BIBLIOMETRIC ANALYSIS OF ARTICLES PUBLISHED IN THE FIELD OF MATERIALS PLANNING AND ESTIMATION OF TRENDS USING GROWTH MODELS

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Thesis for the Master's Program in Industrial Engineering

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ETHICAL DECLERATION

I hereby declare that I am the sole author of this thesis and that I have conducted my work in accordance with academic rules and ethical behaviour at every stage from the planning of the thesis to its defence. I confirm that I have cited all ideas, information and findings that are not specific to my study, as required by the code of ethical behaviour, and that all statements not cited are my own.

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Date:

01.03.2023

Signature:

ABSTRACT

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Silyanaki**,** Ezgi

Master's Program in Industrial Engineering

Advisor: Prof. Dr. Ahmet Sermet ANAGÜN

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In this study, statistical analysis of the data obtained from the VOSviewer program, which is a text mining application, was carried out with the help of bibliographic databases for the keywords MRP, ERP and SAP. In this context, first of all, the concept of Enterprise Resource Planning, its development, the features of enterprise resource planning software, its advantages, its effects on business performance, ERP applications, ERP software, technical specifications, functional features, purposes of use, SAP history, SAP usage purposes, products, SAP modules. and its integration. In the study, information about text mining was given, and information about VOSviewer application and usage was given. Finally, the literature was supported by the studies carried out within the scope of the subject with Gompertz growth curve and Pearl logistic growth curve.

ÖZET

MATERYAL PLANLAMA ALANINDA YAYINLANAN MAKALELERİN BİBLYOMETRİK ANALİZİ VE BÜYÜME MODELLERİ İLE EĞİLİM TAHMİNİ

Silyanaki**,** Ezgi

Endüstri Mühendisliği Yüksek Lisans Programı

Tez Danışmanı: Prof. Dr. Ahmet Sermet ANAGÜN

Mart, 2023

Bu çalışmada MRP, SAP ve ERP anahtar kelimeleri için bibliyografik veri tabanları yardımı ile metin madenciliği uygulaması olan VOSviewer programından alınan verilerin istatiksel analizi yapılmıştır. Bu kapsamında çalışmada öncelikle, Kurumsal Kaynak Planlaması kavramı, gelişimi, kurumsal kaynak planlaması yazılımının özellikleri, avantajları, işletme performansına etkileri, ERP uygulamaları, ERP yazılımları, Teknik özellikleri, fonksiyonel özellikleri, kullanım amaçları, SAP tarihçesi, SAP kullanım amaçları, ürünleri, SAP modülleri ve entegrasyonu ele alınmıştır. Çalışmada daha sonrasında metin madenciliği hakkında bilgiler verilmiş, Vosvierwer uygulaması ve kullanımı hakkında bilgiler aktarılmıştır. Son olarak konu kapsamında yapılan çalışmalar ve literatür Gompertz büyüme eğrisi ile Pearl büyüme eğrisi ile desteklenmiştir.

Anahtar Kelimeler: ERP, SAP, MRP, Metin Madenciliği, VOSviewer, Gompertz Büyüme Eğrisi, Pearl Büyüme Eğrisi.

Dedicated to Mert Can Şermet who support my academic career with as much enthusiasm as I do.

ACKNOWLEDGEMENTS

PREFACE

Here the author informs the readers about their experiences during the writing of this thesis, all the stages from beginning to the completion of the thesis.

İzmir
01/03/2023

Ezgi SİLYANAKİ

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LIST OF ABBREVIATIONS

ERP: Enterprise Resource Planning

MRP: Material Requirements Planning

SAP: Systems Analysis and Program Development

CHAPTER 1: INTRODUCTION

1.1. Subject of Research

Before computers dominated the industry, methods such as reorder point, reorder quantity, economic order quantity were used in production and inventory/stock management developed by Ford Whitman Harris. Joseph Orlicky developed materials requirements planning (MRP) in 1964 as a response to the Toyota Manufacturing Program. The first company to implement MRP was Black & Decker in 1964. By 1975, 700 companies had implemented MRP by 1981, 8000 companies. When we come to the 1990s, the concept of MRP II has emerged, and beyond the integrated finance, customer relations, human resources data, a solution that enables the use of the same database and integrated with each other, where business conduct and processes can be designed, the concept of Enterprise Resource Planning (ERP) has been formed.

ERP systems are computer-based software that gathers all units in the business under one roof and integrates all accessible information (finance, human resources, production, supply-logistics, and market information) in these units. There is no doubt that this integrated software, which spreads rapidly regardless of the sector, is indispensable for companies and provides great benefits in competition. In the management process, business managers need a harmonious cooperation between departments. This harmonization necessitates the use of information processing tools in all corporate transactions, the use of a single language, a common symbol and understanding, and a sense of purpose (Özer et al., 2010). Enterprise resource planning systems are becoming popular not only in large companies, but also in small and medium-sized enterprises (Wall and Seifert, 2002).

Systems Analysis and Program Development (SAP) software is information technology-based software that has the functions of planning, coordinating, and controlling the resources in different geographical regions in the most effective and efficient way in order to meet customer needs in the best way. In addition, SAP is one of the world's leading ERP software. It is compatible with the strategic goals and objectives of the enterprise (Baykoç and Karadere, 2006).

In text mining applications, the term "computerized text analysis" is also used together with the high speed and reliability of the technology. The main reason for this can be expressed as the fact that computer applications dominate the field in studies carried out with the high speed and reliability of information and communication technologies.

In general, text mining applications present the frequency calculated in the context of how many times the keywords are repeated, which is used for the purpose of revealing the characteristics of data in a data stack, providing clustering, performing classification, providing a summary, revealing trend analysis, and creating visualizations. Text mining is used to determine the changing phenomena in a field or subject, as well as to display the change that happens in the literature study. In this scenario, bibliometric analysis, as one of the text mining studies, is critical in terms of presenting study findings.

1.2. Problem Statement

It is extremely important for researchers to classify published articles related to a particular field in categories such as author, year, country, journal, collaboration, and so on. The absence of such classifications can be considered as a problem for researchers. Researchers want to know which area to focus on, which journals should be given priority, which authors' work should be reviewed first, and between which countries the collaborative work takes place. After the publication search using the keywords MRP, ERP and SAP within the scope of the thesis, new areas to be researched were tried to be shown by taking into account the currently published articles. In addition, the fact that it is not known how long scientific studies in the field will continue brings up another problem for researchers. In order to contribute to the solution of this problem, the growth curves have been investigated when the number of articles containing the selected keywords will reach saturation.

1.3. Purpose of the Research

Two purposes are considered in the study. Bibliometric analysis of the data according to keywords of ERP, MRP and SAP obtained from the WOS database with the help of VOSviewer program as a text mining application will be performed. Then, estimating the number of articles using growth curves such as Gompertz and/or Pearl growth curves, will be investigated in terms of saturation or losing interest of researching.

1.4. Importance of Research

Within the scope of the above-mentioned purpose, it has been determined that there are not many studies in the literature in this field. The study will make an important contribution to the literature and will contribute to the development of alternative applications in terms of ERP, MRP and SAP systems. Gompertz and/or Pearl growth curves will be able to apply to provide where the studies will reach the saturation point.

