A Bibliometric Analysis on Inventory Management: on a Time Horizon 2000-2022

Germán Herrera Vidal and Camilo Molina Guerrero
Escuela de Ingeniería Industrial
Universidad del Sinú
Cartagena – Colombia.
Grupo de Investigación DeArtica.
gherrerav@unisinucartagena.edu.co, camilo.molina@unisinu.edu.co

Abstract

Inventory management is an important process in which companies plan, organize and control the goods produced, based on techniques and tools such as demand analysis and production planning and control. This article presents a bibliometric analysis based on inventory management. The proposed methodology is based on the information obtained from Scopus databases, raises and provides answers to six (6) questions, through a descriptive, thematic, collaborative and interrelated analysis, using computer supports such as VosViewers and Bibliometrix - Biblioshiny. The findings identified a positive trend in the volume of annual publications, highlighting the interest of the scientific and academic community in this area of knowledge. The results also allowed the identification of relevant topics grouped by cluster and the future research perspective, oriented to the solution of problems framed in modeling, stochastic process analysis, application of metaheristical algorithms and product design.

Keywords
Management, Inventory, Bibliometric.

1. Introduction
Inventory management is a critical process in manufacturing companies. It consists of the planning, organization and control of tangible products, involving storage, material handling, follow-up and control actions. The main objective is to maximize the value of the company, satisfy demand and minimize storage costs. In the manufacturing industry, companies particularly have inventories, from the arrival of raw materials, during the production process and in the output of finished goods, therefore an inadequate management can lead to failure (Longenecker, J. et al. 2010). According to Osorio, C. (2013), inventories also arise from the gap between consumer demand and the production or supply of these products. Inventory management is a process of vital importance in the operationalization of any company; it involves activities related to the planning, control and efficient and effective storage of goods, with the objective of generating adequate levels of customer service to (Vidal, G. et al. 2019). According to Vidal, G. H. et al. (2019) are activities of transcendental importance for the fulfillment of the objectives of a company, especially in the manufacturing industry. Allowing not to have risks of having excess or missing units (Osorio C. 2013). On the other hand, Valencia, M. et al. (2015) establishes that good inventory management provides security with respect to fluctuations in demand.

For the analysis of the topic "Inventory management", bibliometric studies are used to obtain measurable results from scientific production (Tague-Sutcliffe J. 1992). According to Sancho, R. (1990), they provide an orientation based on advances and approaches. Taking information included in the documents, specifically in titles, abstracts, context and sources, considering elements such as authors, words, affiliations, journals, countries and indicators such as citations, citations and impact factors of publications. The essence of the study should be based on statistical techniques, which lead to a panoramic view of the main trends and the scope of a set of documents (Broadus R. 1987), as well as the analysis of collaborative relationships (Donthu N. et al. 2021) and the evolution of research (Valtakoski A. 2019).

In this regard, Ye, Y. & Ge, Y. (2018) developed a bibliometric analysis of inventory management research based on knowledge mapping. In a time horizon from 1986 to 2017 by exploring Web of Science (WOS) database and applying CiteSpace and VOSviewer computational tools. More recently, Lumban, F. et al. (2022), worked from the Scopus database an analysis focused on inventory control under the machine learning approach. The bibliometric analysis takes some aspects of the analysis, namely: the number of annual publications in the journal, the largest number of

journals in publication, collaboration between authors and network analysis between keywords. Contemporaneously, Hupalo, L. (2022) developed an analysis taking into account publications in the Scientific Periodicals Electronic Library (SPELL), with a time frame from 2016 to 2020, finding that there are few scientific publications published related to the subject matter, in view of the relevance of good inventory management in relation to the performance of organizations.

This is a favorable scenario for the development of this research, using the Scopus database. The article is organized as follows: Section 2 presents the proposed research methodology, based on research parameters and analysis methodology. Section 3 presents the results of the bibliometric analysis which contains descriptive, thematic, collaborative and interrelated aspects. Finally, section 4 presents the conclusions which include an abstraction of the relevant findings of the research on the thematic axis of inventory management.

