, 2011), but do not become platform providers. The third option is for companies that have mastered their transition to becoming a smart service provider: thanks to data generated by smart products, and both smart services and a smart service platform are offered. The BM is also changed to create a digital multi-sided e-market that enables service providers and their customers to interact directly and to co-create service(s).

Hartner et al. (2021) argue that manufacturing companies may introduce a B2B e-marketplace in order to improve the operational efficiency of a supply chain, by connecting the up-stream and down-stream firms (Hui, 2013), thus promoting better communication flows, and better organization of operations which impacts on logistics costs. Platforms make real-time standard data exchange and streamlined data integration possible, thus permitting manufacturers to work closely with suppliers to streamline production planning processes, reduce inventory costs, and improve both supply chain efficiency and production planning (Hung et al., 2012). In supply chains, DB2BPMs can favour the introduction of technology-driven risk management measures, and hybrid inventory models that combine aspects of just-in-time and pre-purchase stock methods, or flexible supply bases and emergency inventory pre-positioning (Dutta et al., 2019). Redundancy and delays are avoided (Innerbichler et al., 2017), while evaluation of potential suppliers, based on criteria such as reliability, costs, and product quality, improve the efficiency and efficacy of the supply chain (Cisneros-Cabrera et al., 2018).

According to Hui (2013), B2B e-marketplace models leverage on customer oriented and procedure-oriented management in order to secure rapid shifts in response to market changes, while also eliminating redundant and inefficient work in firms. Changes are radical, and not only in terms of sales and marketing strategies (Verbivska et al., 2023): manufacturing firms can access the data in real time and can use them to transform their practises, to evaluate data-based processes and, also, to determine their digital transformation roadmaps, interactions with their customers, application, and analysis (Cakir et al., 2022).

More recently cloud manufacturing has emerged as a novel and collaborative manufacturing model that allows the original equipment manufacturers, and their clients, to share their equipment (Hu et al., 2022). Furthermore, virtual marketplaces make it possible to create virtual spaces where companies can efficiently solve capacity shortages and leverage excess capacities (Arica and Oliveira, 2019). From the collaborative perspective, such virtual places can create synergies that allow manufacturers to enter foreign markets and to counter competition from specific areas of the world (Ribeiro et al., 2017).

The literature also highlights the growing role of digital servitisation (DS) in innovating manufacturing firms' BMs. DS defines the development of new services by means of digital technologies (Beverungen et al., 2021). Galvani et al. (2022) suggest three levels of DS: (1) product provision, (2) after-sales servicing, and (3) advanced services taking after-sales to the next level. Although the rapid diffusion of DSs shows the growing recognition of the key role of services offered to manufacturing firms, this path of transformation may be hampered by several challenges (Hyeog-in et al., 2021). First, to ensure advanced services, manufacturing firms should evolve from a product and service-oriented strategy to a service-centric strategy. This latter requires specific managerial skills and capacities, as well as greater managerial effort, which may determine the need for upskilling or reskilling human capital at the firm level. Second, DS by means of a DB2BPM poses the question of applying the concept of "value co-creation" at a practical level. It means that manufacturing firms should redesign their organization, resources, and mechanisms to learn more about their customers and to enable value co-creation. Third, DS implies shifting from a business solely focused on operational excellence towards embracing customer allegiance too. However, as the frequency and intensity of cooperation with stakeholders and customers grows, the likelihood of conflicts increases.

Regardless of the BM implemented in a DB2BPM, key aspects of BM design include involvement of the entire firm ecosystem and a definition of platform governance, while putting the perspective of customer experiences at the centre (Riemensperger and Falk, 2020). Furthermore, DB2BPMs require collaborative networks of partners (Flores et al., 2004), including service buyers, contractors, and machine manufacturers. It means that dynamic participation (Kemper and Wiesner, 2005) lies at the heart of a BM. Nevertheless, it is not easy to achieve involvement of partner companies in the ecosystem, and manufacturing firms do need to plan exactly how to orchestrate the ecosystem in relation to digital BM innovation (Sjödin et al., 2023).

4.5.2. Technological innovation

DB2BPMs facilitate access to key technological innovations for business units, departments and modules: in fact, most of the papers analysed revealed the importance of manufacturing firms' digital platform capabilities in information processing, resource identification and resource allocation (Liu et al., 2023), allowing for greater competitiveness (and scalability) on a global scale (Riemensperger and Falk, 2020). For example, manufacturers and customers may utilize shared DB2BPMs to facilitate connected product and service functionalities, such as remote monitoring, predictive maintenance, digital twins or continuous AI-based process optimization (Struwe et al., 2023). As Pauli et al. (2021) pointed out, DB2BPMs permit both the collection and analysis of data from a variety of industrial assets and devices in manufacturing. Indeed, with a DB2BPM, large volumes of data can be collected, in real-time, from different equipment in the production area, thus improving the traceability of manufacturing processes (Cakir et al., 2022). Along with these traits, which were common to most of the articles included in the present review, four categories of technological innovations, introduced into the manufacturing industry by digital B2B platforms, were also identified. Specifically, these categories are:

- cloud computing and infrastructure, reflecting the need for flexible storage and computing capabilities required to run a DB2BPM;
- Internet of Things (IoT) and connectivity, to allow a DB2BPM to exploit the capabilities of connected sensors and actuators in order to collect data about the entire manufacturing process (from purchase and delivery of materials to production) to be used in conjunction with data analytics;

- advanced data analytics and intelligence, to extract valuable knowledge from the vast amounts of data that are potentially collectable;
- Artificial Intelligence (AI) and automation, to support (and automate) decision making in B2B relations in the manufacturing industry.

