

Article

# Global Research Trends in Financial Transactions

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**Abstract:** Traditionally, financial mathematics has been used to solve financial problems. With globalization, financial transactions require new analysis based on tools of probability, statistics, and economic theory. Global research trends in this topic during the period 1935–2019 have been analyzed. With this objective, a bibliometric methodology of 1486 articles from the Scopus database was applied. The obtained results offer data on the scientific activity of countries, institutions, authors, and institutions that promote this research topic. The results reveal an increasing trend, mainly in the last decade. The main subjects of knowledge are social sciences and economics, econometrics, and finance. The author with the most articles is Khare from the Indian Institute of Management Rohtak. The most prolific affiliation is the British University of Oxford. The country with the most academic publications and international collaborations is the United States. In addition, the most used keywords in articles are “financial management”, “financial transaction tax”, “banking”, “financial service”, “blockchain”, “decision making”, and “financial market”. The increase in publications in recent years at the international level confirms the growing trend in research on financial transactions.

**Keywords:** financial transaction; financial mathematics; financial operation; investment; banking; scientific research

## 1. Introduction

Financial mathematics refers to the set of mathematical methods that allow us to determine the value of money over time [1,2]. Mainly, the importance of this discipline is in its application to banking and stock market transactions, in economic issues and in various areas of finance, since they allow the financial manager to make optimal decisions. Therefore, the study of financial transactions, which describe the exchange of money flows, available at different instants and subject to quantitative variations over time, correspond to the joint field of mathematics and finance [3].

The evident importance of the analysis of financial transactions, both in the field of financial mathematics and its application at the social level, reveal the need for research to provide analytical solutions. It is also relevant that the traditional methods applied in financial transactions lack flexibility and are not adapted to the needs of the client in an unequal and unstable society; for these reasons, the financial sector requires adaptation to the new situations that are generated in this new economic and social scenario [4].

A large part of the research has been aimed at developing methods and models that allow logical financial approaches to be introduced in investments and financing; that is, in two of the most decisive aspects of the economy [5]. However, this topic presents different levels of problems: on the one hand, the investment itself; on the other hand, the different forms of financing; and finally, those derived from the joint investment–financing periodic instalments [6,7].

In this context, financial mathematics studies the quantitative variations that occur in financial capitals over time. They examine simple financial operations, interest rates and discounts, and complex

rents. The financial operation is defined as the substitution of one or more capitals by another or other equivalents in different moments of time, through the application of a valuation function [8]. Therefore, the mathematics of financial transactions has as its object the study of an important body defending us from economic activity—financial operations. This discipline studies the foundations of the financial phenomenon and function that govern it to try to give a unified and deep vision of logic and financial metrics, and thus, provide precision; and it means savings to the solutions of economic problems. In this discipline, notable operations are the amortization of loans and the saving or formation of capital [9–11].

The objective of academic research in an international context is oriented toward proposing an increase in the offer of financial instruments that facilitate access to credit and investment to the greatest number of people who are part of a society in constant evolution. Currently, the economic, financial, and social realities are changing, causing decisions to be made in an environment of uncertainty. Therefore, the research tries to contribute to the development of the complex financial industry and provide solutions to the financial instruments offered by the entities, in order to satisfy the demand of a greater number of subjects in need of different alternatives that meet their particular needs.

In this sense, the publications contribute both theoretically and empirically to the creation of proposals that stimulate the variety of financial instruments put at the service of the client, each time with more difficulties in financing and channeling their savings, using certain factors, such as demographic or financial factors, that affect the wide variety of clients with which financial entities have contractual relationships. Indeed, the dynamic environment in which all business activities take place requires a continuous investigative effort that tries to bring new financial proposals closer to the specific and needs of these companies.

The purpose of this study is to analyze research trends globally in financial transactions in the field of financial mathematics, to examine the evolution of its applications in an international context determined by the different economic, financial, and social crises.

A review of the literature allowed us to find contributions that study this topic, which led to formulating the research question. This sought to answer whether scientific production is linked to previous analyses that underlie the practical application of financial transactions to adapt to new economic realities. Currently, the economic, financial, and social dimensions are changing, and decisions are made in uncertain environments.

This study does not discern whether, among other variables, the number of publications is related to a certain community regulation, is due to the demands of the stakeholders, or to the demands of society in general. Consequently, the main objective of this study is to examine global trends in the research of financial transactions during the period 1935–2019; that is, since the year the first article on this research topic was published (1935) until the last full year (2019).

In order to get answers to the research question, a total sample of 1486 articles was examined from scientific journals selected from the Scopus database. For this, the research has used bibliometrics to elucidate current and future trends in the financial transactions' knowledge base in a global context. The results showed the contributions in this field of research, in a way that has allowed us to identify the main driving agents and their potential tendencies, and reveal certain gaps in critical knowledge. Hence, it can be concluded that research in financial transactions, as an instrument that facilitates and provides a solution to financing and capital formation needs of both individuals and companies with determined and non-uniform cash availability, is advancing in the development of financial transactions that consider different contingencies and cases.

Lastly, among the main lines of research that are currently being developed in relation to financial transactions, some are studying the elimination of barriers in the adoption of Internet banking through the neural network approach, based on the perceptions of customers regarding the use of electronic payment systems; the development of econometric models that take into account the rumors that contribute to alarmism in electronic commerce; or the development of mathematical-financial models that consider the variety of possible casuistry of clients in savings and loan operations.

To achieve the stated objective and clarify your understanding, this work is organized as follows. Section 2 justifies the relevance of the research topic, delimiting the unit of analysis and conducting a review of the most relevant aspects in treating certainty and randomness in financial transactions. It focuses on the description of the characteristics corresponding to certain and random financial transactions, and also, the associated risk in random transactions is described. Section 3 itemizes the methodology used in this study in terms of achieving answers to the question and the research objective. Section 4 indicates the main results obtained and their discussion once the bibliometric methodology is applied. Finally, the conclusions are presented.

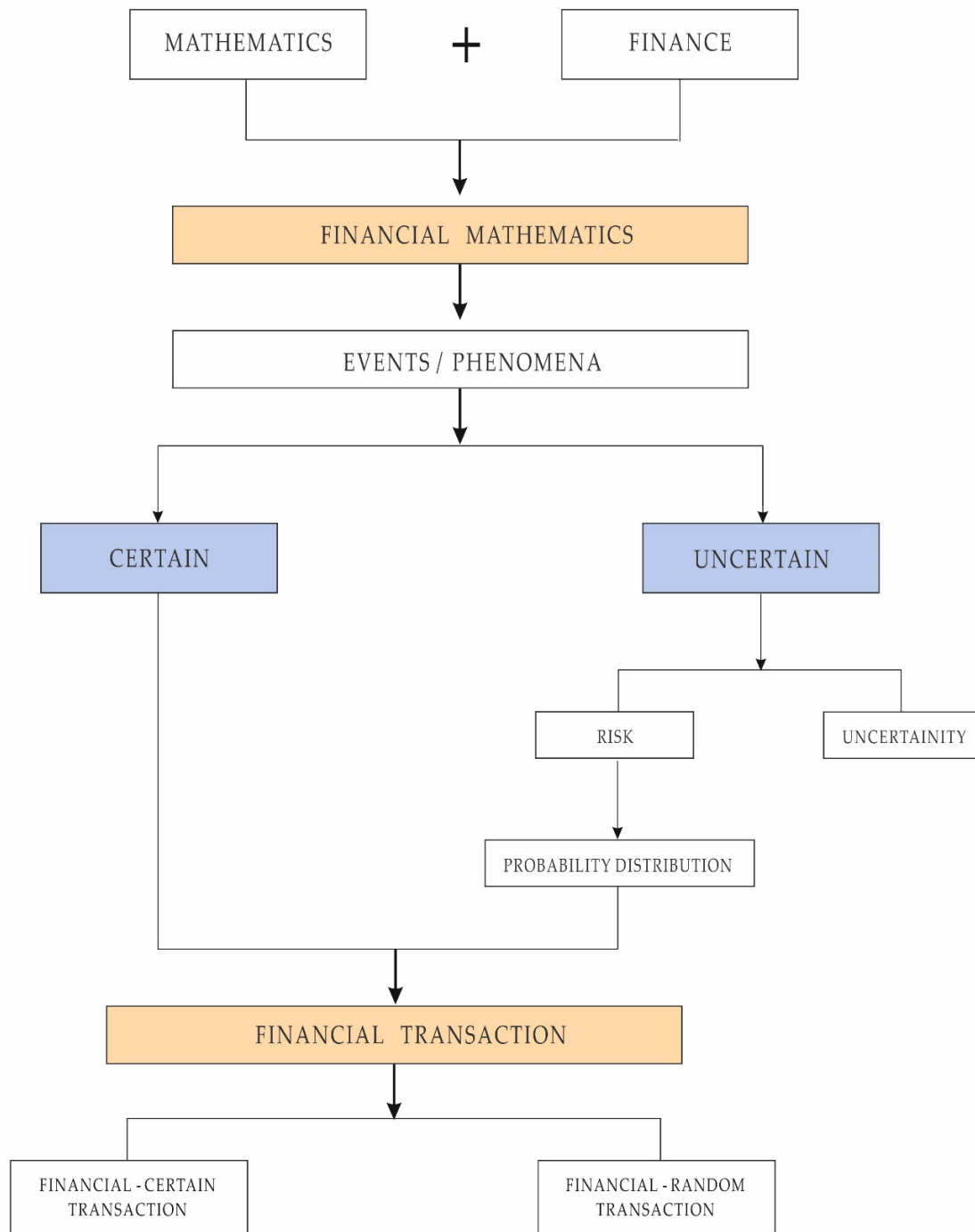
## 2. Research Scope

It is estimated that financial mathematics was originally developed as a complement to commercial transactions, based on commercial arithmetic, before 1500 B.C. In recent decades, commercial banks, investment banks, hedge funds, insurance companies, and regulatory agencies have applied the methods of financial mathematics to problems such as risk management and portfolio structure. In this way, the mathematical-financial analysis supposes an increase of efficiency and severity to the financial markets and to the investment process and is key to regulatory matters [12,13]. Financial mathematics also studies mathematical models related to the quantitative changes that occur in the sums of money, called capitals. Section 2 presents the results of the analysis of the reviewed literature and supposes a framework for the research topic.

### 2.1. Financial Mathematics

Financial mathematics is the application of mathematics to finance, focusing on the study of the value of money over time, combining capital, rate, and time to obtain a return or interest rate, through evaluation methods that allow investment decisions to be made. In the revised literature, financial mathematics is also referred to as quantitative finance, financial engineering, mathematical finance, and computational finance. Likewise, financial mathematics is related to accounting, since it relies on information from accounting records [14–17]. In addition, it is an auxiliary tool of political science, since it allows the study and resolution of economic and social problems, and it provides tools for investment decision-making, budgeting, and economic adjustments [18,19].

Once the literature has been reviewed, we provide the conceptual framework for financial transaction research. The basic aspects and considerations on the terms and concepts used in the particular context defined for this research are included. For this reason, Figure 1 shows the conceptual structure of research; that is, it indicates the organization and representation of the main concepts that allow us to synthesize ideas about a specific theme of this study.