1.1 Objectives
The main objective of this study is to provide an overview of inventory management in manufacturing companies and supply chains. A bibliometric analysis has been developed to identify productions, contributions and interrelationships between the different types of elements associated with the documents and extracted from the Scopus database.

2. Methods
The research is based on some guiding questions that have been defined according to the type of basic analysis in a bibliometric study:

- Question 1 (Q1): How has the annual scientific production been;
- Question 2 (Q2): What are the main citation networks;
- Question 3 (Q3): What are the main citation networks?
- Question 4 (Q4): What has the co-occurrence network been like?
- Question 5 (Q5): What are the main co-authorship networks?
- Question 6 (Q6): What is the relationship between bibliometric elements?

Given the above, the thematic axis is investigated using the Scopus database, since it provides a broad spectrum of scientific knowledge (Echchakoui S. 2020), facilitates greater volumes in citations, articles and summaries (Van Nunen K. 2018), has a diversity of research in different disciplines (Gavel Y. and Iselid, L. 2008) and is considered the most important in the world (Zhu J. and y Liu W. 2020). A filter is performed with an annual horizon between 2000 and 2022. The route used is "Inventory Management", with search field "Title" and document type "Scientific and review articles". These criteria yielded 959 documents in Scopus. The research parameters are listed in Table 1.

Table 1. Research parameters

Database	Scopus
Time horizon	2000 - 2022
Search date	December 2022
Search field	Title
Type of document	Scientific and Review Articles
Research term	Inventory Management
Result	959

The methodology provides six (6) types of analysis, (i) Descriptive, which extracts data from the bibliographic literature and performs an analysis that contributes to identify documents with the highest number of publication per year, citations and co-citations, revealing the trend of the investigated discipline in criteria such as production, sources, authors, countries and references; providing answers to questions Q1; Q2 and Q3. (ii) Thematic, focused on determining co-occurrence in relation to words, providing an answer to question Q4. (iii) Collaborative, an analysis of co-authorship, focused on elements such as authors, organization and countries, providing an answer to question Q5. (iv) Interrelated, allowing an analysis based on the relationship between relevant criteria such as authors, sources and keywords, providing an answer to question Q6. Figure 1 shows the proposed methodology, which contains different types of analysis, methods and tools, and provides answers to the questions posed above.
(i) VosViewers, a program developed for the creation of clusters and network formations (Van Eck N. and Waltman L. 2009), allows the creation, visualization and exploration of bibliometric maps (Cardona G. and Sanz J. 2015),

focusing on graphs that facilitate interpretation (Dae-Hyun J. 2016). (ii) Bibliometrix - Biblioshiny, developed by Aria, M. and Cuccurullo, C. (2017), being Biblioshiny, the web-based graphical interface of Bibliometrix, remarkable for the wide variety of analyses (Moral J. et al. 2020).
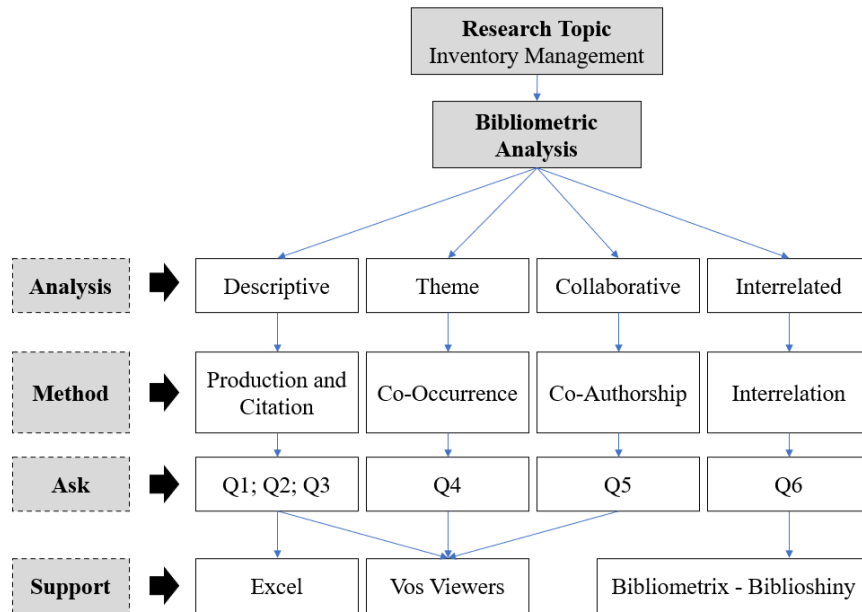
Figure 1. Methodology proposal

