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Dynamic Pricing in E-commerce: Bibliometric Analysis

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Abstract

The paper is designed to present the development of scientific research into dynamic pricing in the e-commerce industry. Researchers all over the world attempt to investigate the influence of dynamic pricing on revenue and operational costs and propose models to solve operational or strategic problems in different industries, including e-commerce. In order to understand the level of development of dynamic pricing in e-commerce, a bibliometric analysis is performed. The analysis covers 153 papers collected from the Web of Science database. The analysis reveals that while dynamic pricing research is widespread, it is often explored in industries beyond e-commerce. Key industries, including electricity, airlines, home delivery, transportation and hospitality, have also adopted dynamic pricing strategies. The study highlights the growth of interest in dynamic pricing in e-commerce since 2001, with a peak in 2021. The results represent the growing interest among researchers in dynamic pricing in e-commerce in line with the development of e-commerce as an industry. The analysis underscores the ongoing relevance and expanding scope of research in this domain, with many unexplored aspects and challenges in the dynamic pricing strategies employed by e-commerce businesses.

Keywords

Electronic commerce; Web of Science; Citation analysis; Publication metrics; Publication trends.

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1 Introduction

Dynamic pricing is a strategic pricing approach employed by companies to set flexible prices for their products or services to maximize profit. The concept of dynamic pricing has evolved over time, with its most cited definition originating from "American Airlines" in 1992, which described it as a tool for maximizing revenue by "selling a suitable product to a suitable client for a suitable price". Later, this definition was expanded to include the aspect of timing, emphasizing the importance of offering the right product to the right customer at the right time. Nevertheless, dynamic pricing lacks a universally accepted standard definition, reflecting the diverse applications and perspectives within the field.

Researchers have directed their efforts towards understanding and dissecting dynamic pricing from various angles, resulting in distinct classifications. These classifications cover areas of application, research goals and challenges posed by dynamic pricing. The diverse domains of dynamic pricing applications include revenue management, demand management, logistics and customer behaviour. Each of these areas holds its unique set of determinants and challenges, shaping the complex nature of the field.

The significance of dynamic pricing extends into various industries, capturing the attention of academics and practitioners alike. Researchers have pursued diverse research goals in the field of dynamic pricing, classifying their work into four pivot categories: creating models, analysing the impact of dynamic pricing, solving problems using dynamic pricing and addressing the challenges inherent in its application. This multifaceted approach underscores the critical role of dynamic pricing in shaping strategies and decisions across diverse sectors, establishing itself as a central focus for both scholarly exploration and practical implementation in real-world scenarios.

This article seeks to provide a comprehensive bibliometric analysis of dynamic pricing and extends the understanding of prevailing trends in dynamic pricing in e-commerce. By examining the body of research, we aim to shed light on the trends, identify key contributors and influential authors, highlight journals that have been instrumental in shaping the disclosure and spot the research institutions that have played pivotal roles in advancing our understating of dynamic pricing in e-commerce. This article aims to refine valuable insights that can inform future research directions and strategic considerations in practice in the expanding field of e-commerce.

While the extensive bibliometric analysis provides a rich overview of the dynamic pricing landscape in e-commerce and highlights the challenges faced by current research, the paper stresses several areas that require further exploration, namely integration of emerging technologies, consumer behaviour in the era of digitization, globalization and cultural and geographical impact and the intersection of dynamic pricing strategies across industries.

According of the research objective, this paper is structured as follows. Section 2 explores the literature on the topic of dynamic pricing in e-commerce. Section 3 describes the methods applied, data collection and data analysis. Section 4 is dedicated to the results of the bibliometric analysis as descriptive statistics, analysis of document types, publication time, research areas and geographical analysis, keyword and cluster analysis, author productivity and co-author analysis, citation and co-citation analysis. Section 5 is devoted to a discussion of results and future research perspectives, and the last section concludes the paper.

2 Literature Review

Dynamic pricing is a pricing strategy in which companies set flexible prices for their products or services. According to Deksnyte and Lydeka (2012), the most cited definition of dynamic pricing was given by “American Airlines” in 1992, defining dynamic pricing as a tool to maximize revenue “selling a suitable product to a suitable client for a suitable price” (Weatherford & Bodily, 1992); later the words “in suitable time” were added as a part of the definition. However, there is no standard widely accepted definition of

dynamic pricing. One of the reasons is that dynamic pricing studies are focused on different areas of dynamic pricing applications as revenue management (Lieberman, 2016; Bitran & Caldentey, 2022), demand management (Koch & Klein, 2020), logistics (Chen et al., 2019; Raza, 2021), customer behaviour (Borenstein & Shepard, 1998; Victor & Bhaskar 2017; Bandi et al., 2018; Zhao et al., 2021) and as a consequence are restricted to a particular set of determinants. As mentioned earlier, scientists analyse dynamic pricing as a research object from different angles, and thus the studies can be classified by the areas of dynamic pricing application. Researchers attempt to investigate the influence of dynamic pricing on revenue, operational costs or different studies propose models that can be applied to solve operational or strategical problems. One of the most analysed areas is customer behaviour and its incorporation into the dynamic pricing model (Borenstein & Shepard, 1998; Su, 2007; Zhao et al., 2021). Victor and Bhaskar (2017) analysed the impact of dynamic pricing on customer behaviour. Based on data collected by means of an online questionnaire, their findings show that dynamic pricing influences the level of customers' satisfaction and desire to purchase. In addition, their results indicate no difference between genders in terms of response to dynamic pricing. The customers are displeased with the proximity and magnitude of price variation.

Within the framework of customer behaviour, discrimination, fairness and ethics have been examined in relation to dynamic pricing. Sometimes dynamic pricing is considered another version of price discrimination. Dynamic pricing is based on customers' willingness to pay and their preferences; thus, optimized prices can be considered discriminatory prices.

Li and Jain (2015) analysed behaviour-based pricing (price discrimination among consumers based on preferences gained from purchase histories). The behaviour study shows that pricing practices utilizing consumer purchase information can lead to perceptions of unfairness when customers are charged a higher price than others for the same product. The authors investigated the impact of customers' fairness concerns on a company's behaviour-based pricing (BBP) strategy, profits, consumer surplus and social welfare. The study showed that with sufficiently strong fairness concerns, utilization of BBP is more profitable than without customer recognition. At the same time, consumers' fairness concerns lead to lower consumer surplus. Moreover, stronger consumers' fairness concerns improve social welfare.

Another type of classification of dynamic pricing papers is based on their research objectives: (1) creation of models, (2) analysis of the impact of dynamic pricing, (3) problem solving by means of dynamic pricing, and (4) challenges arising from dynamic pricing application.

In terms of modelling, Kastius and Schlosser (2021) applied machine learning training methods such as reinforcement learning to solve pricing models. They analysed the performance of Deep-Q-Networks and Soft Actor Critic (SAC) in different market models as a duopoly and oligopoly competition. The results show that both models are effective, while SAC performs better. Mai et al. (2021) created a dynamic pricing game model on the basis of a long-term gradient adjustment mechanism for a book supply chain that consists of a publisher and an e-tailer. The research focused on the impacts of agency fee rates and adjustment speed on the complexity of the dynamic game. The comparison of the system stability and the average profits for a dynamic decentralized decision and a dynamic centralized decision shows that "a higher agency fee rate makes the dynamic system more stable, and a higher adjustment speed makes the dynamic system become more unstable with exhibiting a period-doubling bifurcation". In addition, under the dynamic decentralized decision, the profits of the publisher and the supplier chain decrease, while the e-tailer's profit increases when the game system loses stability.

