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INNOVATION AND PRODUCTIVITY RESEARCH IN THE LAST FIVE DECADES: A BIBLIOMETRIC ANALYSIS

İNOVASYON VE ÜRETKENLİK ARAŞTIRMALARININ SON ELLİ YILI: BİBLİYOMETRİC BİR ANALİZ

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ABSTRACT: Purpose: This study aims to reveal research trends by revealing the evaluation in this field by making a holistic analysis of academic studies that have examined the concepts of innovation and productivity in the last five decades. This analysis aims to reveal the general structure of academic studies that deal with the concepts of innovation and productivity. **Methodology:** Articles searched in the ‘‘Social Science Citation Index (SSCI)’’, ‘‘Science Citation Index Expanded (SCI-EXPANDED)’’ and ‘‘Emerging Sources Citation Index (ESCI)’’-in the ‘‘Web of Science (WoS)’’ database, researching innovation and productivity together between 1980-2023. It was analysed and mapped using the VOSviewer 1.6.19 software and manual methods. Co-occurrence Keyword Analysis, Document Co-citation Analysis and manual analysis methods were used in the mapping. **Findings:** This study reveals how research in innovation and productivity has developed over the last five decades and what trends it has. It has been determined that the most published areas are Economy, Management and Business. The most frequently used keywords were found to be "innovation", "productivity", "research-and-development", "growth", "performance" and "impact". The most published topics on a cluster basis are "impact", "innovation and productivity", "growth", "research and development" and "performance", respectively. In the document co-citation analysis, it was determined that the publication in which all publications were linked included the study titled "Research, Innovation and Productivity: an econometric analysis at the firm level", published by Crépon et al. (1998). This information can be a valuable resource for future research and policy-making and can be used to drive innovation and productivity progress. **Originality:** While the study is the first and only content analysis to reveal the combined trends in this field by examining the "innovation and productivity" studies together, it is thought that the results obtained can guide researchers and professionals.

Key Words: Innovation, Productivity, Bibliometric Analysis, VOSviewer

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ÖZ: Amaç: Bu çalışma, son elli yılda inovasyon ve üretkenlik kavramlarını inceleyen akademik çalışmaların bütüncül bir analizini yaparak bu alandaki araştırma eğilimlerini ortaya koymayı amaçlamaktadır. Bu analiz çalışması aynı zamanda inovasyon ve üretkenlik kavramlarını ele alan akademik çalışmaların genel yapısını da ortaya koymayı amaçlamaktadır. **Metodoloji:** ‘‘Web of Science (WoS)’’ veri tabanında ‘‘Social Science Citation Index (SSCI)’’, ‘‘Science Citation Index Expanded (SCI-EXPANDED)’’ ve ‘‘Emerging Sources Citation Index (ESCI)’’ atıf indeksinde taranan, 1980 -2023 yılları arasında inovasyon ve üretkenliği bir arada çalışan makaleler bu araştırmada kullanılmıştır. Bulgular, VOSviewer 1.6.19 yazılımı ve manuel yöntemler kullanılarak analiz edilerek haritalandırıldı. Haritalamada Birlikte Oluşum Anahtar Kelime Analizi, Döküman Ortak Atıf Analizi ve Manuel Analiz yöntemleri kullanılmıştır. **Bulgular:** Bu çalışma, inovasyon ve üretkenlik araştırmalarının son elli yılda nasıl geliştiğini ve hangi eğilimlere sahip olduğunu ortaya koymaktadır. En çok yayın yapılan alanların Ekonomi, Yönetim ve İşletme olduğu saptanmıştır. En sık kullanılan anahtar kelimeler "innovation","productivity", "research-and-development", "growth” “performance" ve "impact" olduğu bulunmuştur. Cluster bazında en çok yayın yapılan konuların sırasıyla “impact”, “innovation and productivity”, “growth”, “research and development” ve “performance” olduğu bulunmuştur. Döküman Ortak Atıf analizinde tüm yayınların birbirine bağlandığı yayının Crépon vd. (1998) yılında yayımladığı ‘‘Research,Innovation and Productivity: an econometric analysis at the firm level’’ isimli çalışmasının yer aldığı tespit edilmiştir. Bu bilgi, gelecekteki araştırmalar ve politika oluşturmak için değerli bir kaynak olabilir, inovasyon ve üretkenlik araştırmalarının gelişimini yönlendirmek için kullanılabilir. **Özgünlük:** Çalışma “inovasyon ve üretkenlik” çalışmalarını bir arada inceleyerek bu alandaki ortak eğilimleri ortaya koyan ilk ve tek içerik analizi olmakla birlikte, elde edilen sonuçların araştırmacılara ve profesyonellere yol gösterici olabileceği düşünülmektedir.

Anahtar Kelimeler: İnovasyon, Verimlilik, Bibliyometrik Analiz, VOSviewer

1. INTRODUCTION

In recent years, interest in innovation and productivity studies has increased noticeably. Due to its significant interest, researchers have extensively studied innovation and its links to economic growth. It is a widely explored topic in the literature, as understanding how innovation drives economic progress is crucial for advancing economies (Pece et al., 2015: 462). Similarly, the importance of productivity in enhancing operational, organizational, industrial, and national competitiveness has been widely acknowledged (Phusavat, 2013: 23). Efficiently managing all input sources, including labour, capital, energy, and raw materials, is a critical determinant of productivity growth within an industry (Okafor, 2013: 245). Moreover, both innovation and productivity stand as pivotal factors contributing to economic prosperity and overall success.

Bibliometric analysis has become increasingly popular in the field of business research in recent years (Donthu et. al., 2021: 285). The term "bibliometrics", which means "the use of mathematical and statistical techniques in the analysis of books and other forms of communication", was introduced to the literature by Pritchard

(1969) (Estabrooks et. al., 2004: 294). Bibliometric analyses, commonly known as bibliometrics, offer valuable insights into expanding literature and disseminating knowledge within specific academic research domains. By employing empirical data and quantitative analysis, bibliometrics traces formal communications manifested in published literature, thereby facilitating the examination of publication patterns within a given field. Fundamental to this approach is the underlying assumption that research papers serve as vehicles for sharing knowledge generated through scientific research (Okubo, 1997: 8-9).