CHAPTER 2: LITERATURE RESEARCH

2.1. Enterprise Resource Planning

Enterprise resource planning software is a type of system that gradually grows in parallel with the development of previous software over time. The systems that enable the emergence of enterprise resource planning systems are seen as Material Requirement Planning and Manufacturing Resource Planning (MRP II: Manufacturing Resource Planning)" (Anderegg, 2000). Looking at the history of enterprise resource planning software, it has progressed in accordance with the development process of the concept of business integration. Enterprise resource planning systems are derived from MRP and MRPII systems. In line with the demands, MRP systems were further developed and the production resource planning (MRP II) system, which includes sub-functions such as sales, planning, capacity management, and scheduling, was created. MRP II was defined as the next stage for successful production planning in previous periods. As a result, businesses quickly realized that ideas such as profitability and customer happiness apply not only to the production environment, but also to the entire business outside of production. Figure 1 shows the historical evolution of the enterprise resource planning system with the growth of the system based on its increasing relevance over time.
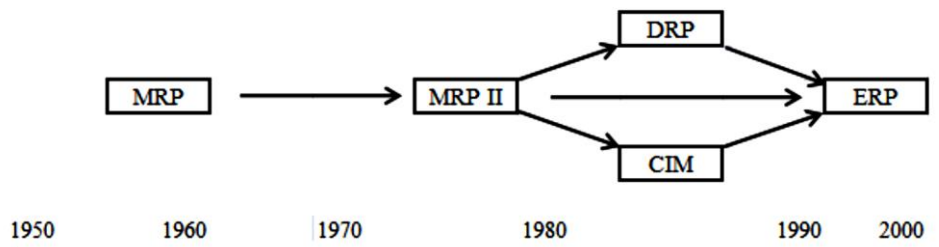
Figure 1. Historical development of Enterprise Resource Planning (Aydın, 2003)

As Figure 1 shows, MRP began and continued to evolve in the 1950s and 1960s and was renamed enterprise resource planning in the 2000s and beyond. Enterprise resource planning continues to develop after the 2000s. After the 2000s, research on business resource planning systems attracted attention, and the number of these studies has gradually increased since the 2010s. Much of the research has focused on the concept of enterprise resource planning, its features, scope, development process, enterprise relevance, impact on enterprise performance, and impact on modules. The use of enterprise resource planning in organizations, its effect on efficiency, sectoral applications, how the installation and selection process is done are emphasized in the

studies conducted after the 2010s. The importance of choosing an enterprise resource planning product is emphasized here (Dulkadir, 2011).

Considering the expected benefits of implementing enterprise resource planning systems in businesses, these systems will reduce unnecessary operations by restructuring business processes, reduce inventory costs by strengthening communication with suppliers, increase customer satisfaction by increasing product/service quality, and positively affect financial performance with increased revenues (Demirhan and Aracioglu, 2010).

Information technology is generally assumed to improve corporate performance through the use of the following elements (Bahadır and Demir, 2006):

• Increasing productivity by increasing the efficiency of business activities,

• By reducing the costs of transaction processes,

• To analyze the information to be used for the decision-making process in a timely manner,

• By revealing the performance of the employees in the best way,

• To improve communication by creating communication channels at the lowest cost.

Creative and follow-on businesses are more likely to thrive in a changing economy (Berkowitz et al., 1997). The main subject of innovation management is "The achievement of the innovation process by transferring the communication between the departments within the enterprise to the market and by providing both competitive advantage and financial rewards to the firm" (Calantone, 2002). Computer-based advanced production technologies require some software changes rather than hardware changes within the company (Gök, 2005). Developing technology over time has offered companies more cost-effective solutions and enterprise resource planning systems have linked cost analyzes in businesses with technical developments as well as other processes (Dulkadir, 2011).

2.2. ERP Applications

When ERP application is mentioned, corporate management interprets it as the application of digitization of corporate processes. Process redesign, integration of the ERP system with other business information systems, and selection, management and training of consultants and personnel are critical (Bingi, Sharma and Godla, 1999). According to Hong and Kim (2002), many firms worldwide have shifted their information technology strategies from replacing and upgrading their internal

information systems to acquiring ERP systems and using software-based management decision support systems since the early 1990s. ERP failure can be attributed to the failure of the ERP system to adapt to the organizational culture (Hong and Kim, 2002).

Businesses that need new business processes and constantly competing challenges to adapt to market conditions are expected to use simpler solutions based on cloud computing and agile approaches to make the information age more accessible and easier to use with ERP solutions. Creating balanced interactions between data and the organization in the implementation of internal controls requires optimization of the ERP system (Manojlov and Lutovac, 2012). Thanks to its modular structure, it makes it easier for the institution to use its resources in the most efficient way and to report in future internal or external audits. In order to create accountable and transparent tables, the institution is expected to build the ERP implementation model in accordance with its own corporate culture and corporate memory.

2.3. Bibliometric Analysis by means of VOSviewer

There are many studies carried out with the VOSviewer program, which is one of the text mining tools. Co-authoring, bibliographic matching, analysis of co-citation networks and bibliometric networks (Perianes-Rodriguez et al., 2016), analysis of collaboration between publications and journal citation relationships, and bibliometric analysis of publications on multi-criteria decision-making (Yu et al., 2018), presentation of the intensity of disasters (Nascimento and Alencar, 2016), and social Bibliometric analysis studies were carried out (Doleck and Lajoie, 2018) in which the effect of sharing websites on students' academic performance was examined.

In VOSviewer, as a result of a bibliometric analysis, the relations of the authors who performed the study with each other and the displaying of the clustering colors that change according to the years. Researchers can view them on the main panel with density view, cluster density view, and scatter view. Again, researchers can create different views for the visual presentation of the map according to the features area displayed on the main panel.

As a result of the analysis in VOSviewer, many different sets and items occur. It is also stated that the VOSviewer program has a unique clustering technique. The resulting clusters are very important for the studies carried out with text mining. Clustering is seen as one of the most important problems in bibliometric research. The clustering method implemented in the VOSviewer program focuses on the total level of the items. The clustering process begins with associating publications with each

other in bibliometric analysis and assigning publications to each cluster; in this way, a broadcast that is not assigned or has a cluster conflict does not occur. The fact that clusters or items are close to each other in VOSviewer is due to the relationship between them.

In the study conducted by Ardito et al. (2019), a bibliometric analysis was conducted on big data analytics on business and management with VOSviewer on behalf of a total of 748 article reviews. In line with the examination, four clusters were identified that show the literature related to Big Data Analytics and management phenomenon. These; The theoretical development of Big Data Analytics is the management transition to Big Data Analytics, Big Data Analytics and Big Data Analytics for firm resources, capabilities and performance and Supply Chain Management.

Mourao and Martinho (2020) examined the bibliometric perspective of 83 articles published on forest entrepreneurship in their study. For this review, the journal, country, author, and keywords of the articles were scanned with the VOSviewer application. In the scanning of the approaches examined in the study, no document could be found with VOSviewer, and it was determined that there was no study on this issue in the literature. In addition, it has been determined that there are some gaps in the literature, that is, in these subjects, apart from forest sciences, with a few multidisciplinary networks.

Bahit et al. (2021) conducted a bibliometric analysis on the management and integration of enterprise resource planning in macro, small and medium enterprises. In the analysis, 32 articles published between 2015-2020 using VOSviewer were examined, and they made a classification about ERP management and integration in MSMEs.

Yanti et al. (2022) conducted a bibliometric analysis for the use of resource planning in the MSME sector. In the study, data between the years 2000-2021 were collected through the web of science database and examined with VOSviewer. In the process so far, 449 research articles have been identified, and it has been concluded that there has been an increase in the volume of publications and the prestige in the field.

