

CREDIT RISK: FROM A SYSTEMATIC LITERATURE REVIEW TO FUTURE DIRECTIONS

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Abstract

More than 3000 papers on risk management have been published since 2000. Although research on risk management is moving towards filling knowledge gaps, the large number of papers has a negative side. Young researchers have difficulty in constructing a concise and comprehensive basis of knowledge that allows new gaps to be found instead of addressing issues already resolved. Bearing this in mind, the aim of this paper is to present a systematic literature review on credit risk for academic papers. To meet this objective, the main studies on credit risk were classified and coded, and a citation-based approach was used to determine their relevance and contributions to the state of the art. This identified some gaps and research recommendations.

Keywords: Credit Risk, Literature Review, Finance, Economics.

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1. INTRODUCTION

A common thread in the economics literature is that agents spend part of their income on consumption. Although this process seems to be very simple and to have little importance for the economics system as a whole, it is actually not simple at all because agents — mainly families — do not pay in cash most of the time, but instead use credit. As a consequence, in simple terms, financial institutions provide credit for agents (families) because they believe they will receive the same amount plus an additional sum for providing this credit, and they can then loan this capital to other agents (companies) for business expansion. Managing the risk for this credit supply is very complex (Crouhy et al., 2000) because non-compliance with the credit terms agreed will affect all parties involved, especially financial institutions.

There are many reasons for studying credit risk. Caouette et al. (2008) highlighted the increase in credit risk and described credit market events that prompted increasing research into this issue, such as the new Basel accords, the sophistication of market participants, the increase in the supply of credit derivatives, and the emergence of hedge funds. However, a large part of literature is addressed to studies of portfolio risks (Atahau and Cronje, 2015), default events and asymmetric information while other topics, such as regulatory capital, are less investigated. In this context, the Basel I and II accords have highlighted the role of credit risk in risk management for financial institutions, which in turn intensified the search for more sophisticated and more robust models to measure credit risk because of the strong influence

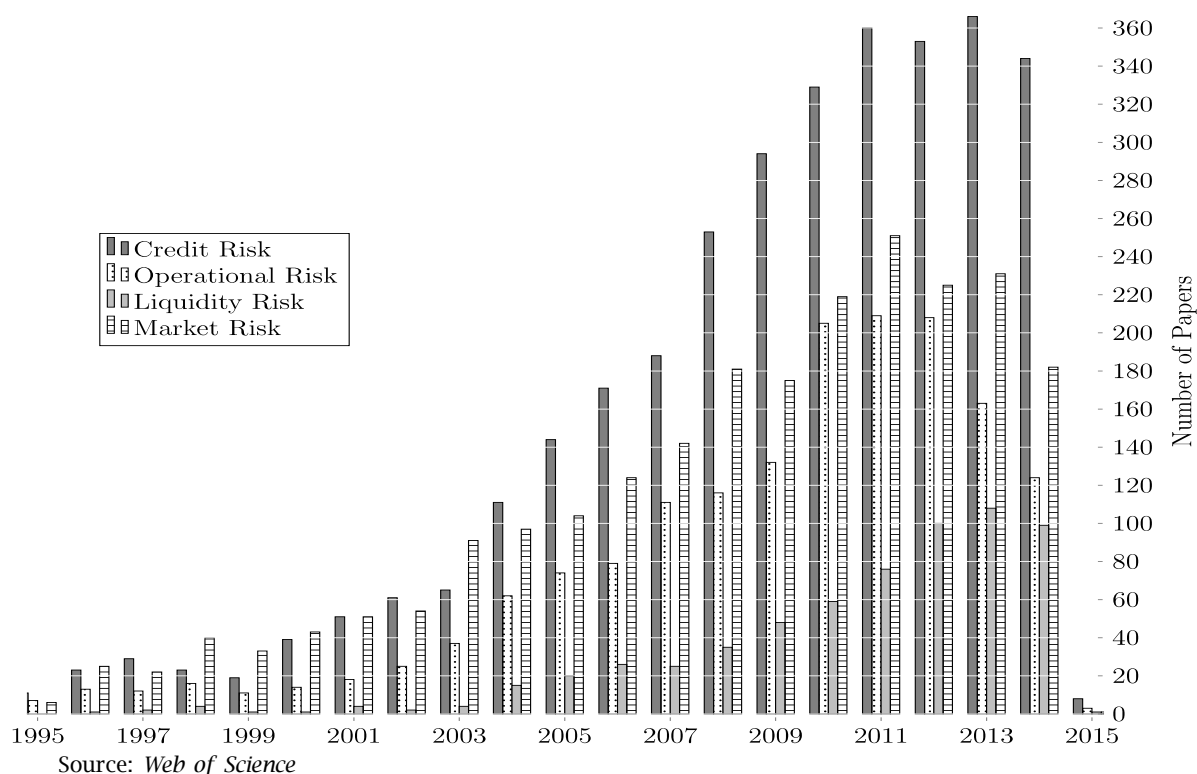
of economic capital on bank returns (Altman and Sabato, 2007; Tian et al., 2012).

