

A BIBLIOMETRIC ANALYSIS OF PLATFORM RESEARCH IN E-COMMERCE: PAST, PRESENT, AND FUTURE RESEARCH AGENDA

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Abstract

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An important economic sector influenced by the development of platforms is e-commerce. The most successful companies in e-commerce employ platform business models and strive to provide other companies with application services. Despite growing economic importance and rising research interest, thus far, no attempts were made to structure existing research into platforms in e-commerce. Hence, a quantitative bibliometric analysis of 7,463 platform-related papers in the context of e-commerce was conducted. The papers were published in major conferences, journals, and books from 1993 to 2021. The authors identified a continuous development of platform research in e-commerce, with the continuous development characterized by three major periods of research. Furthermore, four clusters in platform research are outlined, i.e., business models, social commerce, infrastructure, and socio-technical characteristics. These clusters can serve as a foundation for future research. The conducted bibliometric analysis contributes to scientific research by offering an objective and systematic overview of platform research in e-commerce.

Keywords: Platform, E-Commerce, E-Commerce Ecosystem, Virtual Environment, Technology, Blockchain, Machine Learning, Bibliometric Analysis

Authors' individual contribution: Conceptualization — T.W.; Methodology — T.W. and E.K.; Validation — T.W.; Formal Analysis — T.W.; Investigation — E.K.; Resources — T.W.; Data Curation — T.W. and E.K.; Writing — Original Draft — T.W., Writing — Review & Editing — E.K.; Visualization — T.W.; Supervision — T.W. and E.K.; Project Administration — T.W.

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1. INTRODUCTION

Platforms have enriched many industry sectors, for example, accommodation, entertainment, and transportation. The most valuable companies (e.g., Apple, Amazon, and Alibaba) employ platform business models orchestrating multi-sided markets or from the centre of rich innovation ecosystems (Gawer, 2021). These platform companies form

digital business ecosystems with their surrounding participants (e.g., manufacturers, retailers, third-party developers), which serve (end) customers (Adner, 2017; Wulfert & Karger, 2022). In the extant literature, platforms are conceptualized as organizational capabilities, technology sets, two-sided markets, and extendable systems (McIntyre & Srinivasan, 2017).

As an important economic sector, e-commerce boasts an expected global revenue of \$7.4 trillion and

24.5% of total retail sales (Lebow, 2021). The most successful organizations in e-commerce operate platform business models to benefit from the economic effects of two-sided markets (e.g., matching and subsidizing selected participants) and to execute powerful digital platforms with their application services (Pool, 2022; Wulfert & Karger, 2022). In 2020, Amazon, for example, generated more than 60% of its total \$340 billion in revenue (from product and service sales) from commission fees of third-party sellers on its transaction platform (Amazon, 2021). Platforms form the centre of e-commerce ecosystems, which are surrounded by networks of independent participants (Wulfert et al., 2022). These focal platforms (e.g., Amazon Marketplace, and Walmart Marketplace) actively orchestrate ecosystem participants by executing governance rules (Hein et al., 2020). They match supply-side and demand-side participants to enable retail transactions involving additional actors, for example, content providers (Wulfert et al., 2021). The matching service and other necessary application services are provided by digital platforms (Wulfert & Karger, 2022).

In 1993, the first investigations of e-commerce platforms appeared with the ignition of e-commerce business models (Choi et al., 1997). In recent years, however, research experienced rising interest in platforms in general (Liu et al., 2021), and on platforms in e-commerce in particular (Wulfert & Schütte, 2022). The dominant types of platforms in e-commerce research and practice are platform business models (i.e., transaction platforms) and innovation platforms. While transaction platforms orchestrate participants from multiple market sides (Hagiu & Wright, 2015), innovation platforms provide the technological infrastructure for e-commerce (Wulfert & Karger, 2022). A combination of both types (i.e., hybrid platform) can be considered as a third relevant platform type in e-commerce (Gawer, 2021).

Nowadays, research into e-commerce platforms is difficult to oversee and spreads across a variety of different disciplines. This is unfortunate since e-commerce platforms are likely to be of increasing relevance for practitioners and researchers in e-commerce. Thus far, research has only provided a general overview of platform research in the economics and management domain (Liu et al., 2021). However, to the best of the authors' knowledge, no attempts exist to structure the current body of research into e-commerce platforms as a whole. The authors believe that such a broad analysis of existing research can help consolidate and merge existing research endeavors and integrate the different perspectives on that topic. In view of that, the goal is to extend this view by conducting the first interdisciplinary, bibliometric analysis of research into e-commerce platforms as a whole. Against this backdrop, the following research questions are addressed.

RQ1: How has the literature concerning platforms in e-commerce evolved and what is its bibliometric structure?

RQ2: What are the topical clusters within platform research in e-commerce?

RQ3: What are possible future research avenues within the area of platforms in e-commerce?

In total, 7,463 articles and publications that deal with e-commerce platforms were identified and analyzed. Given a large number of sources, the authors chose a bibliometric approach to find answers to the first two research questions. A bibliometric analysis uses a quantitative approach to analyze and summarize large amounts of literature. A literature review, by comparison, is where relatively less literature is analyzed qualitatively (Donthu et al., 2021). To answer the third research question, the conducted bibliometric analysis was complemented by a qualitative analysis of relevant and often-cited literature. Hereby, the goal was to obtain a better and more detailed understanding of the different research streams.