These categories reflect the diverse technological innovations that DB2BPMs introduce into the manufacturing industry, offering significant enhancements in analytics, connectivity, infrastructure, and automation. The following subsections describe these categories.

4.5.2.1. Cloud computing and infrastructure. Cloud-based solutions have radically transformed interactions on DB2BPMs by providing scalable and flexible infrastructures, thus facilitating the efficient management of large volumes of data and computational tasks (Hartner et al., 2021). The adoption of cloud infrastructure offers scalable storage and computing capabilities, enabling manufacturing firms to dynamically adjust their resource use to meet demand. This flexibility is essential for managing the complex value networks and production processes found in manufacturing industries. Furthermore, the integration of microservices architecture, as highlighted by Wu et al. (2019), permits the independent development and deployment of service components. This enhances system flexibility and scalability, making it easier to update and maintain different parts of the platform without causing disruption. The microservices framework also supports the incorporation of advanced technologies, such as AI and big data, which are able to improve both data processing capabilities and user interactions through personalized recommendations and enhanced decision-making.

Integrated Product-Service Systems (IPSS) are another important innovation, these use real-time data and connectivity to boost operational efficiency (Mourtzis et al., 2021). Such systems transform traditional production equipment suppliers into providers of comprehensive industrial services, in line with the concept of Manufacturing as a Service (MaaS). The use of cloud-based solutions in IPSS also facilitates the seamless exchange of information and services, throughout the supply chain, by addressing the complexities and trust issues often associated with B2B interactions. Furthermore, advanced messaging systems, such as RabbitMQ (Mourtzis et al., 2021), ensure robust communication between microservices, thus supporting the overall reliability and efficiency of the platform.

The technological innovations in cloud computing and infrastructure are crucial for promoting and developing a DB2BPM. These innovations provide firms with the scalability, flexibility, and efficiency required to handle the complexities of modern manufacturing processes, and encourage the development of more integrated and responsive industrial ecosystems.

4.5.2.2. IoT and connectivity. DB2BPMs have augmented technological innovations in IoT and connectivity in manufacturing environments. These advances have been reshaping the landscape by enhancing data utility, real-time monitoring, and decision-making processes (Cakir et al., 2022). One of the pivotal innovations is the integration of IoT technologies (Choi et al., 2023), which connect physical assets to digital networks, promoting seamless data collection and analysis. This connectivity facilitates real-time monitoring and swift decision-making, thus optimizing operational efficiency. The deployment of 5G technology further reinforces this connectivity by providing robust, high-speed, data transfer capabilities that are crucial for real-time applications in manufacturing environments (Yin et al., 2023).

Another transformative innovation is edge intelligence, which combines edge computing with supply chain finance so as to streamline operations and reduce latency. This approach allows data processing to take place closer to the source of data generation, which significantly improves the efficiency of both data handling and of decision-making processes. The integration of big data analytics with edge intelligence further strengthens capabilities for evaluating credit and managing risks effectively, thus contributing to more efficient supply chain financing models (Yin et al., 2023). Radio-Frequency IDentification (RFID) and Global Positioning System (GPS) technologies also play an important role in advancing DB2BPMs by reinforcing tracking and management of inventories. These technologies provide precise, real-time, location data, which improves inventory accuracy and reduces losses due to mismanagement or theft. The real-time data exchange enabled by these technologies leads to better communication throughout the manufacturing supply chain, and ensures that all stakeholders have access to up-to-date information, which latter is crucial for making informed decisions (Dutta et al., 2019).

The use of advanced analytics and statistical methods for risk assessment and performance evaluation is a key innovation within the realm of DB2BPMs. These methodologies facilitate more comprehensive understanding of possible risks and their potential impacts on supply chain performances. By leveraging on these tools, companies can develop more effective risk mitigation strategies, thereby augmenting the resilience of their supply chains (Dutta et al., 2019). Moreover, integration between Cloud Computing and IoT enhances the utility of data in platforms as it connects physical assets and enables real-time monitoring and optimization of machine performances and business operations (Hartner et al., 2021). This connectivity makes the implementation of predictive maintenance and other proactive measures possible, by reducing downtime and improving productivity. Enhancing platform capabilities through AI and machine learning further automates processes and refines decision-making, thus providing a competitive edge in a fast-paced manufacturing environment (Mourtzis et al., 2021).

In the studies reviewed, integrating IoT and connectivity technologies in DB2BPMs is bringing about substantial improvements in efficiency, accuracy, and decision-making capabilities. The use of 5G technology ensures robust and high-speed connectivity, while edge intelligence facilitates efficient data processing and supply chain financing. RFID and GPS technologies enhance inventory management and real-time communication across the supply chain, and advanced analytics provide deeper insights into risk and performance. These innovations are contributing to the transformation of manufacturing industries, making them more agile, efficient, and resilient in the face of evolving challenges.