Bibliometric analysis is a quantitative method used to study and analyse scientific literature based on bibliometric data. It includes analysing the publication and citation patterns of articles, books, and journals to measure scientific research's impact (Donthu et al., 2021: 286). The utilization of transparent and repeatable search and review procedures results in enhanced reliability of outcomes and decreased subjective bias of literature reviews, as suggested by several studies (Bretas & Alon, 2021:52). Additionally, this method can discern the presence of collaborative networks among researchers within the field or identify individual scholars working in isolation. Furthermore, an increase in the number of references per paper can indicate the progressive maturation of the field as a recognized scientific discipline over time (Estabrooks et al.. 2004: 294). Bibliometrics is a widely utilized approach in various fields, including economics (Bonilla et al., 2015), innovation (Fagerberg et al., 2012), entrepreneurship (Landström et al., 2012), management (Podsakoff et al., 2008), and marketing (Martínez-López et al., 2018). By utilizing these metrics, bibliometrics enables researchers to assess the body of literature in a given field (Khan et al., 2021: 296).

In the literature, there are separate bibliometric studies on the concepts of innovation and productivity, which are widely used. However, no bibliometric analysis study has been found in the literature that examines the concepts of ‘‘innovation and productivity’’ simultaneously. Based on this gap, the current study aims to reveal how innovation and productivity research has developed in the last fifty years and what trends it has. Due to the rapid changes in the field of innovation, the existence and number of academic studies in this field are also increasing. This provides us with the opportunity to evaluate the current literature. The biggest motivation of this study is to reveal the relationship between innovation and productivity in terms of academic studies in this age where transformation is accelerating. Based on this gap in the literature, the need to carry out studies that deal with the concepts of “innovation and productivity” together between 1980-2023 in a way that covers all fields arose. To locate the certain literature, search was defined based on two specific keywords together. This research condition includes all published papers that contain the expression ‘‘innovation and productivity’’ simultaneously in “title” as it is the question of this study. However, strict inclusion

and exclusion criteria were also defined on purpose. Within the scope of this study, book chapters, conference proceedings and other similar documents in WoS databases were not evaluated. For this purpose, the articles scanned in the ‘‘Social Science Citation Index (SSCI)’’, ‘‘Science Citation Index Expanded (SCI-EXPANDED)’’ and ‘‘Emerging Sources Citation Index (ESCI)’’ between 1980 and 2023 on the Web of Science database were examined. In addition, this study did not focus on a particular area. In order to observe the intellectual development and evolution of the concept more accurately, no field distinction has been made in the current study.

In analysing the data obtained, maps related to the data were presented using the VOSviewer 1.6.19 software version. Coherent fields of work are often examined using commonly employed techniques such as co-citation and co-occurrence methods. In the current study, these methods describe the fundamental structures of innovation and productivity studies within the literature. This analysis aims to reveal the general structure of academic studies that deal with the concepts of innovation and productivity.

The next sections of the study are structured as follows: In the next section, there is a literature review on the concepts of innovation and productivity. The following sections are devoted to the study's method, findings and results.

2. CONCEPTUAL FRAMEWORK

In this section, the concepts of Innovation and Productivity are examined. Studies examining the two concepts together have taken place in the literature since 1980.

2.1. Innovation

Joseph A. Schumpeter emphasised the significance of innovation and defined it as a novel product that has yet to be introduced to the market. Additionally, he recognised innovation as a fresh approach to production, utilising new raw materials, exploring new business sectors, adopting innovative financial methods, and implementing novel organisational structures (Schumpeter, 1934: 66). Many of the studies in the following years reference Schumpeter's first definition (Barutçugil, 2019: 15).

Nowadays, the most accepted definition of innovation comes from the Oslo Manual published jointly by the OECD and Eurostat (Vural, 2022: 308). According to the Oslo Manual, innovation is defined as "the realisation of a new or significantly improved product (good or service) or process, a new marketing method or a new organisational method in business practices, workplace organisation or external relations"(OECD & Eurostat, 2005: 46; OECD & Eurostat, 2018: 20). In the basic dynamic of innovation, there are innovations that are not only new but also transformed into an economic and social added value (Karabulut & Karamızrak,

2020: 63). In this sense, accepting innovation as the most critical factor for businesses also depends on the profit obtained from it.

However, today it cannot be thought that this economic situation is shaped independently by environmental or social conditions. For this reason, it is inevitable for the concept of innovation to transform into the idea of sustainable innovation, which includes environmental and social dimensions, to realise sustainable development. In recent years, the issue of sustainable innovation has been at the top of the agenda of many companies (Çalık, 2021:186).

2.2. Productivity

The German scientist Georgius Agricola used the concept of productivity for the first time in the literature (Suiçmez, 2002: 170). Productivity, commonly defined as the ratio of output to input in the economics literature, is closely related to the use of resources and value creation. In other words, productivity measures how effectively production inputs such as labour and capital are used to produce at a certain level in an economy (Krugman, 1994: 1). The concept of productivity is sometimes used synonymously with efficiency, and high productivity calculated at the enterprise level indicates that that organization is effective (Özer, 2017: 8).

Dividing outputs by inputs allows us to assess the productivity of resource utilization in producing desired outputs. This analysis provides valuable insights into how effectively inputs, which serve as resources, are employed to generate the desired outcomes. These insights serve as a basis for analysing and improving resource allocation. One can observe the resulting impact on output levels by enhancing resource efficiency. If the perspective is reversed, the analysis can be approached from a control standpoint, enabling better management and regulation of resource utilization during production (Phusavat, 2013: 25). Productivity measurements may also vary depending on the calculation unit and the input type. It can be calculated based on a single, multiple, or entire input. Based on the number of inputs taken into account, it is called partial productivity, multi-factor productivity, and total productivity (Aydın, 2018: 47).

According to some scientific discussions, productivity is regarded as a key variable influencing economic production activities, making it the most crucial factor (Tangen, 2002: 18). Productivity is a key performance measure for processes and businesses, as well as for industries and economies (Krajewski et al., 2010: 19). To comprehend the factors driving productivity, it is essential to understand that economies can achieve medium and long-term growth through three avenues: expansion of the workforce, overall improvement in productivity, and an increase in the proportion of economic activity in high-productivity industries (Atkinson, 2013: 4). Research on productivity is essential for developing and implementing effective strategies to improve in these areas.