**Figure 1.** Conceptual framework of the research.

The main principle of financial mathematics is the preference for liquidity, according to which, equal to the amount of economic assets, those closest in time are preferred to those available at more distant times. This preference characterizes the capitalist economic system, according to which, financial resources have the capacity to generate wealth over time. Consequently, the preference for liquidity has a target price or value. The price of the preference for liquidity, that is, the interest rate, is established in the financing or money market [20,21].

Hence, interest rate is the price for the use of money over a period. It is defined as the compensation for the deferment in the time of consumption and is measured as a percentage of the asset or money loaned. The economic compensation that the interest rate supposes is demanded by the lack of

availability that supposes to get rid of the capital during a time [22,23]. This has an opportunity cost, since capital could be invested in any type of activity that produces a return during the time it is being lent.

The reasons that influence the demand for an interest rate in the use of money are the risk assumed by the possibility of not recovering the money borrowed, and by the depreciation of the value of money over time, derived from inflation. The lack of liquidity, risk, and depreciation determine the existence of an interest rate, so the amount of economic compensation for the use of money depends on the amount of capital invested, the duration of the investment transaction and the type of interest rate to which the investment transaction is agreed [24–26].

Financial mathematics, fundamentally, studies interest rates; that is, the relationship that exists between the amount of money paid or received and the amount of money used; that is, the relationship between profit and investment. In addition, it contemplates the studies of credits, investments, capitalizations, and in general, the development of financial transactions—that is, the substitution of one or more capitals by another or other equivalents at different moments in time, through the application of a valuation function [27,28]. Therefore, the valuation function can be applied by means of a simple interest method when the interest generated in the past is not accumulated, and therefore, does not generate, in turn, interest in the future. Interest rate is calculated based on the original capital. If a compound capitalization method is used, the interest generated in the past does accumulate with the original capital, and in turn, generates interest in the future; that is, the interest is capitalized. For this reason, according to the application of the valuation function, there are capitalization transactions when a present capital is replaced by another future capital, and there is an update or discount when a future capital is substituted by another current capital [29,30].

After reviewing the literature on the topic of study, Table 1 shows the main articles on the state of the question on the research of financial transactions, organized chronologically. For each article in Table 1, information is provided on the year of publication, the title of the article, the reference in the References section, the author or authors, and the journal.

**Table 1.** Main articles reviewed related to the objective of research.

Year	Article title [Reference]	Author(s)	Journal
2019	How do lead banks use their private information about loan quality in the syndicated loan market? [31]	Balasubramanian, L.; Berger, A. N.; Koepke, M. M.	Journal of Financial Stability
2019	Transaction Costs of Factor-Investing Strategies [32]	Li, F.; Chow, T.-M.; Pickard, A.; Garg, Y.	Financial Analysts Journal
2018	CoDetect: Financial Fraud Detection with Anomaly Feature Detection [33]	Huang, D.; Mu, D.; Yang, L.; Cai, X.	IEEE Access
2018	The revenue potential of a financial transaction tax for US financial markets [34]	Pollin, R.; Heintz, J.; Herndon, T.	International Review of Applied economics
2018	Influence of risk preference change on the investment and consumption decision of financial assets [35]	Tian, M.-W.; Yan, S.-R.	Journal of Interdisciplinary Mathematics
2017	On the Inception of Financial Representative Bubbles [36]	Ferrara, M.; Pansera, B.; Strati, F.	Mathematics
2015	A Discrete-State Continuous-Time Model of Financial Transactions Prices and Times [37]	Russell, J. R.; Engle, R. F.	Journal of Business & economic Statistics
2015	Borrower Misreporting and Loan Performance [38]	Garmaise, M. J.	The Journal of finance
2012	The impact of a financial transaction tax on stylized facts of price returns—Evidence from the lab [39]	Huber, J.; Kleinlercher, D.; Kirchler, M.	Journal of economic Dynamics and Control

Table 1. Cont.

Year	Article title [Reference]	Author(s)	Journal
2005	Modelling financial transaction price movements: a dynamic integer count data model [40]	Liesenfeld, R.; Nolte, I.; Pohlmeier, W.	Empirical economics
2002	Credit rationing for bad companies in bad years: evidence from bank loan transaction data [41]	Shen, C.-H.	International Journal of finance & economics
2001	A nonlinear autoregressive conditional duration model with applications to financial transaction data [42]	Zhang, M. Y.; Russell, J. R.; Tsay, R. S.	Journal of econometrics
1983	Simple Sensitivity Analysis by Financial Modelling [43]	Saunders, R.	Teaching Mathematics and Its Applications
1969	Bank examiner criticisms, bank loan defaults, and bank loan quality [44]	Wu, H.-K.	The Journal of finance
1935	Financial Mathematics [45]	Robinson, H. A.; Richeson, A. W.	National Mathematics Magazine

Likewise, the criteria used to select the articles in Table 1 were for carrying out a literature review of the research topic. The main articles allowed us to formulate the research question, and later, both the purpose and the main objective of this study. This literature review also allowed us to determine the main key terms of this research, which were subsequently used to apply the methodology to the sample of selected articles.

## 2.2. Financial Transactions

A financial transaction is defined as any action that exchanges or substitutes financial capital for others with different maturities [31,46]. Most of the works devoted to the study of financial mathematics analyze financial transactions and the risks associated with them [35,47].

The elements that make up a financial transaction, considered as any non-simultaneous exchange of financial capital, are the financial capital that is exchanged; the valuation function that governs the financial exchange; the origin or delivery of the first capital; the maturity of the first capital; (the person who gives the first capital acquires a position, creditor) lender or creditor status; (the person who receives the capital takes a debit) borrower or debtor status; the end or delivery of the last capital, maturity of the last capital; the duration of the transaction, the time that elapses between the beginning and the end of the transaction; and the periodic instalments, return of capital owed, from the debtor position [29,48].

As for the classification, these are determined by different criteria. Therefore, financial transactions are divided into simple ones, with a single capital at the beginning; and another at the end of the spectrum, which includes the study of interest and discount transactions and is complex, are rents, which involve payment streams, such as what happens in the case of the instalments of a loan. The change in the value of capital is due to the fact that capital, the sum of money loaned in a financial transaction, earns interest over time; that is, the remuneration of the capital loaned for its use over time [49,50].

On the other hand, depending on the risk that affects financial transactions, a distinction is made between certain transactions, conditioned by the risk derived from deferring capital over time; and random transactions, which will be affected by this risk, in addition to other circumstances of a random nature that affect the maturities or amounts of the capital that make up the transaction, or its duration [51,52].

Likewise, financial transactions, according to the degrees of certainty of the capitals that comprise them, will be true when all the capitals of the benefit or periodic instalments are true, and will be random when at least one of the capitals of the benefit or periodic instalments is random, or its duration [49].

In a financial transaction, the financial sum of the capital of the benefit must be equivalent to the sum of the capital of the periodic instalments.

Indeed, on the one hand, let  $\{(C_1, t_1), (C_2, t_2), \dots, (C_n, t_n)\}$  be the capitals of the benefit and  $S$  the sum of these at time  $h$ , and on the other hand, let  $\{(C'_1, t'_1), (C'_2, t'_2), \dots, (C'_m, t'_m)\}$  be the capitals of the periodic instalments and  $S'$  the sum of these at time  $h$  (1), so that:

$$S = S' \tag{1}$$

Thus, in a static study, financial equivalency (Equation (2)) is equal to:

$$\sum_{s=0}^n C_s \times f(t_s; h) = \sum_{s=0}^m C'_s \times f(t'_s; h), \quad \forall h \tag{2}$$

In this sense, in financial mathematics, certain financial transactions have been studied in greater depth, while random ones, conditioned on the occurrence of a certain random event that will affect the amount of capital or the duration of the transaction, have not been sufficiently investigated. In a broad sense, the development of random financial transactions is justified by the transformations typical of an advanced and economically developed society, in addition to those inherent in the financial sector [29,50].

Within this context, individuals will find themselves throughout their life cycle with a series of experiences and eventualities that will affect their financial planning. In particular, for example, these events may be derived from the increasing aging of the population; that the credit necessary for them to make their consumption and investment decisions does not reach families; unemployment as an economic and social burden without a clear solution in the short or medium term, which will also affect the distribution of pensions; of the change in the traditional family structure that is taking place; and among other circumstances, the high proportion of elderly people who own a home [51–54].

Although, currently, there is a wide variety of financing instruments, both banking and non-banking, that facilitate the company’s access to financial resources for the development of investment projects, in addition to solving the economic difficulties of individuals and families, it is necessary to recognize that new socio-economic factors in need of particular financial solutions are being generated.

### 2.2.1. Certain Financial Transactions

In traditional amortization transactions, both the origin and the end of the periodic instalments are certain; that is, they are perfectly known, a priori instances, and the capital to be delivered by the borrower for the return of the borrowed capital is certain; that is, they are defined in amount and maturity. This certainty in the first and last payment of the transaction is also equivalent in savings transactions [29,52,55].

The loan is a financial transaction by which an individual, the lender, agrees to deliver to another person, the borrower, at a certain time  $t_0$ , a certain period capital  $(C_0, t_0)$ , which the latter agrees to repay, in a period  $(t_0, t_n)$ , plus interest. Therefore, the loan transaction is made up of a single benefit  $(C_0, t_0)$  and commonly, multiple periodic instalments. For the capital of the periodic instalments  $(a_1, t_1), (a_2, t_2), \dots, (a_n, t_n)$ , whose maturities are associated with the intervals  $(t_0, t_1), (t_1, t_2), \dots, (t_{n-1}, t_n)$ , their mission is to pay the interest that is formed in the transaction and to repay the principal of the debt.

It is usual to carry out the transaction with a capitalization validation function, generally composed, and with uniform periods. The obligation of the lender is almost always immediate; however, the typical forms of repayment of a loan are:

- The borrowed capital is repaid with the interest accumulated at a certain instant.
- The loaned capital is reimbursed through an income that covers capital and interest at the instant indicated in the contract.

Therefore, in the development of financial loan transactions, assuming the amortization of a capital  $C_0$  through the delivery of  $n$  amounts  $a_s$ ;  $s = 1, 2, \dots, n$  postpayable, we start from the equation of certain financial equivalence raised in the origin of the transaction, considering the compounding valuation function and a variable interest rate  $i_h$  for each period (3):

$$C_0 = \sum_{s=1}^n a_s \cdot \prod_{h=1}^s (1 + i_h)^{-1} \tag{3}$$

### 2.2.2. Random Financial Transactions

In certain financial transactions, there is a risk associated with random events; that is, with uncertain events that are known to occur, but not the instant in which the event will occur. This uncertainty is quantified to ensure the risk produced by means of adequate mathematical and statistical techniques [29,49]. Given that financially-random transactions are analyzed in the field of uncertainty, the risk associated with this eventuality must be quantified so that their implicit causes are identified to protect themselves from it. Thereby, the probability in the term of the transaction is introduced as a measure of risk, assigning to each period the probability related to the transaction. In this way, there will be an increase in the amortization term of the transaction greater than if this eventuality did not occur. The probability distribution applied to these transactions will be assigned by the financial institution, so that the conflict between identifying the risk of the financially-random transaction and the interest rate applied according to this risk are resolved by means of a risk quota, where this is considered as the difference between the type of interest in a transaction without risk and associated with financial transactions with randomness [50,56,57].

