

Analysis of digital platforms' business models and their applications in the 4th industrial revolution

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ABSTRACT

Digital revolution, as a result of the fourth industrial revolution is changing the way people live and conduct their business. Its promise of sustainability is building optimism amongst users. However, there is a lack of research in understanding how digital platform business models can be tailored for use in existing businesses and how this technology can be used to revolutionize new businesses. This study conducted a systematic literature review to create a deeper understanding of the technology of digital platform business models and their characteristics and application. The results of this study are used to develop a hybrid structure of the digital platform business models and their components. Also, this study identified the critical elements of the cyber-physical system. Herein, the core, trendy, intermittent, and emergent keywords relating to digital platform business models are placed and analyzed. This study contributed to the body of knowledge by an in-depth understanding of digital platform business models and their relevance in the fourth industrial revolution by removing barriers that may limit their use.

Keywords

- Cyber-physical system
- The fourth industrial revolution
- Business model
- Data-driven model
- Digital transformation
- Digital platform models

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1. Introduction

The 4th industrial revolution (4IR/Industry 4.0) is demonstrated with advancements in artificial intelligence (AI), robotics, the Internet of Things (IoT), genetic engineering, quantum computing, etc. [1]. It was followed by innovation in biotechnology as the fifth 5th industrial revolution, not just ushering in new ways of doing business but also leading to a transformation in the traditional business models. While traditional business models contributed to the pollution of the natural environment, the new business models shown by the fourth industrial revolution are championed by the need to lead sustainable development and limit green gas emissions [2]. A business model represents the main components of a giving business and is a popular terminology in e-business and e-business research [3]. As the adoption of new technologies by the fourth industrial grows, new forms of business models such as –sustainable business models, digital business models, big-data business models, circular business models, and platform business models are emerging [4–7]. Understanding the characteristics of these models by business owners and key players of the innovation system is essential in determining how businesses and their performance can adopt them.

According to [8], a sustainable business model is a configuration that contains components and their relationship, in addition to a relationship with stakeholders that interact with an organization's goods or services to deliver sustainable value. At the same time, big-data business models employ the use of advanced data to gain and maintain a competitive edge against rivals [9]. On the

other hand, circular business models significantly improve sustainable business models. To enhance efficient and adequate consumption of resources based on established regulation, investment in innovation strategies, and the design of business models that add value to the supply chain [10]. In [11], three platforms are introduced as open business models (user, infrastructure, and provider). In comparison, digital business models came about by the rise of digitalization and servitization in business processes [12]. Servitization's primary aim is to improve customer satisfaction, while digitalization is the intensity of the use of the digital tool in the recent industrial revolution [13]. The primary means of delivering change brought about by digitalization is through key technologies (such as the Internet of Things (IoT)), a means for quality data exchange, and the use of predictive tools [14].

The importance of digital business models cannot be overemphasized in the fourth industrial revolution because this revolution is powered by the advanced use of digital technology in ways that have never been seen before [15]. No doubt, digitalization contributes to sustainable development goals in modern society. An important sector of the digital revolution and its business models being used is the supply chain. Not only is the digital revolution of the fourth industrial revolution leading to a positive change in the supply chain, but it also has a risk of disrupting the ways businesses operate [16]. This is particularly true because of the novelty of the technologies used in the fourth industrial revolution compared to previous revolutions. Without the digital components, its ability to



champion wireless connectivity, and its ability to improve machines' autonomous capabilities, the fourth industrial revolution would not happen. For instance, the digital capabilities of the fourth industrial revolution are improving productivity in the construction industry around the globe [17]. Studies of digital business models in the fourth industrial revolution are still in their infancy; however, based on the importance of these models on productivity during the sustainable development era, studies relating to the digital business models are required to inform how

performance and productivity can be enhanced, aligning with the Sustainable Development Goals (SDGs). This study seeks to bridge this gap by systematically analyzing literature and highlighting the significance of digital business models and their application toward achieving sustainable development targets. The first step is the identification of gaps in existing literature (as listed in Table 1) and then recognizing the digital business models' potential in the context of sustainable development tools.

Table 1: A brief analysis of previous most-relevant literature on the digital platform business models.