3. METHODOLOGY

This section gives information about the details of the procedure and data, types of analysis based on the current bibliographic study and the VOSviewer software program used.

3.1. Procedure and Data

In the current research, the contents indexed in Web of Science (WoS) were used as a database. While determining the data set of this research, only journals were selected because journals were perceived as "qualified information sources". "Book chapters", "conference papers", and other similar documents in WoS databases were not evaluated. This current research is based on top-ranked articles that have seen competitive reviews and can provide reliable findings (Akbari et al., 2020: 1809). This research condition covers all journal articles containing the phrase "Innovation and Productivity*" in "Titles", such as the question of this study. This research condition also seeks to identify the connections between journal articles that specifically explore the relationship between innovation and productivity. Therefore the search will focus on ''titles'' of articles that include the keywords "Innovation and Productivity" together.

The search was based on "all years" to get a wide range of journal data. In the research conducted on May 3, 2023, by selecting "all fields" with the keyword "innovation and productivity", 37.344 research results were reached. The earliest documents retrieved from WoS date back to 1980. Applying a selection criterion of "titles" with the keyword "innovation and productivity," 727 research results were obtained on May 3, 2023. When refining the indexes "SSCI", "SCI-Expanded", and "ESCI", that number dropped to 619. When refined the document types to only "journals", that number dropped to 528. The dataset comprised 528 documents, with 96.59% of them being published in the English language. There were a total of 18 papers in other languages, such as Spanish (12), German (2), Russian (2), Arabic (1), and French (1), which were not included in this study. When non-English publications were eliminated, 510 published documents from 1980–2023 were collected.

In this last data set obtained, the WoS database determined that there were documents from various research areas. The majority of the publications, comprising approximately 82.74% of the total documents in the WoS collection, were concentrated in the fields of ''Economics'' (238) at 46.667%, ''Management'' (102) at 20%, and "Business" (82) at 16.078%. These three categories emerged as the most productive areas within the WoS collection. The other areas in the top ten areas were ''Environmental Sciences'' (53) %10,392, ''Environmental Studies''(35) %6,863, ''Green Sustainable Science Technology''(23) %4,510, ''Development Studies''(21) %4,118, ''Engineering Industrial''(19) %3,725, ''Regional Urban Planning''(18) %3,529, ''Multidisciplinary Sciences''(16) %3,137.

The main organizations in our sample were “Maastricht University” (17 records), “University of London” (11), “University of California System” (9), “University of California Berkeley” (8), “Arizona State University” (7), “Seoul National University” (7), “Udice French Research Universities” (7) “Consiglio Nazionale Delle Ricerche” (6) and “Indian Institute of Technology System IIT System” (10).

Firstly, on this data set obtained from WoS, the Number of Publications by Year and The Number of Citations by Year were examined, and their graphics were created. In addition, the data set was examined in the context of the analysis to be made in VOSviewer on the WoS database. Co-occurrence Keyword Analysis and Document Co-citation Analysis were performed with the same data set transferred to the VOSviewer database. The visual maps created through the program were provided to visualize the variables associated with the maps.

3.2. Analytical Methods

The techniques used in bibliometric studies can be categorized as relational or evaluative techniques (Benckendorff & Zehrer, 2013: 126). The current study used relational techniques that explore relationships within research, such as keyword co-occurrence and co-citation documents analysis. An evaluative approach was used to evaluate the development and change of publications through descriptive analyses (Agapito, 2020: 3). Co-citation and co-occurrence analyses are commonly used methods to consider coherent fields of work (Akbari et al., 2020: 1808). As advised in the literature, bibliometric analyses were combined with manual studies (Sinkovic, 2016: 330). This process is detailed in the analysis section.

3.2.1. Co-citations Analysis

The word co-citation is used to refer to two separate processes in various science mapping studies (Boyack & Klavans, 2010: 2391). Co-citation methods measure the frequency with which two documents are cited together and are commonly used techniques to identify areas of consistent work. Two articles that are frequently cited jointly are also highly cited separately. Examining patterns of co-citations allows for detailed mapping of the relationship between key ideas, as these types of articles are assumed to form the foundations of a field. (Small, 1973: 265). This mapping reveals the common perception of all researchers working in that field and the structure of the field, not the judgment of a small group of experts. This method is accepted as dynamic and objective as it changes with the shifts in the focus of research efforts in a field (Culnan, 1987: 343). This provides a more objective way of modelling the intellectual structure of scientific specializations (Small, 1973: 266). Thanks to the co-citation analysis, it is understood that it is possible to identify the past sources that are related to each other, although they do not cite each other (Zan, 2019: 504).

In co-citation analysis, the unit of analysis is either authors or documents. Since the same author is likely to work in more than one sub-field, this study is based on the latter, as the author's common citation patterns may need to reveal the structure of the field. Unlike authors, documents are less likely to be included in multiple sub-domains (Özçınar, 2015: 44). Besides this, co-citation clustering approaches derive significant advantages from the utilization of external references, as these references can also constitute elements within common citation sets (Boyack & Klavans, 2010: 2391).

3.2.2. Co-occurrence Analysis

Co-occurrence analysis, analysing the relationships between terms based on their frequency of occurrence together in a given dataset, such as a set of scientific articles. VOSviewer identifies clusters of terms that frequently co-occur and represents them as coloured clusters in the network map. Terms that are closely related or often mentioned together will be placed closer to each other on the map (Van Eck & Waltman, 2023: 5-6). The concept of co-occurrence in publications refers to the frequency of association between one author's keyword and another. Through lexical analysis, this co-transition creates a network of themes and their relationships, representing a field's conceptual domain (Agapito, 2020: 4).

Keyword analysis helps identify the most commonly discussed topics in bibliometric analysis, and it has been found that articles covering multiple disciplines tend to have a more significant impact (Ellegaard & Wallin, 2015: 1809). Co-occurrence keyword analysis reveals a network of themes representing the conceptual domain of a field and the relationships between them. This type of semantic map facilitates researchers in comprehending the cognitive framework underpinning the research. Such a series of maps produced for different periods helps to understand the changes in this conceptual area (Köseoğlu et al., 2016: 183). This research employs co-occurrence keyword analysis to track the evolution of the conceptual field and map the thematic progression within the domain of innovation and productivity.