4.5.2.3. Advanced data analytics and intelligence. Manufacturing firms can substantially improve their performance by adopting advanced analytics DB2BPMs. These platforms enable firms to extract meaningful insights from customer transaction patterns, thereby allowing for real-time demand satisfaction and precise decision-making. Despite these advances, a knowledge gap still persists in the industry which continues to hinder widespread adoption, and optimization, of these technologies (Hossain et al., 2022). Big Data Analysis Technology (BDAT) has been particularly transformative, helping firms to understand market demands and optimize supply chain operations. Through data collection, exploration, modeling, and analysis, BDAT assists in the construction of effective supply chain platforms (SCPs), which are crucial for competitive cross-border e-commerce (CBEC) markets. This technology enables firms to track, and predict, market trends, thus improving the efficiency, and precision, of their manufacturing processes (Ge and Han, 2022).

Furthermore, the integration of advanced data analytics within supply chain finance has improved credit evaluation and risk management. By leveraging big data, firms can streamline credit assessments and manage risks more effectively which, in its turn, improves operational efficiency and reduces latency. The incorporation of edge intelligence further augments these capabilities, providing real-time data processing and decision-making at the supply chain edge. This integration is crucial for maintaining a competitive edge in fast-paced manufacturing industries (Yin et al., 2023). Advanced data analytics skills also play a vital role in optimizing machine performance and business operations. Integration of the Internet of Things (IoT) and Cloud infrastructure facilitates the connection of physical assets, increasing data utility and scalability. IoT integrations enable real-time monitoring and decision-making, while cloud infrastructure provides scalable storage and computing power, all of which are essential for handling the large volumes of data generated in modern manufacturing environments. These innovations are helping to create more responsive and adaptive manufacturing processes, driving both overall efficiency and effectiveness (Hartner et al., 2021).

Hence advanced data analytics and intelligence are of utmost importance for DB2BPMs, as they offer significant improvements in demand satisfaction, market understanding, supply chain optimization, credit evaluation, risk management, and overall operational efficiency.

4.5.2.4. Artificial intelligence and machine learning. Artificial Intelligence (AI) and Machine Learning (ML) play pivotal roles in supporting decision-making and process automation on DB2BPMs. These technologies improve recommendation systems by integrating social network analyses with traditional recommendation engines, thus addressing specific challenges that are inherent in B2B interactions (Mourtzis et al., 2021; Hadi et al., 2018). AI-driven enhancements facilitate procurement in Industrial Product-Service Systems (IPSS), by utilizing real-time data and connectivity to improve operational efficiency. Furthermore, AI and machine learning contribute to the creation of scalable and flexible cloud-based solutions, which support the complex supply-chain processes within DB2BPMs. Integrating these technologies not only improves decision-making but also optimizes process automation in various industrial operations.

Advanced matching algorithms are another technological innovation that significantly optimizes supply and demand matching within a DB2BPM. These algorithms are crucial for improving capacity management and supplier selection, ensuring that the right resources are allocated both efficiently and effectively (Arica and Oliveira, 2019). The use of real-time capacity management and enhanced data analytics further supports these functions by providing accurate and timely information, thus enabling manufacturers to take informed decisions regarding their manufacturing capacities and their partnerships.

Recommender algorithms are specifically designed to address the complexities of B2B environments by analysing business networks for dynamic recommendation generation. These algorithms leverage social network analysis tools to examine the structure and dynamics of business networks, thereby improving the system's ability to identify and recommend relevant, suitable, business partners and products (Hadi et al., 2018). Real-time data processing capabilities ensure that recommendations are generated dynamically, enhancing both the responsiveness and relevance of the platform.

Overall, the technological innovations introduced by AI, and by automation, in DB2BPMs significantly improve operational efficiencies, decision-making processes, and dynamic recommendation generation, which leads to more effective and streamlined B2B interactions. In fact, along with the works included in this review, AI applications in digital B2B platforms are emerging in further sectors not only the manufacturing industry (Keegan et al., 2024). Such innovation revolves around AI's function to automate and foster marketing processes through data-driven decision-making, predictive analytics, and process optimization. AI enables businesses to harness vast amounts of customer and operational data, improving strategic options, customer segmentation, lead identification, and customer profiling, while also driving cost efficiencies. As Peretz-Andersson et al. (2024) have recently argued AI can boost manufacturing for resource orchestration: AI enhances digital transformation by structuring AI resources, bundling AI capabilities (learning and governance), and leveraging AI technologies, coordinating processes, and empowering skilled workers. This dynamic process enables manufacturing SMEs to optimize production, improve efficiency, and create competitive advantages despite challenges related to digital transformation and investment capacity. In general, AI is able to exert a positive impact on the further development and diffusion of a DB2BPM since it permits automation and augmentation of service tasks, real-time data integration, and decision-making (Kowalkowski et al., 2024). However, this path of transformation may encounter a number of key barriers to full AI integration in DB2BPMs, including lack of trust among manufacturers, the need to improve both the accessibility and usability of these platforms, and the presence of several stakeholders with diverse interests at stake in platform adoption.