The remainder of this research paper is structured as follows. In Section 2, e-commerce as a research context, in general, is introduced, and platforms as a construct of interest in particular. In Section 3, the authors elicit the scientific approach to the bibliometric analysis. In Section 4, the results from the bibliometric analysis are presented. The authors provide a general overview of the literature corpus analyzed, detail the performance analysis, and describe the focus topics of platforms in e-commerce. In Section 5, the contributions of this article are discussed and a future research agenda for e-commerce platforms is provided. The article is closed with a brief summary of the results and the limitations of the study are outlined in Section 6.

2. THEORETICAL BACKGROUND

In e-commerce, transactions involving information, products, and services are executed using information and communication technology (Nath et al., 1998). E-commerce can be characterized as a form of electronic business in the context of commerce exploiting technologies, such as electronic data interchange and the internet (Choi et al., 1997). Alt (2020) provides an overview of different electronic business types, including platform business models.

An important construct in e-commerce on both infrastructure and business model levels is platforms (Schütte & Wulfert, 2022). Different notions for understanding platforms (e.g., two-sided market, extendable system) and various research areas (e.g., construction or management literature) investigating platforms already exist (McIntyre & Srinivasan, 2017). The technological and economic perspectives (Bughin & van Zeebroeck, 2017) are especially relevant in the context of e-commerce (Hänninen et al., 2018). Abdelkafi et al. (2019) emphasize that transaction platforms (economic perspective), innovation platforms (technological perspective), and hybrid platforms (a combination of both perspectives) are especially relevant to research on e-commerce.

Transaction platforms are virtual loci on which participants can conduct retail transactions (Turban et al., 2017). These transaction platforms match and orchestrate organizations as well as individual participants from various markets and social groups to form a dynamic ecosystem (Gawer, 2021). Transaction platforms benefit from two-sided

market concepts, matching two or more previously independent market sides and generating value from transactions between the participants. Direct and indirect network effects are exploited to further propel the transaction platform (Rochet & Tirole, 2003). Network effects for participants and economies of scale for platform owners are strong drivers for the success of transaction platforms (Briscoe et al., 2006). From a customer point of view, transaction platforms “resemble retail agglomerations” (Hänninen et al., 2018), integrating the range of articles of participating suppliers, retailers, and wholesalers through a single digital channel (Wulfert & Schütte, 2022). Furthermore, transaction platforms can offer participants a variety of retail-related services (Wulfert et al., 2021).

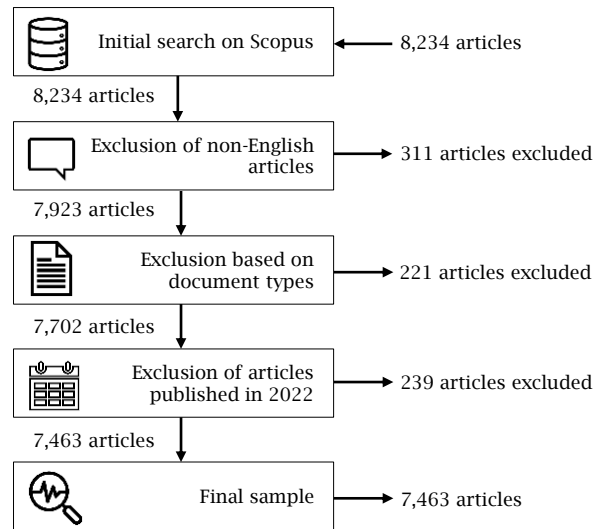
Innovation platforms form the technological infrastructure for e-commerce transactions. Baldwin and Woodard (2009) define an innovation platform as “a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components” (p. 21). Tiwana et al., (2010) emphasize that third-party developers can use these stable components as an “extensible codebase [...] that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate” (p. 675) While the stable components form the core of the innovation platform, the third-party modules resemble the periphery (Staykova & Damsgaard, 2015). The platform core and periphery are evolvable, with only the interface specifications that should remain stable over a longer period of time to avoid necessary module adjustments for the developers (Baldwin & Woodard, 2009). Innovation platforms provide the application services necessary for executing business model-related business routines (Wulfert & Schütte, 2022). Third-party developers implement additional modules (e.g., shop themes, and feature add-ins) and provide them via dedicated extension marketplaces (Wulfert et al., 2022).

3. SCIENTIFIC APPROACH

3.1. Data collection

The first step consisted of collecting data that can be used for bibliometric analysis. Examples of data that can be used for bibliometric studies are, among others, keywords, titles, journals, as well as information about authors and their institutions (Gutiérrez-Salcedo et al., 2017; Moral-Muñoz et al., 2020). For the collection of bibliometric data, several bibliographic databases exist and they all have different characteristics (Moral-Muñoz et al., 2020). Of all available bibliometric databases, the Web of Science (WoS) and Scopus are often considered to be the two largest ones (Forliano et al., 2021). Scopus is used as the database for data collection because it covers a higher number of journals than WoS (Paul & Criado, 2020). Furthermore, Scopus has been chosen by several other bibliometric studies over the past years (e.g., Jagals et al., 2021; Tandon et al., 2021; Karger and Kureljusic, 2022).