3.3. Software

VOSviewer is a computer program designed to construct and investigate maps derived from network data. While its primary purpose is the analysis of scholarly records, VOSviewer can be applied to various types of network data, including social networks. The most outstanding feature of VOSviewer is its particular emphasis on the graphic display of bibliometric maps (Van Eck & Waltman, 2010: 523). By employing VOSviewer, researchers gain valuable insights into academic literature's structural and thematic aspects and other networked information domains.

The program offers three types of visualisation maps: network, overlay and density visualisation. These maps allow users to explore and analyse co-authorship, co-occurrence, citation, bibliographic coupling, and co-citation links (Arruda et al.,

2022: 392). The network visualisation view presents concepts by their significance. The concept's importance is indicated by the size of the label and the circle, with larger sizes denoting greater importance. Additionally, the circle's colour represents the cluster to which the term belongs. The density visualisation view demonstrates the significance of specific regions on the map by considering the number of related items. Researchers can select the cluster density view within the density visualisation, which reveals how items are grouped into clusters and their respective densities (Sinkovics, 2016: 333). In the overlay visualisation map, item colours are determined by transforming their scores into colour values within a specified range. These colour values are then matched with the values in the overlay colours file, and the item's colour is determined by interpolating between two colours in the file. (Van Eck & Waltman, 2023: 44). All three types of visualisation maps are used in the current study by their purpose.

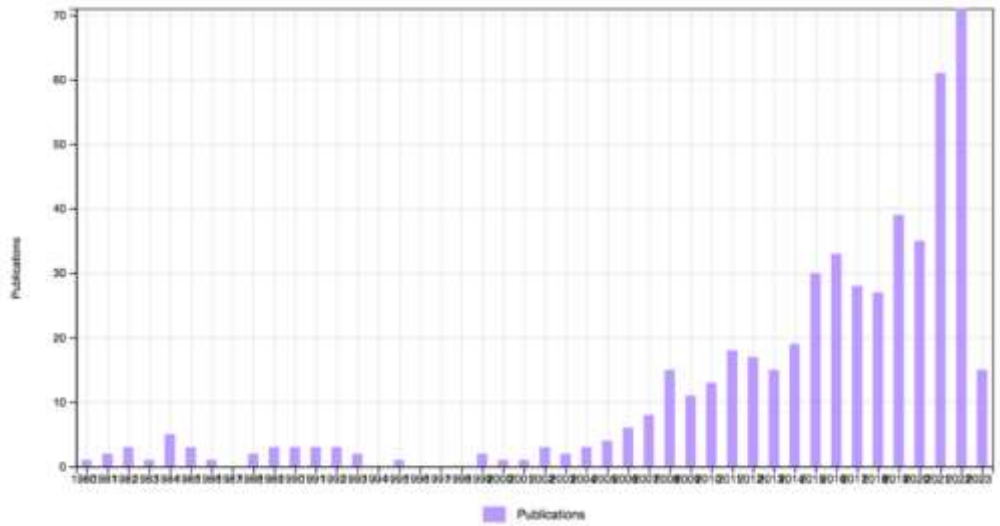
4. FINDINGS

This section gives information about the details of findings of analysis based on the current bibliographic study.

4.1. Publication Trends

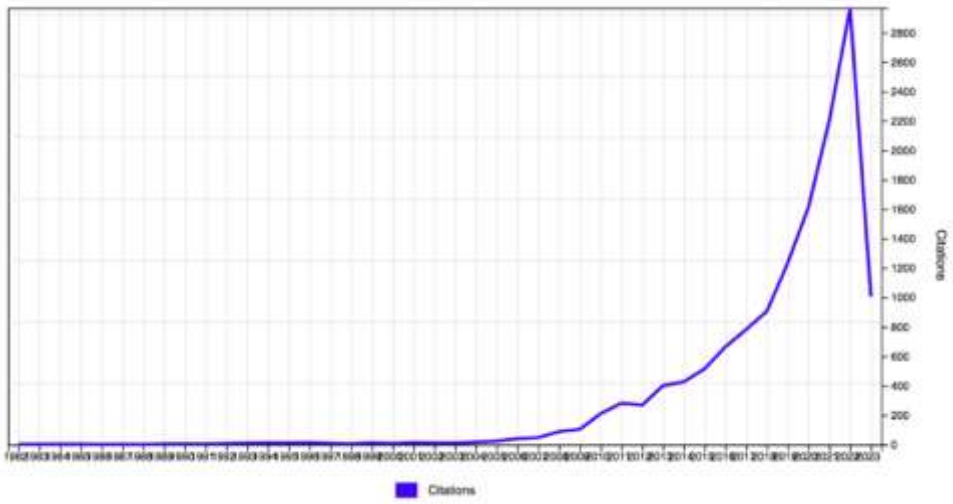
In the Web of Science database, 510 (n=510) studies were found on the topic of “innovation and productivity” and published between 1980-2023. The distribution of the studies conducted over the years is shown in Table 1.

Table 1: Number of Publication by Year



It was determined that most publications were published in 2022 (n=71). The number of publications in 2023 will become apparent after the end of the year.

Table 2: Number of Citations by Year



Although the number of publications has fluctuated, it is understood that there have been more publications in the last decades (ten years) compared to before 2013. To express numerically, it has been observed that 373 of a total of 510 publications, i.e. 73,137%, were published in the last ten years.

4.2. Co-occurrence Keyword Analysis

In this section, the co-occurrence analyses are made in line with the purpose of the research. Concept association of the studies included in the research was carried out in the keyword analysis unit, and the results were mapped as in the section below.