3. Results and Discussion

According to the established method, the analysis of the results contemplates the following aspects (i) Descriptive, (ii) Thematic, (iii) Collaborative and (iv) Interrelated, through the application of different methods and support tools.

3.1 Descriptive Analysis

This section relates bibliometric elements such as scientific production, citations and citations. From the review of the development of the literature in a time horizon, which allows the identification of authors, institutions, journals, countries and references. Using computer supports such as: Excel and VOSviewer. The production of scientific articles published in the Scopus database associated with the subject "Inventory Management", between 2000 and 2022, relates a total of 796 documents. Figure 2 shows a growth trend, it is worth noting that during the first decade (2000 to 2010) 209 papers were published, representing 26.26% of the publications, being this a less productive period; unlike the

last twelve (12) years which reflects 73.74% represented in 587 papers, evidencing a period of higher production. The trend line clearly highlights the interest of the scientific and academic community in this area of knowledge.
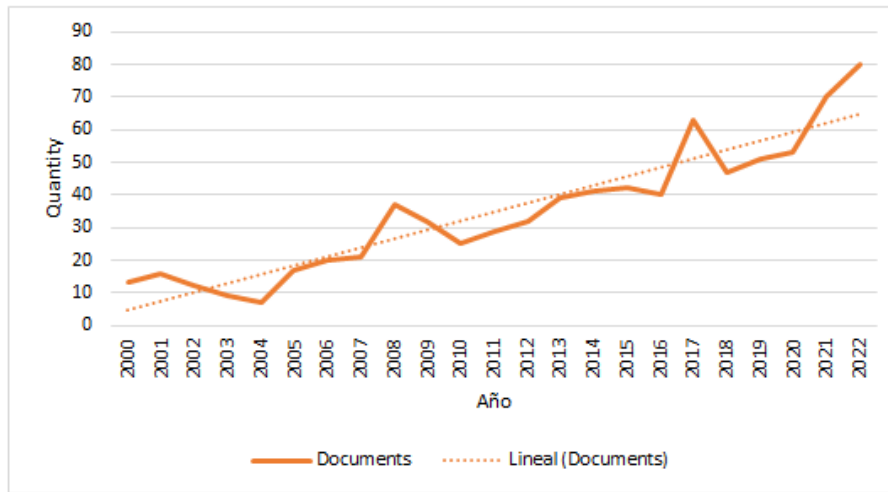

Figure 2. Production and trend in the area of inventory management

Table 2 shows the top ten authors who have contributed productively to the topic "Inventory Management", according to the number of articles published in the Scopus database, with Rabinovich, E., affiliated to Carey School of Business University, Arizona, USA, with 5 articles and expertise in Supply Chain Management, followed by Ozbay, K., affiliated to Rutgers University, New Jersey, USA, with 4 articles and expertise in Transportation Network Systems. Followed by Ozbay, K., affiliated with Rutgers University, New Jersey, USA, with 4 articles and expertise in Transportation Network Systems. Then comes Relvas, S., affiliated with the Technical University of Lisbon, Lisbon, Portugal, with 4 articles and research potential in logistics, operations management and warehouse management. Zhou, W., affiliated to South China University of Technology, Guangzhou, China, with the same number of articles and a research line on porous, metallic and organic materials.

