



BIBLIOMETRIC ANALYSIS OF CENTRAL BANK DIGITAL CURRENCY WITH RSTUDIO

Merkez Bankası Dijital Parasının RStudio ile Bibliyometrik Analizi

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Cite As/Atf: Dugru, M. (2025). Bibliometric analysis of central bank digital currency with rstudio. *Ağrı İbrahim Çeçen Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 11(2), 165-194.

<https://doi.org/10.31463/aicusbed.1605518>

ISSN: 2149-3006

e-ISSN: 2149-4053

Makale Türü- <i>Article Type</i> :	Araştırma Makalesi - <i>Research Article</i>
Geliş Tarihi- <i>Received Date</i> :	22.12.2024
Kabul Tarihi- <i>Accepted Date</i> :	25.04.2025
Sorumlu Yazar- <i>Corresponding Author</i> :	Meltem DUĞRU
Sayfa Aralığı- <i>Page Range</i> :	165-194
Doi Numarası- <i>Doi Number</i> :	https://doi.org/10.31463/aicusbed.1605518



<http://dergipark.gov.tr/aicusbed>

This article was checked by

iThenticate



AĞRI İBRAHİM ÇEÇEN ÜNİVERSİTESİ
SOSYAL BİLİMLER ENSTİTÜSÜ DERGİSİ
Journal of Ağrı İbrahim Çeçen University Social Sciences Institute
AİCUSBED 11/2, 2025, 165-194



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Abstract

Central Bank Digital Currency is a digital currency option of central banks. CBDCs are a subject of research in most of countries due to the way they are produced and used. The bibliometric study also aims to determine the level of research on central bank digital currency, the direction of the trend towards this type of currency and its role in the future. In this context, studies carried out in the WoS database starting from 2018 until February 2024 were taken as basis. The concept of ‘central bank digital currency’ was scanned and analyzed using the biblioshiny method in the RStudio software with 102 sources and 149 documents obtained. The findings obtained indicate that there has been a gradual increase in publications on CBDCs since 2018 and that they are increasingly gaining interest.

Keywords: Central bank digital currency, rstudio, bibliometric analysis.

Öz

Merkez Bankası Dijital Parası, merkez bankalarının dijital bir para seçeneğidir. Bu nedenle üretilmesi ve kullanılma şekilleri birçok ülkede araştırma konusudur. Yapılan bibliyometrik çalışmada da merkez bankası dijital parasına yönelik araştırmaların hangi seviyede olduğu, bu para türüne yönelik eğilimin yönü ve gelecekteki rolünün belirlenmesi amaçlanmaktadır. Bu kapsamda WoS veri tabanında 2018 yılından başlayarak 2024 yılının şubat ayına kadar yapılmış olan çalışmalar baz alınmıştır. ‘Merkez bankası dijital parası’ kavramı taratılarak elde edilen 102 kaynak ve 149 doküman ile RStudio yazılımındaki biblioshiny yöntemi kullanılarak analizler yapılmıştır. Elde edilen bulgular 2018 yılından bu yana CBDC’lerle ilgili yayınlarda kademeli bir artış olduğu ve giderek ilgi gördüğü yönündedir.

Anahtar Kelimeler: Merkez bankası dijital parası, rstudio, bibliyometrik analiz.

Introduction

Currency has emerged in various forms from primitive times to the present day. It is even known that in times when there was no currency, some materials were used as currency within the scope of the barter economy. However, as societies modernize and institutionalization increases, it is

inevitable that new forms of currency will emerge that must keep up with the times. For this reason, today's paper and coins, which generally define currency, are being prepared to be replaced with technologically compatible tools.

It is possible that the known functioning of the traditional system will be disrupted by technology. One of the reasons for this is that societies that adopt technology gradually reduce the use of cash and acceptance occurs. Central banks that are trying to adapt to social transformation are also keeping the issue of digital currency on their agenda.

There are some reasons for the increasing interest of central banks in digital currency. These reasons are as follows (BIS, 2018, p. 3):

- Interest in technological innovations in the financial sector
- Sectoral demand for payment services and intermediary activities
- Decrease in the use of cash in some countries compared to previous periods
- Increased interest in some special digital objects

In addition, there are some reasons that support the implementation of digital currencies by central banks. The first of these reasons is the establishment of a more effective payment system. The second is that households and businesses still need an asset they can trust as a result of the decrease in cash usage rates. Finally, the existence of a system that can work as an alternative and backup to the existing payment infrastructure (Danmarks NationalBank, 2017, p. 1).

While interest in central bank digital currencies is increasing on the one hand, there are some hesitations on the other. One of the main problems that arise is the intermediary activities and economic roles of governments, central banks and financial market participants. It is envisaged that central banks, in particular, will be able to carry out more intermediary activities as a result of the issuance of CBDCs. The predominant role of central banks is discussed in terms of their ability to have a greater influence when considering lending and financial conditions (BIS, 2018, p. 14).

Another issue that is being discussed is how developed and developing countries will be affected by these digital currency applications. It is being discussed how the digital currency will be affected by the monetary policies implemented by countries in the traditional system. In addition, it is a matter of curiosity whether the dominance of the dollar, which is the reserve currency in the world, will be affected. It may be an attractive option for central banks to be able to carry out international financial transactions and

international trade more cost-effectively and faster with the digital currencies they plan to issue. Therefore, it is possible that the dominance of the dollar in the world financial system will be at risk. Or, if this situation can be used in the best way, the dollar may become stronger.

One of the most important innovations brought by digital transformation in the financial world, which is intended to be an alternative to the dollar, is cryptocurrencies. Cryptocurrencies, which were discovered before the emergence of CBDC, attracted great attention in the world. However, the distrust in cryptocurrencies has led central banks to another search. Therefore, preparations have begun for the launch of a new digital asset that is affiliated with a central authority and whose regulatory and control mechanisms function properly.

Although studies are being conducted in the US on the issuance of a central bank digital currency, a consensus has not yet been reached. It is known that China is making serious efforts on this issue. China, which produced the digital yuan, has been conducting pilot studies on CBDC for a long time and intensively. However, it is understood that other countries also want to issue digital currencies quickly and voluntarily. Countries such as Russia, Brazil and Japan, including Türkiye, are among the countries that continue their phase studies and pilot applications (www.atlanticcouncil.org/cbdctracker/). Countries such as Sweden and Uruguay are also discussing CBDCs and conducting pilot applications. Central banks around the world are also evaluating this issue (Tronnier et al., 2020). For example, the European Central Bank (ECB) continues its preparations for multiple digital currencies, including the digital euro. The European Central Bank (ECB) is preparing for multiple digital currencies, including a digital euro (www.atlanticcouncil.org/cbdctracker/).