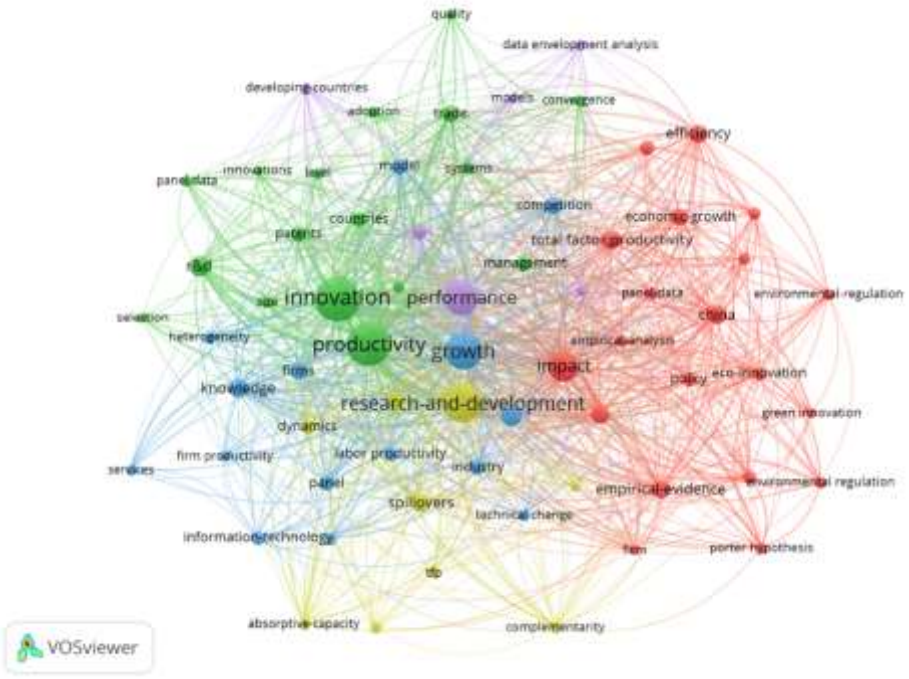


Figure 1: Co-occurrence of Keywords on Innovation and Productivity Researches Network Visualization

A total of 1859 keywords were found in the studies on "innovation and productivity" between 1980 and 2023 in the Web of Science database. When the found keywords are evaluated within the minimum ten repetition constraints, 67 keywords have been identified. According to this analysis, "innovation" 175 times, "productivity" 171 times, "research-and-development" 137 times, "growth" 119 times, "performance" 109 times, "impact" 83 times, "technology " 42 times, "r&d" 36 times, "china" 35 times, "total factor productivity" 34 times, "knowledge" 33 times, "efficiency" 31 times, "determinants" 29 times, "spillovers" 29 times, "empirical evidence" 28 times, "investment" 27 times, "competition" 26 times, "trade", "economic growth" and "firms" 25 times were used. This analysis shows us which variables are used more intensely in the literature with "innovation and productivity ". These findings help researchers who want to study this subject contribute differently to the literature.

Table 3: Core topic in each cluster

Author Keywords	**Occurrences**	**Total Link Strength**
Innovation	175	700
Productivity	171	660
research-and-development	137	642
Growth	119	502
Performance	109	494
Impact	83	398
Technology	42	182
r&d	36	168
China	35	140
total factor productivity	34	113
Determinants	29	148
Spillovers	29	122
empirical evidence	28	169
Investment	27	126
Competition	26	103
Trade	25	125
economic growth	25	101
Firms	25	100

Table 3 details the total link strength of the keywords, while Figure 2 shows the density visualization. When both are examined together, it is seen that six words stand out. The first six keywords with the most repeated and high total link strength are innovation (occurrences=175, total link strength=700), productivity (occurrences=171, total link strength=660), research-and-development (occurrences=137, total link strength=642), growth (occurrences=119 times, total link strength=502), performance (occurrences=109 times, total link strength=494), impact (occurrences=83 times, total link strength=398), respectively.

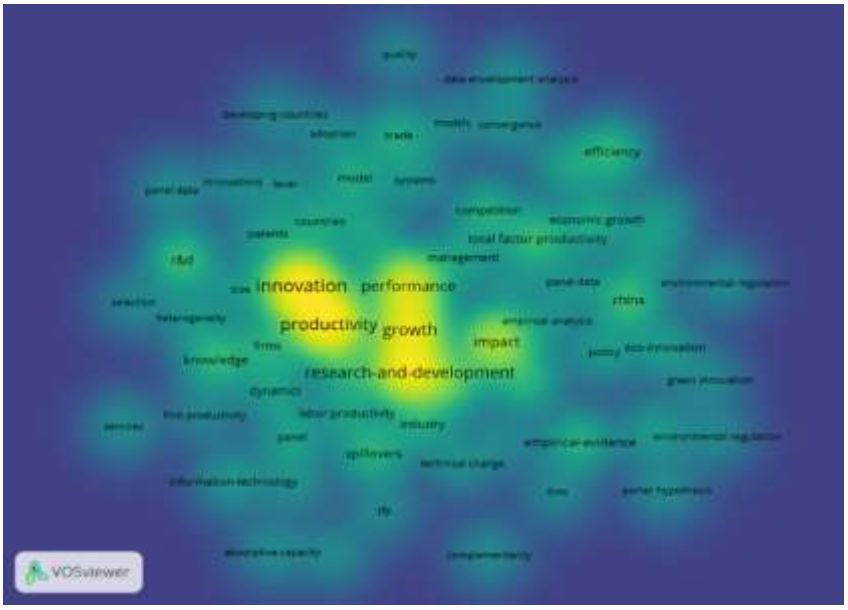


Figure 2: Co-occurrence of Keywords on Innovation and Productivity Researches Density Visualization

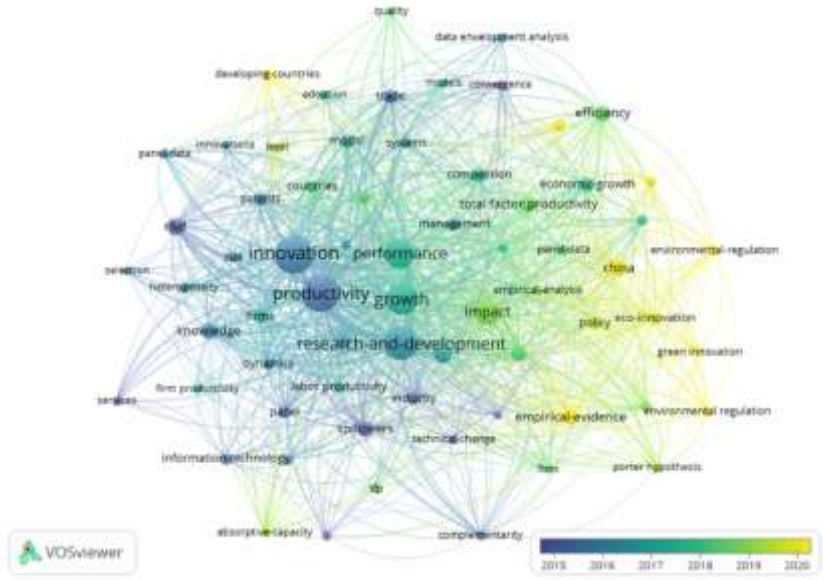


Figure 3: Co-occurrence of Keywords on Innovation and Productivity Researches Overlay Visualization

The colour scale that opens from dark blue to yellow in Figure 3 represents time (Gökmenoğlu & Yavuz, 2020: 240). When the change of keywords over time is examined, it is seen that the most used keywords are also used in the 2015-2020 time period.