Consider a loan transaction consisting of the delivery of capital at instant 0, by the lender, and the delivery of  $n$  amounts  $a_s$ , with respective maturity at time  $s$ , by the borrower, to proceed with the amortization of the principal ( $s = 1, 2, \dots, n$ ). If the repayment of the loan were subject to a contingency, the borrower would have to pay higher repayment terms than if the loan were not subject to such eventuality. The equation of financially-random equivalence is presented at instant 0 of the transaction, considering the valuation function of compound capitalization, and in general, a variable interest rate for each period (Equation (4)):

$$C_0 = \sum_{s=1}^n a_s \cdot \prod_{h=1}^s (1 + i_h)^{-1} \cdot (1 + r_h)^{-1} \tag{4}$$

where  $r_h$  represents the risk rate that the borrower must pay to the lender, also considered variable in each amortization period, and the financial valuation function is compound capitalization.

Thereby, for example, in the event that the contingency is the death of the borrower, the risk represented by  $r_h$  is the risk that the borrower has of dying and that his obligation is extinguished to the detriment of the lender (Equation (5)):

$$C_0 = \sum_{s=1}^n a_s \cdot p_s \cdot \prod_{h=1}^s (1 + i_h)^{-1} \tag{5}$$

where  $p_s$  is the probability of survival. The risk due to the randomness of the capitals, assumed by the lender or borrower in a financial transaction, will affect the amount of the amortization or constitutive terms, the profitability, and the duration of the periodic instalments or benefit.

The randomness of financial transactions is subject to the probability distribution of the occurrence of a certain event that will affect the amount of capital involved or the duration of the transaction. In this way, while chance refers to chance, it makes an event fortuitous or unforeseen. For its part, the adjective random is the term that describes events governed by chance, that is, those that depend on a fortuitous event [58–60].



Indeed, there are some contingencies that will happen with certainty, in which case the randomness affects the exact moment of its occurrence. On the other hand, the occurrence of a random event does not depend on the will of the individual it affects, since it depends on the risk or the uncertainty associated with said eventuality. For this, the risk inherent in a fortuitous event will be measured by probabilities, in order to reduce objective uncertainty to a value that describes its uncertainty, in addition to obtaining information that allows statistically treating the associated risk.

Once the probability of an uncertain event is known, an attitude of aversion or propensity towards it can be adopted. In this context, aversion is considered a negative quality and a fear of the possibility of the fact happening, while to increase the risk the attitude of accepting the probable occurrence of this random fact is adopted. The fundamental difference between risk and uncertainty lies in the fact that the former can be measured, using probability, while the uncertain has no measure [29,61,62].

In relation to financial transactions, one of the subjects involved is usually a financial entity, which, acting as a receiver and transferor of money, assumes risks in its activity, representing a part of the banking profit. As an intermediary between providers and claimants of capital, entities assume the risk of possible defaults. For this reason, among others, the risk is managed based on the information available. To evaluate this situation, it is necessary to identify the areas that are likely to put the financial institution in a situation of instability [63,64].

The risk introduces into the banking business the probability of loss due to the occurrence of an uncertain event, presenting negative economic consequences; but it is also considered by the banking industry as a business opportunity, as it is included in the design of certain financial instruments, and therefore, produces profit in all of its transactions.

In consequence, financial entities assume a financial risk, not insurable, derived from the investment transactions they carry out in the exercise of their activity, with favorable or unfavorable economic results, both assumed by the analytical treatment of the available information [29]. Therefore, for the financial institution, the increase in the cost of capital that implies greater solvency requirements will be compensated with the assumption of greater risks to maintain the profitability of its own resources, and random financial transactions must be added to this purpose [65,66].

These are financial transactions in which the duration is random, and the risk is associated with the fact that it is known that the security will occur but not the instant of its occurrence. In the case of amortization transactions subject to an eventuality, the amortization term will include the risk quota, referring to the sum that the borrower will deliver to the lender in each of the periods to meet the risk assumed [29,50].

Loan transactions can present randomness in the periodic instalments, linked to an eventuality. Thence, for example, in the event that the initial moment of the periodic instalments is true and the end is subject to a contingency, it will be the financial institution, lender, and creditor of the capital, who will assume the risk of the extinction of the return of the amount that was pending. In such a case, the probability of an income's  $n$ -term duration and payment of these terms will be subject, for example, to the random phenomenon of the borrower's survival [67,68]. Likewise, loan transactions can also be considered where randomness affects the origin of the periodic instalments, and even transactions where both first and last of the periodic instalments are random.

Finally, it should be noted that randomness can also be presented in the amounts of capital; that is, they are random. This circumstance will involve the study of the distribution of the amortization or constitutive terms of a financial transaction based on the mathematical-financial concepts of continuous distribution of capital and continuous income. In addition, it is relevant to analyze the particular case of financial transactions with maturity periods of different lengths, which can facilitate the adjustment of the distribution of payments of the transaction with the regular income of the borrower or lender, in loans or savings transactions, respectively [29,49,50,69,70].

### 3. Materials and Methods

Scientometrics is a discipline that studies and analyzes the contributions written by scientists, so considered a science of science. Its origin is associated with Derek de Solla Price with his works: *Science since Babylon* (1961) and *Little Science, Big Science* (1964). The purpose of scientometrics is to identify laws and the characteristics of scientific activity in its entirety. Scientometrics users seek to identify the scientific documents in the databases and subsequently process the information they contain [71].

Within scientometrics, the scientific discipline of bibliometrics is included, which applies mathematical and statistical methods to scientific works, with the aim of studying and analyzing knowledge of scientific activity [72]. Researcher Eugene Garfield, a pioneer along with Solla Price, contributed to the discipline with the science citation index, in 1963, published by the Institute for scientific information (ISI), to increase statistics on scientific contributions. Garfield, in the mid-20th century, introduced bibliometrics, which has become a method of scientific research to assess knowledge in numerous disciplines through the different publications that represent the activity of researchers, academics and scientists. In 1978, with the creation of the journal *scientometrics*, this discipline was institutionalized and allowed its diversification, based on statistics and mathematical methods [73].

In this way, bibliometrics is considered as the science that studies the nature and evolution of a discipline through its publications, through the computation and analysis of various characteristics. Hence, bibliometrics uses bibliometric indicators in order to measure the existing information on the results of scientific activity in any of its publications or documents [74,75]. This set of indicators allows one to quantitatively express the bibliographic characteristics of the documents published in the scientific and academic field. Because of that, a bibliometric indicator synthesizes a bibliographic characteristic or a combination of them using a numerical value that denotes more interest when it can be compared with observations from other sets of documents, such as those from other geographic areas, institutions, disciplines, specific areas of knowledge, or databases, among others, and study its evolution over time [76].

The objective of this paper is to examine and analyze global research trends in financial transactions. In order to achieve this purpose, a quantitative analysis has been carried out, using bibliometric, a documentary method that has reached an important development in recent decades.

This methodology has made it possible to review scientific knowledge from the different publications, and it has been used in many scientific areas, such as economics, administration, finance, mathematics, engineering, psychology, and education [77–79].

The methodology applied in this study has been the search for scientific publications related to the object of study in the Scopus database, which has been chosen for its outstanding breadth of coverage and reliability in peer review, as has been used in other analyses successfully applied [80,81].

Based on the revised literature of the study topic, mainly in Table 1, the terms chosen in the search string are “financial transaction” and “financial operation”, joined by Boolean connectors. Thereupon, the subfields title, abstract, and keywords, in the period that includes the publication of the first article on the research topic, 1935, until the last full year, 2019, that is, a period of 85 years have been analyzed, in the same way that has been applied successfully in various works that have used bibliometric methodology [82–85].

In addition, only article-type publications were included during this process, since they offer all the guarantees of scientific quality with the peer review process. Both open and non-open access articles were included, in order to guarantee that all the articles were collected in the sample. Consequently, the total sample of articles examined included 1486 articles, and was conducted in March 2020. Therefore, Figure 2 presents the outline of the steps followed in the applied methodology.

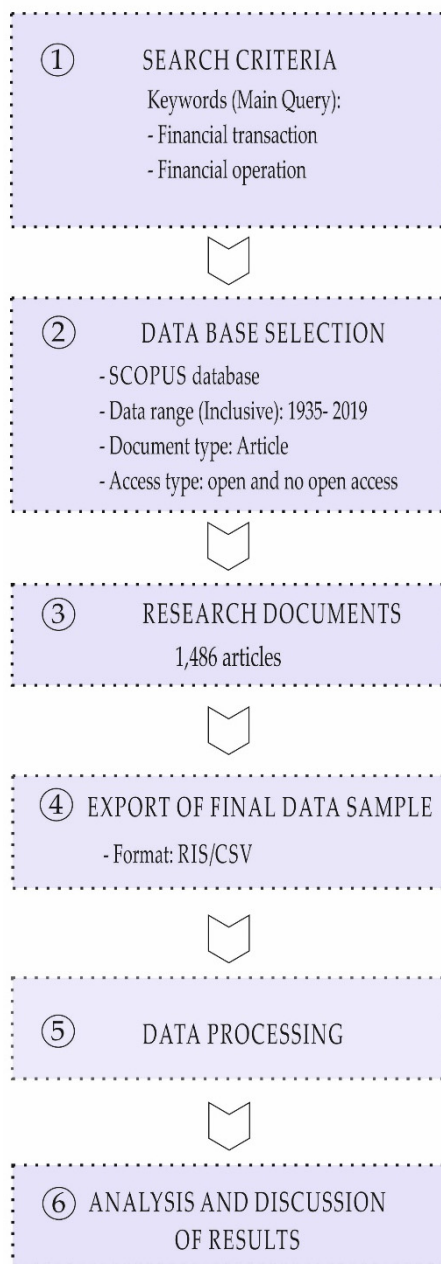


Figure 2. Flowchart of methodology applied.

The bibliometric methodology has been developed to analyze the scientific communities associated with this topic. For this reason, the relationships between the main authors, affiliations, and countries in global research on financial transactions have been analyzed and explained through the co-authorship of each article—and the number of citations received is also considered important for a publication by the rest of the scientific community, as it quantifies the impact achieved by this publication. In addition, the relationships between the keywords of all scientific articles on the research topic, based on co-occurrence, have been analyzed.

In the methodology used, the co-citation analysis allows observing the articles with citations and cited references, which can show scientific knowledge and trends in each discipline in order to establish research strategies. Consequently, bibliometric instruments are used in evaluation operations. The authors (research actors), institutions (research centers), and the countries (territories where the research takes place) are determined from the quotes shared by the other elements, which are relevant to

the discipline [86]. This allows generators of scientific production (authors, institutions, and countries) to be substitutes for the ideas they represent when grouping [87,88].

Likewise, the co-occurrence analysis is used in order to provide a graphic visualization of the connection of the key terms of the analyzed documents. The co-occurrence networks provide a graphic map of the relationships between the authors, institutions, countries, or keywords of a sample article on a given research topic. In this sense, the proximity relationship of two or more keywords is established in a text unit. On that count, if the keywords coexist in a sentence, that is, they appear together, there is a probability of semantic relationship [89,90].

The co-occurrence criteria group strongly related keywords in the set of articles in the sample. This analysis examines the articles in order to search for two or more keywords that tend to be together [91]. It is established that if there are concurrent concepts, a category is generated. In this way, two or more keywords will be co-occurring if they frequently appear together in a sample of articles and if, occasionally, they are separated in the other articles.

In summary, indicators of collaborative structure measure the relationships between authors, institutions, and countries that contribute to a research topic over a period. In this study, these indicators have been analyzed with network processing tools and maps, due to their proven reliability and convenience in bibliometric methodology [92,93].