The possibility of central banks issuing digital currencies, both in practice and in theory, has long been discussed and continues to be a subject of research. The aim of this study is to examine the research done on CBDC and to identify research gaps by determining the trends in the literature to date. Considering the preparations made by many countries for the new monetary period, it is important to know the details on this subject. Research reveals how much countries have researched CBDC or what added value they have created. These results need to be determined for both countries and the banking sector.

In order to achieve the objectives of the study, the following questions are sought:

- What is the place of the concept of central bank digital currency and the studies related to this concept in the literature?
- How has the concept under investigation changed over time?
- What is the periodic distribution of the concept of central bank digital currency among research, sources, institutions, affiliates and countries?
- What are the qualifications of the authors who examine the concept of central bank digital currency?
- What are the most frequently used keywords in studies on the concept of central bank digital currency? What is the extent of the relationship between the keywords?
- Which authors have worked with each other more and which authors' works have been cited the most?
- How important will this concept be in future studies?

With the questions above, the nature of the research and ideas on the concept of central bank digital currency from past to present is tried to be determined. At the same time, it is foreseen that it will form the basis for future research and applications. In this study, in addition to research questions on the stages that CBDC has gone through since its emergence, the question of what path can be followed from now on has been focused on. In other words, how should central banks prepare for the future of this money?

What makes this study different from the studies in the literature is that it was conducted with an up-to-date database. Since it is a rapidly researched topic, it is clear that a current perspective will make a significant contribution to researchers. In addition, emphasizing the inadequacy of the studies in Türkiye and creating awareness in this sense is another reason for filling the gap in the literature. In this context, first of all, a scan is performed on the concept being investigated in the WoS database. It is investigated whether the data obtained as a result of the scan is completely related to CBDC. The aim of this control is that the obtained data may also contain data from other scientific fields and affect the analysis results. After all the checks, the finalized data is loaded into the Bibliometrix program using the biblioshiny method in the RStudio software. It is reported within the scope of some selected categories.

Theoretical Background and Literature Review

The 19th century, known as the dominant acceptance of technology in the banking sector, is also the period when the first steps of the digitalization of currency were seen. During this period, the emergence of the third

generation called 3G and mobile phones made it possible to access both fast internet and internet networks. Again, smartphones such as the iPhone, which took phone technology one step further, accelerated this access. At the same time, the emergence of bitcoin in 2008 took its place among the reasons that started the journey of digital currencies (Terták & Kovács, 2022, p. 492).

While the digital path opened by the emergence of bitcoin was adopted by a segment, it became a risk factor for central banks. The reason for this is that these crypto assets are used to end the central bank's ability to create currency. However, the fact that the crypto asset system is fundamentally independent of central banks and causes control problems has led to the emergence of alternative types of currency (Kovanen, 2019, p. 2). Due to both the continued existence of central banks and the banking system and the decrease in cash use, new solutions have begun to be sought. Thus, the idea of CBDC was put forward and a central bank-based digital currency system was born (Terták & Kovács, 2022, p. 493).

CBDC is called a digital currency issued by central banks in local currency (Bank for International Settlements (BIS, 2022, p. 2). According to another definition, CBDC is basically a type of central bank currency that can be used electronically (Ahmat & Bashir, 2017, p. 1). This type of currency, which may one day completely replace physical currency, is designed as a legal tender. These currencies, which are also referred to as the widely accessible digital form of fiat currency, are considered the next evolution of money. For all these reasons, central banks pay serious attention to it (Mancini-Griffoli et al., 2018, p. 6).

These currencies represent the responsibilities of central banks. Central banks may want to make these digital currencies that they plan to issue publicly available or offer various usage options. When they implement the options, it is expected to observe a different process from some non-cash transactions such as credit transactions, automatic payments, card payments and e- currency (BIS, 2022, p. 2). One of the main goals of CBDC is to provide access to central bank liabilities in a digital form. In addition to facilitating access, it is also important to design it in a practical way (Harahap et al., 2017, p. 17).

The emergence of CBDCs is in the near future. However, as a result of the interest of countries, academic studies on CBDC are increasing day by day. As can be understood from the studies below, CBDC is addressed in many aspects and contains different results.

Ozili, in his study on the latest developments regarding CBDC, emphasized the consensus that the central banks that issue these currencies are liable. Another issue that is agreed upon is that they have cash-like characteristics. It is stated that CBDCs will create advantages when some of their benefits, such as the more efficient implementation of monetary policies, the convenience of digital payments and the increase in financial inclusion, are taken into consideration. However, despite having multiple advantages, the study also includes warnings about being careful. Within the framework of all these, there are suggestions on the CBDCs that central banks plan to issue and the design of these currencies. (Ozili, 2023). On the other hand, the possibilities that legal restrictions and security problems may increase, financial stability may weaken and the effectiveness of monetary policy may decrease were examined. While evaluating these possibilities, it was also taken into account that rapid digitalization in payments would provide more cost and time efficiency. In this context, central bank digital currency was discussed in detail (Beniak, 2019). In a study conducted for Canada, comparisons were made for a system where only CBDC, only cash and both were used together. The findings indicate that CBDC will provide more welfare than the other two options when used alone, under conditions where its cost is not too high (Davoodalhosseini, 2022).

In the study conducted by Kvedaravičiūtė and Šapkauskienė on the impact of CDBC on the banking sector and how the new order for cash, deposits and payments will be, a total of 228 articles were examined in the WoS and Scopus databases. The research, conducted between April 2018 and 2023, emphasized the keywords cash, monetary policy and financial stability and aimed to increase countries' digital currency trials (Kvedaravičiūtė, & Šapkauskienė, 2024). In another study covering the years 2018-2020 on central bank digital currency, 77 articles were examined and analyzed using the bibliometric method. The findings have shown that interest in CBDCs is rapidly increasing and offer researchers a different field of study (Pana, 2021). Tronnier and others have systematically evaluated the research on CBDC within the scope of the literature. Their findings show that CBDC is still in the early stages both from an academic perspective and from the perspective of central banks (Tronnier, 2020). In another study on Indonesia, where the digital rupiah is planned to be issued, a sentiment analysis of scientific literature was conducted with the theme of CBDC. In the research conducted with the qualitative method, 50 articles in the Scopus database were examined. The findings showed that positive sentiment was 30 percent, negative

sentiment was 26 percent, and neutral sentiment was 44 percent (As-Salafiyah et al., 2023). In another study on CBDC in the Scopus database, 190 documents were analyzed. In the research in which the Rstudio package and Biblioshiny method were preferred, it was stated that CBDCs were highly effective on currency and payment systems and could form the basis for a global central bank. In addition, it has been emphasized that CBDCs are the focus of central banks due to their advantages (Riani & Akbar, 2024).