Regarding problem-solving by means of dynamic pricing, Sato (2020) attempted to solve a problem with Internet bots' presence in a dynamic pricing scheme. The author proposed a model that "accounts for tentative reservations made by bots and derives an optimal pricing policy so as to maximize the total expected revenue". Numerically, he proved that optimal dynamic pricing policy is robust against the presence of bots; moreover, with higher bot activity, the optimal price has a tendency to decrease in the

first part of the sales interval. Schlosser (2020) proposed different relaxation techniques to solve stochastic dynamic multi-product pricing problems for the sale of perishable goods. These techniques make it possible to reduce the size of critical model components as the state space, the action space and potential sales events. The author verified numerically that proposed heuristics facilitate the reduction of computation time while obtaining close-to-optimal expected profits.

One of the problems of dynamic pricing is strategic customers (who are aware of dynamic pricing and purchase strategically and maximize the expected present value of utility). Bandi et al. (2018) investigated customer behaviour in terms of dynamic pricing and its influence on product returns in e-commerce. The research identified two types of strategic customers: (a) those who monitor prices after purchase and might initiate opportunistic returns due to price decrease, and (b) those who expect a future return and strategically choose a payment method to facilitate returns. The model shows that the price decrease after purchase lead to a higher probability of return; in addition, the expected price decrease leads to a higher probability of using cash on delivery (the payment method associated with lower return costs for the customer). The authors showed that the optimal pricing policy should integrate the potential costs of the two types of strategic customer behaviour.

In terms of companies' data used for dynamic pricing, Bauer and Dietmar (2018) proposed a new method for automated pricing in e-commerce using sparse and fluctuating data, that is one of the biggest challenges in e-commerce applications. The approach was based on Bayesian inference combined with bootstrap-based confidence estimation and kernel regression. The experiments showed that the proposed method leads to a significant increase in revenue. In this paper, we attempt to conduct a bibliometric analysis of dynamic pricing in e-commerce.

3 Methods

Bibliometric analysis has gained growing traction in broader academic research and specifically in the field of economics. Its purpose is to assess the quality, effect and sway of authors, journals and institutions within a particular domain of research (Hassan & Loebbecke, 2017). In addition, performing bibliometric analysis provides a range of other benefits such as identifying trends, fostering collaboration, optimizing publication strategies, benchmarking against peers, supporting decision-making and revealing knowledge gaps. These advantages make bibliometric analysis a valuable tool for researchers, businesses and policymakers in the pursuit of informed, data-driven decision-making and research management.

3.1 Data collection

The data for this study were collected by conducting a literature search utilizing the widely recognized bibliometric database Web of Science (WoS). WoS covers a wide range of scientific documents with a timespan from 1945 to the present. The WoS database has been selected over the Scopus bibliographic database, which is also a worldwide recognized database, due to several advantages such as strong coverage in the fields of science, technology and the social sciences, well-regarded citation index, data quality that influences the integrity of bibliographic analysis and an extended time frame that allows tracking the evolution of interest in the research topic. Researchers often choose the WoS database for various reasons (Yong & Yuanqin, 2019; Yue et al., 2021; Atsiz et al., 2022), including its reputation as a leader among scientific databases with high-rated journals (Mergio et al., 2015; Mavric et al., 2021) and high quality (Hassan et al., 2022). In addition, one database is used to avoid duplicity (Mavric et al., 2021).

A key-based methodology was utilized for the search process. The primary step of the search strategy involves identification of keywords and constructing an appropriate search query. The search query was based on the topic field (TS), which included records within title, abstract and author keywords (keywords that were identified by an author) and Keywords plus (index terms automatically generated from the titles of cited articles).

The search string included terms such as dynamic pricing and e-commerce. Synonyms for e-commerce were used, namely e-business, e-retailer, online market and online shop, as well as derivates from them with the Boolean operator OR to cover all variations of the term e-commerce. The term dynamic pricing was used with the operator NEAR/2 ("dynamic NEAR/2 pricing"), allowing us to find papers where the term "dynamic pricing" is within 2 words of each other, which acknowledges diversity in the term utilization among authors. The Boolean operator AND was used to get the intersection set of papers covering dynamic pricing in e-commerce. The fully constructed query TS=((dynamic NEAR/2 pricing AND (e-commerce* OR e-business* OR e-retailer* OR "online market*" OR "online shop*"))) identified 153 papers.

3.2 Data analysis

The first stage of data analysis within the performed bibliometric analysis is descriptive statistics and trend analysis. The publication trends and annual scientific production, authors' productivity, types of papers, geographical and language spectrum and research areas are analysed. In addition, keyword analysis, co-author analysis, citation and co-citation analysis were performed. The main analysed tool to perform the bibliometric analysis was VOSviewer, software that visualizes and explores node-link maps based on bibliographic data. VOSviewer employs a distance-based approach to visualizing bibliometric networks.

4 Results

4.1 Descriptive statistics of bibliographic analysis

In order to see how narrow the topic of dynamic pricing in e-commerce is, we performed a search of articles covering pricing in general. The search conditions remained the same, namely a search field with the word "pricing" and its derivates, a time period and the WoS database. The search identified 82,557 papers from 1950 up to the present day. Following the same logic, we found 8645 papers dedicated to dynamic pricing (search expression "dynamic NEAR/2 pricing"). According to the WoS database, researchers started to investigate dynamic pricing in 1968.

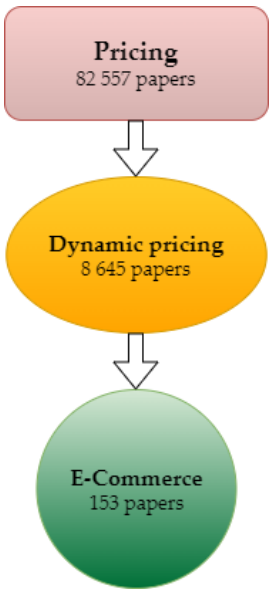

Figure 1. *Pricing topics.*

Despite the relatively short time period, the topic of dynamic pricing is quite popular (8645 articles in the last 22 years), but the majority of studies have focused on industries other than e-commerce. There are

many industries where dynamic pricing is heavily utilized; thus, researchers focus on an industry due to its specifics and influence on the company business model. Several industries have been analysed, most of all in terms of dynamic pricing.

One of the industries that has started to apply dynamic pricing is electricity (Faruqui & Palmer, 2011; Savolainen & Svento, 2012; Chen et al., 2020; Cao et al., 2021; Kang et al., 2021; Dutta & Mitra, 2021). Based on the search in Web of Science Core Collection, there are 1244 articles published from 1985 to 2022 dedicated to dynamic pricing in electricity. Electricity is one of the industries where dynamic pricing has been applied for several decades. The majority of papers belong to authors from the USA (323), China (223), Germany (72), UK (66), India (63) and Italy (62).

Another industry that utilizes dynamic pricing and thus sparks interest among researchers is the airline industry (Fiig et al., 2016; Wittman & Belobaba, 2018; Selcuk & Avsar, 2019; Kummara et al., 2021). Although the airline industry utilizes dynamic pricing heavily, there are only 178 articles published from 1990 to 2022, according to the Web of Science database. The top countries are the same as for the electricity industry except India, with only 3% of publications on dynamic pricing in airlines.

Home delivery services might be considered a separate field due to their specifics and elements of e-commerce (Ulmer, 2017; Prokhorchuk et al., 2019; Strauss et al., 2020). There are 9 articles dedicated to dynamic pricing and home delivery services. Researchers started to investigate the topic in 2009. Most of the countries are European countries. Koch and Klein (2020) reconsidered the problem of demand management through dynamic pricing for attended home delivery services by e-grocers and e-tailers. Their study focused on time window pricing and its influence on customers' bookings. They propose a route-based approximate dynamic programming approach to tackle the challenges such as finding feasible time windows for an incoming customer, estimating the opportunity costs and optimizing the time window prices in real time. Asdemir et al. (2009) examined online groceries and the costs of home delivery operations. The authors developed a Markov decision process-based model to determine the optimal price based on customer choices. Another group of authors (Klein et al., 2008) proposed an approach based on mixed-integer linear programming for online retailers with home delivery business models.