Table 2. Top ten authors with the greatest production

Author	Articles	Affiliation	City, Country
Rabinovich, E.	5	Carey School of Business University	Arizona, Usa
Ozbay, K.	4	Rutgers University	Nueva Jersey, Usa
Relvas, S.	4	Technical University of Lisbon	Lisboa, Portugal
Zhou, W.	4	South China University of Technology	Guangzhou, China
Abouee-Mehrizi, H.	3	University of Waterloo	Waterloo, Canada
Barbosa-Póvoa, A.P.F.D.	3	University of Lisbon	Lisboa, Portugal
Bartoszewicz, A.	3	Technical University of Lodz	Lodz, Polonia
Berman, O.	3	University of Toronto	Toronto, Canada
Borgonovo, E.	3	Bocconi University	Milan, Italia
Chao, X.	3	Anhui University	Anhui, China

Regarding the volume of citations, it is notorious in first position the author "Cachon G. P." "Fisher M." with 1243 Citations, affiliated to University of Pennsylvania, and research potential in areas of stochastic modeling; Analytical optimization and supply chain management, respectively. Next comes "Wang S." with 655 citations, affiliated to Zhengzhou University and research expertise in the line of inventory management. Then "Cheng T. C. E." with 631, affiliated to PolyU Business School and research potential in operations management. On a smaller scale is "Hua G." with 601 citations, affiliated with Beijing Jiaotong University and strength in supply chains. In terms of journals, "Management Science" stands out with 2,635 citations. This is followed by "International Journal of Production Economics" with 2126 citations. Then comes "Manufacturing and Service Operation Management" with 820 citations. Production and Operation Management" with 620 citations. On a smaller scale, "International Journal of Production Research" with 544 citations. All oriented to the disciplines of Business, Management and Accounting; Decision Sciences; Management Sciences and Operations Research; Economics, Econometrics and Finance; Engineering and Industrial and Manufacturing Engineering (see Table 3).

Table 3. Top ten citations of authors and journals

Author	Citation	Journal	Citation
Cachon G. P.	1243	Management Science	2635
Fisher M.	1243	International Journal Of Production Economics	2126
Wang S.	655	Manufacturing and Service Operation Management	820
Cheng T. C. E.	631	Production and Operation Management	620
Hua G.	601	International Journal of Production Research	544
Buzacott J. A.	479	Computers and Industrial Engineering	371
Zhang R. Q.	479	International Journal of Advance Manufacturing Technology	366
Toktay l. B.	334	Journal of the Operation Research Society	344
Wein l. M.	334	IIE Transactions	342
Zenios S. A.	334	Industrial and Engineering Chemistry Research	325

From the VosViewer software, Figure 3 evidences the most cited articles in the field of "Inventory Management", stands out the work developed by Cachon, G. (2000), entitled "Supply chain inventory management and the value of shared information", with 1243 citations, who studied the value of sharing information in a supply chain model with stochastic and stationary consumption demand. Then the research developed by Hua, G. (2011), entitled "Carbon footprint management in inventory management", with 549 citations, who investigated how companies manage carbon footprints in inventory management under the carbon emissions trading mechanism. This is followed by the article by Buzacott, J. A. (2004), entitled "Inventory management with asset-based financing", with 479 citations, incorporating asset-based financing in production decisions. Similarly, the work of Toktay, L. B. (2000), entitled "Inventory management of remanufacturable products", with 334 citations, who addressed the acquisition of new components for recyclable products, with the objective of finding an ordering policy that minimizes the expected total cost of acquisition, inventory holding and lost sales. Consequently, appears Huang, G. Q. (2008), with their research entitled "RFID-based wireless manufacturing for real-time management of shop floor WIP inventories" with 207 citations, who presented an affordable approach for yield improvement by using wireless manufacturing (WM), an emerging advanced manufacturing technology (AMT). Then appear Raviv, T., & Kolka, O. (2013), with their work entitled "Optimal inventory management of a bike sharing station" with 191 citations, who presented an inventory model suitable for bike rental station management and a numerical solution method used to solve it. Also outstanding is the work developed by Steffens, N. K. et al. (2014), entitled "Leadership as social identity management: presenting the Identity Leadership Inventory (ILI) to assess and validate a four-dimensional model", with 186 citations, who developed and validated an identity leadership inventory (ILI) that assesses these dimensions in different contexts and with diverse samples from the USA, China and Belgium. Also noteworthy is the work of Mieghem, J. A. V., & Rudi, N. (2002), entitled "Newsvendor networks: inventory management and capacity investment with discretionary activities" with 154 citations, who presented a class of models, called newsvendor networks, that allow multiple