In addition to all these, there are studies on the relationship of CBDC with more than one subject, and it has increasingly become a subject of continuity. When some studies in the literature are examined, it is possible to come across studies on the basic aspects and effects of CBDCs (Dionysopoulos et al., 2024), the design of CBDC, its impact on monetary policy and financial stability (Mancini-Griffoli et al., 2018), how the emergence of CBDC will affect the stability of the banking system (Keister & Monnet, 2022), macroeconomic effects as well as operational formations and privacy (Auer et al., 2022), economic and institutional driving force (Auer et al., 2020) and the process from cryptocurrencies to CBDC (Cunha et al., 2021) and other different subjects.

Aim of Research

The aim of this study is to determine the extent to which the concept of ‘Central Bank Digital Currency’, which has become increasingly popular in recent years, is included in academic research. The subject of the study will shed light on future research as it arouses curiosity in our world where digitalization is increasingly widespread. It will provide a perspective for both academic literature and economic authorities.

It is important to know the place of the concept of central bank digital currency and studies related to this concept in the literature. This concept is increasingly gaining ground in the banking and finance sectors. It is thought that the experiments carried out by the central banks of countries for different digital currencies may cause a social change in the near future. Therefore, academic research on central bank digital currency should be increased.

In the studies to be conducted, the scope of the research on the concept of central bank digital currency, its distribution in institutions and countries should be determined. In addition, how it has changed over time should be revealed. Thus, the subject can be analyzed in detail and the steps to be taken in the future can be determined. At this point, there is a need for analyses to

be conducted with the existence of academic databases, websites and reliable sources. One of these analysis methods is the bibliometric analysis method.

The term bibliometrics was first introduced by Alan Pritchard in 1969 and its areas of use are quite different. It is a system that allows publications and citations to be used with data science. This system is used by research experts in universities, laboratories and in the evaluation of research performance (Lawani, 1981, p. 294; Pendlebury, 2008, p. 2).

Bibliometric methods are not only measurable but also have objectivity. Thus, it can verify intuitive inferences based on reality without being subject to subjective evaluations. In addition, since analyses can be made over a long period of time, it can help determine the most effective ideas and the relationships between them (Nerur et al., 2008, p. 320).

Bibliometric analysis also provides the opportunity to analyze the vocabulary of the concept under research. Thus, it can be seen which keywords are most frequently used in studies related to the concept of central bank digital currency. Being able to clearly present multiple data, such as the most frequently used keywords, will also shed light on future research and make research easier. When the results of all this detailed analysis are examined, it is thought that the impact and clarity of the researched concept in academic literature will become clearer.

Method

In this study on the central bank digital currency, examinations were made with bibliometric analysis. Science mapping technique and performance analysis were used in the examination. In this context, it became possible to determine the relationships between the data on which the study is based and then to make visual presentations.

The method called 'science mapping' has attracted considerable attention since the first day of bibliometric research. The reason for this is the idea of visualizing bibliometric networks. Strong analyses are obtained by visualizing the citation relations network between publications and journals, co-authorship relations between researchers, relations between keywords and more relations. Increasingly rich research and analysis of larger data also increase the interest in this and similar visualization techniques (Van Eck & Waltman, 2014: 285-286). There are three types of bibliometric networks in the science mapping technique. The first of these is communication networks. Communication networks show the relationship of researchers or institutions with others. The second is conceptual networks. They reveal the relationships

of both concepts and words with each other. Thirdly, there are publication citation networks. While the relationships between the nodes representing publications are revealed, co-citation, bibliographic link and direct links can also be detected (Callon et al., 1983: 194-196; Gutiérrez-Salcedo et al., 2018: 1276-1277).

Another method, performance analysis, can provide quantitative measurements such as the number of documents, authors, journals and countries, as well as qualitative measurements such as the document's citation count and h-index (Alonso et al., 2009; Gutiérrez-Salcedo et al., 2018: 1276).

Some databases such as WoS, Scopus, PubMed, Google Scholar provide the opportunity to use these techniques. However, WoS was preferred as the database in this study due to the presence of more qualified publications in the field of social sciences and its wide data network. Data obtained from WoS, a world-famous database, was analyzed using both techniques. The biblioshiny method was applied using the R Studio (4.3.2) - Bibliometrix program.

The data used in the study on the key concept of 'central bank digital currency' was obtained by scanning all indexes (economics, business finance, multidisciplinary science, etc.). In the analysis, the data obtained from WoS are presented in categories by authors, institutions and countries. Under these categories, there is information on the number of publications by year, the annual publication and citation numbers of countries, the most popular sources, the most cited publications on a global scale, detailed analyses of the authors, the productions of affiliated organizations and the most frequently used words.

The date on which the analysis will be carried out was determined as 2018 and February 2024. The reason why 2018 was chosen as the starting year is that it is a date automatically determined by the system within the WoS database. The ending date can be determined by the researcher and is February 2024, the date on which the analysis was carried out. 102 sources and 149 documents were obtained from the analysis results made through various categories, regardless of language. The findings obtained from the database scans are presented in detail under the sections below.

Findings

The scope of this research consists of studies on central bank digital currency through the WoS database. The findings obtained from the compiled studies were examined in many categories. In the research conducted for the

period between 2018 and 2024, 149 documents were accessed from 102 sources and basic information about the data is presented in Table 1.

Table 1. Basic information about the data

	Results
BASIC INFORMATION ABOUT DATA	
Term	2018:2024
Sources (Articles, Books, etc.)	102
Documents	149
Annual Growth Rate (%)	51.31
Document Average Age	1.75
Average Number of Citations Per Study	6.523
References	7469
DOCUMENT CONTENTS	
Keywords (ID)	157
Authors' Keywords (DE)	464
AUTHORS' INFORMATION	
Authors	296
Single Author Documents	52
Co-Authors Per Document	2.17
International Co-Authors (%)	32.89
DOCUMENT TYPES	
Articles	135
Book Chapter	4
Early Access	9
Declaration	1

Source: (Created by the author using data from R-Biblioshiny).