The literature on credit risk has followed the same trend as for agents connected to this subject; in other words, has been expanding in recent years (Chava and Purnanandam, 2010; Jorion and Zhang, 2007). In comparison to operational, market, and liquidity risks, the number of publications on credit risk points to a global ongoing increase in studies on this subject, as illustrated by Figure 1.

As a consequence, the proposition of new tools, techniques, and models to measure and predict credit risk has also increased; examples include mathematical and statistical approaches such as simulations (Morellec, 2003; Hackbarth et al., 2006; Battiston et al., 2012), econometric analysis (Angelini et al., 2008; Griffin and Tang, 2012; Jiménez et al., 2014), and multivariate statistics (George and Hwang, 2010; Eom et al., 2003; Gordy and Howells, 2006; Veronesi and Zingales, 2010; Altman and Sabato, 2007). Optimisation processes (Bielecki et al., 2005) and the most recent and sophisticated theories have also been applied, such as the use of a copula approach to measure correlation, as reported by Rosenberg and Schuermann (2006) and others (Denev, 2014). Copula is a suitable method to check the dependence of the bivariate distribution with fat tails, which is very common in time series studies in finance.

For those starting to study credit risk, it is difficult to identify milestone or framework studies and any knowledge gaps because of the plethora of ideas, innovations, models, and empirical evidence. Motivated by this problem, we carried out a systematic review of the literature on credit risk and its components in an attempt to show academic advances made in the last 15 years and any gaps that remain or have recently emerged.

Figure 1. Number of studies published on managing risks that were indexed in the main academic databases.
Source: Web of Science



Allen (2004) reviewed the literature concerning about mortgages markets and the influence of Basel Accords I and II. Her conclusions emphasized we have many issues to solve about credit risk models, capital requirements, among other topics. We did not find any systematic review related to credit risk or analogous subjects in the last 15 years. It is important to highlight that a systematic review allows us to impose limits on this work because credit risk is such a comprehensive subject and there are a large number of studies in this area. Conversely, as emphasized by Jabbour (2013), a systematic review of the literature can identify studies about emerging subjects within a specific area of knowledge such as credit risk.

The remainder of the paper is organised as follows. Section 2 presents the research methodology used. In Section 3, we describe the classification and codification used. Section 4 outlines the key concepts regarding credit risk. The main outcomes are reported in Section 5. Finally, Section 6 features the main conclusions and limitations, and directions for future work.

Brief conceptual description of credit risk

Banking activity has been carried out for a very long time. According to Hoggson (1926), there is evidence that, Hamurabi laws, which date back to 2000 BC, regulated the use of water, land rents, and agent commissions, debts, and interest in the Mesopotamian Valley. The presence of rules regarding loans suggests the necessity of establishing a mechanism to manage credit risk, and more specifically to mitigate default risks.

In the context of scientific knowledge, we can argue that credit modelling has been contemplated since the origin of finance theory. Seminal work by

Modigliani and Miller (1958) is connected to credit analysis, since a capital structure comprising a firm's own resources and capital from third parties entails the risk of non-payment of debts, and therefore the existence of a probability of default.

In the context of the strong connection between credit elements and key research on corporate finance and investments, it is important to highlight that capital structure induces agency problems (Jensen and Meckling, 1976) among stockholders and creditors, and supports the assessment of stocks and debts based on the logic of option pricing (Merton, 1974).