To obtain these co-citation and co-occurrence maps, the online software tool VOSviewer, (version 1.6.10., Leiden University, Leiden, The Netherlands) was used in this study. Therefore, VOSviewer offers reliability and guarantee in bibliometric methodology, as a tool for mapping and processing article data, since it has been used in other bibliometric studies. This tool allows the analysis of co-citation and co-occurrence, in order to visualize relationship maps and network links between authors, institutions, countries, and keywords. Subsequently, this software tool allows recognizing research trends based on the use of keywords in research articles [94,95].

Finally, all the results obtained allow the evaluation of research and scientific activity in the financial transactions research area. Likewise, it is necessary to recognize that scientometrics and bibliometric instruments allow the analysis and description of innovation processes, in order to identify themes, authors, institutions, and countries, in addition to monitoring interactions between them. In this sense, the content and options for success of innovation in a research area will depend on the intensity of these relationships and links.

The results obtained from the application of the bibliometric methodology to the sample of the 1486 articles from the Scopus database are revealed to be useful for researchers, academics, financial analysts, and decision-makers to optimize for the rest of the agents involved in this theme.

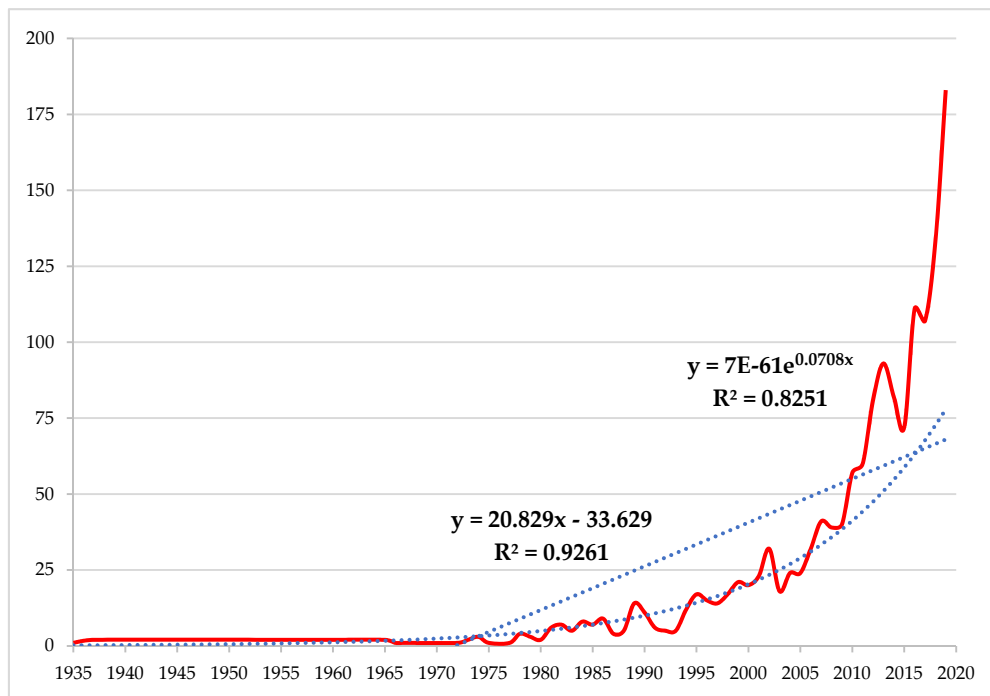
#### 4. Results and Discussion

This section presents and discusses the results of the evolution of scientific production on financial transactions in a global context, in addition to the distribution of publications by thematic area, the analysis of the most prolific journals, the examination of the most cited articles and those with the greatest significant impact, and the analysis of the main keywords associated with the most productive authors, institutions, and countries globally. Likewise, the results obtained from the analysis of the main keywords associated with this research topic are discussed.

##### 4.1. Evolution of Scientific Research, Thematic Areas, and Journals

Figure 3 shows the progress of the total articles from the 1935–2019 sample that have been identified in the search carried out in the Scopus database. The exponential trend is observed in the publication of scientific articles on financial transactions in the last 85 years. In addition, this result makes it possible to notice that during the last five-year period, 2015–2019, 606 contributions have been made to this research topic, representing 40.78% of the total, while in the last decade, 2010–2019, 65.88% of total contributions were published, thereby showing the growing interest and relevance of

this topic. In the first year analyzed, 1935, only one article was published, whereas in 2019, the last year studied, a volume of 183 articles (12.31%) was published.



**Figure 3.** Evolution of the number of articles on financial transactions (1935–2019).

As seen in Figure 3, in the period 1935–2019, the exponential trend line shows its goodness with an  $R^2$  of 0.8251. Hence, the curved line represents that the number of articles on the subject of financial transactions increasing faster with time.

In the period 1972–2015, the trend line also shows its goodness, with an  $R^2$  of 0.9261, which represents the good fit of the line to the data. The linear trend indicates that the number of articles has increased at a constant rate during this period.

Most of the articles on this topic are written mainly in English (91.47%), as it happens fundamentally in the searches carried out in the Scopus database [96]. Articles have also been published in different languages, such as Spanish (1.52%) and French (1.12%), while the rest do not exceed 1% of total contributions.

Table 2 shows the most cited articles in relation to the research topic of financial transactions at a global level, during the period 1935–2019. It was observed that the article with the most citations was from 1998 (768), and it studied a model for irregularly spaced transaction data [97].

**Table 2.** Most cited articles and their significant impacts on the research of financial transactions (1935–2019).

Year	Title [Reference]	Author(s)	Journal	Total Citations	Thematic Area	Percentage of Theamtic Areas Cited
1998	Autoregressive conditional duration: A new model for irregularly spaced transaction data [97]	Engle, R.F., Russell, J.R.	Econometrica	768	Economics, Econometrics and Finance	Economics, Econometrics and Finance (58%) Business, Management and Accounting (19%) Mathematics (15%) Computer Science (8%)
1997	The correlates of change in international financial regulation [98]	Quinn, D.	American Political Science Review	546	Social Sciences	Economics, Econometrics and Finance (50%) Social Sciences (39%) Business, Management and Accounting (10%) Nursing and Health Professions (1%)
1999	An exploratory study of small business Internet commerce issues [99]	Poon, S., Swatman, P.M.C.	Information and Management	319	Computer Science	Economics, Econometrics and Finance (65%) Computer Science (26%) Social Sciences (13%) Engineering (7%)
2005	Does legal enforcement affect financial transactions? The contractual channel in private equity [100]	Lerner, J., Schoar, A.	Quarterly Journal of economics	230	Economics, Econometrics and Finance	Economics, Econometrics and Finance (56%) Business, Management and Accounting (33%) Social Sciences (10%) Computer Science (2%)
2006	Has finance made the world Riskier? [101]	Rajan, R.G.	European Financial Management	226	Economics, Econometrics and Finance	Economics, Econometrics and Finance (62%) Business, Management and Accounting (26%) Social Sciences (9%) Engineering (2%)
2010	How Islamic is Islamic Banking? [102]	Khan, F.	Journal of economic Behavior and Organization	201	Economics, Econometrics and Finance	Business, Management and Accounting (41%) Economics, Econometrics and Finance (40%) Social Sciences (14%) Arts and Humanities (5%)
2015	Understanding mobile banking: The unified theory of acceptance and use of technology combined with cultural moderators [103]	Baptista, G., Oliveira, T.	Computers in Human Behavior	184	Arts and Humanities	Business, Management and Accounting (51%) Computer Science (26%) Social Sciences (12%) Economics, Econometrics and Finance (12%)
1997	Customer-focused manufacturing strategy and the use of operations-based non-financial performance measures: A research note [104]	Perera, S., Harrison, G., Poole, M.	Accounting, Organizations and Society	179	Social Sciences	Business, Management and Accounting (76%) Economics, Econometrics and Finance (14%) Social Sciences (6%) Engineering (4%)
2003	Barriers to Internet banking adoption: A qualitative study among corporate customers in Thailand [105]	Rotchanakitumnuai, S., Speece, M.	International Journal of Bank Marketing	171	Business, Management and Accounting	Business, Management and Accounting (66%) Computer Science (15%) Economics, Econometrics and Finance (12%) Social Sciences (7%) Computer Science (39%)
2005	E-government developments on delivering public services among EU cities [106]	Torres, L., Pina, V., Acerete, B.	Government Information Quarterly	166	Social Sciences	Business, Management and Accounting (29%) Social Sciences (28%) Economics, Econometrics and Finance (4%)

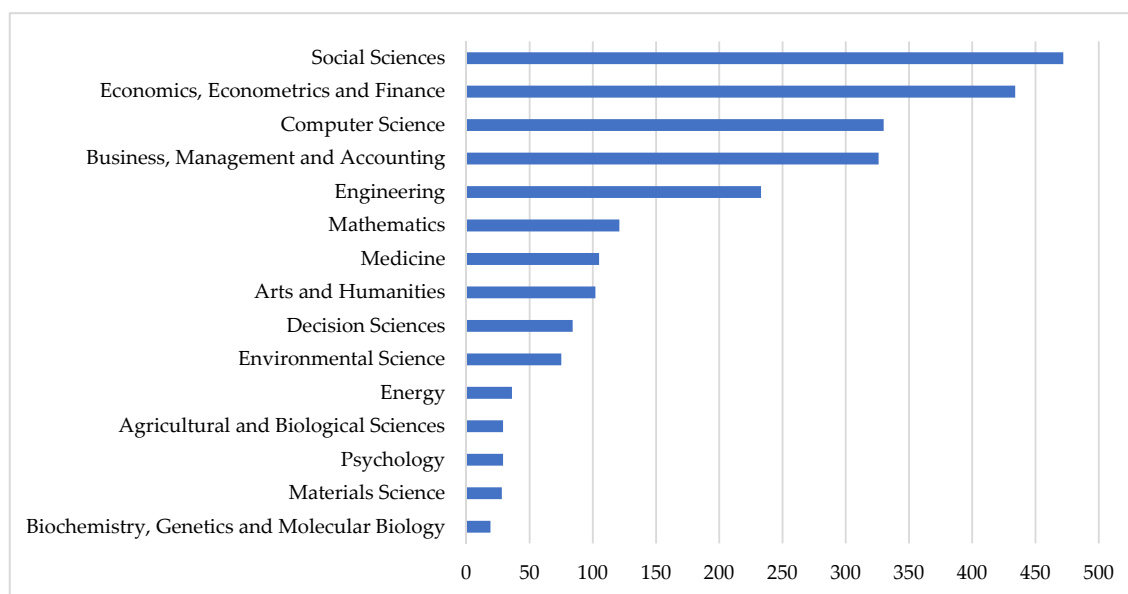
On the other hand, one of the key principles of citation analysis state that the citation counts of publications from different subject areas should not be compared directly to each other, because there are large differences in citation density between them [107,108].

From this perspective, the Table 2 allows us to know the impacts of the articles considering their thematic areas. Starting from the ten most cited articles, the predominant subject areas to which each of them belong are attended, and the areas from which the citations of each article come are counted.

Taking this into account, the article with the highest impact on citations is not the one with 769 citations, but the one with the highest percentage of citations in its own area; that is, “Barriers to Internet banking adoption: A qualitative study among corporate customers in Thailand”, by Rotchanakitumnuai, S. and Speece, M., with 171 citations in its main thematic area (66%).