As seen in Table 1, the first study on central bank digital currency was conducted in 2018. In the period until 2024, 149 documents were identified from 102 different sources. In other words, the studies on this subject have not yet reached a sufficient level. However, on the other hand, the fact that the annual growth rate of these documents is 51.31 percent shows that the studies are gaining velocity.

When the document contents are examined, it is seen that the keywords of the scanned titles are 157 and the keywords of the authors are 464. The gradual increase in the number of studies has caused the study subjects and therefore the keywords to diversify. When the information of the

authors is examined, it is found that the total number of authors for 149 studies is 296.

The results of the bibliometric analysis conducted for 149 data summarized in Table 1 were evaluated within the scope of five different parameters. Statistics of parameters consisting of publications, citation numbers, sources, authors and frequently used words were analyzed and explained with the help of figures and tables. The findings obtained at the end of the study were interpreted.

Firstly, the number of publications within the date range of the study was determined. In this context, it has been observed that there has been a rapid acceleration in the central bank digital currency over the years. The results of the analysis are presented with the help of Chart 1.

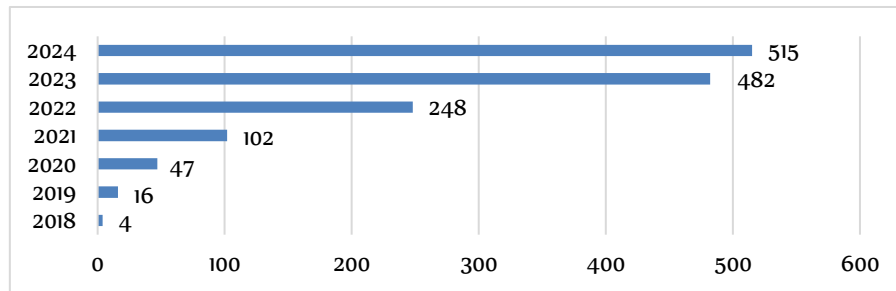


Chart 1. Distribution of publication numbers by years

Source: (Created by the author using data from R-Biblioshiny)

When Chart 1 is examined, it seen that the subject was started to be researched with 4 publications in 2018. The increase that started in 2019 compared to the previous year continued exponentially in the following years. Although the upward velocity continues in all years, the most striking year in these results is 2024. Although the date range of the analysis covers the first two months of 2024, there is more production than 2023. This result is an indication that interest in the researched subject is increasing very rapidly around the world. For example, in Italy, while there were 4 publications in 2018, the number of publications in 2024 was 32. While the number of publications in Germany, America, UK and China was 0 in 2018, 31, 58, 66 and 53 publications were identified in 2024, respectively.

When the number of publications and citations are evaluated on a country basis, the results shown in Chart 2 are obtained.

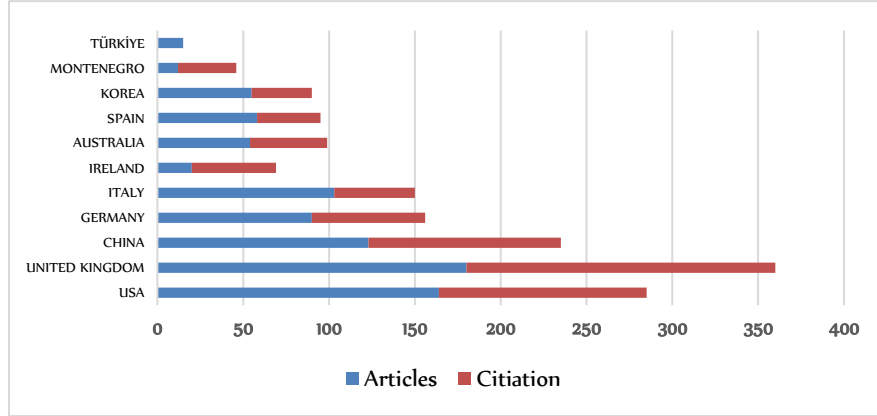


Chart 2. Total number of studies and citations by countries

Source: (Created by the author using data from R-Biblioshiny)

Chart 2 shows the country that published the most and received the most citations between 2018-2024 is the United Kingdom. Although it is known that there are studies on digital currencies in the UK, it has been determined that the subject is emphasized academically. Another result obtained from the analysis is that the USA is the second country with the highest number of publications and citations. The fact that there are different ideas about issuing digital currency in the USA has triggered the studies conducted on this subject. However, the surprising result is that China is the country with the most publications and citations after the UK and USA. Reason for this is CBDC has been at the forefront in China for a long time and has been subject to multiple applications. While it can be considered a pioneer in the world, its research on central bank digital currency is in third place. When we look at the number of studies conducted for Türkiye, it can be seen that there are still very few studies. It is also found that there are no references to the studies carried out.

It is important for researchers to determine in which sources the studies on the concept of central bank digital currency are published so that they can access the right sources. The first 10 sources containing studies on the concept of central bank digital currency, which is one of the problems of the research, are listed in Table 2.

Table 2. Most relevant resources

Research	Publications
Research in International Business and Finance	15
Finance Research Letters	4
Economics and Business Letters	3

Financial Innovation	3
Journal of Banking Regulation	3
Journal of Central Banking Theory and Practice	3
Journal of Economic Dynamics & Control	3
Technological Forecasting and Social Change	3
Accounting Economics and Law-A Convivium	2
Asia Pacific Law Review	2

Source: (Created by the author using data from R-Biblioshiny)

According to Table 2, the majority of studies (15) related to the researched concept are published in the journal Research in International Business and Finance (Kuehnlenz et al., 2023; Jabbar et al., 2023; Bhaskar et al., 2022; Elsayed & Nasir, 2022). There are 4 studies in the Finance Research Letters Journal (Li et al., 2022; Bian et al., 2021, Scharnowski, 2022). There are 3 publications in the journals Economics and Business Letters, Financial Innovation, Journal of Banking Regulation, Journal of Central Banking Theory and Practice, Journal of Economic Dynamics & Control and Technological Forecasting and Social Change (Belke & Beretta, 2020; Le et al., 2023; Jun & Yeo, 2021; Souissi & Nabi, 2023).

In addition to the sources that the concept under investigation is related to, it is also important to know the most cited studies. Thus, it is possible to understand the subject better and increase the contribution to the literature with future studies (Yürük Kayapınar, 2023, p. 821). Table 3 lists the cited studies and their number of citations.