products and multiple processing and storage points and investigated how their single-period properties extend to dynamic environments. Similarly, Braglia, M., & Zavanella, L. (2003), with the work entitled "Modeling an industrial strategy for inventory management in supply chains: the case of 'Consignment Stock'", with 151 citations, who offers an analytical modeling that addresses the problem of a productive situation of a single seller and a single buyer. Finally, the work addressed by Beamon, B. M., & Kotleba, S. A. (2006), entitled "Inventory modeling for complex emergencies in humanitarian relief operations", with 141 citations, stands out, who addressed through the development of a stochastic inventory control model, determining the optimal order quantities and replenishment points for a long-term emergency relief response.
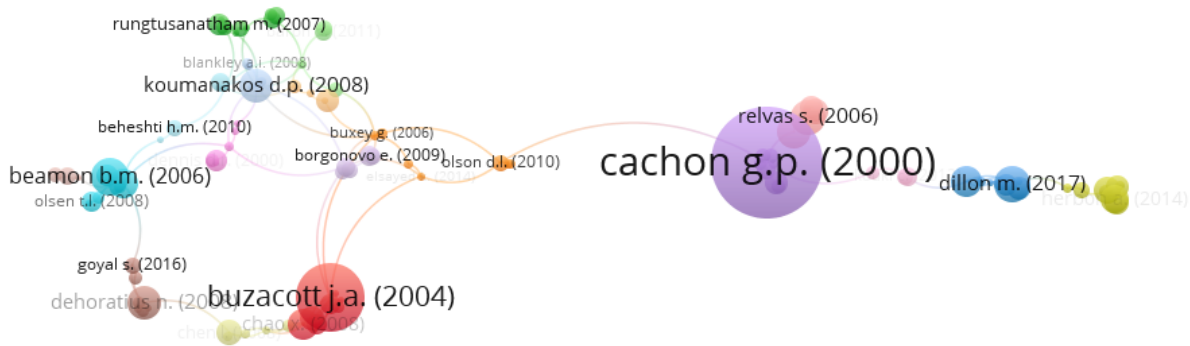

Figure 3. Most cited articles in Scopus database.

A co-citation analysis makes it possible to identify the connections between various authors in a specific area (Herrera, G. et al 2020). From the number of times they are referenced (White H. D. 2003), or also when documents are cited more frequently in other documents (Hjørland B. 2013). Generating research relevance, because the more two authors are cited, the more they are intellectually related (Gmür M. 2003). Using the computer tool VosViewer software, a universe of 30320 authors was identified, where 231 meet citation links with a minimum citation of 20, forming in turn 9 clusters, in the red cluster, with a total of 78 authors Lee h. L. (122 citations) and Silver E. A. (96 citations), in the green cluster with a total of 44 authors, the author Sakar B. (105 citations) stands out, in the blue cluster with a total of 43 authors, Li Y. (62 citations) and Zhang Y. (58 citations) stand out, in the yellow cluster with 20 authors, the author Zhang H. (72 citations) appears as the most representative, in the violet cluster with a total of 17 authors appear Chen X. (121 citations) and Simchi H. (72 citations), in the violet cluster with a total of 17 authors appear Chen X. (121 citations) and Zhang Y. (58 citations). (121 citations) and Simchi-levi (113 citations), in the light blue cluster with 15 authors, Dekker R. (74 citations), in the orange cluster with a total of 10 authors, Nahmias S. (102 citations), in the brown cluster with a total of 2 authors, Chen F. (55 citations) and finally in the fuchsia cluster with a total of 2 authors, Huang G-H. (90 citations). In general, the clustering using VosViewer made it possible to determine the most

influential authors in the citation network for the subject "inventory management", marking the most determining authors (see Figure 4).