Almost two decades later, Leland (1994) was working on this relationship. He developed a well-known structural model that considers the level of leverage as a proxy to determine default boundaries. To enlarge this work, Leland and Toft (1996) presume finite maturity debt by avoiding time dependence. Both papers have been prominent until now (He and Xiong, 2012). For example, Morellec (2003); Yu (2005); Hackbarth et al. (2006); Zhu (2006); Duffie et al. (2009) among others, reinforce their importance. However, Almeida and Philippon (2007) criticize those results because "they do not emphasize the difference between objective and risk-adjusted probabilities of distress". Chen (2010) also contests the observation of the default event and the debt level treated as a constant in Leland's model. Additionally, Eom et al. (2003) suggest the liquidation values assumed by Leland and Toft (1996) are doubtful.

According to Jarrow and Protter (2004), the studies of Black and Scholes (1973) and Merton (1974) in particular provide the basis for one of the main classes of credit risk models, the structural

approach, through which corporate debts have clauses of options regarding the company's assets (Giesecke, 2004). The second class of credit models (also called reduced-form) is more recent, originating from studies by Artzner and Delbaen (1995), Jarrow and Turnbull (1995), and Duffie and Singleton (1999). This class considers that default occurs with calibrated intensity via market prices in an exogenous manner (Giesecke, 2004). Because of this attribute, these models can be applied exclusively in public companies (Bonfim, 2009). Zhu (2006) explains that reduced-form models have many applications, with emphasis being placed on the relationship between CDS and bond spreads, but some assumptions cannot be found in practice, such as risk-free rate, to be constant. Furthermore, Jarrow and Turnbull (2000) recommend them for risk management and pricing. In this historical context, credit study not only has practical relevance because it is connected to operations that humans have been performing for centuries, but also has theoretical importance because it is related to many studies that provide the basis for finance theory.

For aspects directly related to credit analysis, studies by Beaver (1966) and Altman (1968) represent theoretical milestones for research on the development of models to predict failure and bankruptcy.

While Beaver (1966) conducted a univariate analysis to identify financial indexes that could help to predict companies that fail and those that do not, Altman (1968) carried out a multivariate analysis, adapting a classification technique — discriminant analysis — to calculate a score for the bankruptcy risk of publicly listed companies in the US manufacturing sector.

Seminal work by Altman (1968) had considerable repercussions and remains popular in the literature Campbell et al. (2008); its has been adapted for other sectors and contexts. For example, Edmister (1972) investigated the bankruptcy risk of small companies and Sinkey (1975) analysed the bankruptcy of financial institutions. Taffler (1984) developed models for different types of companies in the UK and Altman and Hotchkiss (2005) discussed risk modelling results for non-manufacturing companies and for the credit of emerging markets. Altman's method has some counterpoints, which are adjusted in the model based on logistic regression. On the other hand, Altman and Sabato (2007) assert that Ohlson's model does not provide better prediction power than Altman (1968).

Although the predictive power of models based on multivariate statistics, such as those of Altman (1968) and Ohlson (1980), has decreased (Begley et al., 1996), more recent artificial intelligence and machine learning techniques have represented a new research line for credit risk, specifically for bankruptcy prediction. For instance, Galindo and Tamayo (2000) studied 9000 models of credit risk assessment via statistical and machine learning techniques such as neural networks, classification and regression trees (CART), and the K-nearest neighbour algorithm. Khandani et al. (2010) analysed

consumer credit using CART to improve the classification of credit card holders.

We can describe a lot of pros and cons of these techniques, but that is not the core idea of this paper. However, we can cite that don't require assumptions (Angelini et al., 2008). In the case of support vector machine (SVMs), Tian et al. (2012) made a clarification about SVMs technique by presenting some variations of it. The major issue for machine learning is the occurrence of the overfitting phenomena, because the more independent variables included in the model, the more overestimated the dependent variable will be, which is not desirable for any classification case, especially in credit risk.