4.5.3. Automation of tasks

One of the most important advantages of integrating automation functions into DB2BPMs is the possibility of providing support for decisions by generating valuable insights from extensive and complex data sets (Sjödin et al., 2023). This information is condensed into a manageable format, enabling industrial manufacturers and their customers, to empower and automate solutions to existing business challenges. Manufacturers have the opportunity to introduce AI, to reduce IT complexity, to shorten delivery time, to develop business collaborations and to empower business innovation (Liu et., 2023). Recent advancements in AI enable, amongst other factors, product recommendation (Wu et al., 2019), predictive analytics to manage demand and offer along the supply chain (Mourtzis et al., 2021), optimization of equipment and materials needed (Vuolasto and Smolander, 2021), risk management (Yin et al., 2023), and digital assistants and chatbots for customers (Verbivska et al., 2023).

Based on the papers scrutinized, it is possible to distinguish three main groups of automations carried out when using a DB2BPM:

1. automation of customer relationship management and marketing functions;
2. automation of supply chain management and financial operations;
3. automation of supplier management and transaction handling;

The following sub-sections examine these groups of automations.

4.5.3.1. Automation of customer relationship management and marketing functions. As regards the automation of customer relationship management (CRM) and marketing functions, Liu et al. (2023) describe the construction of CRM systems that utilize customer portraits for accurate recommendations. By leveraging digital technologies, such as cloud computing, big data, AI, and IoT, firms can enhance their digital platform capabilities, reduce IT complexity and encourage business collaboration and innovation. This study found that digital platform capability impacts positively on a B2B firm's performance through resource identification, allocation, and intrapreneurship which, collectively, mediate the relationship between digital platform capabilities and a firm's performance.

Furthermore, Verbivska et al. (2023) examined the automation of the sales process in e-commerce systems. This includes placing customer orders through personal accounts, automated marketing tools, inventory tracking, and document handling via electronic signatures. The study outlines how e-commerce facilitates the automation of daily tasks, such as providing customers with comprehensive product information, promoting products through social media, and generating sales reports automatically. By integrating e-commerce systems with accounting programs, businesses can update their inventory information and improve operational efficiency.

It is worth noting the practical implications deriving from these two examples: the adoption of digital technologies and AI in CRM and marketing functions permits manufacturing firms to identify and allocate resources better, driving business innovation and reducing IT complexity. This transformation is crucial for firms that are seeking to improve their digital platform capabilities, which, in turn, will lead to improved performance in terms of revenues and cost optimization. For as long as manufacturers continue to navigate in the digital landscape, AI integration, and automation in CRM and marketing functions, will remain crucial for improving business processes, stimulating innovation, and maintaining competitive advantage in the manufacturing industry.

4.5.3.2. Automation of supply chain management and financial operations. Examining supply chain management and financial operations, Yin et al. (2023) describe the automation of credit evaluation, risk management, and order processing using e-commerce and financial data. They propose an edge intelligence-enabled supply chain financial model that integrates AI with edge computing to improve the quality of data analysis, risk management, and decision-making processes within their DB2BPM. This model constructs and then evaluates the cost-benefit dynamics among and between dealers, manufacturers, and B2B e-business platforms, by optimizing financing strategies and product order quantities. AI plays a central role here, utilizing advanced data analysis techniques to streamline credit evaluations and manage risks more effectively. Ge and Han (2022) studied the automation of data collection and analysis, and logistics coordination, carried out in order to improve supply chain decisions and response times. The authors emphasised the application of big data analysis technology when constructing supply chain platforms for cross-border e-commerce (CBEC). Furthermore, the study explored the use of big data to understand market demands and optimize supply chain operations. From a practical perspective, the automation of these processes is crucial for enhancing efficiency and precision in logistics and production, particularly in the growing CBEC market.

Vuolasto and Smolander (2021) however, focused on the automation of operation scheduling and real-time reporting for service buyers and contractors within the forestry sector. Their research on a digital platform for forestry operations demonstrates the use of machine learning to optimize the scheduling and use of machinery, as a means of improving operational efficiency. The automated generation of real-time operational reports further helps with managing service contracts and coordinating efforts among forest companies, contractors, and machine manufacturers. Dutta et al. (2019) examined automated inventory management, real-time risk assessment, and logistics management in e-commerce supply chains. The authors proposed the use of comprehensive data analytics for real-time decision-making and risk assessment, suggesting technology-enabled platforms such as GPS and real-time tracking systems to mitigate disruptions.

It is clear that, despite technical diversities in specific automated tasks, all the studies reviewed emphasised the key role of automated systems in improving supply chain management and financial operations within DB2BPMs. In some of these applications, the integration of AI, particularly through edge intelligence and machine learning, permitted more efficient data analysis, risk management, and decision-making processes along the supply chain.

4.5.3.3. Automation of supplier management and transaction handling. Along with transactional processes within DB2BPMs, Arica and Oliveira (2019) also focused on the automation of both supplier discovery and manufacturers' need for identification. These automated processes can be facilitated by the data analytic, which supports decision-making regarding capacity and supplier selection. Wu et al. (2019) however, investigated the automation of payment processing through integration with various payment gateways, and the automation of order and logistics management through streamlined systems. In this application, AI is integrated via a dedicated microservice, leveraging machine learning and data mining tools to better exploit functionalities such as product recommendations and user interaction, thereby improving the intelligence and responsiveness of the platform.