Yu et al. (2020) conducted a bibliometric analysis of the publications related to Covid-19 with VOSviewer in their study. As a result of the study, it was determined that there were 3,626 publications related to the concept and the concept of Covid-19

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was related to the concepts of pneumonia and epidemiology. In addition, it was reported in the study that publications related to the concept generally focus on disease management, clinical features, and pathogenesis.

2.4. Modeling Growth Curves

In proposing the law of human mortality, actuary B. Gompertz proposed utilizing the exponential function to express the link between growing death and age. Makeham (1873) gave the well-known cumulative version of this model, whereas Gompertz merely offered the probability density function. There are other variations of the Gompertz model in the literature, and Tjrve (2017) provides a full discussion of the Gompertz model.

Raymond Pearl and Lowwell Reed devised the logistic function while researching population increase in the United States. They were unfamiliar with Verhulst's work and developed the notion of logistic curves independently. Their hypotheses were founded on the following assumptions:

1. Population growth occurs in a limited geographic area.

2. The population growth rate cannot be limitless.

3. The population's lower limit cannot be 0.

4. The point of inflection of the population growth curve is the point of highest rate of expansion.

After that, the rate of expansion slows gradually until the curve becomes almost horizontal, close to the top asymptote associated with the cultural era and region involved. Pearl's research was founded on two experiments. The first experiment involved feeding a jar of fruit flies a consistent amount of gelatinized fruit pudding. The reproductive rate of fruit flies was initially fast. However, when the density of fruit flies in the jar increased, the reproduction rate fell and became insignificant. Similarly, in the second experiment, Pearl discovered that as the number of hens in their pens increased, the density increased, causing them to produce less eggs owing to a lack of room. Based on his findings, he concluded that human fertility is similarly impacted by population density and carrying capacity.

Looking at the studies in the literature about Gompertz and Pearl, Lartey (2020) aimed to determine a model that predicts future trends in the purchase of FTTH gigabit internet product. According to the analysis results of Lartey, who divided the data set into two groups for the first 12 months and the next 5 months, it was seen that the Bass model gave better results than the Gompertz and Logistics estimations.

Nwakuya and Biu (2021), in their study, aimed to analyze the under-five mortality rates in Nigeria over a 15-year period. Using the transformed Gompertz model for the analysis, the authors found that the increase in the death rate for deaths from HIV and diarrhea also increases the range of mortality growth. They predicted that there would be an increase in diarrhea-related death rates and that death rates from HIV would be constant.

In their study, Omar and Taaren (2021) used data on the number of COVID-19 cases, the number of deaths, and the number of recovered patients in Pakistan to identify the model that best fitted the data that peaked over time. Using the logistic model, the Gompertz model, and the Autoregressive Integrated Moving Average Model (ARIMA), the authors found that the number of COVID-19 cases, the number of recovered patients, and the number of deaths in Pakistan grew exponentially. They also determined that the most suitable model for the data was the ARIMA model.

Moura and Riberio (2009) aimed to obtain empirical findings regarding the change in income distribution in Brazil. Examining the annual data available from 1978 to 2005, the authors conclude that the supplemental cumulative distribution of personal income fits the Gompertz curve for 99% of the less economically fit population.

In their study, Mazurek and Nenickova (2020) aimed to determine the point where the growth of the number of cases slowed down in the COVID-19 pandemic in the United States and to predict the total number of cases. Using the Gompertz curve for this purpose, the authors predicted that the total number of COVID-19 cases in the United States would be 1000000 on 25 April and 2000000 on 27 June.

Wu et al. (2014) aimed to establish a model for forecasting Chinese vehicle stocks and road vehicle energy demand by 2050 based on low, medium, and high growth scenarios. To make their estimations with a Gompertz function dependent on Gross domestic product, the authors used a dynamic computable general equilibrium model. As a result, they predicted that the number of vehicle stocks envisaged for 2050 is 300, 455 and 453 million for each of the low, medium, and high growth scenarios, respectively. They also found that the growth in China's vehicle stock will go beyond the slope of the Gompetz curve by 2020 but will not reach the saturation point between 2014-2050. Finally, they predicted the consumption of road vehicles in 2050 as 380, 575 and 586 million tons of oil for each scenario.

Adamuthe and Thampi (2019) aimed to determine the trend projection and technology maturity curve of six computational technologies, which include three disruptive technologies, namely mainframes, minicomputers, and cloud computing. For the model, they used time series data of patent and study numbers from the US patent office, European patent office, IEEE and Science Direct. The authors tested six functions to determine the optimal trendline. As a result, they found that most of the technologies better fit the 2nd order polynomial trendline. They also concluded that the Gompertz growth curve for the saturation point fits the data better than the Pearl curve in many cases.

CHAPTER 3: TEXT MINING

In text mining applications, the term "computerized text analysis" is used together with the high speed and reliability the technology has (Kobayashi et al., 2018). The main reason for this can be expressed as the high speed and reliability of information and communication technologies and the dominance of computer applications in the field.

As one of the subjects included in data mining studies, text mining emerges as an application area that hosts studies carried out with the use of big data on the web (Salloum et al., 2018). Text mining is the whole of applications in which large volumes of data are found (Kobayashi et al., 2018), meaningful structures are revealed from large data piles (Salloum et al., 2018), and many different applications and analyzes are used in these interpretation processes.

In general, text mining is the application of the frequency calculated in the context of how many times the keywords are repeated, which is used for the purpose of revealing the characteristics of the data in a data stack, providing their clustering, performing their classification, summarizing, revealing the trend analysis and making their visualizations (Karanikas and Theodoulidis, 2022). Text mining is used for the purpose of determining the changing phenomenon in a field or any subject (Kobayashi et al., 2018), and presenting the change in literature analysis (Singh et al., 2007; Delen 2008; Moro et al., 2015; Scherf et al., 2005). When this is the case, bibliometric analysis, as one of the studies on text mining, is of great importance in terms of presenting research findings.

Bibliometric analysis- is based on analyzing the obtained documents or articles according to certain characteristics and revealing the findings (Al and Coştur, 2007). Studies specific to a particular field or articles published in a specific journal are examined according to different parameters and provide findings according to these parameters (Temizkan et al., 2015). These findings may include data such as keywords, number of authors, citations, and research topics. For a better understanding of text mining applications, it is important to make a detailed description of bibliometric analysis and to determine its properties. Bibliometric analysis is carried out for a very broad purpose: presenting findings about fields in general to readers or revealing deep knowledge about a specific topic. Bibliometric analyses are used to analyze citations within studies and to evaluate studies (Al and Coştur, 2007).

Bibliometric analysis has different approaches. While maps of distance-based, graphic-based, and timeline-based approaches used in the context of visualization approach in bibliometric analysis are used (Van Eck and Waltman, 2014), distance-based and graphic-based approach map types are more remarkable (Garfield, 2009). In graphic-based maps, while the relations between the items in the outputs obtained as a result of the analysis are revealed, no finding of the relationship strength is expressed. On the other hand, in distance-based maps, the distance and closeness of the items in the outputs reveal the strength of the relationship between the items (Van Eck and Waltman, 2009). The most important point here is that the researcher makes use of graph-based or distance-based maps for targeted analyzes in his research questions. In other words, distance-based maps can be used in cases where the relationships between items are a research problem, while bibliometric analyzes using graphic-based maps can be used in studies that only aim to reveal existing items.