Figure 4. Author-citation network

3.2 Thematic Analysis

This section relates the bibliometric element as the co-occurrence from the keywords, using computer supports such as: Excel and VosViewer. The analysis identifies a total of 4417 keywords, with a minimum cooccurrence threshold of 5 times per word, limiting the network to 209 nodes for visual effects (see Figure 5).

Figure 5. Keywords in VosViewer with Scopus

Eight clusters were identified, cluster 1 (red) comprising 45 keywords from authors related to supply chains and warehousing logistics. Cluster 2 in green comprises 35 keywords related to stochastic systems and models. Cluster 3 in blue comprises 33 keywords related to inventory management oriented to planning, scheduling and control. Cluster 4 in yellow comprises 32 keywords related to ordering, warehousing and ordering costs. Cluster 5 in purple comprises 24 keywords related to material handling, product identification and logistics information systems. Cluster 6 in light blue comprises 21 keywords related to inventory levels and policies. Cluster 7 in orange comprises 18 keywords linked to total cost optimization. And cluster 8 in brown comprises 1 keyword associated with agents in the retailer-type chain.

3.3 Collaborative Analysis

This section relates bibliometric element such as co-authorship from the collaborative network of authors, using computer supports such as: Excel VosViewer. By means of information obtained in Scopus and with the support of VosViewer of the 1969 authors with a minimum of two (2) articles and zero (0) citations, the configuration shows that 193 meet the collaborative network threshold. Grouped into 8 clusters, cluster 1 in red, cluster 2 in green and cluster 3 in blue, they are distinguished by presenting 7 authors connected with literary links, among the main ones are: Li, Z.; Chen, H.; and Zhang, H. Cluster 4 in yellow, cluster 5 in violet and cluster 6 in light blue contain 5 authors connected with literary links, among the main ones stand out: Chao, X.; Chen, L.; and Cheng, T.C.E. and finally clusters 7 in orange and cluster 8 in brown appear, both with 3 authors, in which Fransoo, J.C. and Lu, Q. stand out (see Figure 6). In general, the appearance of these authors is evident with respect to the volume of scientific production and cited articles (see Table 2 and 3).
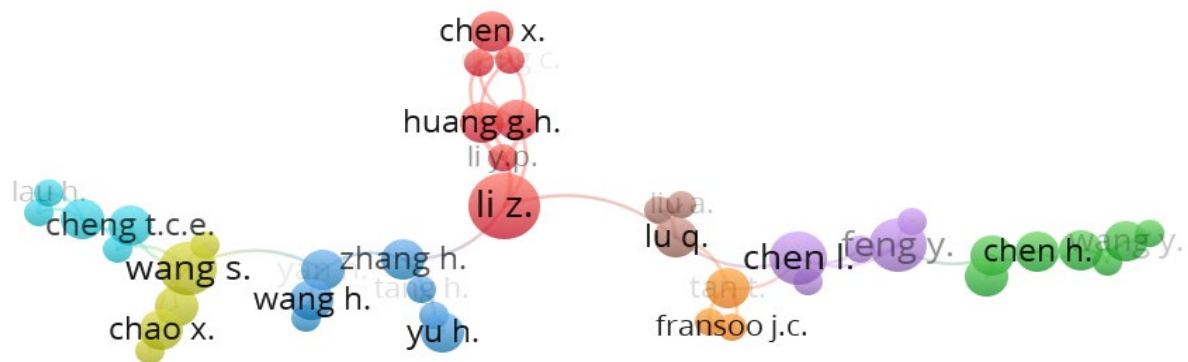

Figure 6. Co-authorship with VosViewer in Scopus database.