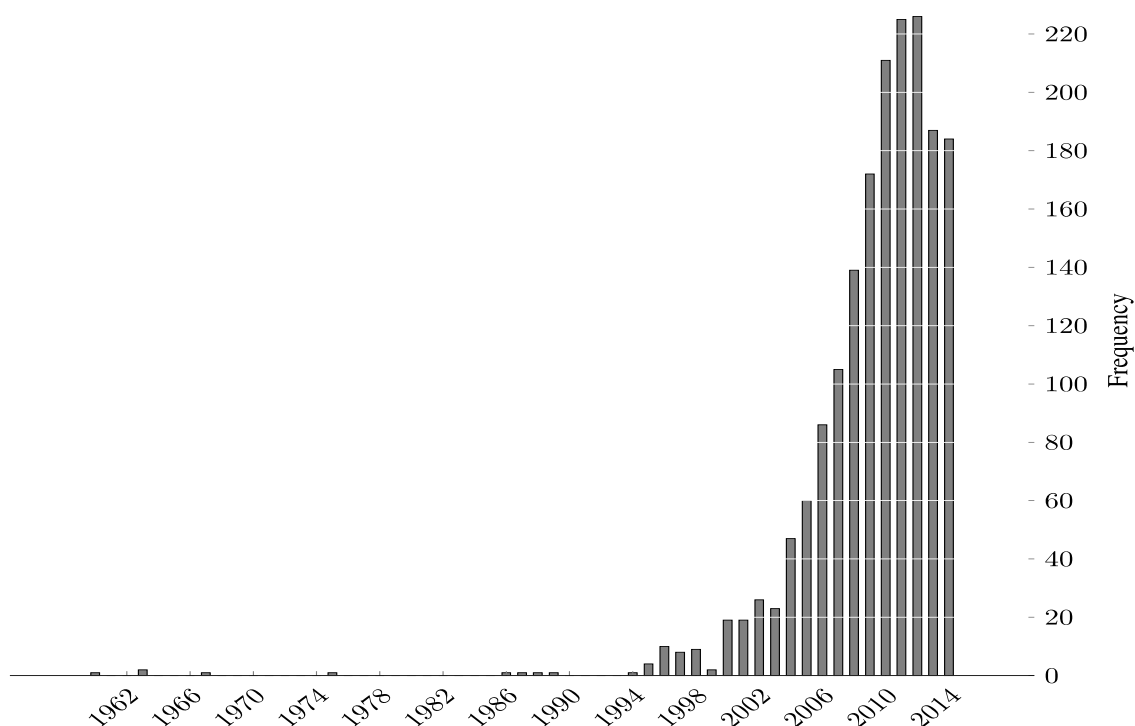
Another research line regarding credit analysis involves risk modelling developed based on demands arising from banking regulation, notably the Basel guidelines (Allen et al., 1996). Studies of models used by market practitioners, such as KMV default probability (Crosbie and Bohn, 2002), Credit Metrics (Gupton et al., 2007), Credit Risk+ (CSFB, 1997), and Credit Portfolio View (Wilson, 1997a,b) have also been carried out. For example, Agarwal and Taffler (2008) compared Altman's Z-score and two models based on market variables. Their results show no significant difference among the models for predicting firm failure. Moreover, Crouhy et al. (2000) conducted a great review of bank models. The authors perceived that no model is better than any other, as they can all provide good results for determining regulatory capital.

Latter research prompted by regulation involves assessment and prevention of systemic crises and mechanisms for assessment of the counterparty credit risk. More specifically, regulation needs exemplified in the BIS document (2012) have encouraged lines of research on adjustment of credit assessments, especially for operations involving derivatives.

Despite not being extensive, the list of topics is complemented by studies analysing credit spread (Forte and Peña, 2009) and operations based on transactions or credit risk, such as securitisation (Greenbaum and Thakor, 1987) and credit derivatives (Norden and Wagner, 2008). There are also many studies on bankruptcy and corporate finance with a diversity of interconnections. For instance, George and Hwang (2010) investigated bankruptcy risks and leverage, while Berk et al. (2010) analysed human capital, capital structure, and bankruptcy risk.

3. RESEARCH METHODOLOGY

Our search for studies on credit risk covered January 2000–December 2014. This period was chosen because of its representativeness with regard to the number of publications on managing risks; the topic of credit risk comprises 97.5% of the studies published during this period. Although this is an interesting fact, it was already noted by Caouette et al. (2008). To corroborate this, Figure 2 shows the results of a simple search using the keyword 'Credit Risk' in the Scopus database.