In the time horizon examined, articles related to the analysis of financial transactions are grouped into different areas of knowledge. The sample of 1486 articles is classified into 27 thematic areas, according to the Scopus database. In this sense, it should be noted that an article could be classified in more than one subject area, depending on the interest of the author or authors of the article and the editor of the journal.

Figure 4 presents the classification by thematic areas of the articles in the global investigation of financial transactions, during the period 1935–2019. Social sciences is the category that collects the most articles with 18.55% of the articles published in the total sample. Next is the economics category, econometrics and finance, with 17.06%. Computer science (12.97%), business, management, and accounting (12.81%), engineering and energy (9.16%), and mathematics (4.76%) are the following thematic areas. The six most relevant thematic areas group 75.31% of the articles published in the period 1935–2019. These are followed by medicine (4.13%), arts and humanities (4.01%), decision sciences (3.30%), and environmental science (2.95%). The rest of the thematic areas do not reach 2% of published works.



**Figure 4.** Main thematic areas on financial transactions (1935–2019).

Most articles on financial transactions are associated with the social sciences category, included in the disciplines of sociology, law, economics, communication or psychology [109]. As can be seen in Table 2, the most cited articles, and to some extent most relevant to the scientific and academic community, collect contributions associated to finance and mathematics, in relation to financial mathematics, as a science derived from the mathematics that studies the value of money over time [45,110,111].

Regarding the most productive scientific journals on this research topic, considering the number of articles published and the percentages they represent of the total, International Journal of Innovative Technology and Exploring Engineering (15, 1.01%) and Journal of Money Laundering Control (15, 1.01%) stand out. They are followed by Journal of Theoretical and Applied Information Technology (10, 0.67%), Journal of Internet Banking and Commerce (9, 0.61%), Lecture Notes in Computer Science (including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (9, 0.61%), Computers and Security (7, 0.47%), International Journal of Applied Engineering Research (7, 0.47%). Next, journals IEEE Access, Intereconomics, and International Journal of Engineering and Technology (UAE) are located, with 6 articles each (0.40%).

Table 3 displays the main characteristics of the ten most prolific journals on the research topic in 1935–2019 period: number of articles, number of citations for all articles, number of citations by article, h-index in research topic, first and article, and country. It is observed that four of these journals are of European origin, four of Asian origin, and two of North American origin.

**Table 3.** Main Journals on financial transactions (1935–2019).

Journal	A	TC	TC/A	H *	CiS *	SJR *	SNIP *	1st A	Last A	Country
International Journal of Innovative Technology and Exploring Engineering	15	1	0.07	1	NC	NC	NC	2019	2019	India
Journal of Money Laundering Control	15	60	4.00	5	1.02	NC	NC	2006	2019	UK
Journal of Theoretical and Applied Information Technology	10	10	1.00	2	0.67	0.166	0.500	2010	2019	Pakistan
Journal of Internet Banking and Commerce	9	169	18.78	6	0.52	0.159	0.835	2009	2016	Canada
Lecture Notes in Computer Science	9	36	4.00	3	1.06	0.283	0.713	2003	2010	Germany
Computers and Security	7	116	16.57	3	4.65	0.667	2.303	1986	2019	UK
International Journal of Applied Engineering Research	7	5	0.71	1	0.13	0.122	0.354	2013	2016	India
IEEE Access	6	53	8.83	3	4.96	0.609	1.718	2018	2019	USA
Intereconomics	6	9	1.50	3	0.53	0.282	0.551	1992	2012	Germany
International Journal of Engineering and Technology (UAE)	6	2	0.33	1	0.08	0.113	0.192	2018	2018	United Arab Emirates

A: number of articles; TC: number of citations; TC/A: average citations; H: h-index or Hirsch index; SJR: Scimago Journal Rank (2018); CiS: CiteScore (2018); SNIP: source normalized impact per paper (2018); NC: not calculated; 1st A: first article; Last A: last article; (\*) in research topic.

This Table 3 also includes the main impact metrics offered by the SCOPUS database; that is, the impact indicators CiteScore, SCImago Journal Rank (SJR), and source normalized impact per paper (SNIP) from 2008.

The CiteScore indicator is obtained from the calculation of the number of citations in a year received by academic articles published in a journal in the three immediately preceding years, divided by the total number of articles published during those same three years. The journals with the highest CiteScore are IEEE Access (4.96) and Computers and Security (4.65).

SCImago Journal Rank (SJR), meanwhile, is based on the count of citations obtained by each publication, that is, it is obtained by counting the number of citations received, weighing the importance of the journals from which these citations originate. The journals with the highest SJR are Computers and Security (0.667) and IEEE Access (0.609).

Finally, the SNIP indicator counts the number of citations received by a journal for three years divided by the potential citation from the journal’s scientific field. The journals with the highest SNIP are Computers and Security (2.303) and IEEE Access (1.718).

#### 4.2. Publications by Author, Institution, and Country

The total sample of articles has been written by 2985 authors at the international level. The five most productive authors in global financial transactions research were Khare, A. (Indian Institute



of Management Rohtak, India), Nerudová, D. (Mendelova univerzita v Brne, Czech Republic), Capelle-Blancard, G. (Universite Paris 1 Pantheon-Sorbonne, France), Musolino, F. (Università degli Studi di Messina, Italy), and Russell, J.R. (The University of Chicago, United States). Among the ten most productive authors, it is worth noting that five are of European origin (Nerudová, D.; Capelle-Blancard, G.; Musolino, F.; Thurner, S. and Batoš, V.) and two are Americans (Russell, J.R. and Brockett, P.L.). On the other hand, it is also necessary to highlight that in this ranking of most productive authors, 50% have contributed to research on financial transactions in the last five years (Khare, A.; Nerudová, D.; Capelle-Blancard, G.; Thurner, S. and Yi, G.).

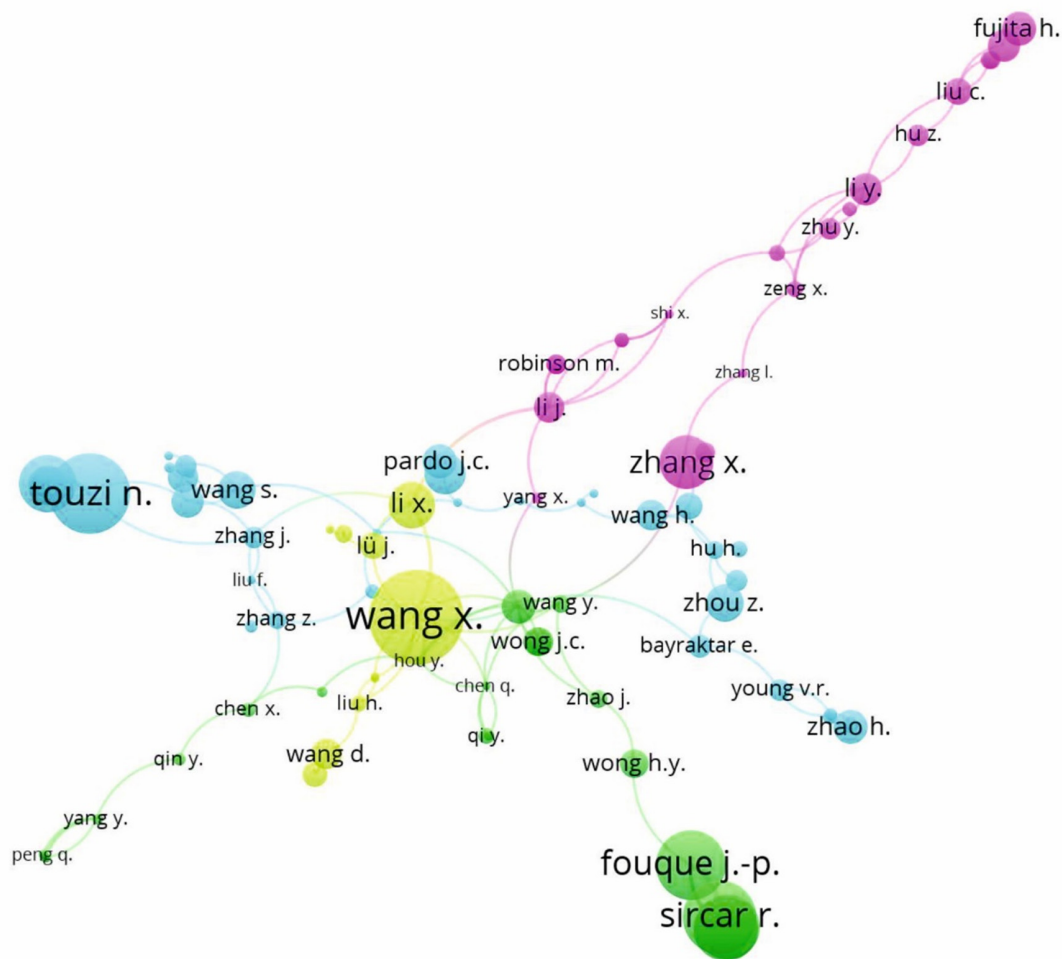
Table 4 indicates the most relevant keywords associated with the ten most prolific authors on the topic of financial transactions research. The keywords related to the works of the main authors are varied. In a first group, those related to regulations are associated, highlighting “financial transaction tax”, “Tobin tax”, “deregulation”, “financial security”, and “banking regulation”. A second group of keywords is in line with financial crises, such as “financial risk”, “speculation”, and “systemic risk”. A third group associates keywords related to the digital transformation applied to financial transactions, such as “Internet banking”, “online banking”, “computer simulation”, and “data acquisition”. Finally, in a fourth largest group, terms related to the activity itself and the financial system can be classified, such as “budget”, “capital market”, “liquidity”, “currency markets”, “market microstructure”, “bid-ask bounce”, “discrete-valued time series”, “batch-storage network”, and “economic order quantity”.

**Table 4.** Featured authors and associated keywords (1935–2019).

Author	Affiliation	City, Country	First Article	Last Article	Keywords
Khare, A.	Indian Institute of Management Rohtak	Rohtak, India	2010	2016	Financial Security-Internet Banking-Online Banking
Nerudová, D.	Mendelova univerzita v Brne	Brno, Czech Republic	2011	2019	Financial Transaction Tax-Budget-Capital Market
Capelle-Blancard, G.	Universite Paris 1 Pantheon-Sorbonne	Paris, France	2016	2018	Financial Transaction Tax-Liquidity-Tobin Tax
Musolino, F.	Università degli Studi di Messina	Messina, Italy	2012	2014	Speculation-Currency Markets-Financial Risk
Russell, J.R.	The University of Chicago	Chicago, USA	1998	2008	Market Microstructure-Bid-ask Bounce-Discrete-valued Time Series
Thurner, S.	Complexity Science Hub Vienna	Vienna, Austria	2009	2017	Systemic Risk Banking Regulation-DebtRank
Yi, G.	Pukyong National University	Busan, South Korea	2004	2018	Investments-Batch-storage Network-economic Order Quantity
Batoš, V.	University of Dubrovnik	Dubrovnik, Croatia	2002	2009	Banking Industry-Computer Simulation-Data Acquisition
Benjamin, R.	Fundacao Getulio Vargas	Rio de Janeiro, Brazil	2010	2010	Deregulation-Financial Crisis-Financialization
Brockett, P.L.	The University of Texas at Austin	Austin, USA	1996	2013	Financial Time Series-Statistical Test-Stochastic Process Model

The literature reviewed indicates that in the period analyzed, 1935–2019, the authors point to different lines within the research topic examined, as seen in Table 1. Therefore, among these, the term “bid-ask bounce” explains the differential between supply and demand in each market [112]; the “Tobin tax”, like the tax on financial transactions proposed by the American economist, James Tobin, and which seeks to find a deterrent to the speculative phenomenon [113]; or the “systemic risk” that refers to the non-diversifiable or market risk that depends on the market itself where the financial asset is listed, and therefore, cannot be reduced [19,114].