At this stage, the keywords are grouped into five clusters. In order to analyse the clusters, the data set in WoS was downloaded, and the keywords, titles and abstracts in each cluster were examined. Table 4 shows five clusters gathered around a main topic within themselves. These topics are "impact", "innovation and productivity", "growth", "research and development", and "performance". The first cluster encompasses keywords such as China, CO2 emissions, competitiveness, determinants, eco-innovation, economic growth, efficiency, empirical analysis, empirical evidence, environmental regulation, firm, foreign direct investment, green innovation, impact, panel data, policy, Porter hypothesis, technological innovation, and total factor productivity, is indicative of the theme "impacts of innovation and productivity". The second cluster is about "innovation and productivity core topics". This cluster includes keywords in the core field, including innovation, innovations, productivity, management, adoption, level, panel data, selection, convergence, countries and firm-level keywords such as patents, r&d, quality, size, systems, manufacturing firms and trade. The next cluster contains keywords related to "growth", including competition, firm productivity, firms, growth, industry, knowledge, technology and labour productivity. The fourth cluster revolves around keywords associated with "research and development", while the fifth cluster is primarily centred on the theme of "performance".

Table 4: Main Topics in Clusters

Cluster	Keywords and Main Topic Details
Cluster I	20 items: china, co2 emissions, competitiveness, determinants, eco-innovation, economic-growth, efficiency, empirical-analysis, empirical-evidence, environmental regulation, firm, foreign direct-investment, green innovation, impact, panel-data, policy, porter hypothesis, technological innovation, total factor productivity. **Main Topic: Impact**
Cluster II	17 items: adoption, convergence, countries, innovation, innovations, level, management, manufacturing firms, panel-data, patents, productivity, quality, r&d, selection, size, systems, trade. **Main Topic: Innovation and Productivity**
Cluster III	15 items: competition, firm productivity, firms, growth, heterogeneity, ict, industry, information-technology, knowledge, labor productivity, model, panel, services, technical change, technology. **Main Topic: Growth**
Cluster IV	9 items: absorptive-capacity, complementarity, dynamics, firm-size, information technology, investment, research-and-development, spillovers, tfp. **Main Topic: Research and Development**
Cluster V	6 items: cdm model, data envelopment analysis, developing countries, firm performance, models, performance **Main Topic: Performance**

4.3. Document Co-citation Analysis

Figure 4 depicts the cited references associated with innovation and productivity. The network comprises 18,756 cited references, each of which has received a minimum of 20 co-citations. This significant citation count has led to the inclusion of 39 nodes representing particular articles within the network. According to the co-citation investigation, three distinct clusters were identified. The map reveals a total of 686 links, indicating the relationships between different references, with an aggregate link strength of 4031. In Figure 4, each cluster is visually distinguished by a unique colour. Figure 4 shows a network with three interconnected clusters: A, B, and C. These clusters are linked based on the findings presented in the research paper titled ‘‘Research, Innovation and Productivity: an econometric analysis at the firm level’’, authored by Crépon et al. in 1998. The network structure displayed in Figure 4 offers a relatively straightforward representation of the interconnections between these clusters.

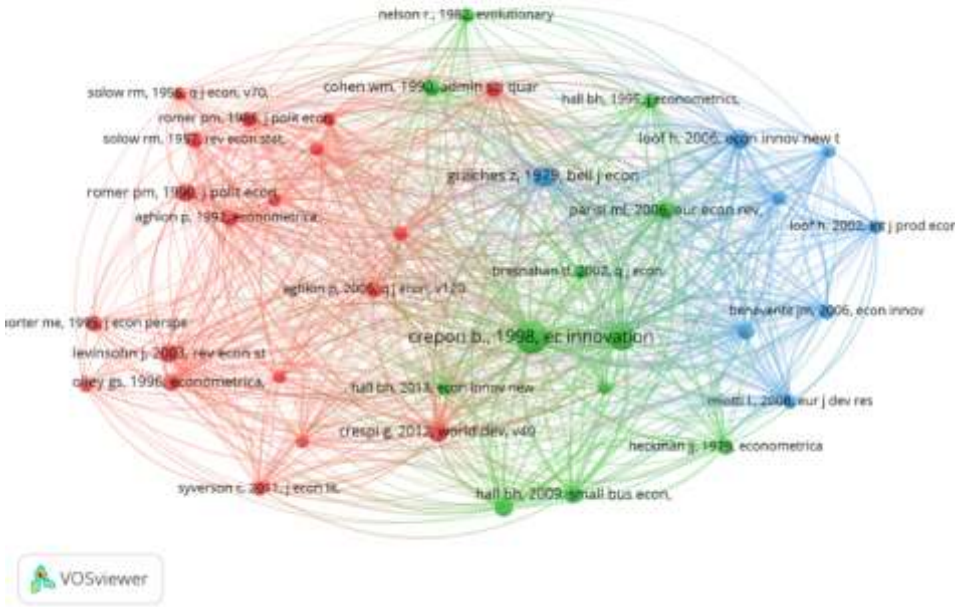


Figure 4: Co-citation Analysis of Documents on Innovation and Productivity Researches Network Visualization

The number of co-citations for more than one study of the same documents with other authors was calculated in this map. According to this, Crepon (1998) 123 citations, Griffith (2006) 86 citations, Griliches (1979) 57 citations, Lööf (2006) 47 citations, Crespi (2012) 45 citations, Parisi (2006) 43 citations, Hall (2009) 43 citations, Levinsohn (2003) 43 citations, Mohnen (2013)) 42 citations, Romer (1990) 40 citations, Olley (1996) 37 citations, Cohen (1990) 36 citations, Chudnovsky (2006) 33 citations, Cohen (1989) 33 citations, Solov (1957) 33 citations, Porter (1995) 32 citations, Aghion (1992) 31 citations, Benavente (2006) 28 citations, Aghion (2005) 28 citations, Heckman (1979) 27 citations were received.