Figure 1. Process of data collection



To collect data from Scopus, the following search term was used: (“platform”) AND (“e-commerce” OR “e commerce” OR “electronic commerce”). Title, abstract, and keywords were searched for the occurrence of the search term. Apart from “e-commerce” and “e commerce,” the written-out spelling “electronic commerce” were also used to make sure to cover all relevant research. The search on Scopus led to an initial sample of 8,234 results. After that, the authors conducted several exclusion steps. First, all non-English articles were excluded. This led to the elimination of 311 articles. Next, 221 irrelevant document types were excluded. Furthermore, the authors follow the argumentation of Forliano et al. (2021) and Massaro et al. (2016) and believe that “more recent publications had not had the time to receive an adequate number of citations” (Forliano et al., 2021, p. 3). To improve the comparability of the bibliometric results (Forliano et al., 2021), articles published in 2022 were excluded. After the final exclusion step, a final sample of 7,463 articles remained, which covers a period from 1993 to 2021 (Figure 1). This sample was exported in a CSV (comma-separated values) file for further analysis which is outlined in the next subsection.

3.2. Data analysis

The analysis of the bibliometric data is the next step after the data collection. For the bibliometric analysis of data, researchers have access to and can use a lot of different software, libraries, and tools (Jagals et al., 2021; Moral-Muñoz et al., 2020). The software R was used as the foundation for the analysis. R is a software environment that covers a lot of functionality like visualization capabilities and statistical and mathematical functions (Derviş, 2019). The authors complemented the usage with the bibliometrix library, which can be used for comprehensive systematic mapping analysis (Aria & Cuccurullo, 2017; Moral-Muñoz et al., 2020).

Furthermore, VOSviewer complemented the used toolset and is a tool for the visualization and evaluation of bibliometric data (Khanra et al., 2021a; van Eck & Waltman, 2014). In this study, VOSviewer was used for the analysis of the keyword

co-occurrences (Khanra et al., 2021b). While VOSviewer proved to be highly suitable for creating a visualization of keyword co-occurrences, Biblioshiny has several options for the statistical analysis of the bibliometric data (Jagals et al., 2021). Moreover, both tools allow the importation of data that is exported from Scopus (Moral-Muñoz et al., 2020). Consequently, it was decided to use both tools in a complementary manner. For the derivation of future research avenues, the set of papers was limited and the most cited articles were investigated qualitatively (Tandon et al., 2021). However, to ensure that the derived future research agenda is up to date, only the most cited articles that were published within the last four years were analyzed.

4. FINDINGS

4.1. Main information

The findings from the bibliometric analysis are presented and structured in a general overview of the final literature sample, a performance analysis, and an elaboration on periods of platform research in e-commerce. A summary of different metrics of the final literature sample is provided in Table 2. The final sample consisted of 7,463 scientific publications from 1993 to 2021. The 7,463 publications we identified were published in 2,783 different sources, among which are conference papers, journals, and books. On average, the documents are cited 8.8 times by other publications. In total, the publications from the final sample have 13,017 different authors who have cited 183,484 different references. Furthermore, the final set included a total of 15,403 different keywords.

Table 1. Overview of author, document, and general information

<i>General information</i>	
Timespan	1993–2021
Sources	2,783
Documents	7,463
Average citations per document	8.767
References	183,484
<i>Author and document information</i>	
Different authors	13,017
Author appearances	22,558
Single-authored documents	1,237
Documents per author	0.573
Authors per document	1.74
Co-authors per document	3.02
Collaboration index	1.93
Different keywords	15,403

In total, 22,558 authors appeared in the publications, with only 1,237 single-authored documents, which is equal to 16.58%. In comparison to other bibliometric studies, this value is the lowest. A comparison of recent bibliometric studies is shown in Table 3. The low value could indicate a comparatively high complexity of the subject matter; this makes projects difficult when dealing with single-authored documents and requires larger teams of authors. On average, each author has contributed to 0.537 articles and each article has 1.74 authors. In comparison, the value of 0.537 articles for each author is the second highest among those which were compared. This might also be a hint to the involvement of domain experts authoring a number of articles.

Table 2. Comparison of bibliometric studies

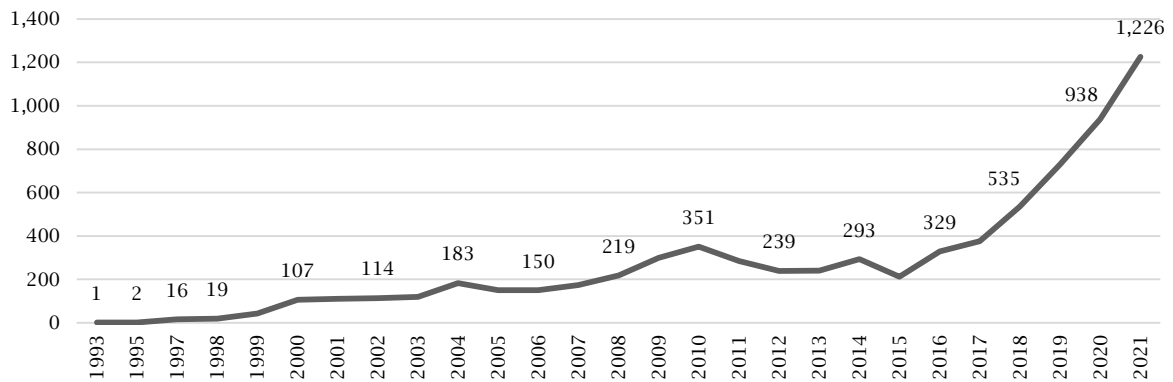
<i>Article</i>	<i>Secinaro et al. (2021a)</i>	<i>Secinaro et al. (2021b)</i>	<i>Uluoyol et al. (2021)</i>	<i>Jagals et al. (2021)</i>	<i>This study</i>
Topic	Data quality for innovation and accounting management	Blockchain in accounting and auditing	Waqf research	Data governance	E-commerce platforms
Documents	159	93	527	780	7,463
Documents per author	0.305	0.443	0.599	0.367	0.537
Collaboration index	3.6	2.83	2.53	3.26	1.93
Single-authored documents	-	29%	50%	22.18%	16.58%
Source dominance	3.46	1.58	2.36	1.59	2.68