Author(s)	Year	Key findings	Area for future studies
Kim and Min [18]	2019	Platform business models' typologies were identified.	The importance of the platform business models in the fourth industrial revolution cannot be overemphasized. However, there is a paucity of studies on this topic and business model innovation in the fourth industrial revolution [19–21]. Research on the characteristics and ways businesses can adopt digital business models within the sustainable development concept is still in its infancy.
Kohtamäki et al. [22]	2019	Digitalization influences individual business models and how it aligns with other business models in the ecosystem.	
Kraus et al. [23]	2019	Six streams of research relating to digital entrepreneurship were identified.	
Martín-Peña et al. [12]	2018	Digitalization and servitization have transformed business models and are responsible for developing digital business models.	
Park et al. [4]	2020	Two pricing models for customer entrepreneurs on digital platforms are developed.	
Ruggieri et al. [24]	2018	Digital platforms offer start-up's product and service innovation, dramatically improving their performance and growth.	
Stallkamp and Schotter [25]	2021	Strategies for digital platform firms to enter the international market were identified.	
Stoian and Tohanean [26]	2021	A discovery that technology businesses are using digitalization to explore the opportunities of platform business models is noted.	
Täuscher and Laudien [27]	2021	Business models are classified into six broad groups.	
Zhao et al. [28]	2019	Platform business models have been successful because they combined various business models and the use of innovative methods.	

Based on the identified research gaps, this study is addressed (1) the key components relating to the intellectual structure of digital business models and how they are assembled. Then (2) assessed the core areas in the field of digital business models within existing literature and their potential to contribute to sustainable development, which is continued by (3) covering the trending areas in the field of digital business models within existing studies and their importance. Finally, it highlighted the role of digital business model platforms in the fourth industrial revolution. This study's framework for the systematic analysis of the topic is adapted from [27], and organized in the following sections. Section 2 contains a detailed discussion on the methodology adopted, Section 3 focuses on the results, Section 4 discusses the process and findings, and Section 5 concludes this study.

2. Methodology

The adapted methodology is based on qualitative analysis; however, gathering quantitative data due to privacy laws in several countries makes adopting this methodology challenge. The literature review and analysis method are one of the most used methodologies of turning figures into comprehensive results, which has various types, including

narrative, textual narrative, meta summary, scoping review, meta-narrative, test, Bayesian meta-analysis, realist review, ecological triangulation, extend, thematic synthesis, meta-interpretation, meta-study, critical interpretive synthesis, framework synthesis, critique, and hybrid method [29]. To help in the systematic review analysis to be performed in this study, keywords that will be used in the literature search will be identified based on existing literature, which is given in Table 2. In line with the literature evaluation, the following keywords are identified: business model innovation, digital business model, data-driven business models, and digital platform businesses.

Table 2: A review of leading literature on digital platform business models.

Author(s)	Scope
Guggenberger et al. [30]	Understanding the characteristics and different digital models is discussed.
Isabelle and Westerland [31]	A relationship between digital technologies and professional service firms was studied.
Tashiro and Choi [32]	This study focused on the impact of digitalization on the taxi industry as the case study.
Fürstenau et al. [33]	The role of multi-sided platforms in healthcare and standardization of processes and services are studied.

Hänninen et al. [34]	The impact of digitalization on the retail sector and its impact on both retailers and suppliers are investigated.
Stölzle and Häberle [35]	The role of digital platforms on traditional logistics methods and how they lead to a paradigm change are discussed.
Von Delf and Zhao [36]	The use of business models in process industries is covered.
Mishra and Tripathi [37]	Considering artificial intelligence business models on customer relationship management and enterprise resource planning, business systems are addressed.
Bilcan et al. [38]	An examination of the revolution in the accounting sector brought about by the use of digital technology is studied.
Enes [39]	Steps taken to regulate the rise of the digital platform in the European Union are studied.

run on the first day of March 2022 using the identified keywords with the given search string in Figure 1. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline [28] is adopted in the literature search. The PRISMA guideline contains an updated format for carrying out a systematic review. The PRISMA guideline presents checklists to help researchers in their quest to obtain relevant literature in their research endeavors. This checklist was adopted in this study. First, an extensive search was executed before the main literature review commenced. This search was to determine the relevant keyword that should be included in the search, gain the required knowledge for a detailed review, and understand the trends in the area of study.

2.1. Material search

The related and essential information is obtained from the Wiley Online Library and Google Scholar Databases. These databases were chosen because they possess a powerful tool for literature search, have been used extensively within the research community, and are amongst the best databases available to researchers [27]. The query was

Second, the inclusion and exclusion criteria are set. A summary of the entire process followed based on the PRISMA guideline is presented in Figure 1. The initial screening based on the inclusion criteria yielded a result of 1,871 contributions. The unpublished contributions, studies without the keywords used, papers published before 2017, literature in languages other than English, and published entries with duplicates are eliminated from the search result. Then, 126 entries are left and analyzed.