Figure 5 shows the Clusters Density Visualization of Co-citation Analysis of Documents on Innovation and Productivity Researches. This map helps us understand clusters. As can be easily seen from the map, the papers examining innovation and productivity together are basically gathered under 3 clusters.

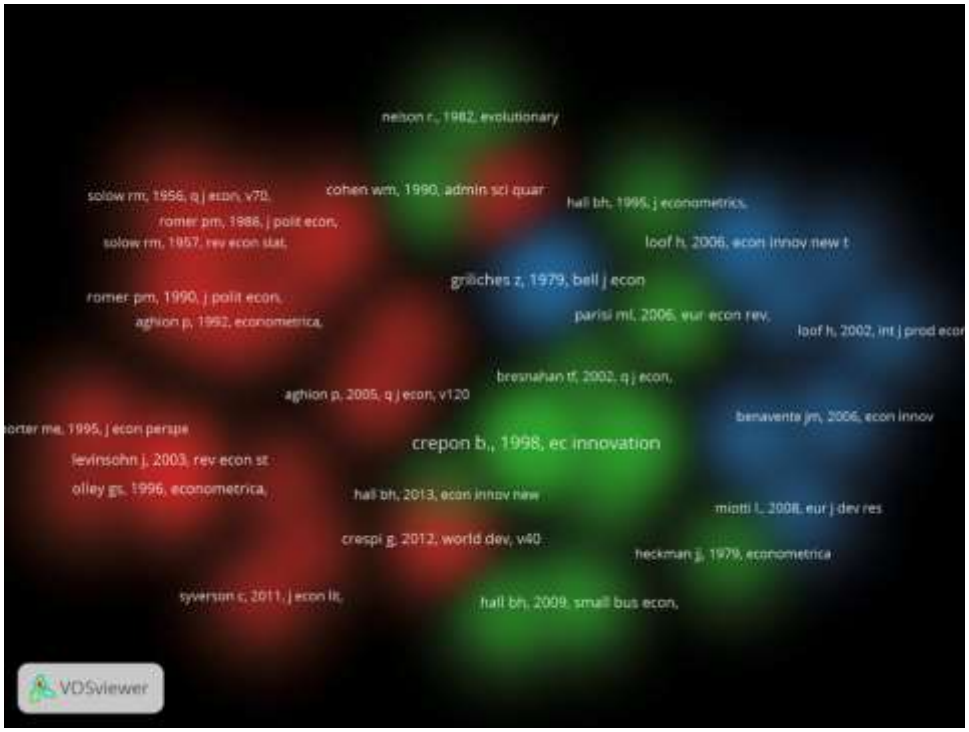


Figure 5: Co-citation Analysis of Documents on Innovation and Productivity Researches Clusters Density Visualization

Table 5 gives the author/references, links, total link strengths and co-citation details of the studies in these clusters. These studies listed in Table 5 were brought together manually, as suggested in the literature. The first five papers with the highest "total link strength" representing each cluster were also manually examined in this table. As a result of this examination, it has been observed that the studies in Cluster A are in the field of ‘‘Economic Studies’’, the studies in Cluster B are in the area of ‘‘Innovation and Productivity Studies’’, and the studies in Cluster C are in the field of ‘‘Production Economies’’. In all clusters, it has been observed that there are studies on a firm basis, on a country basis, and on a cross-country basis.

Cluster A consists of economic studies. Among them, Crespi and Zuniga (2011), which has the highest total link strength with the number 309, deals with the world development theme. This study used microdata from innovation surveys to investigate the determinants of technological innovation and its impact on firm labour productivity in six Latin American countries (Crespi & Zuniga, 2011: 273). Levinsohn and Petrin (2003), one of the studies that stand out with 202 total link strength in the second place in this cluster, categorized their studies in the field of Economic Studies (Levinsohn & Petrin, 2003: 317). The following research by

Cohen and Levinthal (1989) has a total link strength of 189. In their work, the duo examines innovation and learning as outputs of R&D with economic models over a large sample (Cohen & Levinthal, 1989: 569). The fourth study is by Olley and Pakes (1996), with 184 total link strengths. In this study, which examines productivity dynamics, the development of productivity at the factory level for the industry is analysed with economic models (Olley & Pakes, 1996: 1263). The fifth study by Romer (1990) has a total link strength of 178. This study analyses how knowledge provides a direct return equal to its private marginal productivity for long-run economic growth (Romer, 1990: 1027).

The central theme of the studies in Cluster B is Innovation and Productivity Studies. It has been observed that the analysis unit of the studies in this cluster is mainly firm level, but there are also studies in the country and continent units. Being at the centre of all networks with the 730 Total Link Strength, Crepon et al. (1998) are also included in this cluster. This article examines the links between productivity, innovation and research at the firm level (Crepon et al., 1998: 115). Griffti et al. (2006) study ranked second in this cluster with 600 Total Link strengths. This study examined innovation's role in productivity in some European countries (Griffti et al., 2006: 483). The Total Link Strength of the Parisi(2006) study, ranked third in this cluster, is 320. The analysis unit of this study is firm level. This study provides empirical evidence of the impact of R&D on innovation and the impact of different types of innovation on productivity (Parisi et al., 2006: 2037). Mohnen and Hall's (2013) study with the theme of Technological Change has 311 Total Link Strength. This study focused on the effects of technological and non-technological innovations on firms' productivity (Mohnen & Hall, 2013: 47). The fifth study, Hall et al. (2009), has a total link strength of 287. This study presented a structural innovation model considering R&D expenditures and productivity measures (Hall et al., 2009: 13). Another remarkable study in this cluster is the study of Cohen & Levinthal (1990). The unit of analysis of this study is the final level. The study examines the critical importance of firms' absorptive capacity for innovation capability as a function of their previous relevant knowledge level (Cohen & Levinthal, 1990: 128).