As regards streamlining data management and reduce manual intervention, Wortmann et al. (2019) described the potential of the automation of data collection and processing, and transaction handling. This automation makes predictive maintenance and advanced data analytics possible, thus increasing both decision-making and operational efficiency. Choi (2018) too studied the automation of real-time monitoring, anomaly detection, and device provisioning within IoT systems. Machine learning techniques for anomaly detection not only permit predictive maintenance but also improve decision-making accuracy in smart factories, thus confirming the vital role of automated tasks in improving these platforms.

Overall, these studies have illustrated the important impact of automation for augmenting the efficiency, responsiveness, and intelligence of DB2BPMs. This integration of advanced technologies has the potential both to streamline supplier management, and to optimize transaction handling, thus transforming traditional manufacturing processes into more agile and data-driven operations.

5. Conclusion

This review has sought to define the state of the art of the literature on DB2BPMs. In particular, it has synthesised, clarified and systematised the knowledge about both the roles of B2B platforms in the digital transformation of the manufacturing industry, and the conditions, innovations, and governance models that stimulate or hamper this transformation. We have adopted a novel and interdisciplinary approach which combines applied economics and information engineering. This perspective contributes to capture the cross-disciplinary nature of DB2BPMs, to identify the opportunities and challenges posed by the digital transformation for manufacturing firms, and to understand the emergence, governance and paths of evolution of DB2BPMs which are acting, more and more as innovation and transaction platforms. An interdisciplinary approach also facilitates knowledge transfer from the scientific domain to industrial practice. By combining and integrating knowledge from diverse disciplines, the manuscript seeks to support innovation processes and to guide manufacturing firms towards more effective corporate strategies.

Comprehensive examination of the topic has revealed that, since the late 1990s there has been increasing demand for « inexpensive and easily employable software that allows platform-independent exchange of business data between companies» (Fellner and Turowski, 1999, p. 164). At that time, the integration of computing systems and platforms was one of the most challenging avenues of research envisaged by computer scientists (Mittmann et al., 2006), one which required further development, and testing, of platform applications (Xu, 2008). Since then, the literature has addressed DB2BPM creation in a more "compartmentalised" way by focusing either on the technical or on the economic domain of these platforms. Indeed, scholars have tended to conceptualise DB2BPMs either as « types of markets » or as « modular technological architectures» (Gawer, 2014, p. 1239).

5.1. Theoretical contribution

Based on our findings, there is a growing need to advance the understanding of the cross-disciplinary and cross-sectoral nature of digital B2B platforms within the manufacturing industry. This is due both to their key role within this industry, and to the opportunities DB2BPMs could, potentially, offer to firms in terms of strengthened collaboration, increased revenues, cost optimization, trustworthy supply, flexibility, traceability, and transparency along today's supply chains which are becoming more and more complex (He and Zhang, 2022; Marzi et al., 2023; Pauli et al., 2021). Along with factors which stimulate the adoption and, then, the transformation of a DB2BPM, there are also barriers at firm-level, industry-specific-level and supply chain-level, all of which involve a variety of actors and infrastructures, including manufacturers, suppliers, platforms and their owners, as well as emerging players such as, amongst others, application servers, content providers, trading communities and integrators. It is worth noting that these actors are neither assumed, nor expected, to play one fixed role. Indeed, they can have multiple roles simultaneously, roles that may even evolve over time. Considering both the uncertainty of the environments where manufacturers operate, and the distinctive features of these firms, it is of utmost importance that actors adopt appropriate modes of governing DB2BPMs, based on clear and shared rules. The latters should serve to increase openness and trustworthiness both in the platform and between its participants.

Such conditions allow DB2BPMs to stimulate innovation processes in three key domains. The first is related to business model adoption, especially leveraging on the opportunities offered by the digital servitisation of the manufacturing industry. The second is focused on the tecnological advancements and capabilities needed by manufacturing firms, including cloud computing and infrastructures, IoT and connectivity, Advanced Data Analytics and intelligence, and AI and Machine Learning. The third domain of innovation concerns the automation of tasks carried out by DB2BPMs, namely the automation of customer relationship management and marketing functions, the automation of supply chain management and financial operations, as well as the automation of supplier management and transaction handling.

Given the set of common categories that have been obtained from the SLR, a DB2BPM could be defined as a platform which promotes trustworthy value-added interactions between diverse actors of the manufacturing industry, heterogeneous industrial sectors, and/or a set of industrial assets and devices, along the supply chain. Leveraging on scalable, secure, compliant and automated information technologies and computer infrastructures, DB2BPMs provide a collaborative ecosystem to govern a co-created digital servitisation which - leveraging on automated tasks – in its turn, facilitates the exchange of complementary capabilities, resources, products, services, information and/or data.

5.2. Future research avenues

This review suggests a selection of research avenues that, based on the findings discussed in the thematic analysis, could focus on the following categories: (a) Actors; (b) Value creation; (c) Trust and capabilities; (d) Governance; (e) Impact; and (f) Technological innovations. Fig. 7 summarizes the main research avenues related to Actors, Value Creation, Trust and capabilities, and Governance.