For the identification of cooperation and collaboration among researchers, the collaboration index (CI) is applied. The CI is calculated by dividing the total number of authors of multi-authored articles by the total number of multi-authored articles (Elango & Rajendran, 2012; Koseoglu, 2016). The CI of the final sample is 1.93, resembling a relatively low collaboration between researchers. Given the small number of single-authored documents, this value is interesting to observe since it shows that very large author teams, as well as contributions that are written in single authorship, are also rare.

The first research article focusing on platforms in the context of e-commerce was published in 1993 (Klein, 1993). Since 1993, the number of publications concentrating on platforms has steadily increased.

In the year 2000, 107 documents had already been published. The following years have brought publication peaks, with 183 publications in 2004 and 351 in 2010. After 2010, the number of publications decreases, with only 213 documents in 2015. This decline can be explained by the consequences of the global financial crisis and the European debt crisis. These crises resulted in decreased customer spending and decreased research focusing on risk management and the reinvention of e-commerce (Song et al., 2013; Wang, 2013). Since then, the analysis revealed a sharp increase in the number of publications, with 535 in 2018 and as many as 1,226 in 2021. The overview of the number of publications per year on platform research in e-commerce is depicted in Figure 2.

Figure 2. Number of publications per year



In Figure 3, the distribution of publications among different research domains is shown. A publication was assigned to a discipline based on the outlet in which it appeared. For the generation of Figure 3, the data from Scopus were used, which link a journal or a conference to a certain discipline. Since a given source can belong to more than one discipline, the sum of the publications shown in Figure 3 (12,972) is higher than the total number of publications in this article’s final sample (7,463).

If the distribution of research contributions across disciplines is scrutinized, a strong dominance of computer science is found with a total of 5,156 publications, followed by engineering. This is not necessarily surprising, as computer science and engineering are the traditional disciplines that first addressed the topic of platforms from a technical or

socio-technical focus. This also involves the investigation of certain technologies in the context of e-commerce platforms. Examples of those technologies are blockchain (Chen et al., 2018; Ying et al., 2018), machine learning (Gupta et al., 2014), and big data (Xie et al., 2016; Ye et al., 2013). Computer science and engineering as the most dominant disciplines are followed by business and management. While engineering and computer science are mainly concerned with technical topics, business-and-management-related research is mostly concerned with the managerial implications of e-commerce platforms. Other disciplines with a high number of contributions are decision sciences, mathematics, social sciences, and economics.

Figure 3. Number of publications per research domain

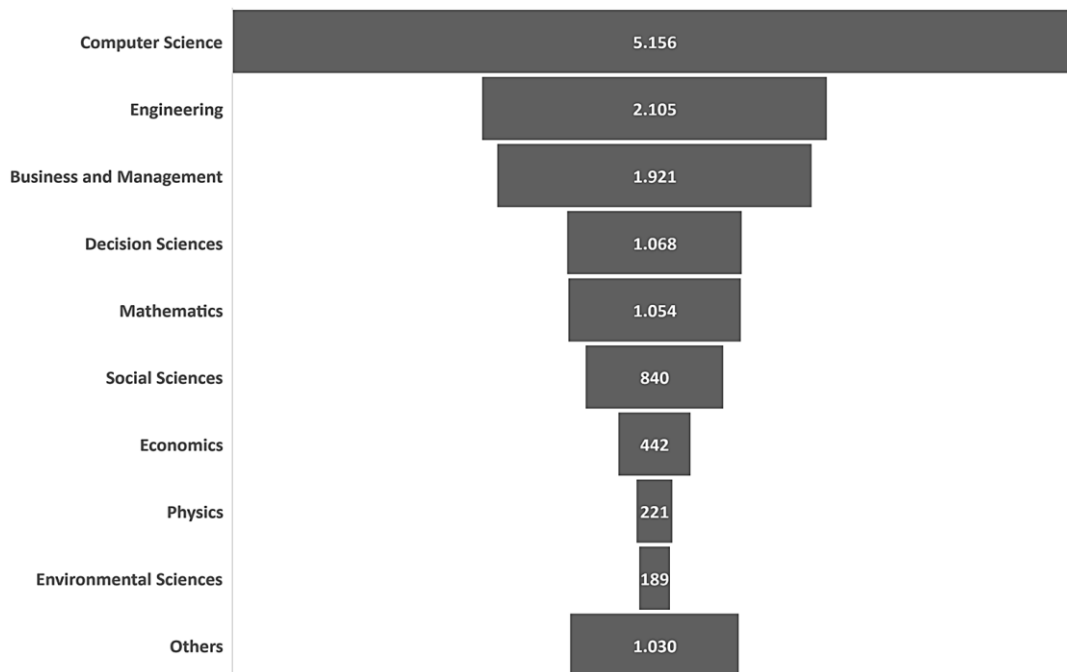


Table 3 shows the distribution of contributions among different types of publications. The majority of research contributions from the final sample were published in conference proceedings (4,613 papers), followed by 2,468 journal articles. The publication in conference proceedings and the discussion at

conferences with usually shorter review cycles compared to journals reflect research progress being made in short cycles in e-commerce. The number of book chapters (156), reviews (134), and books (22) focusing on platform research in the context of e-commerce is significantly smaller.