The studies in Cluster C are mainly united under the main theme of "production economies". In this cluster, it has been observed that there are researches at the firm level or country level as an analysis unit. The highest Total Link Strength, 387 in this cluster, belongs to the study of Lööf and Heshmati (2002). This firm-level study examines the relationship between innovation and firm performance (Lööf & Heshmati, 2002: 61). The following study is Griliches (1979), with 367 total link strength, and is on productivity growth (Griliches, 1979: 92). The third study is Chudnovsky et al. (2006) related to the subject of firm behaviour, and it has 289 Total Link Strengths (Chudnovsky et al., 2006: 267). On the other hand, Miotti et al. (2008) is a study comparing transcontinental countries based on innovation and has

242 Total Link Strengths (Miotti et al., 2008: 219). Benavente (2006), with 241 Total Link Strength, linked the innovation and productivity subjects to the research variable. At the beginning of this study (2006), Benavente states that the study continues the empirical research line of work by Crepon et al.(1998) study's (Benavente, 2006: 301). Crepon et al. (1998) study also appeared in this bibliometric analysis study as the main document linking innovation and productivity studies (See. Figure 4). Also, Jefferson et al., who associated this cluster with R&D. (2006) and Knowledge capital-focused Lööf and Hashmati (2006) support and enrich the cluster (Jefferson et al., 2006: 345; Lööf & Hashmati, 2006: 317).

Table 5: Cluters Details

Cluster A				**Cluster B**				**Cluster C**			
Main Topic: Economic Studies				**Main Topic: Innovation and Productivity Studies**				**Main Topic: Production Economies**			
19 items				*12 items*				*8 items*			
Author / References	**Links**	**TLS**	**CC**	**Author / References**	**Links**	**TLS**	**CC**	**Author / References**	**Links**	**TLS**	**CC**
Acemoğlu (2006)	35	114	20	Bresnahan (2002)	34	111	24	Benavente (2006)	36	241	28
Aghion (1992)	36	169	31	Cohen (1990)	37	151	36	Chudnovsky (2006)	35	289	33
Aghion (2005)	36	142	28	Crepon (1998)	38	730	123	Griliches (1979)	37	367	57
Aghion (2009)	37	124	24	Griffith (2006)	38	600	86	Jefferson (2006)	34	184	20
Cohen (1989)	36	189	33	Hall (1995)	35	167	27	Lööf (2002)	33	191	25
Crespi (2012)	38	309	45	Hall (2009)	38	287	43	Lööf (2006)	37	387	47
Griffith (2004)	37	135	26	Hall (2013)	37	142	21	Miotti (2008)	36	242	26
Griliches (1990)	35	84	22	Heckman (1979)	36	210	27	Van Leeuwen (2006)	37	220	23
Hsieh (2009)	22	66	20	Mohnen (2013)	38	311	42				
Levinsohn (2003)	37	202	43	Nelson (1982)	32	101	25				
Melitz (2003	31	92	21	OECD (2005)	34	150	21				
Olley (1996)	37	184	37	Parisi (2006)	37	320	43				
Porter (1995)	23	62	32								
Romer (1986)	36	122	27								
Romer (1990)	38	178	40								
Schumpeter (1976)	37	141	23								

Solov (1956)	32	81	21								
Solov (1957)	34	128	33								
Syverson (2011)	36	146	26								

TLS: Total Link Strength; CC: Co-citation

5. CONCLUSION

The current research investigated “innovation and productivity” trends between 1980–2023. In this way, it aims to reveal the general structure of academic studies dealing with innovation and productivity. This study includes 510 papers published in the WoS database and analyses these two subjects together. The initial record in this field dates back to 1980, and since then, the number of publications has shown a consistent upward trend, reaching 510 documents published in the year 2023. In 2022, a significant number of publications (n=71) were recorded. However, the number of publications for 2023 will only be known after the year concludes. Over the last ten years, there has been a noticeable increase in publications compared to before 2013, indicating a rising trend in recent years. The publication count has experienced fluctuations, but the overall trend shows a clear upward trajectory in the past decade.

This study obtained some interesting results by analysing the Co-occurrence Keyword and the Document Co-citation. According to co-occurrence keyword analysis, the most used keywords are innovation, productivity, research and development, growth, performance and impact. The five theme clusters determined by the current study also showed compatibility with these words. In the first cluster, the prominent theme word was impact. In the second cluster, innovation and productivity, growth in the third cluster, research and development in the fourth cluster and performance in the fifth cluster came to the fore. These thematic groups clearly illustrate the trends in research that combine innovation and productivity over the past five decades. By analysing the document co-citation, a network of three clusters was found. The main themes of these clusters were economic studies, innovation and productivity studies, and production economies studies. In the middle of this network map, Crepon et al. (1998) initiated a series of empirical research. It was observed in the maps that economic studies were carried out intensively by the researchers working together on innovation and productivity concepts. In addition, the document analysis showed that these studies were carried out at the firm, country, and international levels. In this sense, the results of this study emphasized the importance of innovation and productivity studies for world development and economic growth.

To our knowledge, there has not been any bibliometric study examining "innovation and productivity" research together in the literature. Most of the existing bibliometric analysis studies on innovation and productivity focus on specific areas.

(Technological innovation, open innovation, research productivity, green productivity, etc.). In this sense, the results of the current study could not be compared with similar research results in the literature. However, this critical case shows that the meaningful results produced by the current research fill this crucial missing gap in the literature.

This study examined only high-index journal documents in the WoS database. Future research may include other work, such as book chapters, conference proceedings, etc., which are excluded from this research. They can also repeat the search by merging other databases other than WoS. This current study exclusively focused on articles in the English language. Future work may examine issues in innovation and productivity, including research in other languages. In this study, a quantitative method was applied to a certain number of articles. Still, some manual and qualitative techniques were also used to transform these results, as suggested by the literature. In cases where bibliometric analysis techniques are developed further in future research, the research can also be conducted purely quantitatively. Since innovation and productivity are global phenomena, it would be good practice for future researchers to conduct studies investigating how total factor productivity is affected by them and how to manage it. Additionally, examining the relationship between these two concepts and sustainability will contribute to current academic discussions.

Ethical Declaration

In this study, all the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were followed.

Ethics Committee Approval

The author declare that the research is one of the studies that does not require ethical committee approval.

Conflict of Interest and Funding

No conflict of interest and funding has been declared by the author.

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