The transportation industry is close to home delivery services, but much broader (Agarwal & Kachroo, 2017; Jin et al., 2020; Guo et al., 2022). Dynamic pricing in transportation has been analysed in 243 articles. One of the first articles according to our search was published by Supernak et al. (2003) and focused on dynamic value pricing and its influence on the utilization of high-occupancy toll lanes. The transportation industry is one of the industries that has started a shift into the e-commerce sphere. There are companies that use e-commerce as their sales channel, but some others have chosen the online environment as their primary focus. For example, Uber is a great example of an online marketplace in transportation. Chen et al. (2015) investigated the utilization of dynamic pricing based on a so-called "surge pricing" algorithm with lack of transparency on supply and demand data. The authors raised concerns about the fairness of pricing algorithms both for customers and drivers. They found that the discrete surge areas that are a main component of the company's pricing algorithm introduce unfairness in the system. In addition, based on their empirical research, the authors raised awareness of the impotence of algorithm audits, which are a vital tool for identifying problematic behaviours by algorithm systems.

The hotel and hospitality industry is another industry that has applied dynamic pricing heavily (Gan & Zhou, 2014; Mohring et al., 2019; Talon-Ballestero et al., 2022). Research into utilization of dynamic pricing in the hotel and hospitality industry started in the early 1990s and 136 articles have been published on this topic. At the same time, rapid growth in the popularity of the online marketplace has provided short-term homestays and experience (AirBnB), meaning that the hospitality industry has received increased interest among researchers. There are 19 articles focused on this particular company that has become a synonym for travel accommodation. Since AirBnB is an online market, it represents a shift of the industry into the

e-commerce sphere. Gibbs et al. (2018) analysed the utilization of dynamic pricing by AirBnB hosts compared to hotels, and surprisingly the usage is limited.

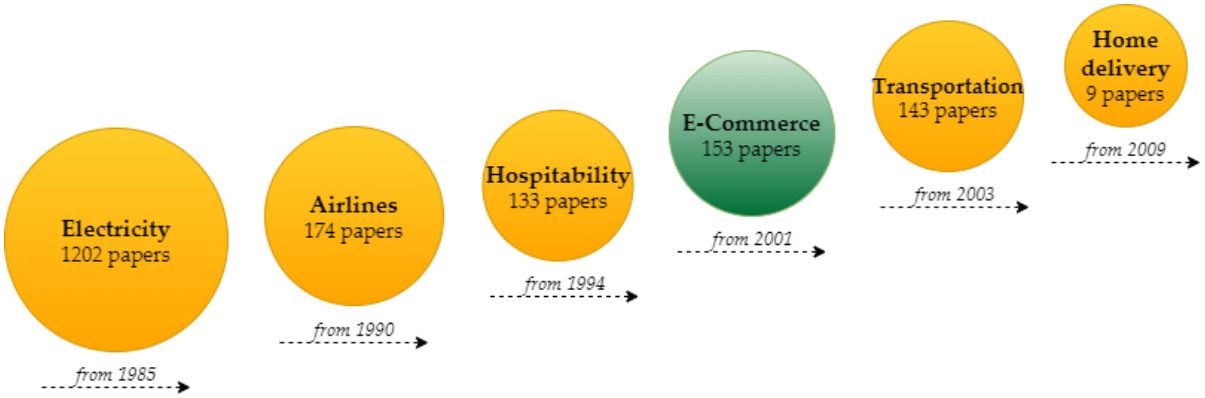

Figure 2. *Industries utilizing dynamic pricing.*

Despite the fact that dynamic pricing in e-commerce is still a quite narrow area by itself, it has started to intersect with other industries as sale channels in many industries have shifted to online sales in the form of e-shops or online marketplaces. Examples include the airline industry, where customers buy tickets and supplement products mostly online, where e-commerce rules apply, or online marketplaces in the tourism and hospitality industry.

The main focus of this paper remains on e-commerce as a distinct industry. We collected 153 documents by applying the search conditions above from Web of Science Core Collection and performed an exploratory bibliometric analysis. Table 1 presents the search conditions and results.

Table 1. *Search conditions of data collection and results.*

Description	**Conditions and results**
Search target database	Web of Science
Search expressions	dynamic NEAR/2 pricing AND (e-commerce* OR e-business* OR e-retailer* OR "online market*" OR "online shop*")
Search field	Topic
Search period	1945–2022
Search results	153 documents
Citing documents	2470 documents
Citing documents without self-citation	2407 documents

4.2 Publication time

The timespan that the Web of Science search engine enquires is from 1945 to 2022. Figure 3 shows the 22-year trend in scientific interest in the investigated topic. Researchers started to investigate dynamic pricing in e-commerce in 2001 during the so-called Internet bubble crisis (dot-com boom or tech bubble), which took place from the late 1990s and peaked in 2000. The enormous usage and adoption of the Internet resulted in a bubble that burst in 2000, leading to bankruptcy of many online companies. Researchers started to demonstrate stronger interest in this topic in 2007 with constant growth resulting in 19 articles in 2022, which is the highest number of articles per year on the topic of dynamic pricing in e-commerce.

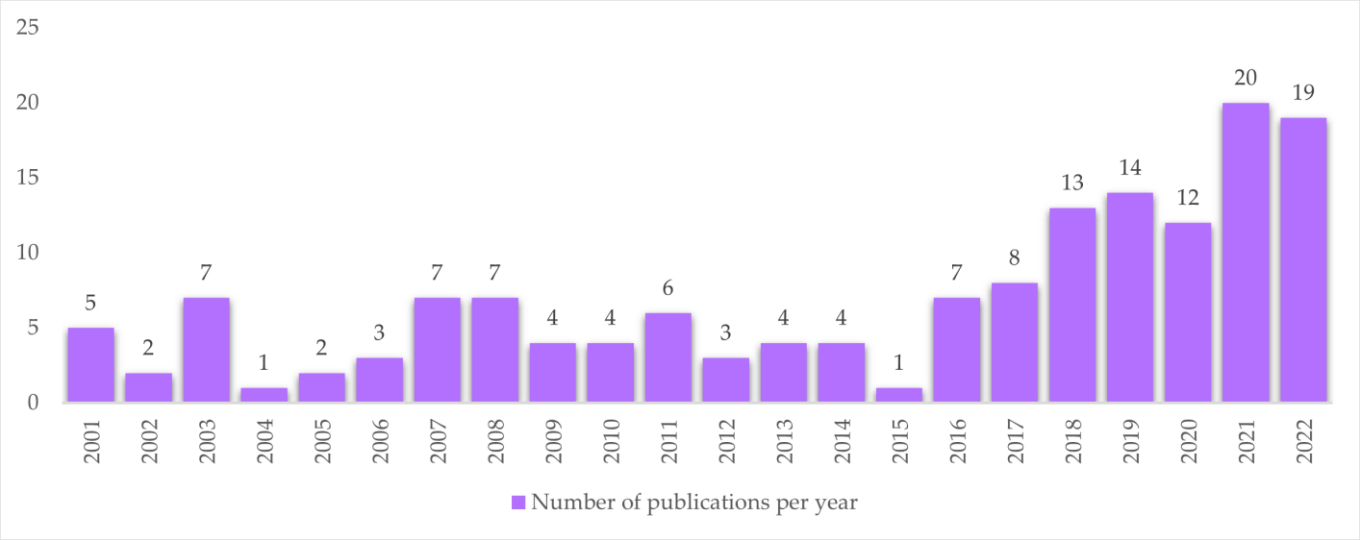

Figure 3. *Dynamic pricing in e-commerce publications over time (2001–2022).*

4.3 Document type

There are 61% of articles (94 articles) and 37% of proceedings papers (57 documents). The rest represents 2% of early access documents (4 papers) and 4 reviews (2%). Some articles are of two document types, namely article and early access article. As the majority of the documents are scientific articles, the sources or publication titles are scientific journals. Table 2 presents the top 15 journals (the criterion being more than 1 article per title).