5.2.1. Actors

The literature has already extensively investigated digital platforms in B2C and C2C contexts, by focusing on digitalized firms (He and Zhang, 2022; Michel et al., 2023). Whereas there is a lack of conceptualization and classification of DB2BPMs which have unique features and are very different from platforms based on other business models (Hartner et al., 2021a, 2021b). Furthermore, there is little knowledge about the barriers and the facilitators which, respectively, hinder and motivate manufacturing firms to integrate digital B2B platforms into their processes. More attention should also be dedicated to the analysis of technological, organizational and cultural factors (Arica and Oliveira, 2019; Marzi et al., 2023; Sjödin et al., 2023) through providing exemplary case studies which offer generalizable results.

Future research should also look in more depth into the roles of platform actors (Chakravarty et al., 2014) in order to reveal their impact on the transformation of digital platforms (Vuolasto and Smolander, 2021). Along with the need to provide more empirical evidence about manufacturing enterprises operating in emerging markets (Espinosa-Garza et al., 2017), there are also as yet very few insights, studies, of the perceptions of, and the relationships between, manufacturers, suppliers, platform owners, service providers and regulators participating in DB2BPMs (Hartner et al., 2021b; Kapoor et al., 2022; Sjödin et al., 2023; Yin et al., 2023). Understanding how these actors interact is fundamental for orchestrating the platforms better (Kapoor et al., 2022; Sjödin et al., 2023), for attracting new agents and, for encouraging the emergence and transformation of digital ecosystems for manufacturing (Pauli et al., 2021).

5.2.2. Value creation, trust and capabilities

Future studies should address how manufacturing firms transform their business model into platform-based servitisation (He and Zhang, 2022; Tian et al., 2022), and examine how they coordinate digital servitisation and value co-creation (Struwe and Slepniov, 2023). Since DB2BPMs offer a unique context to explore the evolution from closed to open ecosystems, it is of utmost importance to investigate the mechanisms that contribute to the development of service-oriented business, of personalized products, and of value distribution among diverse actors. In particular, researchers should support and encourage firms to co-create value - not only monetary value - from DB2BPMs, by looking more deeply into the real needs of users and by encouraging their engagement in digital innovation efforts (Drewel et al., 2021; Hartner et al., 2021a; Jovanovic et al., 2022; Pauli et al., 2021; Sun et al., 2023; Wang, 2017; Wortmann et al., 2019). As yet, there is still a lack of empirical validation for the new theoretical paradigms of value creation in DB2BPMs.

The creation of value within a DB2BPM largely depends on establishing trust between users and on improving actor's ability to exploit the full potential of such platforms. Thus, researchers should contribute to making appropriate strategies for establishing and strengthening trust and security within digital platforms more accessible to users (Beverungen et al., 2021; Innerbichler and Damjanovic-Behrendt, 2018). Indeed, there is little information available regarding the specific capabilities required by firms if they are to understand the

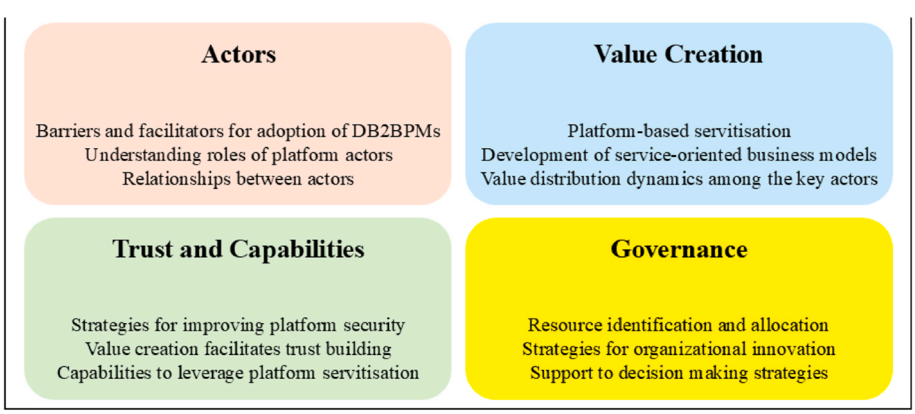

Fig. 7. Main research avenues proposed.
Source: Authors' elaboration.

dynamics in and of, platform-based servitisation and thus be able to exploit the opportunities this offers. How such capabilities would impact on company performance could be a fruitful area for analysis (Liu et al., 2023; Struwe and Slepniov, 2023; Tian et al., 2022).

5.2.3. Governance

Future research should investigate DB2BPMs by adopting a process perspective in terms of how platform architecture, actor-specific data, and governance mechanisms co-evolve. This approach would encourage the transformation towards platform-based servitisation (Jovanovic et al., 2022), as well as enabling users to explore opportunities for collaborating with others (Ribeiro et al., 2017). Researchers should also investigate factors and conditions under which firms should build their own platform rather than using already existing ones (Drewel et al., 2021). Indeed, there is still little understanding of governance mechanisms in early-stage platforms (Vuolasto and Smolander, 2021). A pre-requisite for a good governance design is the digital platform capabilities of manufacturing firms, i.e. the ability to communicate, collaborate and market online, while being connected with other actors. Such capabilities facilitate resource identification and allocation (Liu et al., 2023). Supporting models are also required (Barni et al., 2018) in order to help firms to define and evaluate governance strategies (Pauli et al., 2021; Wortmann et al., 2019). To this end, managers ask for guidance on how they can govern and integrate both technological and organizational innovations (Yang et al., 2017), and on how to facilitate the transformation of corporate culture in order to embrace a platform-based business model within complex digital ecosystems (Hung et al., 2012).