Figure 5 displays the cooperation map, based on co-authorship, between the authors who have published globally on financial transactions. Likewise, the color of each group is associated with the group of authors in the production of articles, and the size of the circle refers to the number of articles by the author. On that account, the authors on this research topic are associated in four groups.



**Figure 5.** Cooperation network between authors based on co-authorship.

Cluster 1 (blue) groups 39.33% of the authors, and presents the collaborations between Bayraktar, E.; Bouchard, B.; Kuznetsow, A.; Liu, X.; Pardo, J.C.; Soner, H.M.; Liu, F. and Touzi, N.; and others. Cluster 2 (green) brings together 25.84% of authors, and includes the collaborations, among others, by Qin, Y.; Sircar, R.; Solna, K.; Wong, H.Y.; and Yu, Y. and Zhao, J. Cluster 3 (pink) groups 23.60% of authors investigating financial transactions at the global level, and is composed, among others, by authors Robinson, M.; Shi, X.; Yang, X.; Zeng, X.; and Liu, C. and Zhu, Y. Finally, group 4 (yellow) links 11.23% of the authors and presents the collaborations, among others, of Rao, R.; Wang, D.; and Zheng, M. and Wang, X.

The association between authors, among other reasons, is sustained in globalization. The further development of research on financial transactions and instruments is propitiated by the advancement of technology; that is, the digital transformation resulting from the emergence of the Internet in the 1980s [115,116]. This collaboration also comes from the need to find answers to the particular financial needs of the different regions of the world, so that, indirectly, the research seeks a global financial sustainability [117].

The 1486 articles on financial transaction research have been written with 2326 international affiliations. Of these, the five most published articles have been the University of Oxford (United Kingdom), New York University (United States), International Islamic University Malaysia (Malaysia), University of New South Wales UNSW Australia (Australia), and International Monetary Fund (United States). In the ranking of the top ten most productive institutions, it stands out that four are American (New York University, International Monetary Fund, Massachusetts Institute of Technology and University of Michigan), two are Malaysian (International Islamic University Malaysia and

Universiti Kebangsaan Malaysia), and two are of European origin (University of Oxford and Göteborgs Universitet).

The global connection is a key factor in the research and disclosure of financial transactions. For this reason, research arises that analyzes the financing of active financial operations, the granting of guarantees to companies, the financing of innovation, the growth and expansion, and regeneration or sustainable development of urban development projects. In this way, the research carried out by current economies looks for efficient systems that evolve in parallel with the speed at which technology does [118].

Table 5 displays the keywords of the most prolific institutions in the investigation of financial transactions, during the period 1935–2019. The main keywords are related to financial activity stand out mainly: “behavioral feature”, “average run length”, “agent-based modeling”, “Accelerated Share Repurchase (ASR)”, “Earnings Per Share (EPS)”, “likelihood ratio”, “fat-tailed distribution”, “data stream clustering”, and “autoregressive conditional duration”. A second group of keywords is related to financial rules and regulations: “Tobin tax”, “cash-flow tax”, “corporate income tax”, “bank cost”, “consumer protection”, “bonus tax”, “financial activity tax”, “change point detection”, and “default”. A third group is linked to the digital transformation applied to financial transactions: “financial services”, “islamic mobile banking”, and “digital banking”. Finally, a fourth group of keywords is related to banking activity: “balanced budget requirements”, “credit rating”, and “commercial bank”.

**Table 5.** Main institutions and keywords (1935–2019).

Institution	Country	First Article	Last Article	Main Keywords
University of Oxford	UK	2006	2018	Financial Services, Banking, Economics, Tobin Tax, Agent-based Modeling
New York University	USA	1907	2017	Approximation Theory, Autoregressive Conditional Duration, Balanced Budget Requirements, Bid-ask Bounce, Debt
International Islamic University Malaysia	Malaysia	2012	2019	Islamic Mobile Banking, Banking Product, Consumer Protection, Credit card, Credit financing
University of New South Wales UNSW Australia	Australia	1990	2019	Bank Capital, Close-out Netting Provision, Digital Banking, Forward contract, Financial Transaction Tax
International Monetary Fund	USA	1985	2007	Banking, Capital, Cash-flow Tax, Corporate Income Tax, Capital Market
Massachusetts Institute of Technology	USA	1988	2018	Finance, Financial Transaction, Behavioral Feature, Commercial Bank, Credit Card Data
Islamic Azad University	United Arab Emirates	2012	2017	Accelerated Share Repurchase (ASR), Earnings Per Share (EPS), Intellectual Capital, Bank Cost, Banking
Universiti Kebangsaan Malaysia	Malaysia	2014	2019	Banked Consumers, Consumer Protection, Credit Rating, Default, Data Stream Clustering
Göteborgs Universitet	Sweden	2007	2017	Monitoring, Average Run Length, Change Point Detection, Financial Transaction Tax, Likelihood Ratio, Fat-tailed distribution
University of Michigan	USA	1988	2013	Bonus Tax, Economic, Financial Activity Tax, Financial Transaction Tax, International Finance

The 1486 articles were written in 95 different countries. Thence, the country with the most contributions to financial transactions is the United States (20.13%), followed by United Kingdom (7.96%), India (5.38%), China (3.81%), Germany (3.76%), Italy (3.14%), Australia (3.03%), France (2.58%), Malaysia (2.58%), South Korea (2.47%), Canada (2.36%), Spain (2.19%), and Russia (2.02%). The rest of the countries did not exceed 2% of the total contributions.

Figure 6 displays the collaboration network between the main countries, based on co-authorship, in the writing of articles on financial transactions. In this Figure 6, colors are associated with groups of countries, while the size of the circle of each country is linked to the number of articles whose authorship it represents. Hence, applying the software tool, VOSviewer, the countries have been associated in six groups.

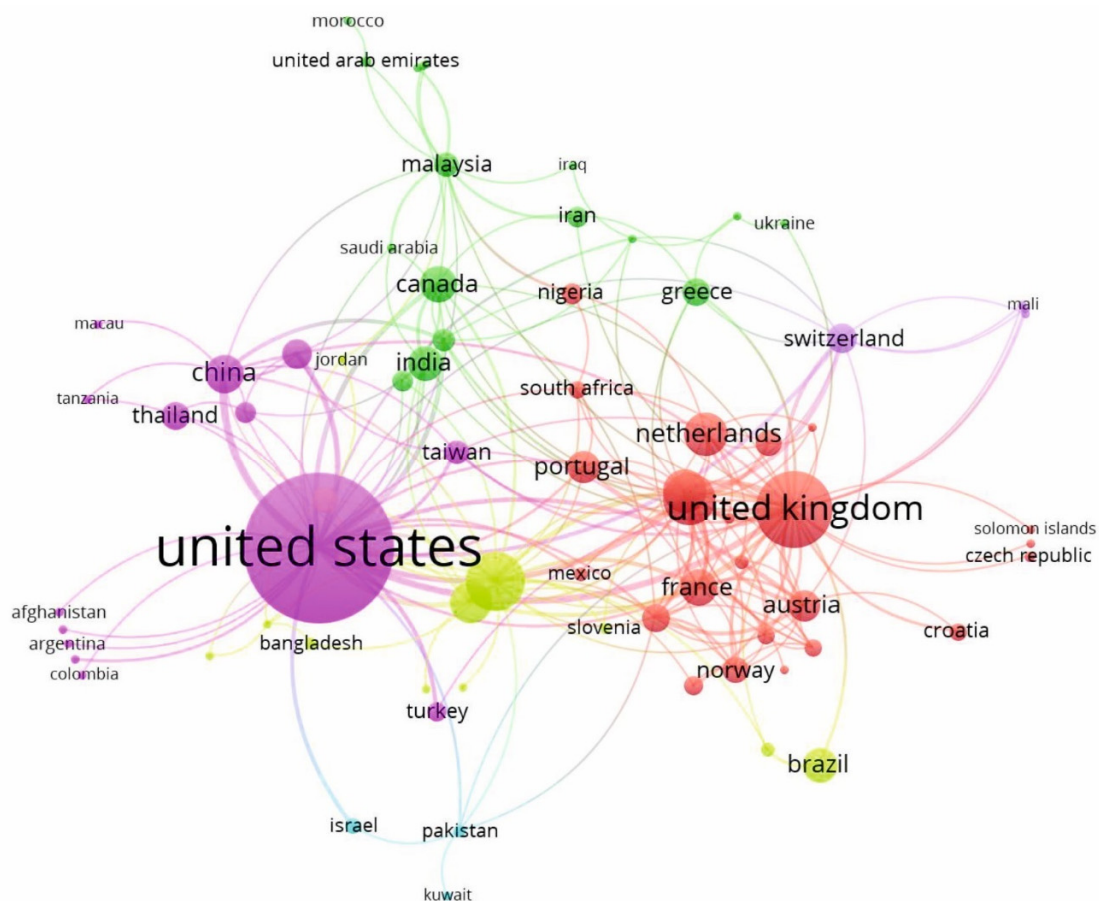


Figure 6. Network of cooperation between countries based on co-authorship.

Therefore, cluster 1 (red) is the group with the most associated countries and incorporates 32% of the total. It is led by the United Kingdom, and is associated, among others, with Austria, Belgium, France, Netherlands, Norway, Portugal, Sweden, Spain, Hungary, or Denmark. Group 2 (green), made up of 23%, is led by Canada and shares articles, mainly with Greece, Russian, Malaysia, India, Iran, Poland or the United Arab Emirates. Meanwhile, cluster 3 (pink), made up of 19%, is led, in this case, by United States, and collaborates in the production of articles on the study’s research topic, with China, Argentina, Colombia, South Korea, Thailand, Turkey or Japan. Cluster 4 (yellow), made up of 17%, is led by Australia and forms its network, with Brazil, Cameroon, Italy, Slovenia, or Chile, among others. Group 5 (violet), with 5%, is led by Switzerland and incorporates into its network to Mali or Mozambique. And, cluster 6 (blue), with 4%, is led by Pakistan, and cooperates with Israel or Kuwait.

The interest generated by the analysis and development of the banking and financial sector has repercussions and direct implications on the social and economic dimensions of the regions at a global level [119]. Academic and financial institutions cooperate in the environment of the global economy to respond to current and future financial challenges [120,121], reflecting this in the research collaboration between countries.

Table 6 shows the six clusters on the thematic field of financial transactions, according to cooperation between countries, based on co-authorship. It is named as the country with the highest number of articles published within each group.