Table 3. Distribution of contributions among different types of publications

Type	No.
Conference paper	4,613
Journal article	2,468
Book chapter	156
Review	134
Book	22
Others	70

4.2. Performance analysis

Performance analysis is a standard practice in reviews to present the research constituent's performance and can be found in the majority of bibliometric studies (Donthu et al., 2021). Possible units of analysis are, for example, outlets and

sources, institutions, articles, or authors (Jagals et al., 2021; Massaro et al., 2016).

Table 5 and Table 6 give an overview of the most relevant sources, based on the number of published articles. While Table 5 shows the 20 most relevant sources in total, Table 6 shows only the most relevant journals. In Table 5, the authors notice a clear dominance of conferences, which is not surprising in view of the distribution of contribution types shown in Table 4. With a total of 309 articles, the *ACM International Conference Proceedings Series* is the most frequent source in total, closely followed by the *Lecture Notes in Computer Science* with 296 publications. This strong dominance of the first two sources is not surprising, as they publish articles from a variety of different conferences (Association for Computing Machinery, 2022; "Lecture Notes in Computer Science", 2022).

Table 4. Distribution of articles among conference proceedings

Rank	Source	Articles
01	ACM International Conference Proceeding Series	309
02	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	296
03	Proceedings of the International Conference on Electronic Business (ICEB)	132
04	Advances In Intelligent Systems and Computing	122
05	Journal of Physics: Conference Series	85
06	Communications in Computer and Information Science	80
07	Lecture Notes in Business Information Processing	75
08	IFIP Advances in Information and Communication Technology	72
09	Proceedings of the International Conference on E Business and E Government ICEE	69
10	Electronic Commerce Research and Applications	67
11	Applied Mechanics and Materials	66
12	2011 2nd International Conference on Artificial Intelligence, Management Science And Electronic Commerce, AIMSEC 2011 Proceedings	51
13	CEUR Workshop Proceedings	51
14	Sustainability	51
15	Advanced Materials Research	42
16	Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining	41
17	International Conference on Information and Knowledge Management, Proceedings	38
18	Lecture Notes in Electrical Engineering	38
19	Electronic Commerce Research	34
20	Decision Support Systems	32

With a large gap, the *Proceedings of the International Conference on Electronic Business (ICEB)* follows in third place. It is noteworthy that among the 20 most relevant sources, the names of only three journals appear. These are *Electronic Commerce Research and Applications*, *Sustainability*,

and *Electronic Commerce Research*. Likewise, the distribution of disciplines that is depicted in Figure 3 is very well reflected in the outlets, since most conferences and journals belong to engineering and computer science.

Table 5. Distribution of articles among journals

Rank	Source	Articles
01	Electronic Commerce Research and Applications	67
02	Sustainability	51
03	Electronic Commerce Research	34
04	Decision Support Systems	32
05	IEEE Access	30
06	Journal of Retailing and Consumer Services	23
07	Computers & Industrial Engineering	20
08	Information & Management	20
09	International Journal of Production Economics	20
10	Journal of Theoretical and Applied Electronic Commerce Research	19
11	Future Generation Computer Systems	18
12	International Journal of Information Management	17
13	International Journal of Electronic Commerce	16
14	Complexity	15
15	European Journal of Operational Research	15
16	Expert Systems with Applications	15
17	Industrial Management and Data Systems	15
18	Journal of Theoretical and Applied Information Technology	15
19	Management Science	15
20	Boletín Técnico/Technical Bulletin	14

Table 6 shows the 25 most productive affiliations and institutions. This list is strongly dominated by Chinese institutions. Among the 25 affiliations with the most published articles, 21 are located in China and two are from Hong Kong. With the Nanyang Technological University and the National University of Singapore, there are also two affiliations from Singapore within this list.

This is rather surprising since Singapore is only in the 19th place on the list of the most productive countries (see Table 7). The two affiliations from Singapore might indicate that those two universities are the most dominant ones in Singapore in terms of platform and e-commerce research since they are responsible for 73 of Singapore's 96 publications.

Table 6. Overview of the most productive affiliations

<i>Rank</i>	<i>Affiliations</i>	<i>Country</i>	<i>Articles</i>
01	Alibaba Group Holding Limited	China	115
02	Tsinghua University	China	92
03	Zhejiang University	China	89
04	Wuhan University	China	79
05	Chinese Academy of Sciences	China	70
06	Beijing University of Posts and Telecommunications	China	65
07	South China University of Technology	China	48
08	City University of Hong Kong	Hong Kong	47
09	Hong Kong Polytechnic University	Hong Kong	45
10	University of Science and Technology of China	China	45
11	Shanghai Jiao Tong University	China	44
12	Renmin University of China	China	42
13	Shanghai University	China	42
14	Tongji University	China	42
15	Ministry of Education of the People's Republic of China	China	40
16	Harbin Institute of Technology	China	40
17	Huazhong University of Science and Technology	China	39
18	Nanyang Technological University	Singapore	38
19	Xiamen University	China	38
20	Beijing Jiaotong University	China	37
21	Zhejiang Gongshang University	China	37
22	National University of Singapore	Singapore	35
23	Sun Yat-Sen University	China	35
24	School of Management Fudan University	China	35
25	Fudan University	China	35

With 3,092 articles, Chinese authors are responsible for around 41% of the sample's 7,463 articles. The U.S.A. follows in second place with about one-third of the articles. India holds third place with 500 articles. The most productive

European countries are the United Kingdom (321 publications) and Germany (310 articles). An overview of the 20 most productive countries is shown in Table 9.