There are different mapping techniques to create graph-based and distance-based maps. While there are techniques such as Kamada–Kawai, Fruchterman–Reingold and Pathfinder networks for graph-based mapping, there are techniques such as multidimensional scaling, VOS, VxOrd, Kopcsa–Schiebel for distance-based mapping (Zvereva and Shams, 2018). As examples of a graph-based map with Kamada-Kawai technique and a distance-based map with VOS technique are given in Figure 2 and Figure 3, respectively.
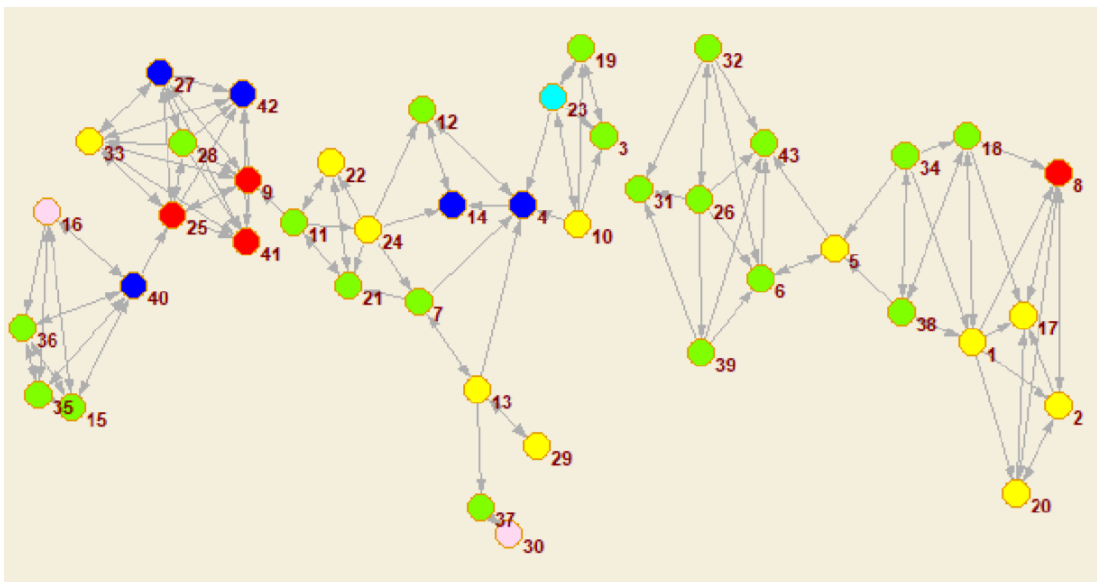
Figure 2. Graph-based map with Kamada–Kawai technique (Zvereva and Shams, 2018)
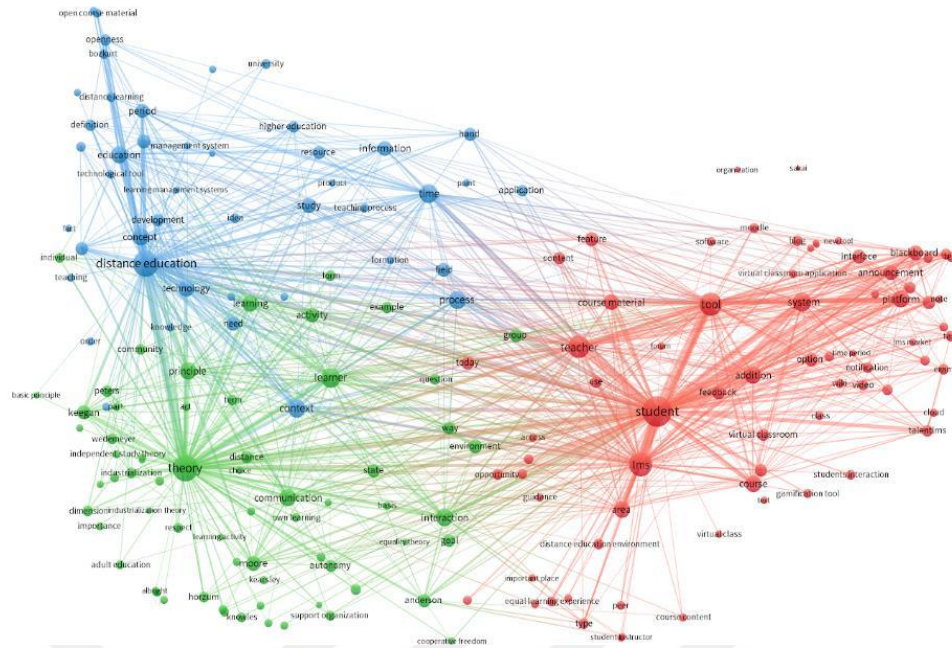
Figure 3. Distance-based mapping with VOS technique

The VOS technique (Van Eck et al., 2008), which has the best performance among these techniques, is remarkable in the studies carried out in the field. In general, VOS is a multidimensional scaling process for visualizing similarities between elements and is notable for its features such as presentation of ideal coordinates, indirect analogy, and multidimensional scaling. In other words, as the similarity between the two objects increases, the weight of the square distances in total also increases. In this context, it is a technical method based on the fact that the sum of all distances must be equal to some positive constant in order to avoid solutions where all objects are in the same coordinates (Van Eck and Waltman, 2007).

Unlike other methods in the field, detailing the features of VOS is important in order to understand the operation of this method. The sij function is important for presenting similarity and distance between items i and j. In the representation of ideal coordinates, the ideal coordinates of an item are defined as the weighted average of the coordinates of all other items, with more weight being given to calculating the weighted averages of items that are more similar to the i coordinates of the items. In the context of indirect similarity, where there is 0 similarity between the elements i and j, the said similarity depends on the number of the third element with which both objects are similar. That is, the more indirect similarity detected for the third elements, the closer i and j are to each other. Besides the basis of the VOS technique, there are

programs such as BibExcel, SciMat, SAINT, and VOSviewer, used for the visualization and creation of the obtained bibliometric networks. VOSviewer (Van Eck and Waltman, 2007), one of the software in which the VOS technique is used, is widely used for the visualization of bibliometric networks.

3.1. Application of VOSviewer

The VOSviewer program consists of were different panels. These; main panel, information panel, overview panel and action panel.

Main panel: It is the area where actively used maps are presented and navigation buttons are located. Information panel: It is the section where detailed information about the item is actively displayed in the main panel. Overview panel: It is the area where a general view of the active map is located in the main panel, and this panel occupies a very small space compared to the main panel, allowing the colors on the maps to be displayed. Action panel: It is the area were creating a new map, saving the map, taking a screenshot and restoring an existing map are performed