**Table 6.** Clusters of countries and keywords (1935–2019).

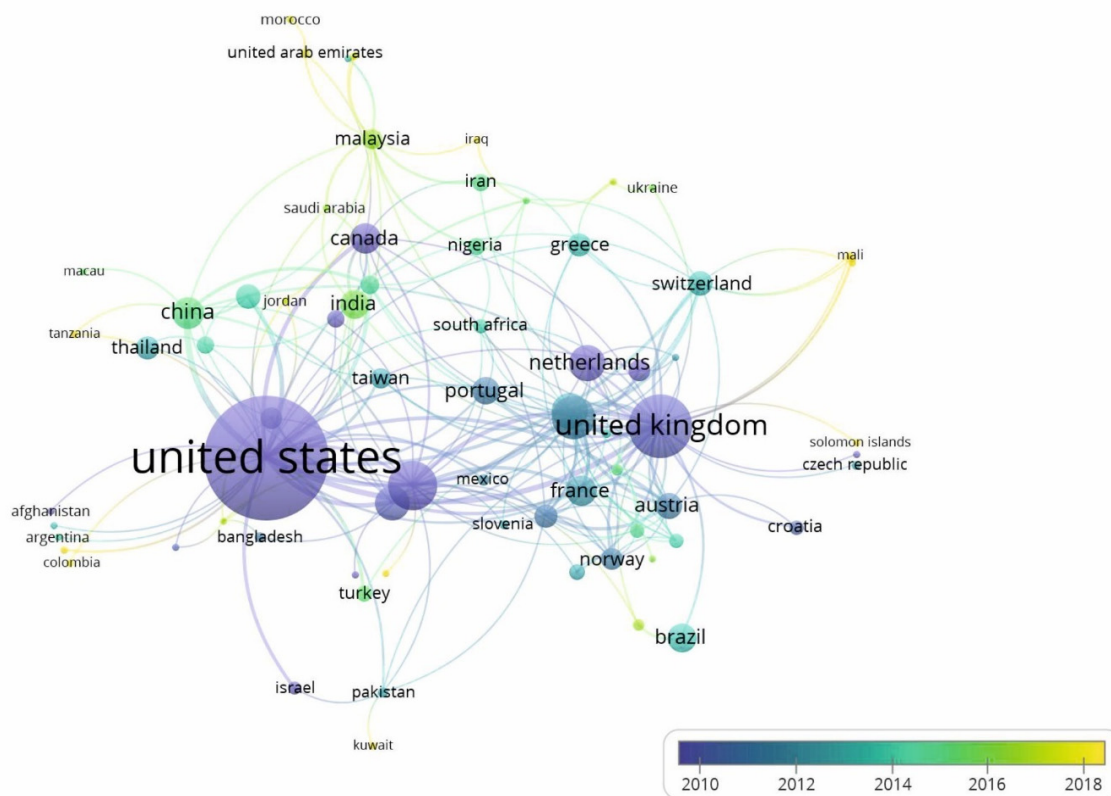
Cluster Number *	Color	Cluster Name **	%	Main Keywords
1	Red	UK	32.00	Financial Transaction Tax, Network Security, Financial Data Processing, Mathematical Models, Agent-based Modeling
2	Green	Canada	22.67	Money Laundering, Biometric, Currency Devaluation, Banks' Accounting, Artificial Intelligence
3	Pink	USA	18.67	Security, Banking, Financial Services, Blockchain, Financial System
4	Yellow	Australia	17.33	Money Laundering, Blockchain, Bitcoin, Risk Management, Audit Risk
5	Violet	Switzerland	5.33	Financial System, Banking IT Innovation, Bitcoin, Blockchain, Business Ethic
6	Blue	Pakistan	4.00	Internet Banking, Anti-money Laundering, Financial Time Series, Banknote Verification, Barter Credit

(\*): see in Figure 6; (\*\*): Main country; %: Network percentage.

In the development of research on financial transactions during the period analyzed, it is observable that collaboration based on scientific activity between countries is not associated with cultural, economic, political, legal or technological aspects. The association between countries in the promotion of research on financial transactions is linked to the process of globalization and digital transformation [122,123].

The main keywords used in the articles published in the research area by country are “financial management”, “financial transaction tax”, “financial services”, “blockchain”, “financial market”, “financial crisis”, “money laundering”, “globalization”, “financial data processing”, “investments”, “network security”, “risk assessment”, “tax system”, “Tobin tax”, “bitcoin”, “data mining”, “biometric”, “electronic money”, “cryptography”, “game theory”, “mathematical models”, “artificial intelligence”, and “financial regulation”. The main terms of the articles on financial transactions relate primarily to the risk of global financial operations, security of money laundering, current and future credit mechanisms, auditing, the management of financial resources and the position of liquidity, and financial assistance to low-income countries [34,124,125].

Figure 7 shows the evolution of each group of countries during the period analyzed, 1935–2019. Consequently, it allows us to see which countries have recently joined the research on this subject of study, and which have been developing their research from the beginning. Thus, the countries in violet (United States, United Kingdom, Netherlands, Portugal, and France, among others) have published on financial transactions since before 2010. In addition, another group of countries in cyan was observed, which were incorporated between 2013 and 2015 (Brazil, Switzerland, Greece, and South Africa, among others). Subsequently, another group of countries in green published mainly between 2015 and 2017 (India, Malaysia, Turkey, and China, among others). A final group, represented in yellow, joined after 2017 (Morocco, Mali, Ukraine, Colombia, and Kuwait, among others).



**Figure 7.** Evolution of cooperation between countries based on co-authorship.

China is currently the world's second largest scientific power, behind only the United States, and ahead of other traditional science superpowers, such as Western Europe and Japan. In addition, China has endured a scientific stagnation derived from its social, economic and political system, which has reduced its production compared to other countries and world regions. To understand this situation, it should be noted that, in the decades of the 80s and 90s, the Chinese leader, Deng Xiaoping, encouraged national scientists to travel and look for work in the United States and other major scientific centers of the moment, to learn directly of the best scientists. At that time, China was a country that was just beginning its development.

Subsequently, since 1985, the Chinese government underwent significant reforms under the motto "Building the nation with science and education", symbolized by policies implemented by the government. Between 1992 and 1999, China gave public research institutions and universities greater operational autonomy. After 1999, the motto "Building the nation based on science and technology" was introduced. Starting in 2005, the national innovation system was strengthened and economic investment in innovation projects was increased, launching talent attraction programs, and resources invested in laboratories and infrastructure [126,127].

All this explains the gradual development of the successful in Chinese scientific production. Thus, at present, the geopolitical context and the difficulty of accessing the internet, preventing the visibility of its growth from its scientific production. This sequenced development and the veiled system of science is also associated with researchers and their impact at the international level [128].

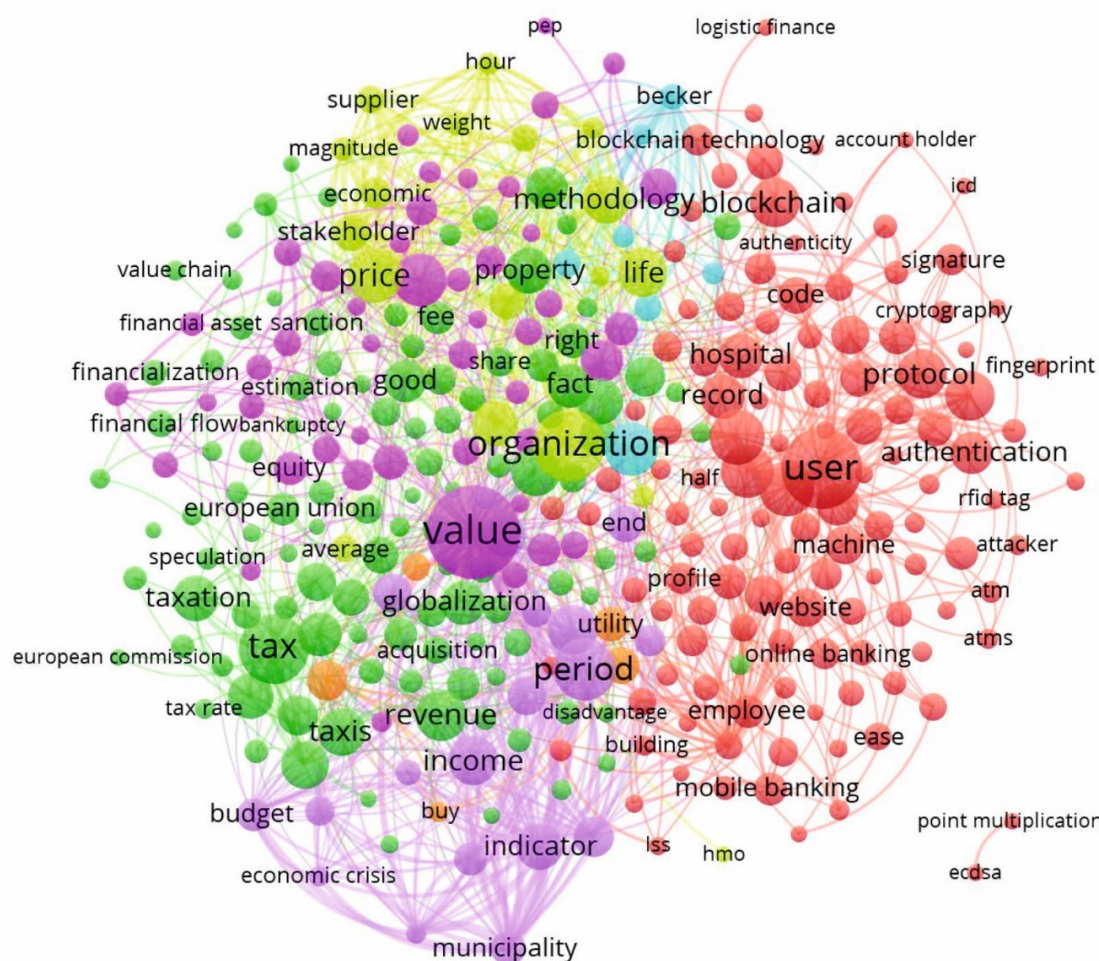
#### 4.3. Keyword Analysis

The main keywords associated with the total sample of 1486 articles on the research of financial transactions are "financial management", "financial transaction tax", "banking", "financial service", "blockchain", "decision making", "financial market", "financial crisis", "money laundering", "financial data processing", "investment", and "risk assessment".

Figure 8 shows the keyword network on this research topic, based on co-occurrence. One of the main utilities of the bibliometric method is the examination of the analysis units of the article text, that is, of the keywords extracted from the title and abstract fields [79,91]. Therefore, seven clusters of keywords composed of interrelated units have been detected, on the topic of financial transactions at a global level.

Cluster 1 (red), the most numerous, groups 31.40% of the keywords in the articles. In this cluster, the main keyword is “user”, for the largest number of co-occurrences, and is associated with “banking industry”, “smart contract”, “payer”, “logistic finance”, and “biometric”. Group 2 (green) agglutinates 27.14% of the total keywords on financial transactions. The main keyword for the number of co-occurrences is “tax” and is associated with “financial transaction tax (FTT)”, “lender”, “loan”, “liquidity”, and “microfinance”. Group 3 (pink) concentrates 12.50% of the keywords on financial transactions. The main keyword is “value”, and it is associated, among others, with “borrower”, “conventional banking”, “financial asset”, “money laundering”, and “leverage”. Group 4 (yellow) gathers 10.06% of the keywords on this research topic. The main keyword, by its number of co-occurrences, is “price” and is associated with “financial instrument”, “average”, “economic”, “balance”, and “equity”. Cluster 5 (violet) collects 7.93% of the keywords on the research study. In this group, the main keyword is “income” and is associated with “saving”, “period”, “budget”, “economic crisis”, and “debt”. Cluster 6 (blue) groups 6.40% of the keywords about study. The main keyword is “amount” and is linked with “industry payment”, “fee”, “algorithm”, “bankruptcy”, and “amount”. Finally, cluster 7 (orange), the least numerous, only concentrates 4.57% of the keywords. It is led by the keyword “ratio” and is linked with other terms, such as “buy”, “probability”, “magnitude”, “volatility”, and “trader”.