Table 7. Overview of the most productive countries

<i>Rank</i>	<i>Country</i>	<i>Publications</i>
01	China	3,092
02	United States	1,010
03	India	500
04	United Kingdom	321
05	Germany	310
06	Taiwan	276
07	Australia	201
08	Hong Kong	175
09	Italy	168
10	Canada	163
11	Spain	156
12	South Korea	152
13	Indonesia	134
14	Malaysia	129
15	France	109
16	Greece	103
17	Netherlands	98
18	Japan	97
19	Singapore	96
20	Switzerland	82

The duopoly consisting of China and the U.S.A. is also well reflected in the collaboration map depicted in Figure 4. In this figure, the collaboration between authors from different countries is shown. The thicker the line is between two countries, the more collaboration there is between the authors of those two nations. Furthermore, the total

productivity of a country is shown in grey colors, with a darker grey referring to a higher number of articles. Here it is obvious that the U.S.A. and China as the most productive countries also enter into the most collaborations with authors from other countries.

Figure 4. International collaboration map

Source: Biblioshiny.

4.3. Trending topics and content analysis

Following the performance analysis, the focus is on the keywords applied by the authors of the publications. After providing an overview of the most used keywords in the final sample, three phases of platform research in e-commerce were derived, based on the application of keywords. The first four ranks are occupied by synonyms of the context area, i.e., e-commerce, with a total of 7,810 appearances (i.e., electronic commerce 5,118, e-commerce 1,127, sales 907, commerce 658), followed by Internet (543) and World Wide Web (426).

Social networking appeared 405 times on publication in the final literature sample, which reflects the focus on social commerce in recent years of research (Huang & Benyoucef, 2013; Wang & Zhang, 2012). While marketing (397) is an important activity in e-commerce increasing sales, information systems (395) form the necessary infrastructure for conducting retail transactions. From the perspective of this research, information systems are likely to be composed of innovation platforms as the “core” of e-commerce ecosystems (Blaschke et al., 2019). The 25 most used keywords from the final literature sample are shown in Table 8.

Table 8. The 25 most used keywords

Rank	Keyword	Amount
01	Electronic commerce	5,118
02	E-commerce	1,127
03	Sales	907
04	Commerce	658
05	Internet	543
06	World Wide Web	426
07	Social networking	405
08	Marketing	397
09	Information systems	395
10	E-commerce	376
11	Data mining	349
12	Websites	337
13	Information management	305
14	Web services	295
15	Big data	292
16	Decision making	282
17	Online shopping	278
18	Recommender systems	278
19	Competition	268
20	Artificial Intelligence	263
21	Costs	250
22	Information technology	243
23	Social media	227
24	Mobile commerce	223
25	Supply chains	216

The keyword analysis revealed three phases of platform research in e-commerce. The first phase (Platform 1.0) from 1993 to 2004 consists of 716 publications and is concerned with the emergence of the internet facilitating first electronic business models. The platform’s focus is on the technological foundation for conducting e-commerce. The second phase (Platform 2.0) ranges from 2005 to 2014 and

includes a total of 2,400 publications. This phase is concerned with new business models in e-commerce from a transaction platform perspective and focuses on advanced architectures and services for conducting e-commerce. The second phase also includes first social commerce considerations. The third phase (Platform 3.0) from 2015 to 2021 consists of 4,347 publications. Research in this

The fourth cluster focuses on the socio-technical characteristics of information systems and their architecture in e-commerce. Innovation platforms in e-commerce enable the development and application of third-party extensions to serve a variety of different business models and retailers' requirements (Aulkemeier et al., 2016). The extension development involves developers as additional participants (Salminen & Teixeira, 2013). Due to varying resource demand, cloud applications are especially suitable for e-commerce contexts, enabling flexible resource allocation provided by external providers (Crabb, 2014). Involving a number of cloud providers that have an on-demand recovery function can also avoid service downtimes (Addo et al., 2014). Another research stream is concerned with the investigation and application of different architecture paradigms for e-commerce platforms. Besides research into traditional multi-tier architectures (Chen & Feng, 2016), the focus of architectural research in e-commerce is on service-oriented architectures involving a variety of service providers (Yaddarabullah et al., 2019).

5. DISCUSSION

The analysis of 29 years of platform research in e-commerce resulted in the identification of three phases of research and four topical clusters of research. Based on these four clusters, the authors derived potential streams for future research and formulated concrete research questions worth pursuing. For this analysis, the set of papers was limited to the last four years, and the most cited articles were investigated for future research endeavors. Eight avenues for future research are proposed to advance the body of knowledge on e-commerce platforms. These avenues are summarized together with exemplary research questions in Table 9.