3.4 Interrelational Analysis

This section deals with the bibliometric element of interrelation between different fields such as authors, sources and keywords, using computer supports such as Bibliometrix with Biblioshiny. An analysis based on the volume of articles obtained in the Scopus database, with a configuration of ten (10) elements in each of the fields, showed that three (3) authors with the highest production have published in "Computers and Industrial Engineering". Regarding the interrelation between journals and keywords, it is observed that "International Journal of Production Research" is linked with eight (8) out of ten (10) keywords, followed by "International Journal of Production Economics" with six (6) out of ten (10). This reflects a wide coverage of these sources to the researched topic. Regarding the keywords, the highest incidence of entry is presented in "Inventory Management"; "Inventory"; "Supply Chain Management"; "Inventory Control"; "Simulation and Optimization Models", which shows that the top ten journals have shown interest in publications on these topics together (see figure 7).
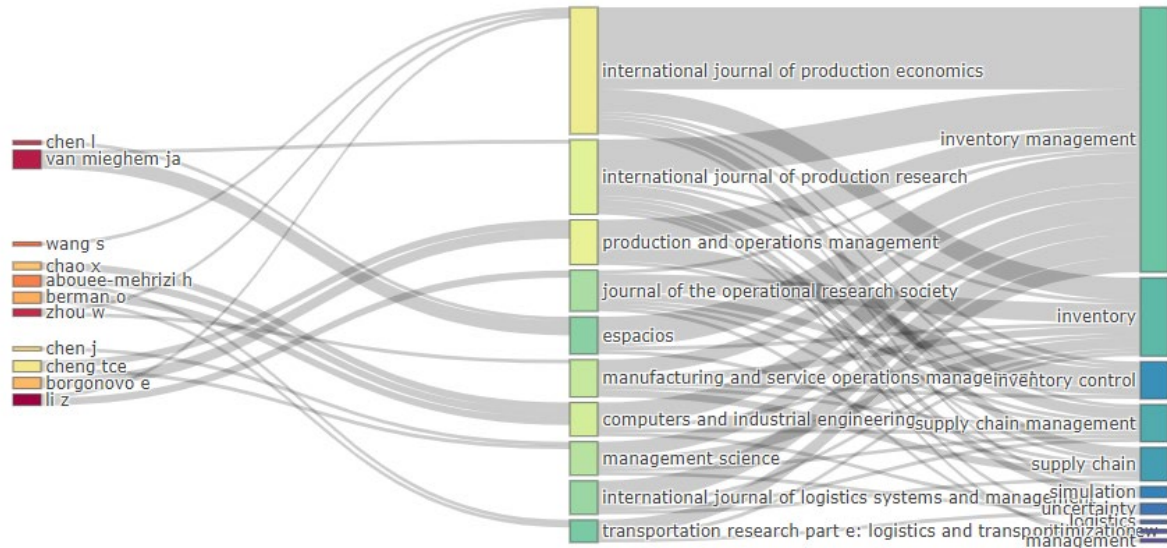
Figure 7. Graph of three fields in Bibliometrix - Biblioshiny