Table 2. *Top journals by number of published articles.*

Publication title	Impact factor	Documents
European Journal of Operational Research	6.363	5
Journal of Revenue and Pricing Management	1.14	5
Management Science	6.172	5
Journal of Business Research	10.969	4
M Som Manufacturing Service Operations Management	7.103	4
Computers Industrial Engineering	7.18	3
Journal of Industrial and Management Optimization	1.411	3
Kybernetes	2.352	3
Operations Research	3.924	3
Advances in Neural Information Processing Systems	9.71	2
International Journal of Electronic Commerce	7.73	2
International Journal of Production Research	9.018	2
KDD 18 Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery Data Mining	n/a	2
Managerial and Decision Economics	1.379	2
Marketing Science	5.411	2
Transportation Research Part E, Logistics and Transportation Review	10.047	2

The leading publisher for the selected list is Elsevier (17% or 26 documents), the second publisher is Springer Nature (with 15% of the share) and IEEE takes third place with 12%. The average 2021 impact factor among the top 15 publication titles is 5.99. The European Journal of Operational Research, the Journal of Revenue and Pricing Management, and Management Science have published 5 articles each on the topic of dynamic pricing in e-commerce.

4.4 Author productivity and co-author analysis

Table 3 presents the top authors ranked by number of articles. The most productive author is Schlosser with 9 documents published on the topic. The author has focused on analysing efficiency of dynamic pricing models and price optimization. In his papers, he shows that automated data-driven strategies in combination with an efficient dynamic programming optimization approach outperform rule-based strategies. In addition, in some articles he investigates stochastic dynamic pricing models on competitive markets, including dimensions such as price, quality and rating, and its impact on customer behaviour and price reaction strategies (Schlosser et al., 2018; Schlosser & Boissier, 2018; Kaminsky et al., 2021).

Table 3. *Top authors by number of documents.*

Author	Documents
Schlosser, R.	9
Boissier, M.	6
Dasgupta, P.	4
Uflacker, M.	4
Wang, H.	3
Basu, P.	2
Bornstein, M.	2
Chen, Y. J.	2
Choy, K. L.	2
Delina, R.	2
Javanmard, A.	2
Kim, S.	2
Latt, J.	2
Liang, L.	2

Author	Documents
Lindemann, J.	2
Maier, E.	2
Melliar-Smith, P. M.	2
Moser, L. E.	2
Nazerzadeh, H.	2
Podlesny, N.	2
Selke, J.	2
Serth, S.	2
Shang, J.	2
Simchi-Levi, D.	2
Walther, C.	2
Yang, F.	2
Yang, Q. Q.	2
Zhao, L.	2

Analysis of co-authorship can assist researchers in finding potential collaboration opportunities and provide information on the research network. There are 416 authors in the sample, where only 24 authors have 2 or more papers on the analysed topic. As mentioned, the two most productive authors are Schlosser and Boissier. The conducted co-author analysis shows that these authors also lead in cooperation with other researchers. Figure 4 presents the co-author analysis. The authors collaborate within the same cluster of authors in a given period of time. An interesting observation is that the most productive author has cooperated on research with all the clusters through all the analysed time frames.

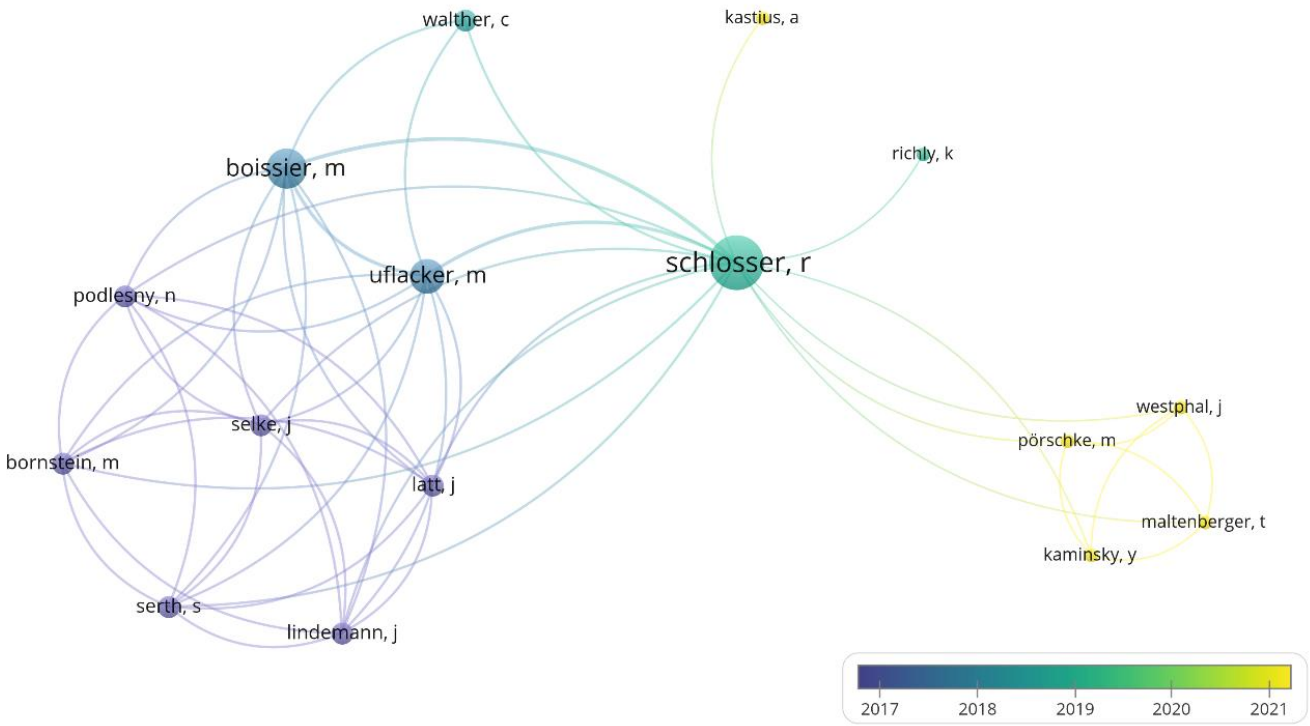

Figure 4. *Co-author network.*

4.5 Research area analysis

The articles on the topic of dynamic pricing in e-commerce have been categorized into various research areas. Specifically, business economics and computer science are identified as research areas for approximately 45% and 44% of the analysed articles, respectively. It stands to be mentioned that an article might belong to multiple research areas simultaneously. The research area of operations research management science covers 28% of the articles, while engineering accounts for 23% of the sample. It is worth noting that only a small fraction, around 5%, of the articles fall within the domain of mathematics research. However, numerous articles utilize mathematical modelling as their primary approach for addressing the problem rather than empirical study. Figure 5 presents the top 5 research areas in terms of dynamic pricing in e-commerce.