5.1. Business model and transaction costs

The bibliometric cluster pertaining to business models and transaction costs of platform research in e-commerce includes two important streams for future research. The first stream is concerned with the description of e-commerce business models and with the digital transformation of affiliated participants in e-commerce ecosystems. Since participants in e-commerce ecosystems are likely to take on multiple roles (Hawlitschek et al., 2016; Wulfert & Schütte, 2022), future research can investigate the success of different role configurations (e.g., consumer-provider, seller-provider) and their impact on other e-commerce ecosystem participants. Moreover, platform owners' measures for providing transparency with regard to the actions of single participants can be analyzed (Cennamo, 2021). Future research can also examine how cross-channel effects impact the business model choice for ecosystem participants in multi-sided markets. A particular research question to pursue is the impact of the sales channel chosen (e.g., direct sales, platform sales) on product sales (Tian et al., 2018). In this regard, future research can also develop metrics that support the decision for selecting the appropriate platform to affiliate with.

The focal platform of e-commerce ecosystems may induce a certain degree of digital transformation for affiliated participants. Hence,

the focal platforms' impact on the organizational structure and business processes of these ecosystem participants needs to be analyzed (Li et al., 2018). Specific calls were made for longitudinal and international case studies on platform-induced digital transformation in e-commerce (Li et al., 2018). Furthermore, it might also be worthwhile to investigate how platforms wield power over affiliated participants with regard to their specific business models (e.g., multi-channel, omni-channel). Another research question can address specific measures the platform owners implement to wield power over affiliated participants.

5.2. Social commerce

While analyzing the literature on platforms in the context of social commerce, the authors identified two major streams for future research. First, platforms as intermediaries in social commerce cumulate huge volumes of customer-generated content and electronic word of mouth in the form of customer reviews and recommendations. Since the virtual environment makes product testing quite complicated, reviews of previous customers are a major source for product evaluation, trust in transaction partners, and risk aversion. In social commerce, this involves a variety of roles (e.g., customers, and sellers) and different settings (e.g., mobile commerce) (Gibreel et al., 2018; Kong et al., 2020). Hence, future research not only needs to investigate means to increase the motivation for providing product and business partner reviews but also needs to investigate algorithms to evaluate the reliability of the reviews. Another research question worth pursuing would be the investigation of the impact of additional reviewer information (e.g., personality, demographics, financial information, risk perception, emotional state) when analyzing reviews in general and review utility in particular (Tran, 2021). The utility analysis also involves the effect of reviewer rewards on product sales and seller revenues. Furthermore, potential moderating factors for the relationship between extrinsic motivation and intention to contribute to customer reviews should be considered (Wang et al., 2019).

5.3. Technology and infrastructure

New or evolving technologies can have a big impact on and a lot of potential for e-commerce and associated platforms. A technology that is increasingly discussed in research and practice is the blockchain. First proposed in 2008 as the underlying technology for an electronic payment system (Nakamoto, 2008), blockchain is nowadays investigated for a lot of different use cases and industries. An idea that is particularly interesting for e-commerce platforms is the concept of blockchain-based marketplaces. Subramanian (2017) was the first to propose blockchain-based marketplaces, which are supposed to be a counter design of conventional marketplaces with one central controlling instance or company (Karger et al., 2021). Perhaps it might be worthwhile to investigate the potential that blockchain could have as an underlying technology for platforms in e-commerce, or if blockchain-based marketplaces could form a new type of e-commerce platform. Furthermore, recent research believes that blockchain could serve as a technical foundation and

system for data quality improvement and assurance (Karger et al., 2021). Future research might address if and how blockchain could lead to benefits when it comes to the management of data that are generated by, or that are part of, e-commerce platforms.

Another topic of increasing relevance is the analysis of data. The use cases and benefits of analyzing data in the context of e-commerce are manifold. In existing research, different algorithms and technologies are used for the purpose of data analysis. Examples include graph neural networks (Fan et al., 2019) and deep learning (Yang et al., 2020). In previous research, it can be observed that individual algorithms and methods have been used for specific applications or scenarios. According to the authors' understanding, there is a lack of comparative overviews comparing different methods for one use case. There is still little knowledge about the extent to which a particular algorithm or method of analysis is superior to another algorithm or method of analysis for a given use case. Future research should therefore focus to investigate what technology is most suitable for a given use case by comparing different results and algorithms.

5.4. Socio-technical system

Information systems (IS) research as a discipline is concerned with knowledge about the interaction of technological and social systems. Besides technical application services, IS research also includes organizational and human factors (Martinsons & Chong, 1999; Petter et al., 2012). The authors identified two potential streams for future research into e-commerce platforms: technology acceptance and platform configurations.

An important aspect that is often considered within IS research is technology acceptance.

A variety of models were developed to measure how technology is perceived and accepted by its users. Among the most popular ones are different technology acceptance models (TAM) (see, e.g., Venkatesh et al., 2003) and the unified theory of acceptance and use of technology (UTAUT) model (Venkatesh et al., 2016). In the context of e-commerce, there are a few examples of attempts that tried to measure acceptance based on the UTAUT (Chen et al., 2021) or TAM (Yadav & Mahara, 2019). These studies are, however, most often focused on, for example, specific kinds of enterprises (Habeeb et al., 2021) or certain types of products (Yadav & Mahara, 2019). However, to date, research has not yet investigated acceptance for all products, countries, and industries (Cui et al., 2019). Furthermore, as stated, new types of e-commerce platforms might emerge, for example, blockchain-based marketplaces. These new technical designs could also have implications for acceptance, which still need to be addressed by future research.