Table 3. Most global cited documents

Most Global Cited Documents (Top 10)	Total Citations	Annual Total Citations
Li, Z., Yang, C., & Huang, Z. (2022). How does the fintech sector react to signals from central bank digital currencies?. <i>Finance Research Letters</i> , 50, 103308.	64	21.33
Allen, F., Gu, X., & Jagtiani, J. (2022). Fintech, cryptocurrencies, and CBDC: Financial structural transformation in China. <i>Journal of International Money and Finance</i> , 124, 102625.	60	20.00
Barrdear, J., & Kumhof, M. (2022). The macroeconomics of central bank digital currencies. <i>Journal of Economic Dynamics and Control</i> , 142, 104148.	56	18.67
Agur, I., Ari, A., & Dell’Ariccia, G. (2022). Designing central bank digital currencies. <i>Journal of Monetary Economics</i> , 125, 62-79.	51	17.00

Wang, Y., Lucey, B. M., Vigne, S. A., & Yarovaya, L. (2022). The effects of central bank digital currencies news on financial markets. <i>Technological Forecasting and Social Change</i> , 180, 121715.	47	15.67
Fabris, N. (2019). Cashless society—the future of money or a utopia? <i>Journal of Central Banking Theory and Practice</i> , 8(1), 53-66.	34	5.67
Bindseil, U. (2019). Central bank digital currency: Financial system implications and control. <i>International Journal of Political Economy</i> , 48(4), 303-335.	33	5.50
Cunha, P. R., Melo, P., & Sebastião, H. (2021). From bitcoin to central bank digital currencies: Making sense of the digital currency revolution. <i>Future Internet</i> , 13(7), 165.	28	7.0
Bhaskar, R., Hunjra, A. I., Bansal, S., & Pandey, D. K. (2022). Central bank digital currencies: agendas for future research. <i>Research in International Business and Finance</i> , 62, 101737.	28	9.33
Nabilou, H. (2020). Testing the waters of the Rubicon: The European Central Bank and central bank digital currencies. <i>Journal of Banking Regulation</i> , 21(4), 299-314.	28	5.60

Source: (Created by the author using data from R-Biblioshiny)

As seen in Table 3, the study with the highest number of 64 citations among the studies on the concept of central bank digital currency is Li et al. (2022) 'How does the fintech sector react to signals from central bank digital currencies? has happened. In the study, the reactions of the fintech sector to the central bank digital currency were measured. It has been concluded that the development of CBDC has a positive impact on the fintech sector and that governments should continue their incentives.

The second most cited study was 'Fintech, cryptocurrencies, and CBDC: Financial structural transformation in China'. The research by Allen, Gu & Jagtiani (2022) received 60 citations in total. In this study, fintechs, cryptocurrencies, stablecoins and central bank digital currencies were evaluated within the scope of the Chinese economy. It has been stated that the introduction of the Chinese yuan as a digital currency (e-CNY) can make a positive contribution to the traditional financial system.

Barrdear & Kumhof (2022)'s study titled 'The macroeconomics of central bank digital currencies' ranked third with 56 citations. In the research examining the macroeconomic consequences of central banks issuing digital currencies, it was predicted that the risks to banks can be minimized when they are issued appropriately.

As can be understood from the findings of the first three studies, the compatibility of the financial system with technology continues rapidly. The diversity of financial instruments and the integration of the banking system with CBDC are the subjects of studies in different countries. It is seen that countries have some academic and systematic practices regarding the integration of CBDC into the banking system. Thus, past practices and conducted research are important for future planning.

The fact that the three most cited studies were published in different journals is another finding showing that the subject is increasingly accepted and widespread. In addition, it has been observed that authors prefer different sources. Other detailed analyzes about the authors are also included in Table 4.

Table 4. Authors' publications, citations and h-indexes

Authors	Publications	Total Citations	H- Indexes
Buckley, R. P.	3	5	2
Agur, I.	2	52	1
Alonso, S. L. N.	2	2	1
Auer, R.	2	21	1
Belke, A.	2	20	2
Beretta, E.	2	20	2
Chen, C. H.	2	2	1
Chen, X.	2	2	1
Didenko, A. N.	2	3	1
Frost, J.	2	21	1

Source: (Created by the author using data from R-Biblioshiny)

The findings regarding the qualifications of the authors examining the concept of central bank digital currency are given in Table 4. The top 10 authors who contributed the most to data on central bank digital currency in the WoS database are listed. This table presents the authors' publication numbers, total citations and h-indexes.

Accordingly, Buckley, who has done the most work with 3 publications, has a total of 5 citations received in 2022 and 2023 (Didenko & Buckley., 2022; Buckley & Trzecinski, 2023, Buckley et al., 2023). Although Agur published 2 publications, he received 52 citations in total. He took 51 of these citations from his work titled 'Designing central bank digital currencies', published in 2022, and 1 from his work titled 'Lessons from crypto assets for the design of energy efficient digital currencies', published in 2023 (Agur et

al., 2022; Agur et al., 2023). Authors such as Auer R., Belke A., Beretta E. and Frost J. also have the same number of publications and the same number of citations.

Chart 3 shows the number of publications of the institutions the authors are affiliated with. In the relevant display, the change in the number of publications of the 7 most productive institutions is discussed.

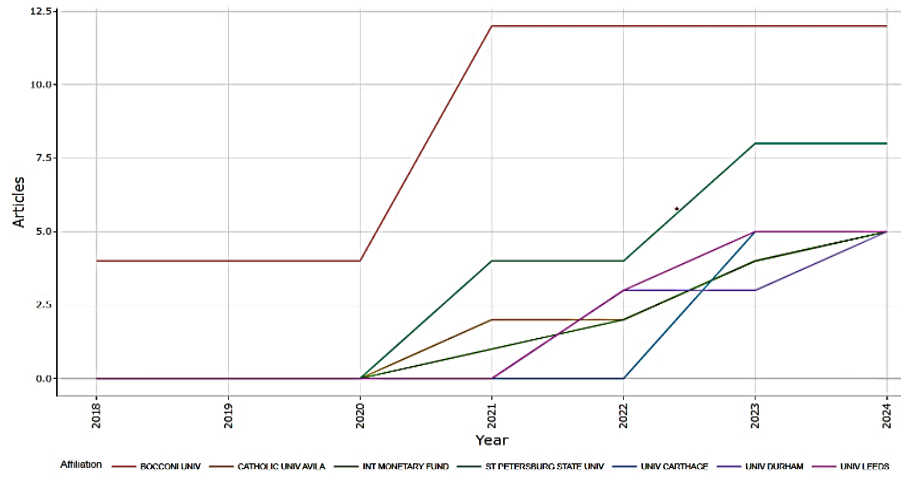


Chart 3. Production of affiliations over time

Source: (Created by the author using data from R-Biblioshiny)

Chart 3 shows the number of publications of all institutions has increased over the years. However, it is understood that the highest rate of increase in recent years has occurred in the International Monetary Fund and Durham University. The break lines of these two affiliates point upwards.