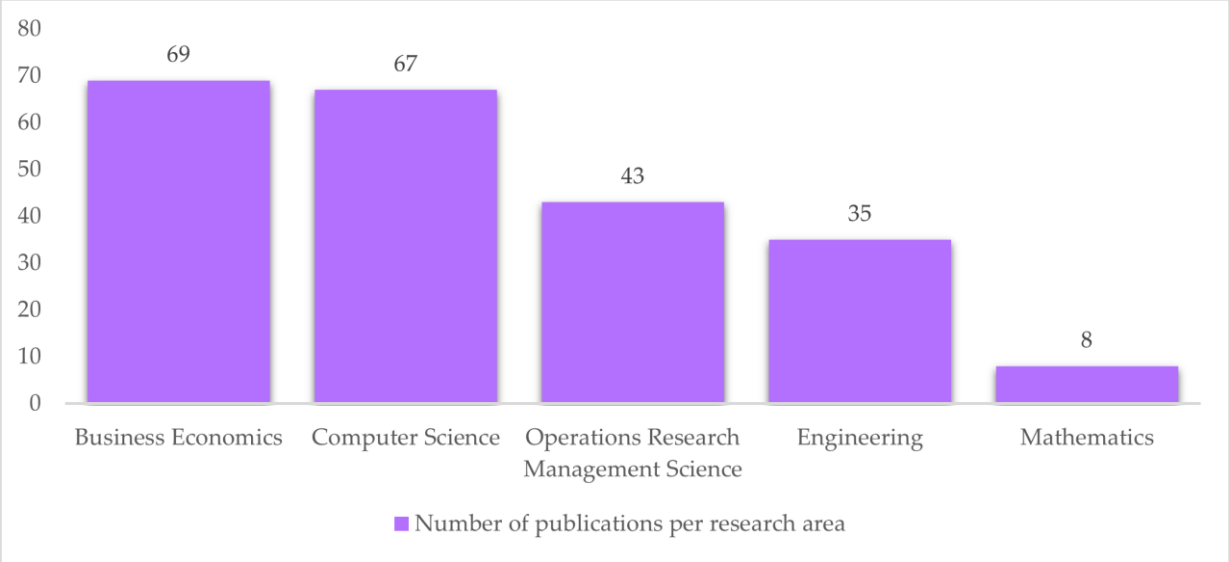

Figure 5. *Top five research areas.*

4.6 Regional analysis

We analysed the geographical spread within the field of dynamic pricing in e-commerce. A substantial number of articles emanated from China or the USA (58%). Germany takes the second place with 25 articles (16%), and 26% of articles belong to countries that produced one or two articles on the investigated topic. This underscores the worldwide significance of dynamic pricing in e-commerce and the predominant roles of two top regions. However, the high number of papers can also be explained by the size of the countries and numbers of universities and research centres. Figure 6 presents a tree map by countries. The analysis indicates potential prospects for global cooperation and cross-country comparative studies.

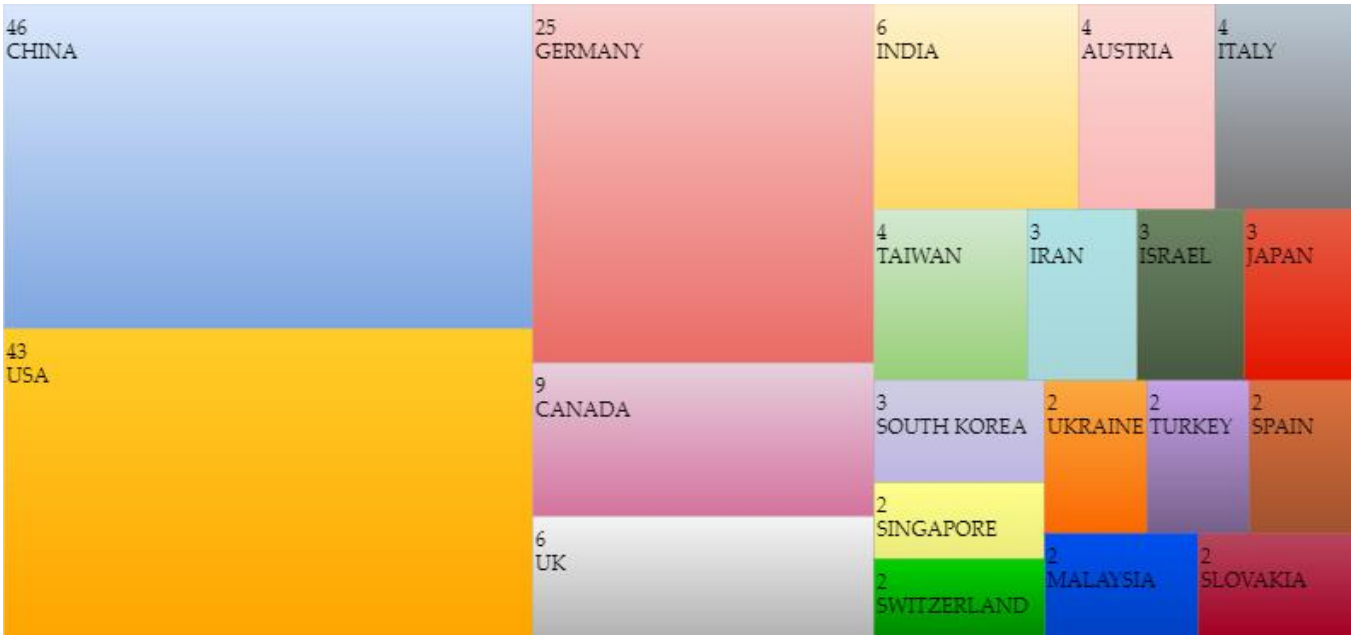

Figure 6. *TreeMap chart by geographical parameter with two articles and more.*

The most common language is English, i.e., 99% of publications, with one article published in Russian (that can be explained by the type of database and sources that are included, as most of the journals have English as the criterion language).

4.7 Keyword and cluster analysis

Keyword analysis is a valuable method to extract meaningful information from academic literature, helping researchers, academics and organizations better understand the content, trends and intellectual structure of a research topic. The analysis shows that the articles have 218 total keywords; the limit was set to 3 keywords as a number of occurrences, which led to 13 keywords that meet the threshold. The "dynamic pricing" keyword has the largest number of occurrences (24), with "e-commerce" having 12 occurrences in the sample. As popular areas of dynamic pricing research, demand and revenue management are also common keywords. As dynamic pricing faces a lot of challenges, one of the common keywords of the research is "uncertainty". Another area of dynamic pricing studies is the analysis of the influence of dynamic pricing models and their determinants. The keyword "impact" represents this trend. Figure 7 shows the results.