5.2.4. Impact

Monitoring, understanding and evaluating the diverse impacts which may be generated by the implementation of DB2BPMs is not merely an exercise. Indeed, the lack of empirical studies that combine both quantitative and qualitative research on their benefits and pitfalls of platform applications, could discourage potential developers and adopters from investing financial and human resources in them, as well as from making the cultural effort required by setting out on the path towards platform-based servitisation (Barni et al., 2018; Beverungen et al., 2021; Li, 2019; Yin et al., 2023). Furthermore, future research should advance the understanding of the impact of DB2BPMs on manufacturers' decision-making (Hu et al., 2022), firm economic performance (Sjödin et al., 2023), innovativeness within the firm (Wang et al., 2022), on after-sales services (Galvani et al., 2022), and on risk control and supply chain benefits (Yin et al., 2023). In addition, so far how these platforms influence business model innovation at the level of the firm, of market dynamics (Hartner et al., 2021b) and of business relationships (Arica and Oliveira, 2019) has not been well documented.

Cross-disciplinary longitudinal studies are required in order to reveal the long-term impacts of DB2BPMs on both circularity and sustainability in the manufacturing industry, also to compare the performance and outcomes of diverse AI-enabled platforms (Sjödin et al., 2023). Moreover, long-term empirical studies could and should contribute to understanding the social implications of platform ecosystems (Kapoor et al., 2022), and to how actors' decisions shape the evolution of platforms (Beverungen et al., 2021). Given the heterogeneity of manufacturing industries and their distinctive features, there is also need for deeper knowledge about the effects of DB2BPM dynamics, business models and innovation at sector-specific levels (Hartner et al., 2021a; Ribeiro et al., 2017; Vuolasto and Smolander, 2021; Yang et al., 2017).

5.2.5. Technological innovations

Technological innovations also include cloud computing for flexible infrastructure (Hartner et al., 2021), IoT for real-time data collection (Cakir et al., 2022), advanced data analytics for market trend predictions (Ge and Han, 2022), and AI for decision-making and process automation (Mourtzis et al., 2021). AI supports customer relationship management, supply chain automation, and supplier management (Sjödin et al., 2023; Yin et al., 2023). Overall, these technological innovations facilitate competitiveness and scalability in manufacturing by integrating advanced technologies and enhancing operational efficiencies (Riemensperger and Falk, 2020).

Nevertheless, there is still room for improvement, from the technological perspective. A general lack of interoperability between different DB2BPMs impedes wider adoption and federation of these platforms (Barni et al., 2018). In this regard, exploring the potential of edge intelligence and IoT for real-time data processing and supply chain optimization is crucial (Yin et al., 2023). Studies dealing with AI applications lack conceptualization and empirical evidence (Hossain et al., 2022), for example, when they are used to enhance trust and functionality on B2B platforms (Mourtzis et al., 2021). Future research should focus on integrating advanced AI and machine learning to support decision-making and automation processes (Sjödin et al., 2023). Moreover, developing robust cybersecurity measures to protect data integrity and privacy within these platforms is essential (Choi, 2018; Jovanovic et al., 2022; Michel et al., 2023).

Overall, continuous innovation and advances in DB2BPM developments are imperative in order to address cross-disciplinary and cross-sectoral challenges, and to fully promote the potential of manufacturing firms in their ecosystems.

5.3. Policy and practical implications

The results of this review have implications for policymakers and practitioners involved in the design, adoption and transformation of digital business-to-business platforms for manufacturing. It is worth noting that exploiting the potential of a DB2BPM in terms of economic growth, competitiveness, and industrial innovation, requires an orchestrated effort from both policymakers and practitioners. This could contribute to establishing conducive regulatory environments, supportive infrastructures, and appropriate institutional frameworks for the strategic implementation (Rame et al., 2024) of these platforms for the manufacturing industry.

As for national and regional **policymakers,** they should design both the regulatory frameworks and industrial policies, which create an attractive environment for manufacturers, by balancing the promotion of digital transformation and the mitigation of risks related to data security, interoperability, and market fairness in DB2BPMs. To this end, policymakers should adopt a number of policies.

First, local governments should support structural changes in their manufacturing systems valorising digital servitisation, service-oriented business, personalized products, and value chain optimization. From an infrastructural perspective, policymakers should also ensure that digital connectivity, such as broadband and 5G networks, is widely accessible to manufacturing firms, particularly those operating in industrial clusters and rural regions (Yin et al., 2023). Policymakers should establish industrial data spaces that enable firms to share and monetize data in a structured manner, ensuring trust, competition, and compliance with ethical considerations (Behera et al., 2022). The implementation of regulatory sandboxes, for example for data sharing (Zoboli, 2020), where businesses can test digital platform solutions under relaxed regulatory conditions, would allow firms to experiment with new digital models before wider deployment (Hu et al., 2022; Pauli et al., 2021).