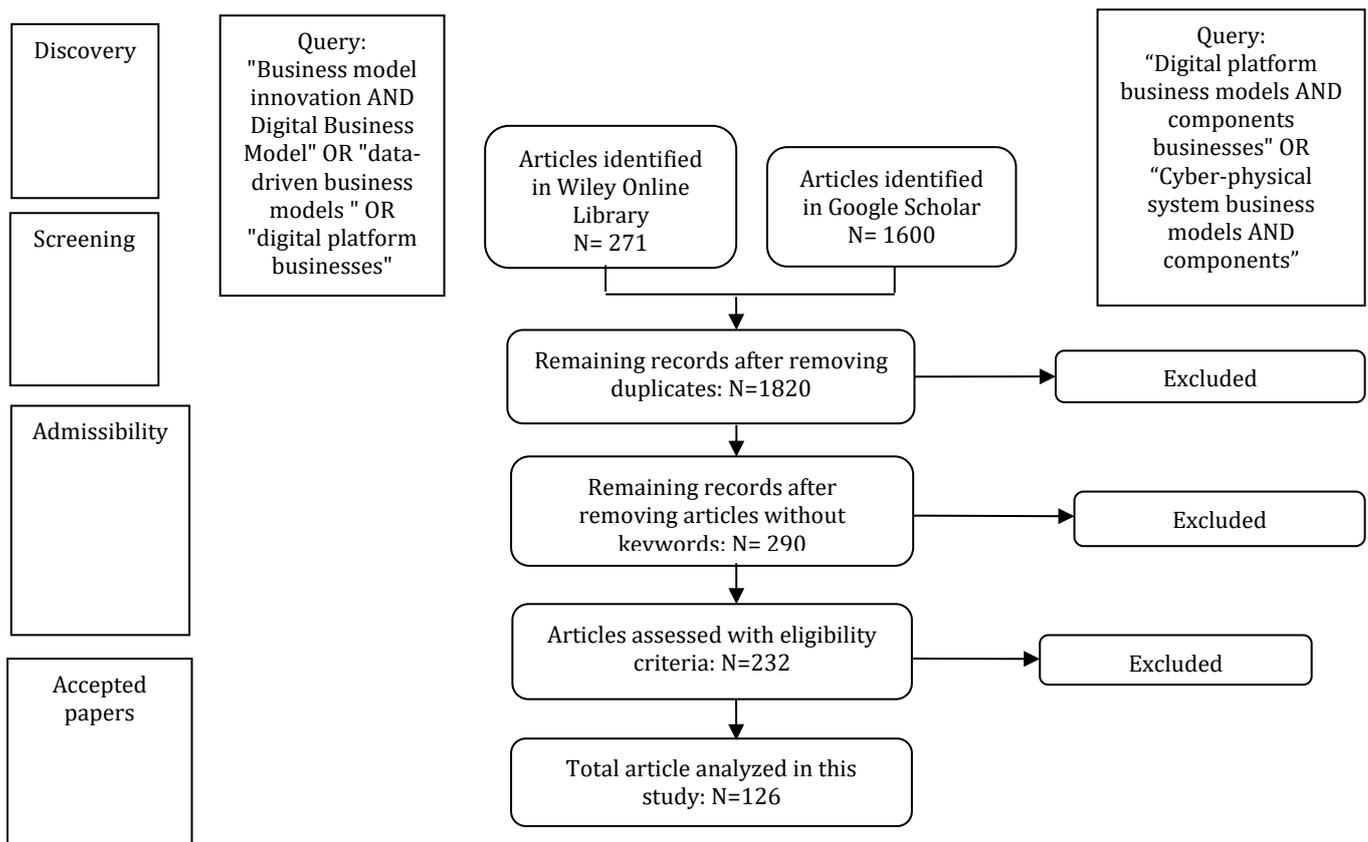


Figure 1. Literature analysis based on the PRISMA guideline.

3. Results

3.1. Data statistical analysis

The meta-data of the results of the analysis are discussed in Section 2. Figure 2 presents the information regarding the year of publication of each included material. The results show that there has been a steady rise in publications since 2017. It is important to note that studies published in 2022 are also included. Since the literature search is carried out in March 2022, the number of studies included is just a fraction of the representation of the publications that will be published in 2022. Based on the trend from 2017 to 2021, it is projected that the number of publications in 2022 will increase compared to 2021.

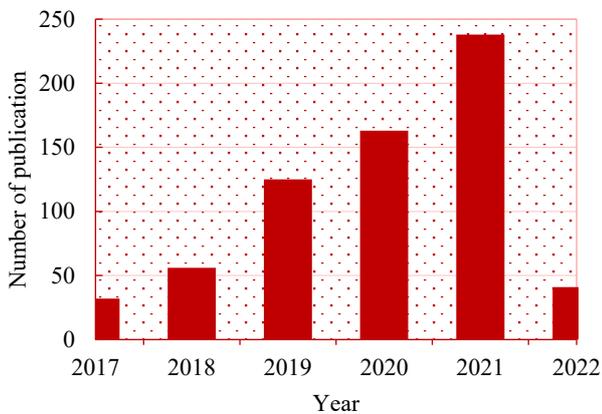


Figure 2. Trend in publication related to the topic.