In Figure 4, the main panel (1), information panel (2), overview panel (3) and action panel (4) are located in the program.
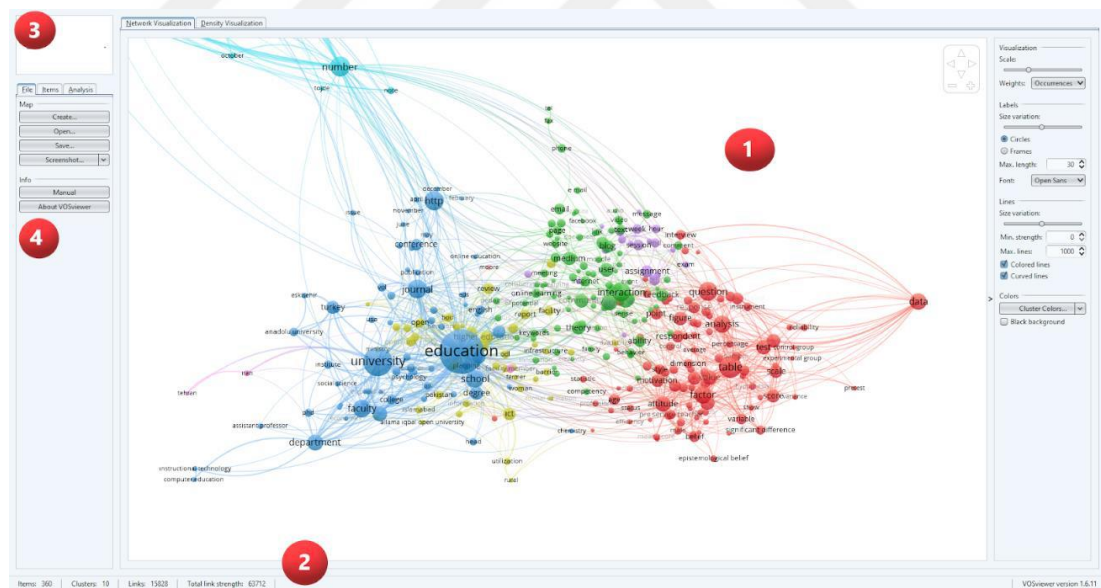
Figure 4. Panels and tabs of VOSviewer program

Main panel: In this panel, the result of the bibliometric analysis performed in the VOSviewer program can be displayed. The main panel has the ability to get closer to all the elements on the panel, thanks to its flexible structure. In this way, it allows the visualization of detailed relationships of an item with other items. This feature is quite remarkable in terms of detection and visibility of new contexts between items.

Information panel: As a result of listing the overall results, this panel includes the number of items, the number of clusters, the number of links, and the strength value of all other links. Again, in this panel, if any item is focused on, there is information about which cluster the item is in, the number of links it has, and the total weight of the links it has.

Overview panel: There is a smaller view of the map resulting from the analysis carried out within this area. It is possible to view the current general situation from the overview panel, even when zooming in or out in the main panel. The location information of the researcher's zooming and zooming operations on the main panel can also be displayed on this panel interface.

Action Panel: There are functions that can be used for different purposes in the file, object and analysis tabs here. In the File tab, there are functions to create a new analysis, to display the previous analysis in the main panel, and to save the analysis. In addition, there are functions used to take screenshots that can be used in research. The Object tab is the tab where the clusters formed as a result of the analysis and the items belonging to the clusters can be displayed. The Analysis tab, on the other hand, is an area that can be used when it is desired to make adjustments about the size and structure of the clusters that will be formed. This area contains options where different analysis methods can be used.

There are different views in the VOSviewer program. These; density view, cluster density view, and scatter view. In the density view, although each point on the map has a color according to the density of the relevant item, it is important to provide an overview and draw attention to important areas. As the number of items around an item begins to increase, the color of the item becomes more intensely red. On the contrary, the intensity of the color begins to decrease as the number of elements around the element decreases. In such a case, it may appear that the item is approaching the blue color. In Figure 5, there is the density view in the main panel.

Figure 5. VOSviewer density view

In order to obtain a cluster density view in the VOSviewer program, the items must be divided into clusters. The color of a spot in the cluster density view; close to the color of the set if there are many elements of the set around the point. Items with a high weight are considered to have higher density than items with a low weight. In this context, densities varying according to altitude can be easily displayed on the map. Scatter view, on the other hand, is a view in which each of the items is presented in circles. If a color assignment is made for the items, the circle of each item can be displayed with the color of the set it is in. The most remarkable point here is that you do not encounter labels. The scatter view is important for us to have an overview for a map. Because it provides a general summary of the concepts.

In addition, the VOSviewer program offers many different eases of use. The navigation buttons on the main panel provide the zoom function for a more detailed view by focusing on certain points on the presented maps. On the other hand, the data set can be loaded in different file formats in the studies carried out in VOSviewer. It supports Excel, SPSS, MATLAB and R file extensions as well as txt file extension. Read data from bibliographic database files option when data obtained from directories such as Web of Science and Scopus are desired to be used, read data from reference manager files in case the source file is on the current computer or Download data through API if data is desired to be obtained directly from API sources in VOSviewer program available.

After loading the data file into the program, the program automatically presents the number of the most frequently used words in the data set. In the Choose threshold window, researchers must specify at least how many times a phrase must be repeated in the data file in order to become visible on the map to be created. This specified figure is called the threshold value. Here, if the number given by the researcher is high, the items to be created will be less, and if the given number is low, the items to be created will be more. At this point, it is very important for researchers to specify the most accurate threshold numbers in order to reveal meaningful information from the data set. After the threshold number is determined, the relevance of the items is scored with the threshold number in the Choose Number of Terms window. It is helpful to select the most relevant items based on this relevance score. This window is the area where the relevant score is automatically calculated and represented by the number specified in the threshold number and how much of the items appearing, and in general, the items that are sufficient for the whole map are indicated by the program. While researchers can only continue with the items that occur with the relevant score, they can continue with the number of items that occur with the threshold number, if they want.

In the context of being an analysis process, there are some priorities for researchers who want to perform VOSviewer analysis. Researchers must first clean the data to be analyzed, then convert it to the appropriate format that the VOSviewer program accepts. The steps that the researcher should follow after this data cleaning process are as follows:

Step 1: The VOSviewer program is downloaded from the www.vosviewer.com/download web page in accordance with the operating system.

Step 2: The VOSviewer application opens.

Step 3: A new project is opened by clicking the Create button.

Step 4: Continue by selecting the Create a map based on text data option from the Choose type of data window that opens to perform text mining analysis.

Step 5: In order to add the data file prepared by the researcher, continue by selecting the Read data from VOSviewer files field from the Choose data source window.

Step 6: Continue by adding the previously created data file to the VOSviewer corpus file (required) field in the Select files window.

Step 7: Continue by selecting Full counting from the Choose counting method window that opens.

Step 8: Continue by specifying the threshold value from the Choose threshold window.

Step 9: There is a threshold value specified as sufficient for the entire map in the Choose number of terms window, and it can be changed by the researcher if desired, or it can be continued directly with the threshold value offered by the program.

Step 10: From the verify selected terms window, if the researcher wishes, he or she can continue the process by ensuring that the item or items are not included so that words outside the research context are not included on the map.

Step 11: Click the Finish button.

As a result of the analysis, in addition to the scatter view map presented on the main panel, the density view map of the same map can also be viewed from the Density Visualization area. On the other hand, in the main panel, operations specific to each map can be performed in the properties area, which changes according to the relevant map views. The researcher can make the necessary adjustments so that the relationships on the map in the distribution view of the variation field can be shown thicker or thinner on the map. The same feature can be used in the density view to make the density on the map more or less obvious from the Density field. Because, in addition to the fixed colors directly defined by the program, researchers can use the colors in the context of their own subject by specifying them under the Colors tab. From the Labels area, it is possible to increase the font size of all items displayed on the map. Again, if desired, they can decide how the elements will appear as Circles and Frames from the same area.

CHAPTER 4: METHODOLOGY

4.1. Research Questions

The methodology is structured in two parts. First, a literature search via WOS database will be made by using selected keywords and a time interval for a bibliometric analysis. In this analysis; criteria such as number of publications, authors, countries, collaborative work will be taken into account. At this stage, answers will be pursued to research questions such as the author(s) who produced the most publications, the country(s) with the most publications, and the country(s) with which they collaborated the most.