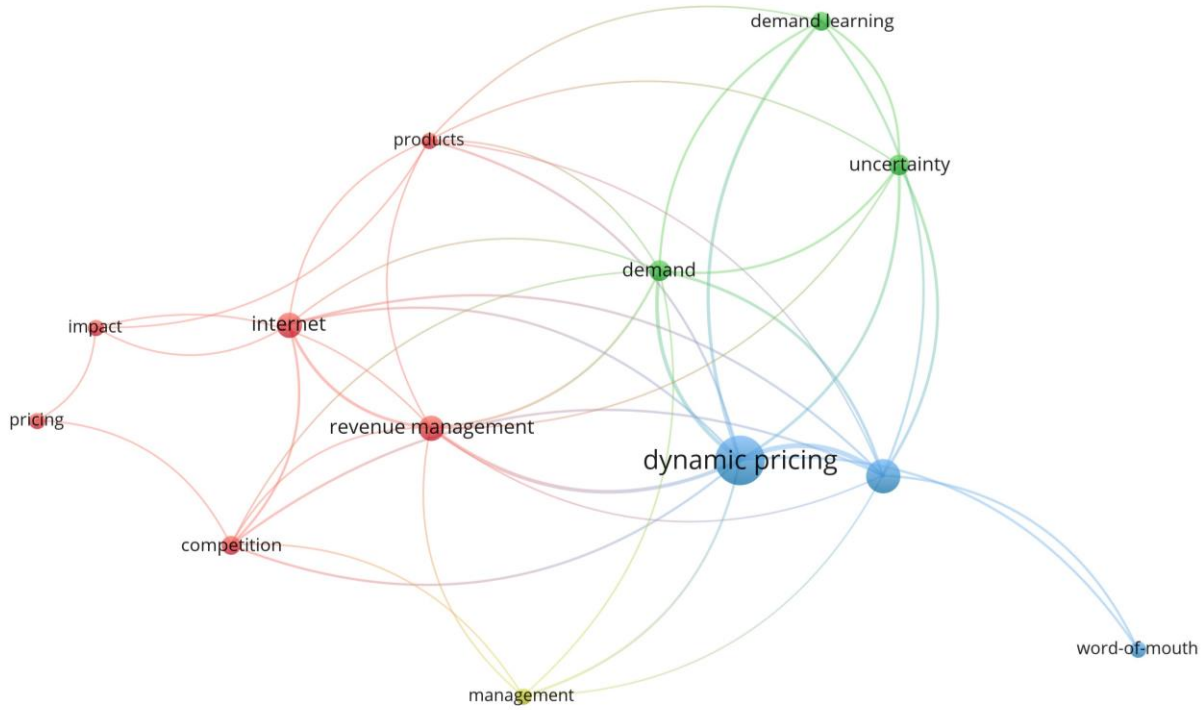

Figure 7. *Keywords analysis network.*

The cluster analysis is another tool in bibliometric analysis that can shed light on the complex and dynamic landscape of the topic of dynamic pricing in e-commerce. Figure 8 shows that the focus of the research topic is moving through time. Papers at the beginning of the research focused on one cluster that covered topics such as information, technique, competitor and pricebot. This can be explained by the time after the Internet bubble crisis and the financial crisis, when the focus was on technical determinants of dynamic pricing, models and techniques. Later the focus of researchers and business shifted to strategy, opportunity, competition and merchants (which represents another cluster). In the same time period (around 2016), the research focused on the business chain and organization types (manufacture, retailer, e-commerce). However, the term e-commerce is a new term. The previous names that characterised this industry or sale channel were e-business, e-seller, etc. The newest trend in the research into dynamic pricing in e-commerce can be represented by a separate cluster with a focus on policy, revenue, parameters, features (of models), revenue and financial performance. However, revenue management is an area of dynamic pricing research that was popular much earlier. The last cluster does not belong fully to any time period but looks at dynamic pricing research from a technical perspective and includes keywords such as system, application, optimality rate and e-business. Research within this cluster tries to find the optimal model and solve implementation problems.

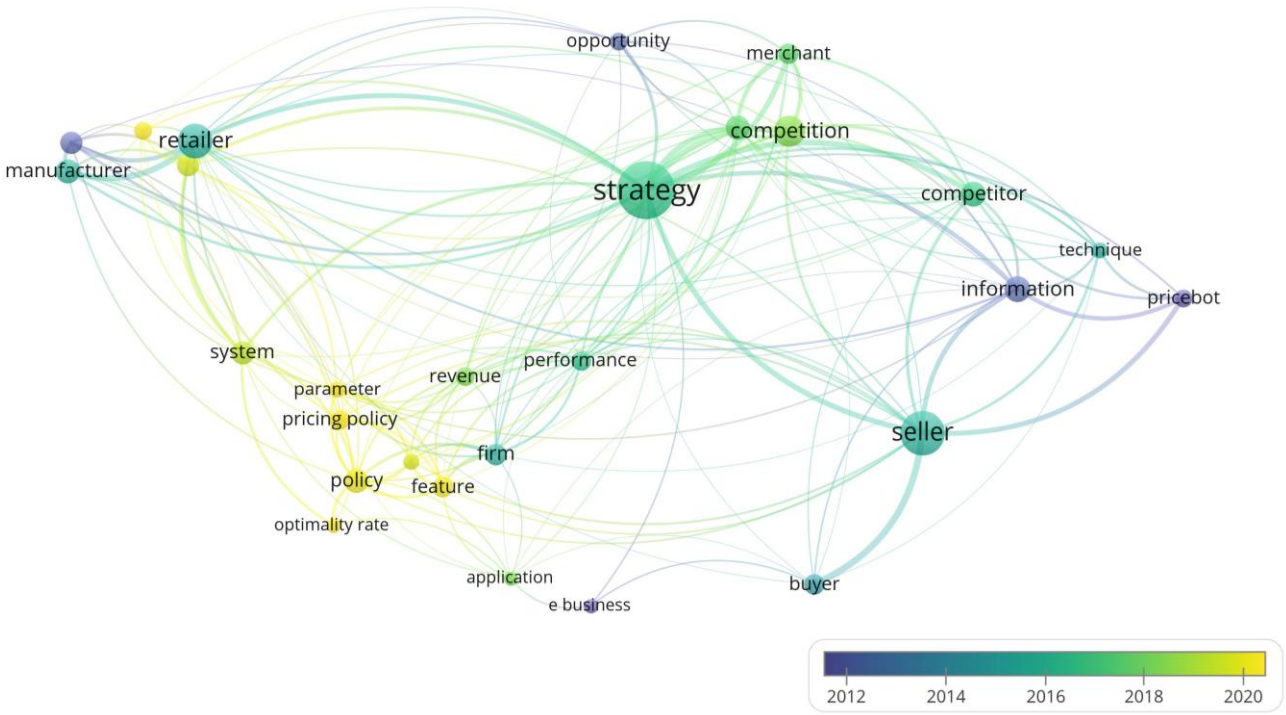

Figure 8. *Cluster analysis network.*

4.8 Citation analysis

Citation analysis is an essential part of bibliographic analysis. The number of citations represents the popularity, significance and beneficial effect of a paper in the field from other researchers' points of view. Figure 9 shows the growing interest in articles on the topic of dynamic pricing in e-commerce. The citation analysis shows high interest and a rapidly growing trend. This trend started in 2016, when researchers started to show a bigger interest in dynamic pricing in e-commerce and other related topics. There was another surge of interest in 2021 and 2022. The total number of citations for the 153 analysed articles is 2470 papers, where 63 articles are self-citations. The research domains of citations lie in several main areas, such as science technology, social sciences and technology. Table 4 shows the 10 most cited articles.

Table 4. *Top 10 cited articles on dynamic pricing in e-commerce.*

Title	Authors	Year	Citations	Paper type
Dynamic Pricing in the Presence of Inventory Considerations: Research Overview, Current Practices, and Future Directions	Elmaghraby, W. & Keskinocak, P.	2003	772	Literature review
Dynamic Pricing on the Internet: Importance and Implications for Consumer Behavior	Kannan, P. K. & Kopalle, P. K.	2001	155	Theoretical
Revenue Management and E-Commerce	Boyd, E. A. & Bilegan, I. C.	2003	112	Mathematical
Innovative Solutions to Increase Last-Mile Delivery Efficiency in B2C E-Commerce: a Literature Review	Mangiaracina, R. et al.	2019	106	Literature review
Price Discrimination in E-Commerce? An Examination Of Dynamic Pricing in Name-Your-Own Price Markets	Hinz, O. et al.	2011	83	Empirical (experiment)
An Empirical Analysis of Algorithmic Pricing on Amazon Marketplace	Chen, L. et al.	2016	73	Empirical

Title	Authors	Year	Citations	Paper type
Technical Note-Dynamic Pricing and Demand Learning with Limited Price Experimentation	Cheung, W. C. et al.	2017	65	Theoretical/ mathematical
Consumer Response to Norm-Breaking Pricing Events in E-Commerce	Garbarino, E. & Maxwell, S.	2010	62	Empirical (experiment)
Dynamic Pricing of Omnichannel Inventories	Harsha, P. et al.	2019	59	Theoretical/ mathematical
Join dynamic Pricing and Order Fulfillment for E-commerce Retailers	Lei, Y. Z. et al.	2018	59	Empirical (experiment)