On the other hand, the statistics on the publication included in this study based on the top 10 published journals, which are presented in Figure 3. IEEE, SSRN Electronic Journal, Journal of Business Models, and others had 15, 9, 4, and 2 publications, respectively.

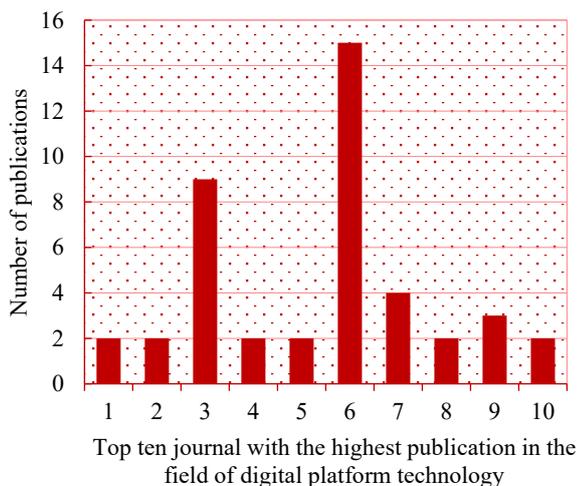


Figure 3. Top 10 journals with the highest publication in the field of digital platform technology.

The top 10 countries with the highest number of publications: Germany (53), UK (7), Austria (6), Finland (5), USA (4), China (4), Spain (4), Netherlands (4) and USA (3) ranked amongst the top 10. Figure 4 contains a diagrammatic representation of this demography.

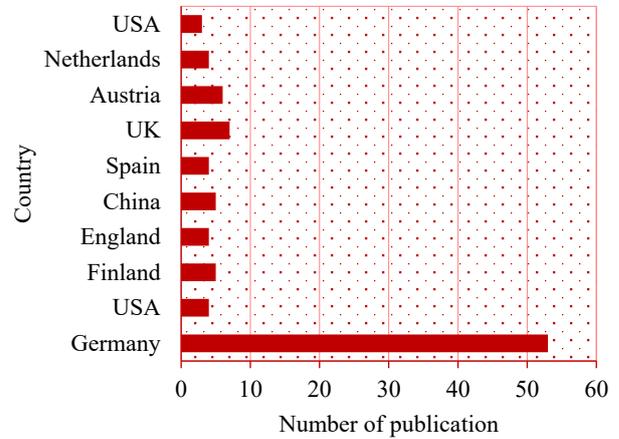


Figure 4. Publication by countries in the field of digital platform technology.

On the other hand, the top four researchers with the highest number of contributions in the included literature are P. Drews (6), B. Otto (3), F. Rashed (3), and S. Hecht (3), as shown in Figure 5. Paul Drews is a Leuphana University of Lüneburg professor and lectures on information systems.

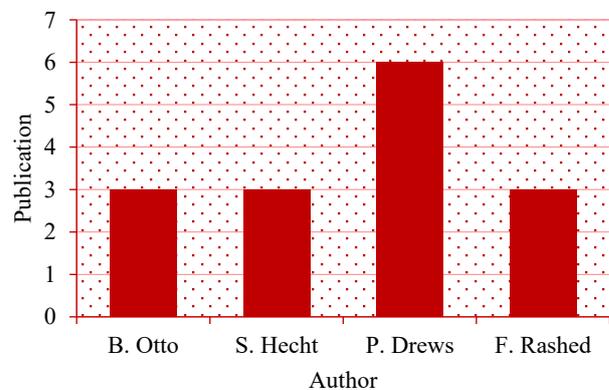


Figure 5. Four main contributors in the field of digital platform technology.

3.2. Analyzing trending keywords in the field of digital platform technology

By analyzing the trending keywords in the field of digital platform technology, the [27] recommendations are adopted. Keywords should be classified by their dominance and persistence. The dominance count represents the frequency of a word in the selected contributions, while the persistence count is a measure of how long a keyword is consistently used over a period of time. The Average dominance count can be derived from the number of times a given keyword appears in literature

(excluding keywords with dominance equal to one). In contrast, the Average persistence count of a keyword is the average of the difference between its persistence and the average persistence of keywords. With the two concepts, four groups of keywords can be identified, as shown in Based on Figure 6, a keyword is a core topic (if it has high persistence and dominance), trendy topic (if it has a low persistence and high dominance), intermediate topic (if it has high persistence and low dominance), and emerging / phantom (if it has a low persistence and low dominance). Based on these criteria, the results of the keyword analysis in this study show that the Average Dominance Count (ADC) is equal to 3.81, while the Average Persistence Count (APC) is equal to 4.60.