The regulation of financial activity has led to contributions in the line of establishing mathematical-financial models that consider these regulatory changes. Hence, the European Union through Directive (EU) 2015/2366 on payment services in the internal market, established the rules for the Member States with payment service providers, in order to strengthen security in the electronic payments to protect users, businesses, and banks [129]. In other words, the regulations seek greater transparency in financial transactions derived from the operators that have emerged, such as Fintech [130,131]. In addition, this regulation opens the financial market to companies, such as payment initiations service providers (PISP), that is, software that act as intermediaries between financial entities and businesses, and the account information service provider (AISP), which orders all the data on a platform of the client’s financial products [132].



**Figure 8.** Network of keywords based on co-occurrence.

In relation to the analysis of keywords, it was observed that this research topic is characterized by its dynamism and by the variety of lines of research it comprises. The articles collect the trends of the moment in which they are published, although always with a vision of traditional mathematical-financial methods [133,134].

New lines of research on financial transactions globally are associated with the emergence of new keywords. Mainly, these arise from the digital transformation that the banking and financial sectors support, and that, in this sense, encourage the increase of academic research and the development of this research topic, in line with the dynamism mentioned.

Therefore, the keyword “Blockchain technology” has emerged, which has been a disruptive innovation by offering greater transparency and reducing the duration of financial transactions. The increase in the number of companies of Asian origin, focused on cryptocurrencies, and the interest of millennials means an increase in the visibility and potential of blockchain.

The keyword “Next-gen Bank” relates to digital-only financial intermediaries. This term is in line with “Digital-only banking”, which refers to the new generation of virtual banking institutions, which have no brick-and-mortar outlets, and which has made a significant difference in the financial sector in recent years, where they highlight companies like Loot, Starling Bank, Curve, or Revolut.

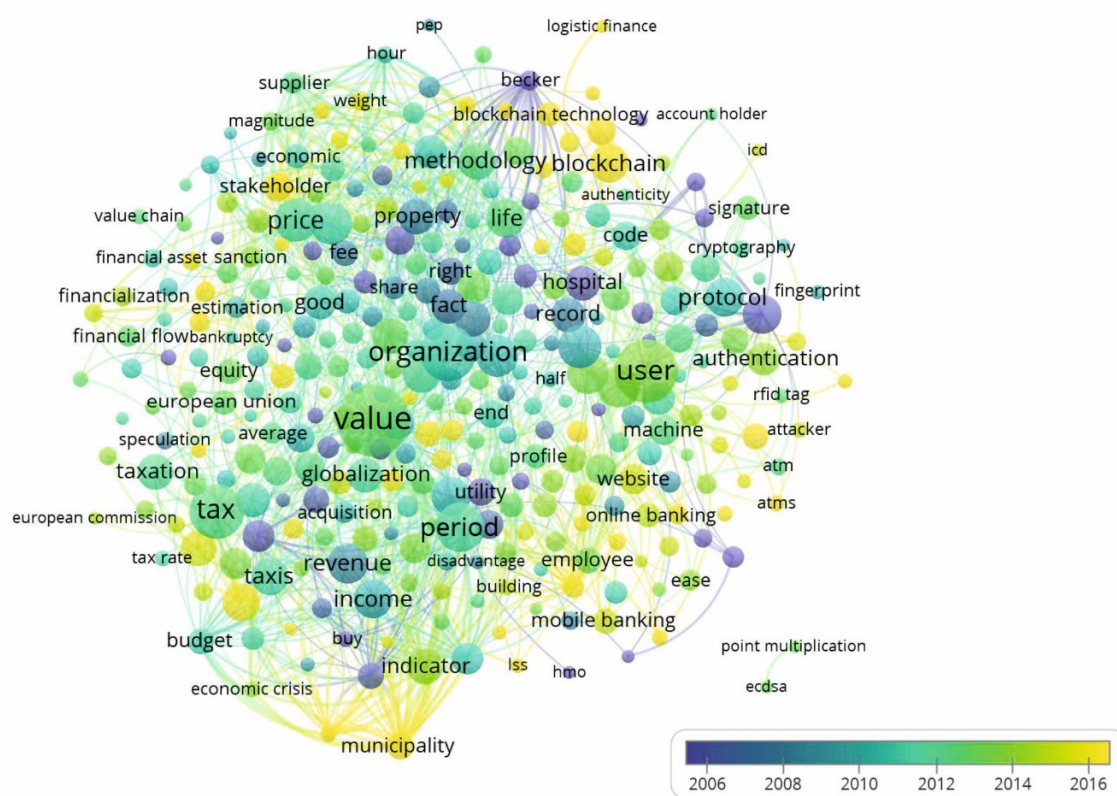
The term “Chatbot” refers to the virtual assistant for applications from banks and other legal financial institutions, in order to improve communication with their clients. Additionally, chatbots in customer service systems tend to increase customer loyalty, reduce processing time, and reduce administrative costs.



The keyword “Platform as a service” (PaaS) includes solutions based on cloud computing technologies, which allows companies to extend customized solutions to meet their business needs. In addition, PaaS providers delegate budget planning, credit risk management, payment processing, billing, and customer service. Hence, the company benefits from the rapid launch of the financial product, the post-paid service and database management.

Additionally, the Asian continent, as a giant in the financial technology industry and provider of solutions to financial transactions, is associated with the keyword “Asian FinTech market”. In addition, among the concepts that arise associated with the digital transformation of financial transactions, others arise, such as the “Advanced credit model”, which refers to the model that allows the efficiency of credit risk assessment. These are based on the use of information resources, such as those of social networks to determine the behavior patterns of the customer, or to record the location and the transactions that help to define the buying habits of the customers.

Finally, Figure 9 displays the evolution of each of the keyword clusters, during the period analyzed, 1935–2019. This Figure 9 allows perceiving the value of the main keywords, according to when they emerged and were reflected in the articles on financial transactions. In addition, it was observed that the keywords that were initially linked to this topic have had a notable influence on subsequent ones, as terms of reference. On the other hand, each cluster is associated with the period in which, mainly, they have appeared in research articles.



**Figure 9.** Evolution of the network of keywords based on co-occurrence.

In addition, Figure 9 shows that most of the key terms of the research topic arose before 2012, and as mentioned, these have been a reference for the terms that emerged later. Additionally, of the most recently emerged keywords, the term “cybersecurity” highlight, refers to the development of security systems to prevent cyber-attacks on the data set. The new financial services pose security problems related to data manipulation—the loss of financial records, malware intrusion, and misuse of the cloud environment. Biometric technologies are helping to prevent some of these security and privacy problems more efficiently, as well as detecting fraud and money laundering.

Additionally, the keyword “Big Data” is added, which is also linked to the study topic, due to the collaboration between traditional banks and FinTech companies, which involves advanced analysis of transactions and personalized finance.

Along those lines, the keyword “digital assistant” stands out, which is related to advanced Artificial Intelligence (AI) technologies and which, in addition, have replaced humans in banking call centers in response to financial inquiries from customers.

## 5. Conclusions

This work has analyzed the main trends in global research on financial transactions, in the period that began with the publication of the first article on this research topic (1935) until the last full year (2019). For this purpose, the bibliometric methodology was applied to a sample of 1486 articles obtained from the Scopus database. This analysis allowed obtaining the evolution of scientific production and the main thematic areas wherein the published articles are linked, in addition to identifying the main authors, institutions, and countries that contribute to global research on financial transactions.

The number of academic and scientific articles by year has increased during these 85 years, particularly in the last decade, 2010–2019, wherein 979 articles have been published, representing 65.88% of the total contributions to financial transactions research.

The analysis allows identifying the most influential areas of knowledge. Accordingly, social sciences stands out for the largest number of articles published, followed by economics, econometrics, and finance. This indicates that research on financial transactions, that is, on the relationship between mathematics and finance, has links related both to society and to human behavior. Therefore, it was observed that this research topic has implications and interest for a wide sector of the international scientific community.

As for the most productive authors, five of European origin (Nerudová, Capelle-Blancard, Musolino, Thurner, and Batoš) and two Americans (Russell and Brockett) stand out. On the other hand, the keywords associated with these authors include those linked to financial regulation and regulation (“financial transaction tax”); to financial crises (“financial risk”), with digital transformation applied to financial transactions (“Internet banking”); and with the activity and the financial system (“capital market”).

Four American universities were among the institutions with the largest numbers of articles on financial transaction research (New York University, International Monetary Fund, Massachusetts Institute of technology and university of Michigan), along with two Malaysian (International Islamic University Malaysia, and Universiti Kebangsaan Malaysia) and two European ones (University of Oxford and Göteborgs Universitet); the main associated keywords are “behavioral feature”, “corporate income tax”, “digital banking”, and “credit rating”.

The countries that have contributed the most to the development and growth of this research topic are the United States, the United Kingdom, China, India, and Germany. The main keywords used by countries are “financial management”, “financial transaction tax”, “financial services”, “blockchain”.

Analysis of keywords shows that there are seven well-differentiated groups around which all articles on financial transactions are gathered. In relation to the largest number of co-occurrences, the most detailed keywords are “banking industry”, “smart contract”, “financial transaction tax”, “microfinance”, “money laundering”, “saving”, “economic crisis”, and “bankruptcy”.

The keywords associated with the articles allow verifying their evolution with a defined trend towards lines of research that link financial transactions with the digital transformation of the sector. These implications are verified in the application of mathematics to finance, with terms such as “cybersecurity”, “Big Data”, or “digital assistant”.

Research on financial transactions based on the traditional financial and savings financing operations, both true and random, evolves to respond progressively to all the peculiarities of globalization. In this sense, financial mathematics tries to provide solutions adapting its methodologies from traditional methods to the diversity of current and future financial problems.

This work presents a series of limitations, the bases for other future investigations. Among these conditions, the main one refers to the bibliometric methodology, since it is fundamentally a method of quantitative analysis and does not consider the qualitative aspects of the data. Another is related to the fact that in some fields of study, with certain regularity, there are relevant authors who publish few articles, but with a high impact. In order to overcome these circumstances, in future works the bibliometric method should be completed with other qualitative and quantitative methodologies to analyze research trends. In addition, the study analysis period could be narrowed, and the results compared with those obtained in this study.

This research topic is evolving through the work and collaboration of researchers, institutions, and countries. As has been observed with the appearance of new terms, future lines of research should include (i) the study of methods to process financial transactions using mobile devices for payment; (ii) analyze a blockchain approach to financial reputation; (iii) examine the impact of digital transactions in less developed economies; or (iv) identify potentially risky transactions.

It is noteworthy that both the most significant articles and the most cited ones are linked to the same main subject areas of the total sample; that is, to social sciences, economics, econometrics and finance, and computer science. Likewise, both the main lines of research that have been developed and the future lines that can be studied, according to the evolution of the keywords, are also related to the most prominent thematic areas.

In conclusion, the growing interest in research on financial transactions in the last decades has been demonstrated by the authors, institutions, and countries shown. Hence, the global increase in the number of articles published supports the increase of participation in financial transaction research by the international scientific and academic community.

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