The analysis findings of the keywords in the studies were examined. This analysis, which is also among the research questions, is important in terms of shedding light and guiding the studies to be conducted on the central bank digital currency. For this reason, the most frequently used keywords are presented with a word cloud and a word tree. In the analysis presented with the help of Figure 1 and Figure 2, the long versions of the concept of 'CBDC' were not included in order to reach more accurate findings.

conducted and reveals which concepts come to the fore. In this context, when the first five keywords are examined, it is seen that a consistent result is obtained in the central bank digital currency literature.

Another finding obtained with the R-Biblioshiny program is keyword networks. The size of the node in the networks in Figure 3 shows the number of times the keyword is mentioned. The connection between the nodes represents the keywords they occur together, while the thickness of the links indicates the number of times they occur together. The growth of the node indicates the abundance of keywords (Donthu et al., 2021, p. 292).

In the study, the keywords related to the studies on the central bank digital currency are expressed with red, blue, purple and green thematic clusters. The aim of this representation is to determine which words the keywords in the studies are in the same cluster and to be able to draw the framework of the subject. The representation of the cluster networks related to the keywords is given in Figure 3.

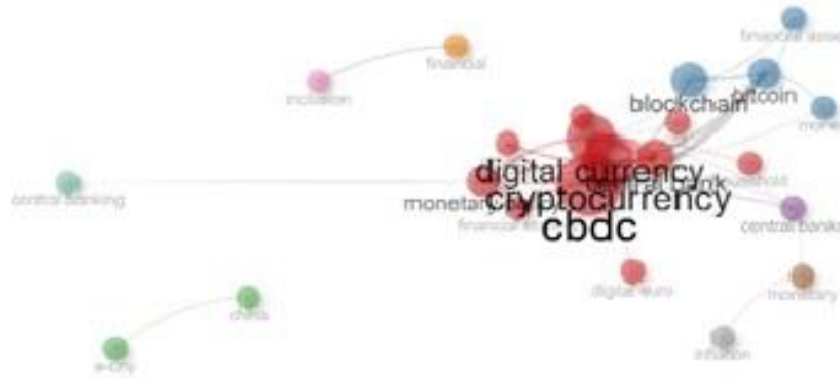


Figure 3. Word networks

Source: (Created by the author using data from R-Biblioshiny)

As seen in Figure 3, the keywords determined by the authors are cbdc, cryptocurrency and digital currency in the red cluster. The blue cluster reveals the connections between the keywords blockchain, bitcoin, money and financial asset. Central banks expressed in the purple cluster are more connected to the red cluster.

Figure 4 shows the authors whose work on central bank digital currency is at the forefront and the authors they work with. It can be seen that more than one team is working together, with each color representing a different working team.

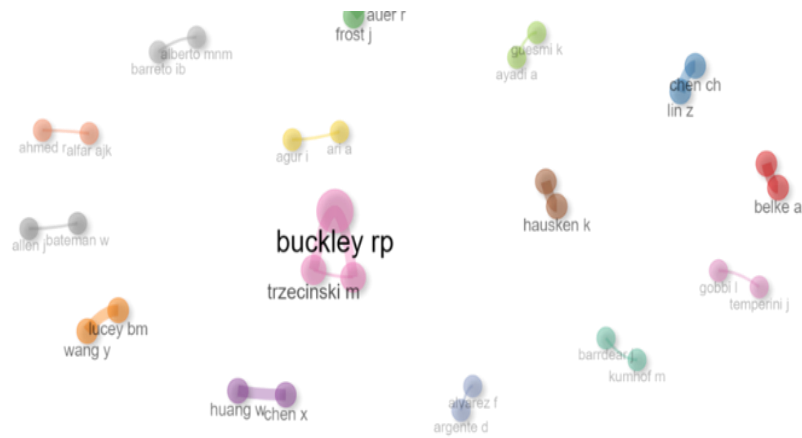


Figure 4. Authors' collaborative networks

Source: (Created by the author using data from R-Biblioshiny)

As seen in Figure 4, the prominent working team is Buckley and Trzecinski. As a result of the findings, the joint work of these two authors titled 'Central Bank Digital Currencies and the global financial system: the dollar dethroned?' was examined (Buckley & Trzencinski, 2023). Another group of writers with a thick connection line is Chen and Huang. The authors' joint work titled 'Central bank digital currencies: Consumer data-driven sustainable operation management policy' was evaluated within the scope of the subject (Chen et al., 2023). Another group of writers that stands out are Auer and Frost. The study titled 'Central bank digital currencies: motivations, economic implications, and the research frontier', conducted by these authors in 2022, is another study conducted within the scope of the subject (Auer et al., 2022).

In addition to the authors' collaboration networks with each other, the authors' citation networks are also presented in Figure 5.

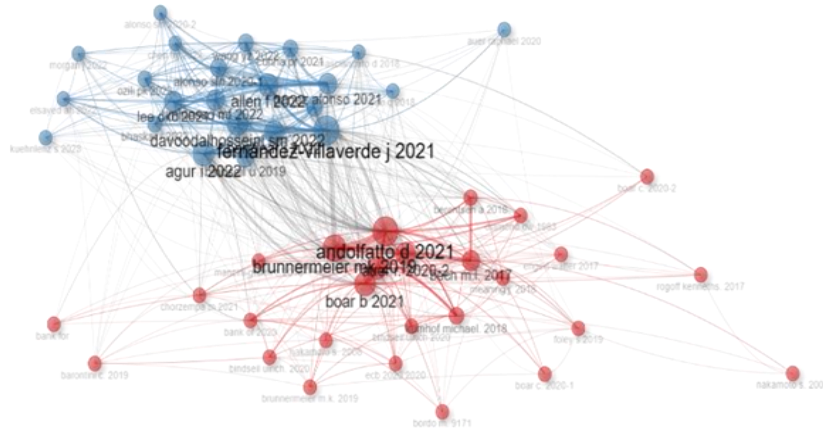


Figure 5. Citation networks of authors

Source: (Created by the author using data from R-Biblioshiny)

As seen in Figure 5, the studies in the reference sections of the studies in the data set are expressed in large and bold text according to their most citations. Accordingly, the authors with the highest number of co-citation networks are Andolfatto, D., Agur, İ. and Fernandez-Villaverde, İ. came to the fore. This is an analysis in which the biggest supporters of the article are obtained.