Secondly, using the data set on the number of publications, the number of publications expected to be made in the following years will be tried to be estimated with growth curve models. At this stage, answers will be pursued to research questions such as when the studies compatible with the selected keywords will reach saturation or the interest in such studies will decrease.

4.2. Data Collection

In order to perform the bibliometric analysis, number of articles was published in the Web Of Science database using the keywords of "ERP", "MRP" and "SAP" between the years of 1991-2022.

The characteristics of the data are defined below:

- About 298 articles were obtained from 40 different sources.

- Approximately 48% of the articles were scanned in the SCI index, 32% of them in the SCI-EXPANDED and SSCI indexes, and the remaining articles in the ESCI index.

- Approximately 36% of 298 articles were published by Taylor & Francis, 11% by Pergamon, 30% by Elsevier Science, the remaining by Emerald Group, Verlag, and IEEE.

- The annual growth rate of articles written with these keywords is happen to be 4.9%. While the articles received approximately 24 citations per article, articles written with these keywords within one year received an average of 1983 citations.

- A total of 7472 different sources were cited in the 298 articles.

- The number of articles written by a single author was 41 and the rate of international co-authored studies was about 22%.

As mentioned before, firstly, a word cloud analysis was done in order to determine the most frequently used words in the studies. As in Figure 6, the words that are most frequently mentioned in the context of the subject in the abstracts of the articles are "production", "system", "erp", "study", "mrp", "enterprise", "resource", "rights", "critical", "process", "model" and "supply".

Figure 6. The most common words in the abstracts of the articles

CHAPTER 5: RESULTS

5.1. Results of Bibliometric Analysis

Comprehensive analyses of the data were performed not only using VOSviewer software itself, but also using the "Bibliometrix" package developed by Aria and Cuccurullo (2017). The statistics describing the data about the 298 articles obtained will be discussed below under subheadings:

1. What is the number of articles with selected keywords by years?

The number of articles written with these keywords between 1991 and 2022 is given in Table 1. When the Table 1 is examined, it is seen that the year with the most articles on this subject was 2005, while the years with the least number of articles were 1991 and 1995.

Table 1. The number of articles written with these keywords (1991-2022)

Year	Number	Year	Number	Year	Number	Year	Number
1991	1	1999	4	2007	19	2015	12
1992	0	2000	4	2008	15	2016	7
1993	0	2001	11	2009	19	2017	18
1994	6	2002	4	2010	5	2018	3
1995	1	2003	8	2011	14	2019	12
1996	14	2004	8	2012	18	2020	6
1997	4	2005	20	2013	13	2021	6
1998	12	2006	9	2014	10	2022	4

2. Who are the most productive authors over the years?

While the author who has done the most work on this subject is Bogataj M, HO CJ is the author who has done the least amount of work among the authors with more than one study. Figure 7 is visualized by the top 10 authors who have done the most work on this subject, that is, the most productive authors in terms of number of articles.
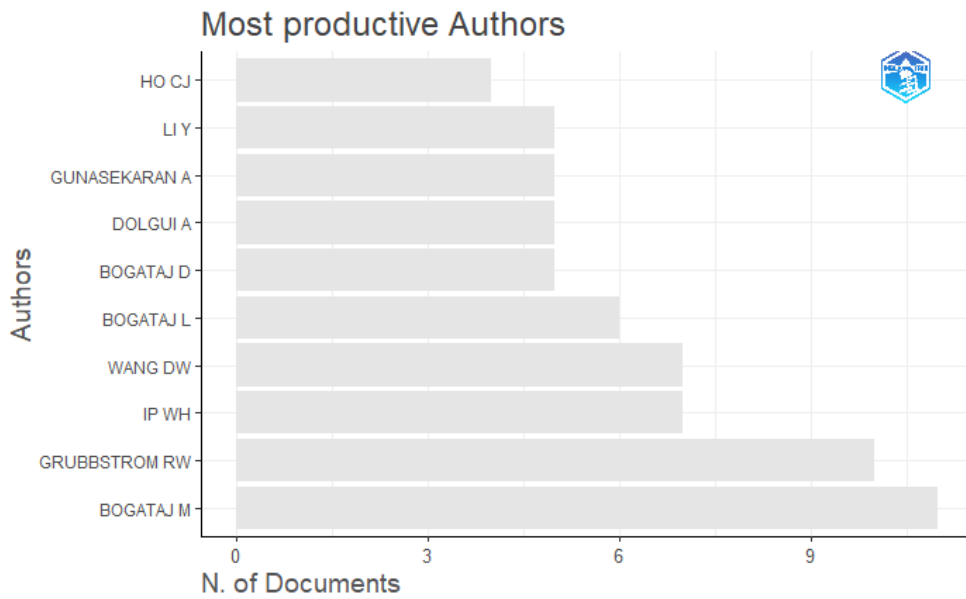
Figure 7. Top 10 Most Productive Authors

"Bogotaj, M." who was the most productive author in terms of the number of articles, has been conducting scientific studies regularly since 2000, as can be seen in Figure 8. The most unproductive author among others was Li, Y. with four articles published between 1996 and 2005.
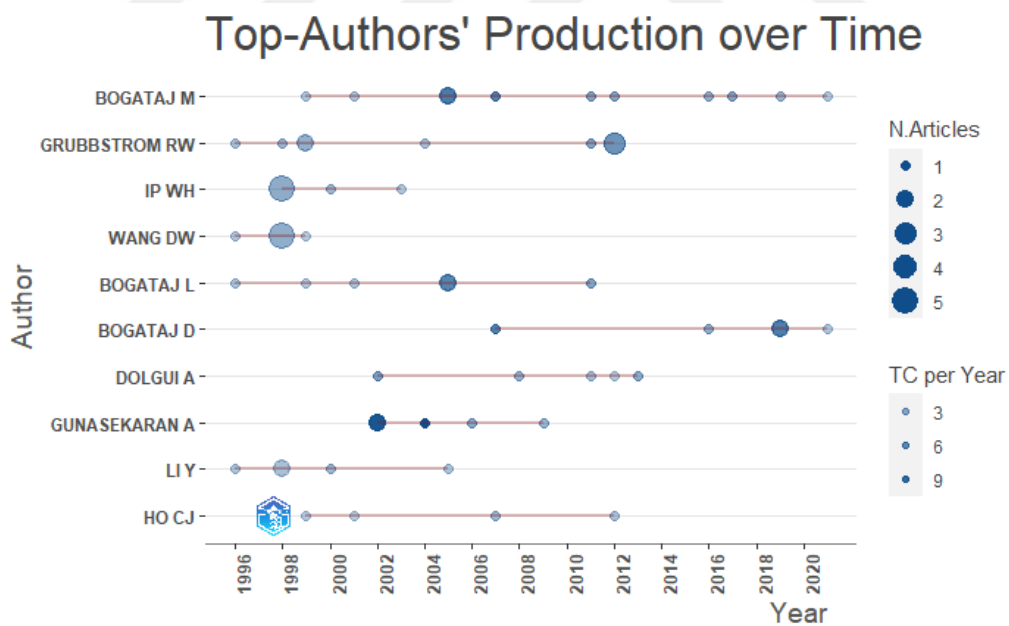

Figure 8. Top-Authors' Production Over Time

3. Which countries are the most productive?

The countries that produced the most co-authored articles from the keywords are given in Table 2. As seen in the Table 2, the country with the most articles using the keywords "ERP", "MRP" or "SAP" in the field of engineering is the United States

of America, while China, Turkey, and United Kingdom are the second and third most productive countries in this regard. Although Turkish authors are not in the top 10 Authors' list, Turkey is third most productive country.