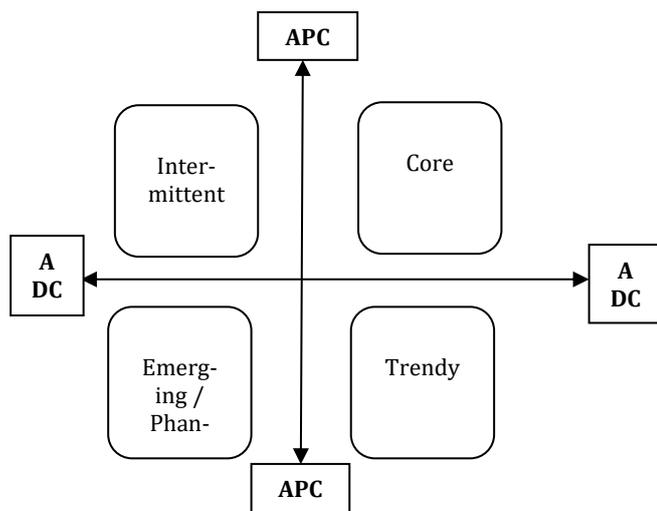


Figure 6. Framework for referencing (Adapted from [27]).

4. Discussion

In this study, the core topics identified from the review of existing studies were just two: business model and data-driven model innovation. The business model is the primary topic because traditional business models are no longer valid in leading sustainable development in the age of the industrial revolution. As such, there is a need to develop novel business models that can perform optimally in the fourth industrial revolution. Therefore, traditional business models must be reconfigured to capture value creation, capture, and delivery [40]. Traditional business models without the elements of value have not performed well and will continue to fail. Hence, it is important that restructuring of the model should be carried out.

Another study concludes that for business models to be relevant in the fourth industrial revolution, they must be based on collaboration, the efficient/effective use of resources, and supply chains must be enabled by cyber-physical technologies [41]. Collaborations are needed to enhance open knowledge, and innovation is the fundamental driving force of industry 4. A firm or organization's possession, absorption, change, and manipulation of knowledge from the operational environment allows firms to be innovative [42]. The primary potential of digital platforms in the fourth industrial revolution is their

ability to reduce production costs, economies of scale, and collaboration amongst firms [21]. The effects of reduced cost, economies of scale and seamless partnership in the fourth industrial revolution are vital in boosting sustainable development efforts. Development cannot be achieved without collaboration amongst the key elements of the national innovation system.

On the other hand, the concept of collaboration in this era also involves collaboration amongst machines and developing a human-machine interaction [43]. This collaboration is guaranteed to lead to sustainable development. Various models emerged in the fourth industrial revolution. In [44], these models are classified as:

- crowdsourcing and open innovation
- mass customization
- product service systems
- internet of things business models

Open innovation models are characterized by their ability to optimize performance with external knowledge while taking advantage of their digital platforms [45]. Mass communication business models use SMART (Specific, Measurable, Attainable, Relevant, and Time-bound) to communicate independently while integrated into production processes [46]. Conversely, product service systems business models are integrated (product and service) models that concentrate on delivering optimal value for both customers and manufacturers [47]. And the internet of things business models is enabled by the internet of things and machine to machine technology [48]. All these models are grounded in the advanced use and adoption of the digital platform models and will power economies in the fourth industrial revolution.

On the other hand, data-driven business models are systems characterized by their use of data (data capturing and generation; transmission of data; processing and storage of data; and the application of data) [49]. This use of data can be grouped into enabling and value creating technologies. Enabling technologies are digital technologies that enable accurate decision making and efficient resource use. Some notable technologies that fall into this category are cyber-physical systems, the internet of things, big data analytics, cloud computing, machine learning, and advanced manufacturing technologies [50]. The concept of cyber-physical systems emanated from the growth of SMART factories. SMART factories are systems that utilize advanced machines to collect and process data with multiple feedback loops [51]. Conversely, the internet of things encompasses a world where machines are integrated into networks (information) where these components can interact as a system [51].

Big data analytics allow organizations to make decisions based on analyzing large volumes of complex data in a complex and fast-paced situation [52]. Meanwhile, cloud computing is an advanced system made-up of on-demand services (independent virtual resources), resource

pooling, quick allocation of resources, measured service, and metric templates [53]. Conversely, machine learning is training machines to develop the capacity to learn and improve algorithm programming and decision-making [54].