As a result of all the findings obtained, it has been seen that CBDC is a very new research topic but has vital importance. Countries are working on a new way of using monetary systems that have been changed and developed for years after the digital transformation. Although there are differences of opinion on every issue, the survival of economies and fierce competition forces countries to work for this type of currency. Therefore, the advantages and disadvantages of CBDC should be evaluated very carefully. Each country should determine the most appropriate time by prioritizing its own economic and social structure.

Conclusion

When CBDCs are evaluated in the light of recent developments in the world, it is seen that they are constantly being researched by many institutions and the research are being published. It is understood that public institutions and scientists, especially central banks, are following the development of digital currencies and their effects on the economy. The main reason why this concept is the subject of academic studies is the curiosity of how its future will

shape. Therefore, it is important that studies that include bibliometric analysis clearly show the development of the CBDC concept.

Accordingly, the place of the central bank digital currency in the literature is examined in the study. It is aimed to shed light on future studies by examining its current status in the WoS database, which concepts are used together, and the change in the number of publications over the years.

The studies published in the WoS database on central bank digital currency between the dates starting from 2018 and February 2024 were analyzed within the framework of certain parameters, in this study. The data obtained by scanning the concept of 'Central Bank Digital Currency' from the WoS database for bibliometric analysis are reported in the categories of publication numbers by year, annual publication and citation numbers of countries, most popular sources, most cited publications on a global scale, detailed analysis of authors, productions of affiliates and most frequently used keywords of authors. The biblioshiny method is used for the obtained data through the R Studio-Bibliometrix program.

According to the findings obtained from a total of 102 sources and 149 documents, the studies on central bank digital currency have increased over the years. Although it was just the beginning of the year, it was determined that the most studies were made in 2024 from the data set used in the analysis. It was found that the country with the most publications and the most citations was the United Kingdom. It is a surprising result that UK ranks first in both publication and citation rankings. The reason for this is that there are other countries where more comprehensive applications regarding central bank digital currency are made. Similarly, Riani and Akbar (2024) stated in their study, where they examined 190 articles, that there was a geographical formation led by major economies such as China, Europe and the USA.

Another finding is that the number of studies on Türkiye in the WoS database has not yet reached a sufficient number and there are no citations. However, as a result of increasing studies, it will be inevitable for the number of citations to increase in the coming years.

Among all publications, the most cited study by Li, Z., Yang, C., & Huang, Z. in 2022 was titled 'How does the fintech sector react to signals from central bank digital currencies?' As can be seen from the data in the WoS database regarding the central bank digital currency, the authors who contributed the most were authors such as Buckley, R.P., Agur, I., Alonso, S. L. N., Auer, R.. The number of citations received by these authors, especially Agur, I., is also notable.

The prominent team in the findings is Buckley and Trzecinski. Another group of authors with a thick connection line is Chen and Huang. Another group of authors that stands out in this context is Auer and Frost. The authors with the highest common citation network in the obtained data set were Andolfatto, D., Agur, I. and Fernandez-Villaverde, I.

When the contributions of the institutions are examined, it is seen that the institutions that contributed the most are Int Monetary Fund and Univ Durham. In addition, the most frequently used keywords by the authors regarding central bank digital currency were determined as CBDC, cryptocurrency, digital currency, blockchain and central bank.

According to all these findings obtained from the study, it is understood that CBDC is a new concept, but it has attracted considerable attention. It has become a subject that central banks are particularly focused on due to multiple reasons such as speed, cost, efficiency and worldwide integration. It is seen that countries are almost in a race to issue their own digital currency first. For all these reasons, CBDCs are accepted as a digital innovation that has the ability to shape the future of the financial system.

For CBDCs to be subject to effective implementation and management, the digital infrastructure must first be strengthened. In addition, it is important that they adapt to payment systems in the country and around the world. Thus, a seamless operation can be achieved by integrating with all types of currency. Another advantage of the created digital infrastructure is that the masses who cannot access financial services can access these services. Organizing the technological infrastructure in this context will also lead to positive developments in terms of the financial system.

It is also important to explain CBDCs to all segments of society and evaluate the feedback. Improvements made in line with the feedback received will contribute quickly to the system. Thus, the impact on both the banking sector and the general economic system will be discovered more quickly. However, the findings of Pana (2021) in his study, in which he analyzed 77 articles obtained from the Scopus database using the biblioshiny method in the RStudio program, indicate that CBDC is important not only economically but also technologically and legally.

Filling the gaps in both technological and legal fields is important for the use of this currency. Because there are concerns about the issuance of these currencies due to security and privacy reasons. In this context, it is very important to evaluate all risks against all cyber threats and to establish an effective control mechanism.

As a result, this bibliometric analysis performed with RStudio provides a general perspective on the current status and future trends of the CBDC literature. At the same time, it helps to recognize literature gaps by providing guiding information for future research in the academic field. When evaluated from this perspective, it is inevitable that multidisciplinary approaches are encouraged and wider data sources are integrated, the literature is mapped comprehensively and academic production is contributed. On the other hand, the effects of CBDC are not only in the theoretical framework but also on the applications of the banking sector. CBDC, which is trying to find a place in traditional banking practices, allows the discovery of potential development areas in this sector. Its combination with bibliometric analysis makes it easier to see these potential areas and gives clues about the future of the sector.

Ethical Aspect of Research

I declare that my study, the information of which is given above, is among the studies that do not require ethics committee approval because it includes bibliometric analysis.

Conflict of Interest Statement

I declare that there is no financial or other fundamental conflict of interest in this study that could affect the results or interpretations.

Contribution Rate Statement

All stages of the study were designed and prepared by the author.