Table 2. Countries That Produce the Most Co-Authored Articles

Country	Number of Articles
USA	55
China	42
Turkey	18
United Kingdom	18
Germany	15
Canada	13
Slovenia	12
Sweden	12
France	11
Japan	11

4. Which countries are the most cited countries?

Table 3 shows the 10 most cited countries on this subject. Looking at Table 3, among the 10 countries with the highest number of citations for articles containing these keywords, the most cited country is the United States (1,736 citations), while the least cited country is Japan (157 citations). On the hand, the most cited country per article on average is United Kingdom (38.78), while the least cited country on average is Sweden (21.42).

Table 3. The 10 Most Cited Countries on This Subject

Country	Total Citations	Average Citations per Article
USA	1736	31.56
China	1237	29.45
United Kingdom	698	38.78
Turkey	575	31.94
Canada	335	25.77
Slovenia	323	26.92
France	271	24.64
Sweden	257	21.42
Australia	176	25.14
Japan	157	14.72

5. In which journals have the relevant articles published?

According to the Table 4, it is seen that the articles on the keywords have mostly been published in the journals of "International Journal of Production Economics" and "Production Planning and Control". On the other hand, "IEEE Transactions on Engineering Management" and "Management and Production Engineering Review" have the least number of articles on this subject. This journal list may help researchers for finding a prestigious journal for their potential articles.

Table 4. The 10 Journals Publishing Articles Related to Keywords.

Journal	Number of Articles
International Journal of Production Economics	77
Production Planning and Control	52
International Journal of Production Research	45
Computers & Industrial Engineering	18
Expert Systems with Applications	14
PPS Management	12
Industrial Management and Data Systems	9
Technovation	6
IEEE Transactions on Engineering Management	5
Management and Production Engineering Review	5

6. How has the number of articles changed over the years?

As in Figure 9, it is seen that the numbers of articles published with these keywords are high in the years of 2005, 2007, 2012, and 2019, low in the years of 1992 and 1993, respectively. Due to Covid-19, studies may have decreased after 2019. It is considered that the change in the number of articles published on a yearly basis (increasing or decreasing direction) may be under the influence of global events such as pandemics or that the subject attracts a large number of researchers.
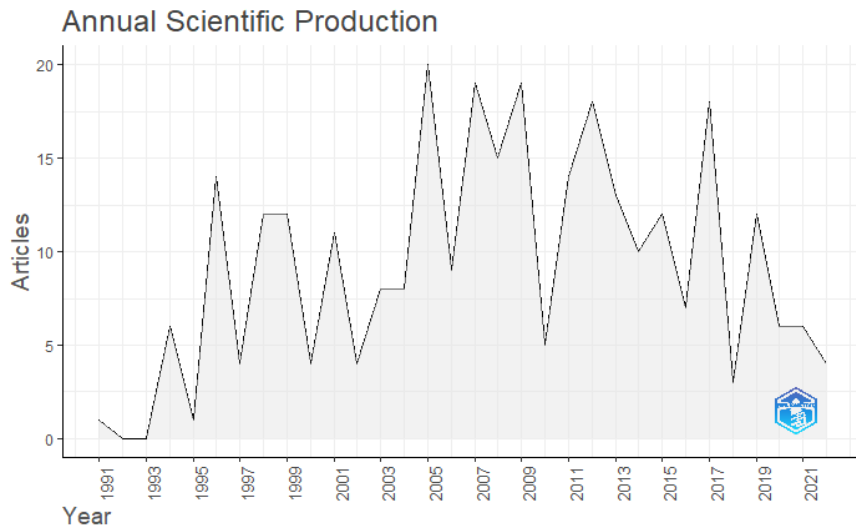

Figure 9. The Change in The Number of Articles by Years

7. Which are most productive countries with collaboration information?

According to Figure 10, the most productive country is appeared to be the United States of America in terms of the category of single country publications (SCP). In addition, the number of co-authored articles by authors from different countries (multiple country publications-MCP) in the United States of America and China is much higher than in other countries. Interestingly, there is no MCP with the authors between Turkey and the other countries.

Figure 10. The Most Productive Countries Based on Collaboration

8. Which keywords have the most co-occurrences?

The network graph according to the keywords in Figure 11 shows that the most cited keywords for the most cited article are "performance" and "implementation". Based on these keywords, it may be possible to infer that future research will be directed towards performance and implementation. According to the graph, in the next period, studies may focus on the concepts of "model", "impact", "management" and "enterprise".

Figure 11. The Network Graph According to The Keywords

9. Which countries collaborate with which countries the most?

According to network graph for the countries in Figure 12, the United States of America, England, and China are the most cited countries. There are collaborations among the most cited countries. In addition, there are collaborations between China and countries such as Portugal, Italy, Sweden, Japan and Australia; between USA and countries such as Korea, Brazil and Finland; between France and Saudi Arabia; between the United Kingdom and countries such as Portugal, Germany and Turkey.
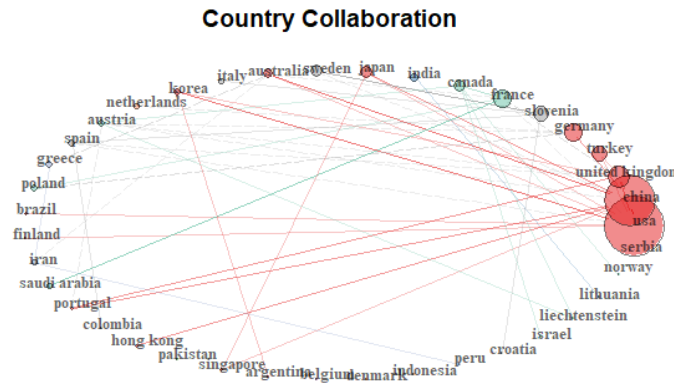

Figure 12. The Network Graph for The Countries

5.2. Results of Modeling Growth Curves

In order to estimate the number of articles for future periods using the growth curves, the data composed of the number of articles has been converted to cumulative format. Gompertz curve and Pearl which are most used curves in the literature, are used for estimation.