4.1. Digital transformation and relevance in the fourth industrial revolution (trendy topic)

Digital transformation takes place in three phases: digitization, digitalization, and transformation (digital) [55]. While digitization involves the process of encoding analog forms of information into digital form, digitalization underscores the ways digital technologies or information technology are used to create positive change in business processes. Digital transformation is a remodeling of an organization's business model and introducing a new business logic to create value [55]. The digital revolution required for business models in the fourth industrial revolution requires a total move of data processing methods from analog to digital. This transformation ensures an advanced process for capturing, processing, and storing data is developed. Factors that affect digital transformation include the focus on customers, proximity of the customer, margin pressure, and the rapid rate of change in business activities [56]. The drivers of digital transformation are commercialization, democratization, and new business logic [57]. Another aspect of this digital revolution is using digital technologies to revolutionize business models. This change is a must for business models to be relevant in the fourth industrial revolution. The primary focus of model restructuring during the fourth industrial revolution was the infusion of the concept of 'value' into existing and newly developed models.

4.2. Digital platform business model innovation

Adopting the digital platform business models by

organizations in the fourth industrial revolution are the key requirement to spur productivity and ensure that firms remain relevant in the ever-competitive environment. A business model encapsulates the ability of a firm to develop, deliver, and grab value [58]. As such, a business model innovation represents a shift in the traditional approach to doing business (where businesses seek to deliver a product or service) to a new form of doing business (focused on providing results-based services). According to [58], the main aim of deploying a business model innovation is to make a shift to selling outcome-based services. One of the benefits of the digital platform business model is its ability to reduce the cost of participation by key players in the economy [59]. According to [60], the platform business model has eight characteristics: value proposition, ability to generate profit, manufacturers, consumers, filtering to aid efficiency in value exchange, a governing system, adaptability, and a network effect.

The value proposition of an organization represents a statement that captures the reason a firm's product or services should be bought by consumers [61]. An organization's value proposition does not only determine how it performs in the market, but it also determines how consumers view the product or service. However, firms that utilize digital business models adopt digital technology to enable digitalization. Still, their performance, competitiveness and growth are determined by their ability to create, propose, and capture value [62]. To capture value, a firm must generate revenue to cover the cost of production, and the cost of sustainable growth and profit, while value creation stands for the ways a firm seeks to develop value in its value chain based on its resources and organizational performance. In Figure 7, a summary of the key components of the digital platform business model is presented.

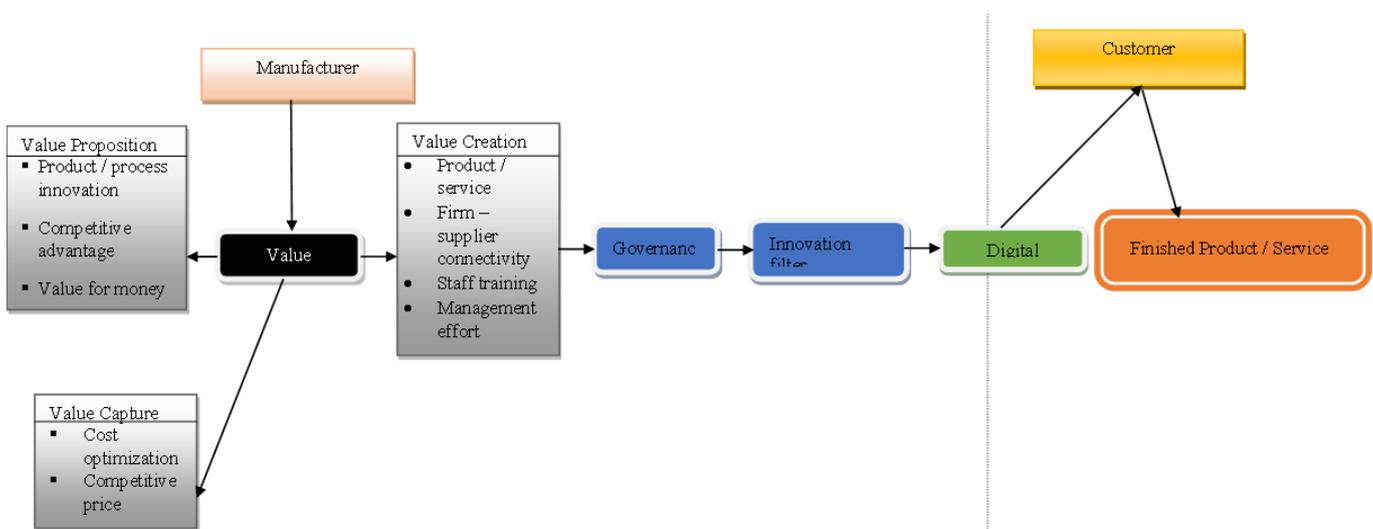


Figure 7. Digital platform business models, structure, and components.