Second, to promote cross-border transactions and collaborations, policymakers should encourage international cooperation on interoperability standards, by fostering an integrated global manufacturing ecosystem. To this end, policies for standardized data governance should be adopted to ensure secure data exchanges and compliance with international regulations on data protection, such as the reference framework proposed by Zorrilla and Yebenes (2022).

Third, financial incentives, such as tax credits or grants, should be offered to encourage manufacturing SMEs to adopt DB2BPMs and to integrate them into their existing operational processes.

Fourth, embedding DB2BPMs in national or local industrial policies for innovation might create more trust and confidence, especially among small-sized actors or less innovative players in the innovation ecosystem. For example, the design of Smart Specialization Strategies (S3) of European Union regions, with their specific guidelines, incentives, and training, could support the diffusion of DB2BPMs among manufacturers and key stakeholders. Synergies among and between these actors could be encouraged by promoting clear and shared rules for governance. Mutual learning exercises, intersectional workshops and match making events might also stimulate dialogue and active interaction, by increasing openness and trust both in platforms and among participants. Public-private partnerships could facilitate innovation intermediaries that connect academia, industry, and government institutions to encourage the co-development of DB2BPM-based solutions, tailored to meet specific manufacturing needs (Biibosunov et al., 2020).

Fifth, local academic actors and schools should, perhaps even would, be encouraged to redesign their training, reskilling and upskilling programmes for both students and workers. Indeed, manufacturing firms usually lack expertise in the domain of data driven technologies. Thus, orchestrating coordinated education and industrial policies might help create a good stimulus for the whole innovation ecosystem.

To ensure the successful adoption of a DB2BPM, **practitioners** could also undertake several actions. A strategic shift in business operations and workforce capabilities is of utmost importance. Manufacturing firms should move from traditional supply chain models towards platform-based ecosystems that prioritize agility, transparency, and collaboration. Investing in cloud-based infrastructure and artificial intelligence-driven data analytics will become crucial for real-time decision-making, predictive maintenance, and resource optimization. Manufacturers should adopt modular platform architectures that permit scalable integration with existing enterprise resource planning (ERP) systems, so as to ensure seamless interoperability across different business functions (Mancuso et al., 2024).

A further critical challenge for manufacturers is balancing customization with standardization in DB2BPM environments. To address this issue, firms should develop hybrid models that offer personalized solutions even while leveraging standardized data formats and application programming interfaces (APIs) to facilitate interoperability along the supply chain (Shoomal et al., 2024). Here, digital twin technology should be employed to simulate and optimize manufacturing processes before implementation, thus reducing waste and improving operational efficiency (Zhang et al., 2024).

Practitioners should structure DB2BPM governance carefully, in order to ensure transparency and equitable value distribution. Decentralized decision-making models allow stakeholders in the platform ecosystem to contribute to rule-setting and dispute resolution. Trust-building mechanisms, such as blockchain-based smart contracts and reputation scoring systems, can further enhance transaction security and foster collaboration among platform participants (Mustafa et al., 2025).

It is worth suggesting that policymakers and practitioners should cooperate also to align their efforts to navigate the complexities of digital transformation in the manufacturing industry. While policymakers provide the necessary regulatory and infrastructural support, manufacturing firms should proactively embrace new technologies and business paradigms. By fostering a symbiotic relationship between regulation, infrastructure, and industry innovation, DB2BPMs would be able to stimulate efficiency, global competitiveness, environmental sustainability, and the resilience of manufacturing environments.

5.4. Limitations

As a final consideration, the methodological strategy adopted, as well as the features of this SLR may explain some of its limitations. First, a manual search process was followed to obtain the sample of articles, rather than involving an automated software-driven search process. This could mean that the authors might have missed some relevant studies, thus may have underestimated the extent of DB2BPM-related research. Second, this SLR was built on one database only. The use of further sources may permit to extend the scope of analysis. Third, the search was refined to journal papers and articles in conference proceedings while other studies and books, including grey literature – which is out of the scope of this SLR – may add further knowledge about the topic. Fourth, an integrated investigative approach was adopted combining both the information systems and the industrial economics perspective in order to explore industry dynamics and value creation approaches while capturing the opportunities offered by DB2BPMs and the technologies available. However, the cross-disciplinary nature of DB2BPMs may require the exploration of further adjacent fields of knowledge, especially the legal dimension. Indeed, these platforms present a broad spectrum of regulatory challenges and implications, including, for example, the enforcement of existing, novel or amended legal frameworks for regulating liability and competition in DB2BPMs.

CRediT authorship contribution statement

Lorenzo Compagnucci: Writing – original draft, Formal analysis, Methodology, Writing – review & editing, Conceptualization, Data curation, Investigation. **Francesca Spigarelli:** Formal analysis, Supervision, Writing – original draft, Writing – review & editing, Resources. **Paolo Sernani:** Writing – original draft, Data curation, Writing – review & editing, Formal analysis, Visualization. **Emanuele Frontoni:** Writing – original draft, Supervision, Writing – review & editing. **Paolo Seri:** Formal analysis, Writing – review & editing, Methodology.

Declaration of interest statement

The authors report there are no competing interests to declare.

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Data availability

No data was used for the research described in the article.

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