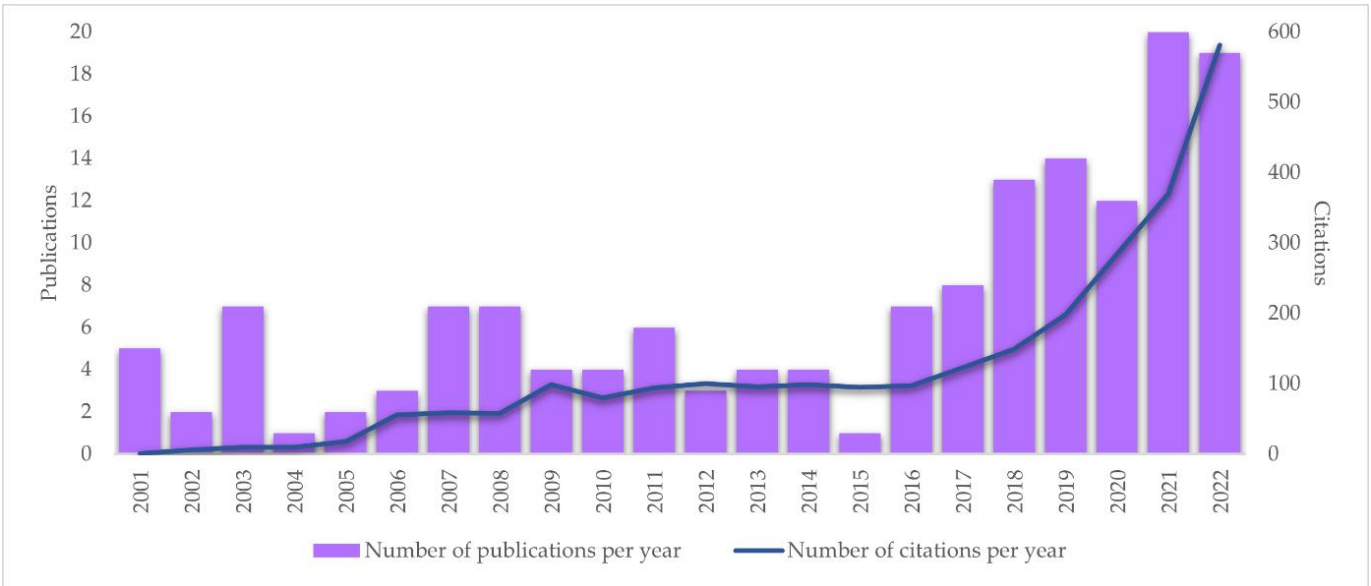

Figure 9. *Publications and their citations from 2001 to 2022.*

The final result of the citation analysis is presented in Figure 10, which shows the network of citations by authors. The minimum number of citations of a document for analysis is 1 (122 documents met the threshold). Elmaghraby and Keskinocak's 2003 article on dynamic pricing and inventory is the most cited paper in the sample (772 citations); however, there are only 18 links within the sample. The trend is natural, as the oldest articles gain a higher number of citations. However, such a stable trend also shows the currency of the topic over more than 20 years. The studies provide knowledge that researchers value and utilize in current research. Another observation of outliers is the fact that the collective of authors Mangiaracina et al. (2019), analysing efficiency of last-mile delivery from a dynamic pricing aspect, is citied most frequently (115 citations in three years); however, the paper is used outside the current research topic.

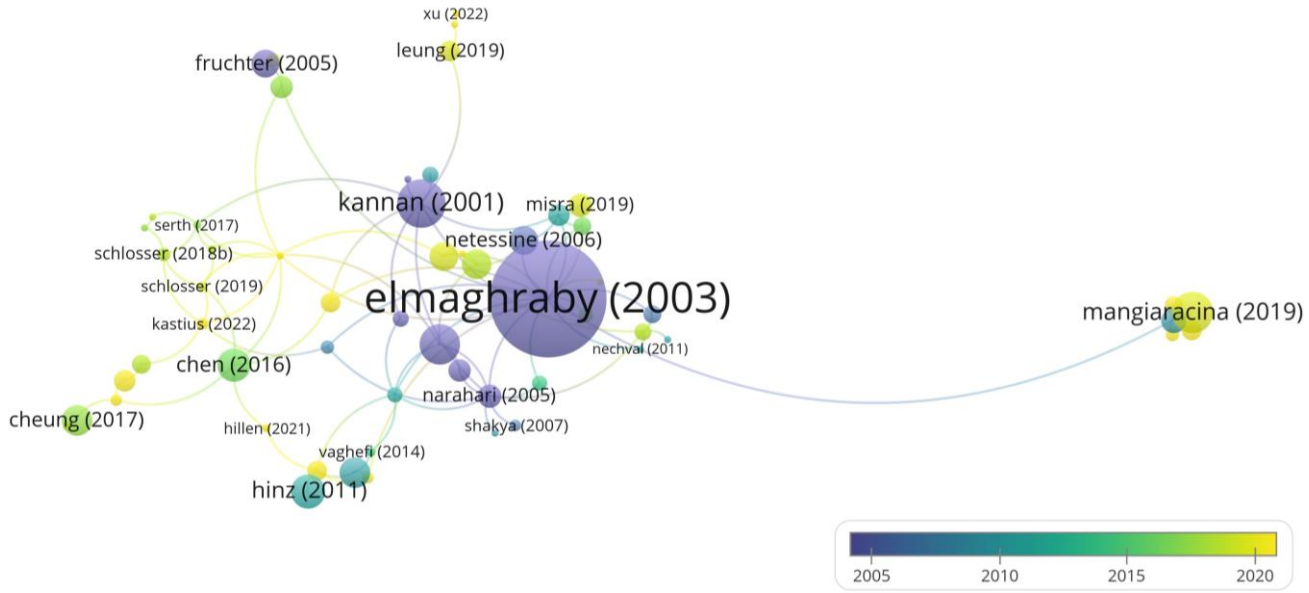

Figure 10. *Citation network by authors by time.*

4.9 Co-citation analysis

Another important element of bibliometric analysis is co-citation analysis. Its goal is to provide researchers with a systematic and quantitative approach to understand the structure and dynamics of the investigated research domain. The research sample covers 3296 authors, the minimum number of citation authors is 10, which identified 29 authors that meet this threshold. Figure 11 shows the co-citation network for selected authors.

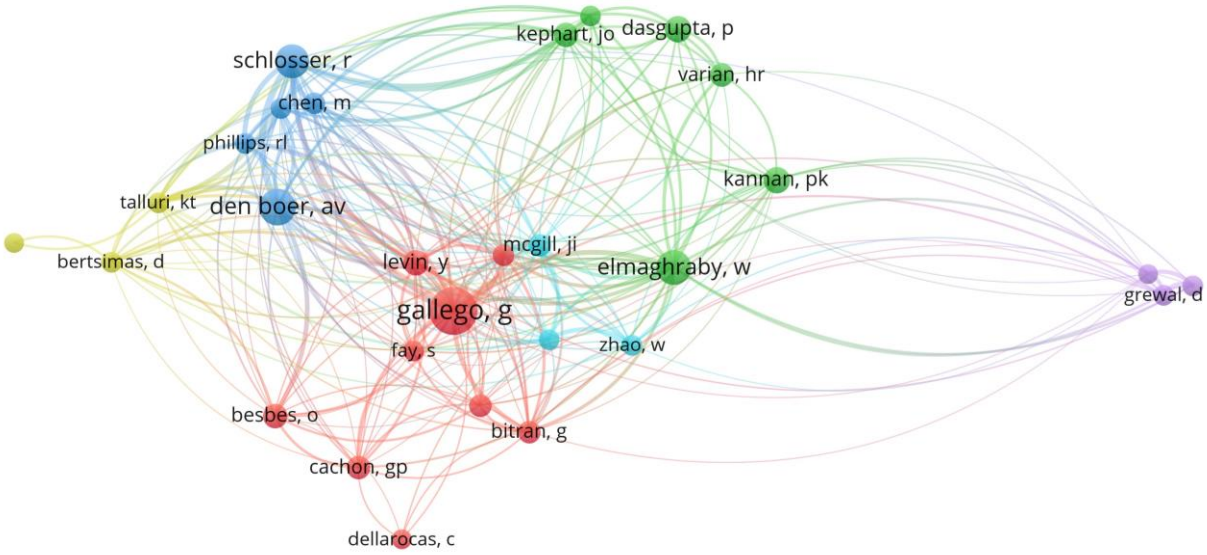

Figure 11. *Co-citation network by authors.*

5 Discussion

This scientific article provides an in-depth analysis of dynamic pricing in the context of e-commerce. It explores various aspects of dynamic pricing, including its definitions, applications, challenges and ethical considerations. The methodology section outlines how the research was conducted, using the Web of Science database to collect relevant articles. The findings are presented in several sections, including descriptive statistics, publication trends, document types, productive authors, co-author analysis, research area, regional, keyword and cluster analysis, citation and co-citation analysis.