Figure 8 shows the evolution of the research axis and the trend in a time horizon. It is evident in the last years (2021-2023), that inventory management is oriented to the solution of problems framed in the modeling, control and information of manufacturing systems and supply chains, considering approaches of simulation and optimization models, metaheuristic algorithms, forecasting techniques, production design and Markov chains.
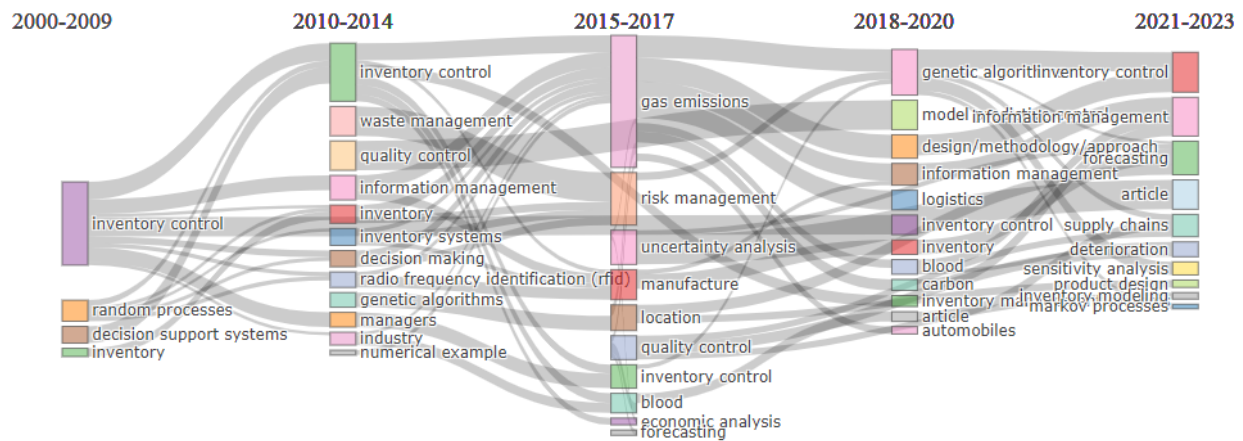

Figure 8. Evolution and trend of the thematic with Bibliometrix with Biblioshiny

4. Conclusion

This research investigates the Scopus databases in search of a bibliometric analysis on the thematic axis inventory management, during a period of time from 2000 to 2022. It is worth noting that during the first decade (2000 to 2010) 209 papers were published, representing 26.26% of the publications, being this a less productive period; unlike the last twelve (12) years which reflects 73.74% represented in 587 papers, evidencing a period of higher production. The trend line clearly highlights the interest of the scientific and academic community in this area of knowledge. Regarding the volume of citations, it is notorious in first position the author "Cachon G. P." "Fisher M." with 1243 Citations, affiliated to University of Pennsylvania, and research potential in areas of stochastic modeling; Analytical optimization and supply chain management, respectively. According to the list of journals, "Management Science"

stands out with 2635 citations. This is followed by "International Journal of Production Economics" with 2126 citations. Using the VosViewer software, the most cited articles, the co-citations between the different authors, the co-occurrence from the keywords and the co-authorship by means of the collaborative component were evidenced. Being notorious the appearance of several main authors regarding the volume of scientific production and cited articles, with research inclination related to stochastic systems and models; planning, programming and control; costs of ordering, storing and ordering; materials management, product identification and logistic information systems; inventory levels and policies; and total cost optimization. An analysis by means of the Bibliometrix with Biblioshiny computer support, evidences the evolution of the subject and the future perspective, being this one oriented to the solution of problems framed in the modeling, control and information of manufacturing systems and supply chains, considering approaches of simulation and optimization models, metaheuristic algorithms, forecasting techniques, product design and markov chains.

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Biographies

Dr. German Herrera Vidal is a professor at the University of Sinu, Cartagena – Colombia, faculty of engineering. PhD in Engineering with mention in Industrial Engineering from the Universidad Nacional Lomas de Zamora (UNLZ-2017), Master in Engineering with emphasis in Industrial Engineering from the Universidad Tecnológica de Bolívar (UTB-2013), Specialist in Business Management from the Universidad Tecnológica de Bolívar (UTB-2008), Productivity and Quality Engineer from the Politécnico Jaime Isaza Cadavid (PJIC-2000). Integral professional with research training, capable of providing solutions to all types of problems in administrative and operational areas. Applying solutions to problems that fit business needs, through the use of optimization techniques, simulation and modern methods that help to improve productivity, quality and competitiveness.

Ms. Camilo Molina Guerrero is a professor at the University of Sinu, Cartagena – Colombia, faculty of engineering. Master in logistics management from the international university of la rioja, logistics expert and specialist in six sigma. Industrial engineer from the technological university of bolivar, research coordinator, teacher and researcher in the area of logistics and operations optimization.