4.3. Digital platform business models, intellectual structure, and components

Digital business models have revolutionized how businesses and services are offered in various sectors of the global economy. In [39], a study on the impact of digital technology on the transportation sector concluded that this technology is already bringing about improvements in this sector and must be embraced by managers not as a support but as a principal component of their business. However, businesses must understand the enabling factors for the use of digital technologies in order to apply the technology properly. These enablers include the organization's leadership style, systems within the organization, corporate strategy, staff, customer integration, and deployed technologies [63]. Authors of this study identified three primary digital business models and their key components. In their research, they identified the multi-side platform (used by McDonald, Rolex, and Stihl), pipeline business (used by McDonald, Rolex, Stihl), and manufacturing platforms (used by Airbus, Boeing, and VW).

The fourth industrial revolution is ushering in a new form of doing business through adopting the digital platform business models. Authors in [40] concluded that this revolution is leading to a trend in businesses adopting a cyber-physical system. These types of businesses use advanced technologies that improve communication and

computation capabilities of organizations. The rise in this type of system gives rise to SMART products and services. As this study focuses on understanding the role of digital platform business models in the fourth industrial revolution, this section will focus on cyber-physical systems and their components. This system has already been successfully used in healthcare, communication, energy generation, governance, and transportation [41–44]. A key component of Cyber-Physical Systems (CPS) is its advanced data management system. For industries to optimize their performance using cyber-physical systems, intelligent data management systems are a prerequisite [41].

On the other hand, studies are argued that to optimize the performance of cyber-physical systems, two key systems are needed monitoring/learning, scheduling/rescheduling, and innovative energy-efficient models [42]. The first system enhances the manufacturing lifecycle by improving system adaptability, while the second system is built to optimize energy consumption. Other important components of the CPS are control systems, security systems (cyber security), validation/verification systems, communication, wireless networks, management systems, and applications [43]. A summation of the key components of cyber-physical systems is presented in Figure 8.