In the virtual environment, these electronic transactions rely on participant information as electronic signals (Meents & Verhagen, 2018). However, the ways in which the participant's signals impact purchase intention and repurchase intention are still vague in research. E-commerce platforms can standardize and validate participant signals. Those platforms also offer customers a central touchpoint with a unified user interface for a wide assortment even across multiple devices. Beyond standardized user interfaces, future research may investigate how actors can distinguish themselves in standardized and predefined platform environments. Furthermore, the impact of different platform configurations and shop themes on customer experience, satisfaction, and loyalty is worthwhile investigating (Faraoni et al., 2019).

Table 9. Summary of research streams and research questions

<i>Cluster (color)</i>	<i>Research streams</i>	<i>Potential research questions</i>
Business model and transaction costs (Cluster 1)	Description of business models, digital transformation of ecosystem participants	How can the appropriate platform in e-commerce be determined for affiliation? How are e-commerce ecosystem participants transformed, from a longitudinal perspective, when affiliating to a specific platform? What (strategic) measures can platform owners implement to wield power over affiliated participants in e-commerce? What are the future platform-based business models in e-commerce? How can new technologies be exploited to generate value in e-commerce? How can recommendation engines be improved and customized using emerging technologies?
Social commerce (Cluster 2)	Value of customer-generated content, role of virtual influencers on platforms	How can the motivation for creating reviews in e-commerce be increased? What are successful means of reviewer rewards and platform configurations that would lead to accelerated review generation and provisions? How can the utility of customer reviews be increased for ecosystem participants? How can trust be transferred using influencers in social commerce? How can metrics measuring influencers' impact on participants and transactions in social commerce be improved?
Technology and infrastructure (Cluster 3)	Application of blockchain in platforms, advanced data analysis	How could blockchain be used in the context of e-commerce platforms? How can e-commerce platforms be implemented as blockchain-based marketplaces? How can blockchain be used for the management or storage of data in the context of e-commerce? How should a blockchain be designed when it is used in the context of e-commerce platforms? What are implications of accepting cryptocurrencies on e-commerce platforms? What is the best algorithm or technology for analyzing user behavior in e-commerce platforms?
Socio-technical system (Cluster 4)	Technology acceptance, platform configurations	What are efficient user interface configurations for e-commerce? How can participants differentiate themselves on standardized platforms in e-commerce? How can an efficient user interface in e-commerce be designed and evaluated? What is the impact of new technologies on user acceptance in e-commerce? How can the technology acceptance of e-commerce be measured? What are successful platform configurations in terms of customer experience, satisfaction, and loyalty? How can innovation services propel the success of platforms in e-commerce?

6. CONCLUSION

Besides an increase in research interest with 1,226 publications in 2021, continuous development of the research field is depicted, i.e., platforms in e-commerce. The conducted keyword analysis revealed three phases of platform research in e-commerce. While the first phase depicted the technical foundation for conducting electronic business, the second phase is characterized by research into a variety of business models. The third phase is centered around emerging commerce on social media platforms and the exploitation of customer-created content and word of mouth with new technologies. Overall, the keyword co-occurrence analysis showed four clusters of platform research in e-commerce. The first cluster involved publications related to platform business models in e-commerce. The second cluster was concerned with social commerce platforms. The third cluster focused on innovation platforms as the necessary infrastructure for e-commerce. The fourth cluster investigated the socio-technical characteristics of platforms in e-commerce. While the first cluster addressed transaction platforms and the third cluster focused on innovation platforms, the second cluster and the fourth cluster contained research into both platform types. For each cluster, potential research questions for future research were derived.

With this article, the authors make the following contributions. First, this paper aimed to conduct a quantitative bibliometric analysis of research into platforms in e-commerce. The last 29 years of the research field from its first appearance in 1993 involving 7,463 publications were analyzed. Hereby, a structured overview of this research field was given by identifying relevant scientific clusters, the most cited articles, and the most important topics and keywords during different periods. Furthermore, this research aims to establish a first foundation and structure for future

research into e-commerce platforms. Based on an in-depth analysis of recent articles, several interesting research streams and questions for future research were derived.

This study has a few limitations and constraints that must be considered. First, given a large number of identified publications, it was not possible for us to conduct a manual analysis of all articles. Therefore, although it is able to give an overview of platform research in e-commerce, a detailed analysis of this topic and its areas of research cannot be given. Instead, the authors limited the qualitative analysis to a limited number of recent articles to identify future research opportunities. Nevertheless, the presented overview should guide future research in selecting relevant research gaps. Furthermore, the data collection for the bibliometric analysis relied on only one scientific database, namely Scopus. Although Scopus is a widely used database for bibliometric studies and covers a large number of relevant sources, other databases might contain publications and articles that were not covered by this study. Moreover, Scopus only contains scientific sources that are published in, for example, journals, books, and conference proceedings. Other documents like grey literature, patents, and papers published on platforms like arXiv were therefore intentionally not considered in the sample. Since the article's scope was to analyze scientific literature, it is therefore possible that additional types of sources might lead to additional insights.

This article identified two major avenues for future research. First, research might investigate in more detail the areas of interest the authors identified and answer the potential research questions summarized in Table 9. Second, future research can extend the scope of this bibliometric analysis by considering additional scientific databases and more practitioner-oriented grey literature.

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