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Bibliometric Analysis of Central Bank Digital Currency with RStudio

Genişletilmiş Özet

Merkez bankası dijital parası, ülkelerin merkez bankaları tarafından ihraç edilebilen ve yasal ödemeye aracılık edebilen dijital para birimleri olarak tanımlanmaktadır. Literatürde birden fazla tanımı bulunan merkez bankası dijital parasının yalnızca merkez bankalarının değil bunun yanı sıra kamu otoritelerinin de dikkatini çektiği görülmektedir. Bu nedenle dijital paraların gelişimi ve ekonomiye olası etkilerinin araştırma konusu olmaya devam etmektedir. Günümüzde oldukça ilgi gören bu para birimi dünyadaki son gelişmeler ışığında değerlendirildiğinde akademik çalışmaların da konusu olmakta ve bu kavramın geleceğinin nasıl şekilleneceği merak edilmektedir.

Bu çalışmanın amacı da henüz çok yeni bir kavram olan merkez bankası dijital parası (CBDC) konusunda yapılan araştırma düzeyini genel bir bakış açısıyla ortaya koymaktır. Aynı zamanda merkez bankası dijital parası hakkında yapılmış araştırmaların incelenmesi ve bugüne kadar ki literatürün eğilimlerinin tespit edilerek, araştırma boşluklarının ortaya çıkartılmasıdır. Bu bağlamda yapılan analizde 2018-2024 şubat tarihleri arasında merkez bankası dijital parası ile ilgili Web of Science (WoS) veri tabanında yayınlanan çalışmalar belirli kategoriler dikkate alınarak analiz edilmektedir.

Yapılan analiz RStudio programı aracılığıyla gerçekleştirilmektedir. RStudio programındaki bibliometrix seçeneği kullanılarak biblioshiny uygulaması kullanılmaktadır. Bibliyometrik analiz için WoS veri tabanından 'Merkez Bankası Dijital Parası' kavramı taranarak elde edilen veriler, yıllara göre yayın sayıları, ülkelerin yıllık yayın ve atıf sayıları, en popüler kaynaklar, küresel ölçekte en çok atıf alan yayınlar, yazarların detaylı analizi, bağlı kuruluşların üretimleri ve yazarların en sık kullandığı anahtar kelimelere ilişkin sonuçları raporlanmaktadır.

Gerçekleştirilen analiz sonucunda toplam 102 kaynak ve 149 dokümana ulaşılmıştır. Bu kaynak ve dokümanlardan elde edilen bulgulara göre merkez bankası dijital parası üzerine yapılan çalışmalar yıllar geçtikçe artış göstermektedir. Analizde kullanılan veri setinden yapılan tespitlerde ise henüz yılın başı olmasına rağmen en çok çalışmanın 2024 yılında yapıldığı görülmektedir. Bir diğer bulgu en çok yayın yapan ve en çok atıf alan ülkenin Birleşik Krallık olduğu yönündedir. İngiltere'nin hem yayın hem de atıf sıralamasında ilk sırada yer alması şaşırtıcı bir sonuçtur. Bunun nedeni, merkez bankası dijital parasıyla ilgili daha kapsamlı uygulamaların yapıldığı başka ülkelerin (Çin, Avrupa, ABD) olmasıdır. Elde edilen bir başka sonuç ise WoS veri tabanında Türkiye ile ilgili yapılan çalışmaların henüz yeterli sayıya ulaşmamış olması ve bu yayınların hiç atıf almamış olmasıdır.

Tüm yayınlar arasında 2022 yılında Li, Z., Yang, C., & Huang, Z. tarafından yapılmış ve en çok atıf alan çalışma 'How does the fintech sector react to signals from central bank digital currencies?' başlıklı çalışmadır. WoS veri tabanından elde edilen merkez bankası dijital parasıyla ilgili verilerden de görülebileceği gibi en çok katkıda bulunan yazarlar Buckley, R.P., Agur, I., Alonso, S. L. N., Auer, R.'dir. Özellikle Agur, I. başta olmak üzere bu yazarların aldığı atıf sayısı da dikkat çekicidir. Bağlı kuruluşların katkılarına bakıldığında en fazla katkı sağlayan bağlı kuruluşların Int Monetary Fund ve Univ Durham olduğu görülmektedir. Ayrıca yazarların merkez bankası dijital parası ile ilgili en sık kullandıkları anahtar kelimeler cbdc, kripto para birimi, dijital para birimi, blockchain ve merkez bankası olarak belirlenmiştir. Bulgularda öne çıkan çalışma ekibi ise Buckley ve Trzecinski'dir. Kalın bir bağlantı çizgisine sahip bir diğer yazar grubu ise Chen ve Huang'dır. Bu bağlamda öne çıkan bir diğer yazar grubu ise Auer ve Frost'tur. Elde edilen veri setinde en fazla ortak atıf ağına sahip yazarlar ise Andolfatto, D., Agur, İ. ve Fernandez-Villaverde, İ.'dir.

Çalışmadan elde edilen tüm bu bulgulara göre CBDC'nin yeni bir kavram olmasına rağmen önemli ölçüde ilgi gördüğü anlaşılmaktadır. Bu durum, dijital paraların beklenen avantajları nedeniyle merkez bankaları tarafından dikkatle takip edildiğine işaret etmektedir. Ayrıca ülkelerin kendi dijital paralarını daha önce çıkarmak için bir yarış içerisinde olduklarını göstermektedir. Tüm bu nedenlerden dolayı CBDC'ler finansal sistemin geleceğini şekillendirme yeteneğine sahip dijital bir yenilik olarak kabul edilmektedir.

Sonuç olarak, RStudio aracılığıyla gerçekleştirilen bu bibliyometrik analiz, bir taraftan CBDC literatürünün mevcut durumunu ortaya koyarken diğer taraftan gelecekteki eğilimleri hakkında genel bir bakış açısı sunmaktadır. Aynı zamanda, akademik alanda yapılacak araştırmalar için yol gösterici nitelikte olup literatür boşluklarını görmeye yardımcı olmaktadır. Bu çerçevede, multidisipliner yaklaşımların teşvik edilmesi ve daha geniş veri kaynaklarının entegre edilmesi, literatürün kapsamlı bir şekilde haritalanması ve akademik üretime katkıda bulunulması kaçınılmazdır. Öte yandan, CBDC'nin etkileri yalnızca teorik çerçevede değil aynı zamanda bankacılık sektörünün uygulamalarında da görülmektedir. Geleneksel bankacılık uygulamalarında yer edinmeye çalışan CBDC, bu sektördeki potansiyel gelişim alanlarının keşfedilmesine olanak tanımaktadır. Bibliyometrik analizle birleştirilmesi ise bu potansiyel alanların görülmesini kolaylaştırmakta ve sektörün geleceği hakkında ipuçları vermektedir.