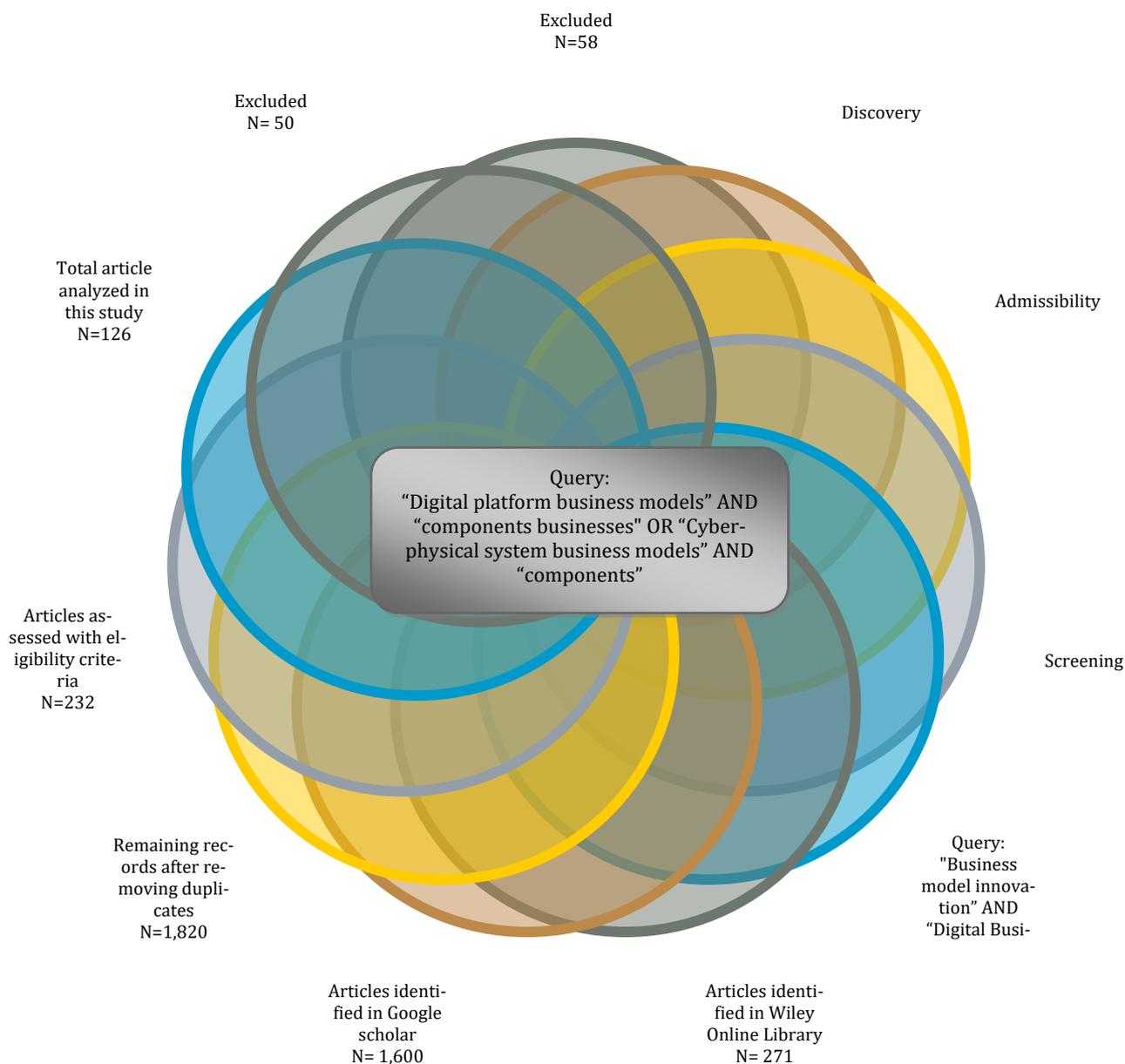


Figure 8. Key components of a cyber-physical system in the context of business models analysis

5. Conclusion and future research direction

This study identified the future research trend in the digital platform business model field by examining keywords from existing literature. The emerging keywords (which determine the future trends) consist of sharing economy, digital innovation, digital platform, General Data Protection Regulation (GDPR), and taxonomy. The concept of the sharing economy has increased as the fourth industrial revolution continues to grow. This concept is responsible for giving rise to businesses such as Airbnb and Uber. Sharing economy can be defined as the co-use of under-

utilized assets with the help of digitalization [64]. According to [65], disruptive technologies like the digital platform business models and servitization are working with the sharing economy to lead to sustainability in the value chain. Sharing economy is an important strategy relevant in the fourth industrial revolution because of its potential to maximize the use of scarce resources, hence its emergence as a phantom / emerging keyword relating to the digital platform business model.

Another emerging keyword relating to the digital platform business model is digital innovation. Digital innovation encompasses an innovation (digital) that creates

positive change in an organization's product or process or business model using digital platform business models [66]. Some of the digital innovations contributing to the growth of the fourth industrial revolution are artificial intelligence, machine learning, 3D printing, collaborative robots, software development, multidirectional communication, integration of information flow into value chain, and the internet of things [67]. The associated digital innovation needed for the fourth industrial revolution to thrive is novel. It seeks to revolutionize value chains as well as maximize the use of resources to increase profit. Every day, new disruptive innovations are being developed because of the need to meet the disruptive innovation needs of the fourth industrial revolution.

Digital platforms are two-sided networks that facilitate interaction between entities such as buyers and suppliers [68]. The emergence of the digital platform as an emerging keyword is not surprising because it remains an essential part of business models in the fourth industrial revolution. One of the core components of the fourth industrial revolution is digital platforms, enabling digitalization and digitization. However, digital platforms can be classified into three broad groups based on their building blocks: platform ownership, autonomy (complementor) and value-creation mechanism [69]. On the other hand, General Data Protection Regulation (GDPR) is also a growing keyword because of data privacy associated with the emergence of big data in improving processes and in machine learning, among other things. The GDPR contains explicit information on which Data Protection Authority regulates an organization [70]. The GDPR is an essential guideline for organizations that process people's information in decision making, gather information on needs within the market, or inform information about their products/competitors. Therefore, the GDPR is essential to protect the use of personal data by organizations to ensure they are used to protect the interest of individuals and guarantee their privacy.

This study set out to answer this broad question by answering four research questions. The methodology employed in this study aims to identify the key components of the digital business model, cyber-physical system, and current/future research trends. Furthermore, a notable highlight of this study is identifying the enabling factors of digitalization, including the organization's leadership style, system, corporate strategy, staff, customer integration, and deployed technologies.

The main limitation of this study arises from the difficulty in gathering quantitative data regarding the subject matter due to a scarcity of data and data privacy laws in many countries. Using quantitative data and case analysis will improve the knowledge of digital business models and provide empirical evidence on how they perform. Furthermore, most of the contributions used in this study emanated from developed countries. It will be interesting to see how digital business model platforms are revolutionizing businesses in the least developed and developing

countries. A competitive analysis of developed and developing countries' technology integration will provide new insight into the technology. Future studies are needed to offer viable outcomes to overcome these limitations. The contributions of this study to the body of knowledge are essential in understanding the role of digital business model platforms in the fourth industrial revolution.

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