The Gompertz curve is a mathematical function named after Benjamin Gompertz and used in time series modeling. According to this function, the growth rate is slowest at the beginning and end of the process. In other words, the future asymptote to the right of the function converges more gradually than the asymptote to the left of the curve. The difference from the logistic function is that it is asymmetrical. While the Gompertz function is defined as in Eq. (1):

$$y = ae^{-be^{-ct}} \tag{1}$$

where,

a is an upper asymptote when the time (t) approaches ∞

b sets the displacement along the x-axis (translates the graph to the left or right).

c sets the growth rate (y scaling)

e is Euler's Number (e = 2.71828...)

y is the observation number of articles

Pearl Function is defined as in Eq. (2):

$$y = \frac{L}{1 + ae^{-bt}}$$ (2)

where,

L is the upper limit of y

a describes the location of curve at time (t) zero

b is the growth rate (controls the shape of the curve)

e is Euler's Number (e = 2.71828...)

y is the observation number of articles

It was tried to determine in which year the studies in the field would reach saturation by using the Gompertz and Pearl models. Before making forecasts for the future to show the rate of growth about the number of articles being published related to ERP, SAP and MRP keywords, the optimum values of the parameters of Gompertz curve have been investigated through Excel by using Solver. According to the solution obtained via Solver, the mathematical function of Gompertz curve may be typed as follows:

$$y = 256.87e^{-0.106e^{-3.816t}}$$

The number of articles being published for the future are forecasted by using Gompertz function above. Both the forecasts of the number of articles up to the year of 2050 and the published articles between 1997-2022 are depicted in Figure 13.
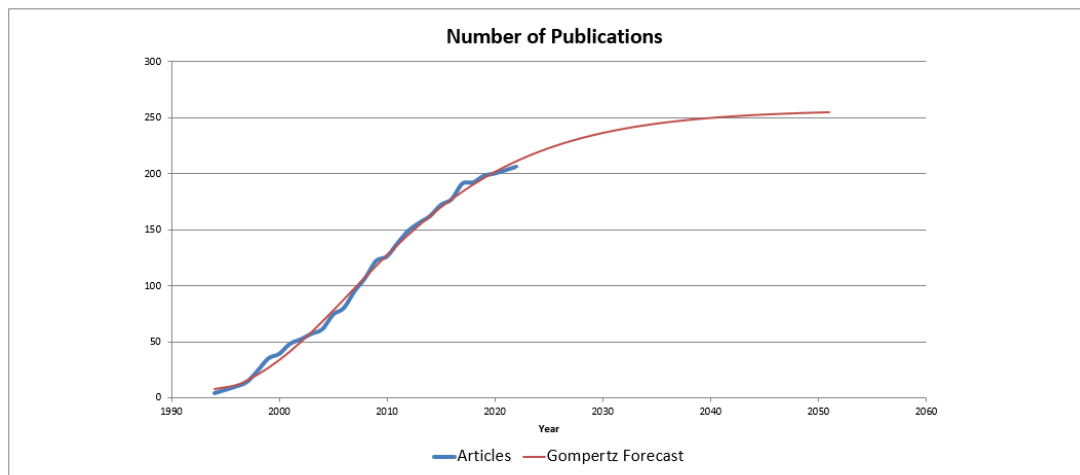

Figure 13. The Number of Articles Forecast via Gompertz Curve

Looking at the Figure 13, it is seen that the studies in the field have not reached saturation even in 2050, so it can be said that the field is still open to studies on this subject.

Similar analysis is conducted by using Pearl curve. The optimum values of the parameters of Pearl curve are investigated through Excel by using Solver. According to the solution obtained via Solver, the mathematical function of Pearl curve may be typed as follows:

$$y = \frac{200}{1 + 21.564e^{-0.233t}}$$

The number of articles being published for the future are forecasted by using Gompertz function above. Both the forecasts of the number of articles up to the year of 2050 and the published articles between 1997-2022 are depicted in Figure 14.
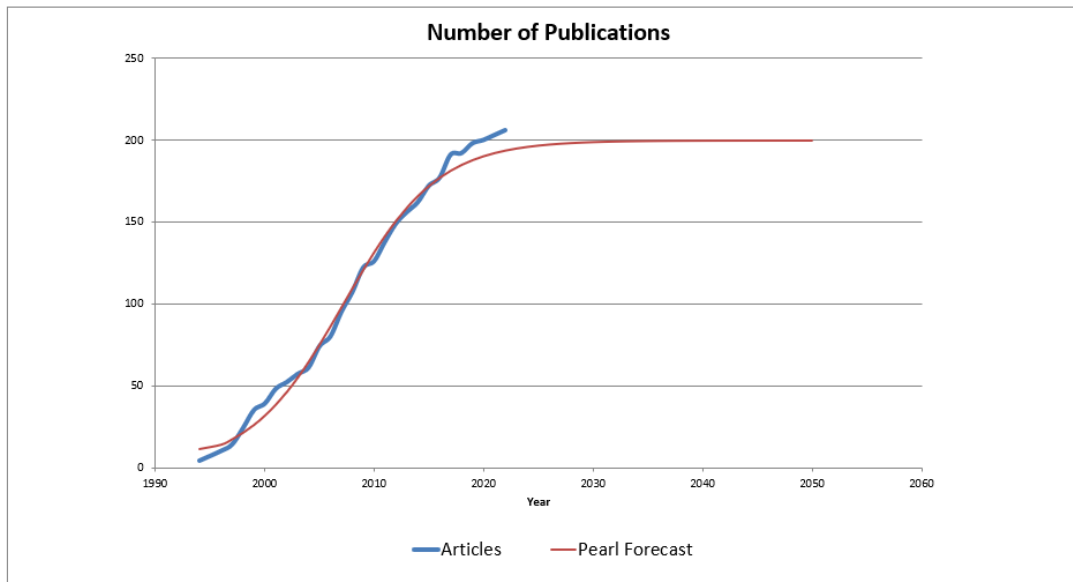

Figure 14. The Number of Articles Forecast via Pearl Curve

According to the Figure 14, it is seen that the studies in the field will reach saturation at the beginning of the 2030s, from this point of view, it can be said that the field is open to studies on this subject until 2030.

In order to evaluate the performances of Gompertz and Pearl curves, the error sum of squares have been calculated by considering each curve has the optimum values of parameters. While the Gompertz curve provided about 449.22 error, the error for the Pearl curve was appeared to be 1089.73. For this reason, it can be said that the Gompertz model fits the data better because it has smaller error.

CHAPTER 6: CONCLUSION AND FUTURE WORK

Today, the value of information in business has reached insurmountable proportions. Knowledge must be carefully handled in order to make the most use of finite resources. The ERP system, which tries to organize resources by integrating production and information systems, arose from the need for effective information management. This approach, which is regarded novel not only for Turkey but also for global markets, is expected to be explored and investigated for a longer length of time. In order to investigate the accuracy or consistency of this idea, studies in the fields of ERP, MRP and SAP were tried to be analyzed with the VOSviewer software.

The VOSviewer software, a text mining tool, can do bibliometric analysis of journals, analysis of specific topic areas, analyses to identify word density in studies, analysis of website content, analysis of student performances, analysis of theses, and co-authorship. Related terms in the field can be detected. On the other hand, important links in massive data may be made more detectable. The themes of a field or journal can be presented in clusters using the VOSviewer program's cluster density feature. Detailed analyses of the themes defined by the journals and the issues they publish can be presented. In-depth analyses and clusters can be used to construct interdisciplinary research.

Within the scope of this study, as a result of the research made with the keywords selected as a result of the scanning with WOS, different dimensions were analyzed, and cross-judgments were reached. For example, even though Turkey is among the most productive countries, it is not in the top ranks among the countries that collaborate. At the same time, although there is no Turkish author in the field of most productive authors, Turkey is at the top of the list of most productive countries.

According to the Pearl model, which has a sum of squares of error of 1089,73, the studies will reach saturation in 2030. As it is known, technology grows exponentially, so ERP, MRP and SAP systems will be replaced by other systems day by day, and for this reason, studies on ERP, MRP and SAP systems will be replaced by studies in other systems. For this reason, the prediction made with the Pearl model is consistent with the expectations.

Within the scope of future work, studies drawn from different databases within the same time interval can be uploaded back to Vosviewer and the outputs obtained from there can be interpreted and compared with the existing outputs. The similarities

and differences that emerged because of this comparison can be interpreted. At the same time, new results can be obtained by using different growth curves other than the growth curves used in the study, and these results can be compared with previous results or within themselves.

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