One interesting observation is the intersection of dynamic pricing in e-commerce with other industries, such as electricity, airlines, home delivery services, transportation and hospitality. As more industries adopt e-commerce as a sales channel, dynamic pricing strategies that were initially developed for e-commerce are being applied in various sectors. For example, dynamic pricing in the airline industry has become well-established.

The study categorizes the research areas of the articles into business economics, computer science, operations research, engineering and mathematics. This suggests a multidisciplinary approach to studying dynamic pricing in e-commerce. Additionally, there are notable regional differences, with the majority of the articles originating from the United States and China. This might reflect the dominance of these countries in the e-commerce industry; nonetheless, it is noteworthy that these countries also exhibit a substantial volume of research output in other areas.

The keyword analysis highlights the key terms that dominate the literature with “dynamic pricing” and “e-commerce” being central. The presence of keywords such as “demand”, “revenue management” and “impact” indicates the analytical nature of dynamic pricing research. The term “uncertainty” reflects the challenges inherent in dynamic pricing, highlighting a significant focus on addressing uncertainty in pricing strategies. The cluster analysis offers a dynamic perspective on and significant insights into how the research focus has evolved over time. The initial emphasis on technical determinants, models and techniques aligns with the period following the Internet bubble crisis. As the field matured, researchers shifted their attention to strategy, competition and the role of different market participants. Interestingly, the emergence of the term “e-commerce” as a distinct cluster signifies the industry's shift towards online sales channels, coinciding with the rise of online marketplaces.

The article addresses the aspects of fairness and ethical concerns related to dynamic pricing. This is an important facet of research in this field, as companies need to consider the ethical implications of their pricing strategies. Ensuring fairness and transparency in dynamic pricing is crucial to maintain customer trust.

We conduct a citation analysis to measure the impact of dynamic pricing research in e-commerce. The most cited articles are those that provide theoretical frameworks, empirical studies and practical insights. This analysis illustrates the influence of certain papers and authors in the field, which can guide future research. The author co-citation analysis highlights the intellectual influence within the field. Key authors such as Schlosser and Boissier have significantly affected the discourse on dynamic pricing in e-commerce. The network of co-citations suggests a collaborative and interconnected community of researchers. This indicates that scholars are actively engaged in cross-disciplinary discussions and sharing insights to advance the field collectively.

The conducted analysis underlines that dynamic pricing in e-commerce remains an active and evolving area of research. It highlights the need for continued exploration of efficient pricing models, addressing revenue and demand management challenges, and examining issues such as fairness in pricing. There is a high potential for future research focusing on emerging technologies such as artificial intelligence, machine learning or blockchain and their integration into dynamic pricing models. As customer behaviour has been changing in the digital age, future research should be adopted to such changes: how customers’ preferences are evolving due to personalized recommendations, social media influences, online reviews and other factors. Furthermore, future research might investigate the impact of globalization on dynamic pricing and, at the same time, the role of regional and cultural variations on pricing strategies, explore how dynamic pricing models adapt to diverse consumer behaviour and possible regulatory limitations. In addition, exploring the transferability of pricing models between industries could provide valuable insights to better understand cross-industry dynamics.

In conclusion, analysis of dynamic pricing in e-commerce is a complex and multifaceted research area that continues to evolve alongside changes in technology, consumer behaviour and industry dynamics. This study sheds light on the current state of research in this field and underscores the importance of ongoing exploration and ethical considerations in dynamic pricing strategies.

6 Conclusion

The comprehensive bibliographic analysis highlighted the dynamic and evolving landscape of research in the field of dynamic pricing in e-commerce. The study showcases several key findings and insights. The analysis identified that there is a rapid growth in the topic of dynamic pricing in e-commerce. Moreover, many industries have started to shift their sales online; thus, new business models and pricing strategies include elements and specifics of the e-commerce industry. Scientific papers have attempted to create an efficient dynamic pricing model, solve existing problems in revenue and demand management, analyse impacts of dynamic pricing or even investigate challenges caused by dynamic pricing itself, for example, fairness issues. There are 153 articles focused on dynamic pricing in e-commerce according to the scientific database Web of Science. The results show that the majority of the articles are theoretical mathematical models. In terms of geographical criteria, most of the papers originate from the USA and China, a few papers are focused on East European countries. The main research areas of the analysed articles are business economics and computer science. A citation analysis was conducted, showing rapidly growing interest in the investigated topic. The most cited articles have continuously been cited over time in scientific areas such as science technology, social sciences and technology. Throughout the analysis, ethical concerns related to dynamic pricing, such as fairness and transparency, emerged as significant areas of interest. Ensuring ethical pricing practices was recognized as vital for maintaining customer trust. The analysis affirms that dynamic pricing in e-commerce is a dynamic and evolving research domain with a wide array of topics and applications. As the e-commerce industry continues to evolve, so too does the research that seeks to optimize pricing strategies, address challenges and uphold ethical principles in this dynamic landscape. Researchers in this field are well-positioned to contribute valuable insights to both academia and industry, shaping the future of pricing strategies in e-commerce.

The study highlights the intersection of dynamic pricing strategies between e-commerce and other industries, such as electricity, airlines, home delivery, transportation and hospitality. This observation suggests that dynamic pricing strategies originally developed in other industries are finding applications in e-commerce, and at the same time other industries start to apply dynamic pricing approaches adopted from e-commerce. This cross-industry applicability is a noteworthy finding that can help identify future research and business strategies. In addition, the study discovered the multifaced nature of dynamic pricing and provides opportunities for researchers from diverse backgrounds such as business economics, computer science, operations research, engineering and mathematics to contribute to the field. Furthermore, the citation analysis showed a growing interest in dynamic pricing research, with a notable increase in citations starting around 2016. This indicates that the research in this field is gaining recognition and influence within the academic community. The ethical aspect of dynamic pricing is emphasized. The recognition of the importance of ethical considerations in the dynamic pricing, such as fairness and transparency, is critical for maintaining customer trust and ensuring sustainable business practices.

The network of co-citations suggests a collaborative and interconnected community of researchers. This indicates that scholars are actively engaged in cross-disciplinary discussions and sharing insights to advance the field collectively. The enduring interest, as indicated by the citation trends, highlights the relevance of the topic and expanding scope of research in the field of dynamic pricing in e-commerce. There is a need for further exploration of the efficiency of pricing models, addressing revenue and demand challenges, and examining issues related to fairness in pricing. Thus, the future research in this area will continue to provide valuable insights and solutions to emerging challenges.

In conclusion, dynamic pricing in e-commerce is a vibrant and multifaceted field that has shown substantial growth and interest over the years. Researchers, academics and industry professionals should continue to advance our understanding of dynamic pricing to navigate the evolving e-commerce landscape effectively.

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