Figure 2. Number of documents found in a search of the *Scopus database* using 'Credit Risk' as keyword.

Our literature search was carried out using the following three databases:

Proquest;

Scopus (in conjunction with Science Direct); and Web of Science Core Collection.

These academic databases were chosen because of the scope of the bibliometric information supplied. They comprise a large volume of articles from different publishers, including Elsevier, JSTOR, Springer, Taylor & Francis, Emerald, and Wiley, and offer data on the number of citations of each article. Our research involved the following steps.

Step 1: Analysis of positive and negative points of the databases. We took into account the scope, the total period for data capture, the search method (simple and advanced), the clarity of the information provided, and inconsistencies among search engines. This step was carried out to confirm whether the same search parameters were used identically in all databases.

Step 2: Use of the following search parameters:

Keywords: 'Credit Risk', 'Probability of Default', and 'Bankruptcy' ;

Language filters: English;

Areas of concentration: Business, Economics, and Finance;

Type of material: Article;

Source: Scholarly Journals; and Period: January 2000-December 2014.

Step 3: Selection of the most-cited articles. In this step, to define the number of papers to be considered, the articles were ordered based on citations. Thus, articles published during the period considered (2000-2014) that were not cited were excluded from the analysis.

Step 4: Downloading of articles and database creation. Using the results from Step 3, the articles were downloaded, and basic information (title,

author names, year of publication, publisher name, journal name, keywords, JEL classifications, DOI number) and the number of citations were collected for each article to create a database.

Step 5: Descriptive statistics. The database created in Step 4 was subjected to descriptive analysis to identify information, patterns, and gaps.

Step 6: Reading and coding of articles. All the articles were read to identify the objective, the results, and contributions to the field of credit risk. In addition, each article was classified and coded as described in Section 4.

Classification and coding

Classification is one of the most important aspects of our systematisation because it identifies the main characteristics of the articles reviewed. This systematisation of the literature was performed according to Lage Junior and Godinho Filho (2010), Jabbour (2013), and Seuring (2013). We first identified the following data from each study:

Title;

Author names;

Affiliations;

Country of origin of the author or of the institution according to the address supplied in the article;

Year of publication;

Journal name;

Volume, issue number, and final and initial pages (this information was collected to establish if there were special editions on credit risk in any journal);

Origin and period of time considered in the data used by each study;

Keywords;

Number of citations of the article in the Scopus and Web of Science databases; and Digital Object Identifier (DOI) reference.

Some of these data required greater consideration before collection. The following procedures were used:

If an author was affiliated to more than one institution, we identified only the most important institution according to the following criteria:

Contact details for the author;

The first institution named by the author; and

Current location if neither of the previous conditions was satisfied.

Not all articles listed the same keywords, so we used the following sources to search for these data:

We first searched for any version of the paper in the Social Science Research Network (SSRN)

database of working papers, which provided most of the keywords for articles published, for instance, in the Journal of Finance.

If no version of the article was found in the SSRN database, we used the Web of Science Plus database, which has a tool called Keyword Plus that provides keywords by selecting words that appear more frequently in the titles of the most-cited works.

After this analysis, 17 articles were identified as being unrelated to credit risk and were excluded from our database. For the remaining articles, seven classification categories were defined. For each of these categories, other subcategories were established, as shown in Table 1.

Table 1. Categories and subcategories used in this work

<i>Category</i>	<i>Meaning</i>	<i>Codes for alternatives</i>
		A - Risk management.
		B - Credit risk modelling.
1	Main subject.	C - Rating analysis.
		D - Predictions/forecasting.
		E - Credit derivatives.
		F - Other.
		A - Theoretical framework.
		B - Time series analysis.
2	Method.	C - Multivariate analysis.
		D - Simulation and computational methods.
		E - Empirical analysis (case studies or similar).
		F - Other.
		A - Financial institutions.
		B - Corporate (balance sheets).
3	Type of data source.	C - Bonds.
		D - Derivatives.
		E - Macroeconomics.
		F - Other.
		A - USA.
4	Data source location.	B - Europe.
		C - Asia.
		D - Global / other / not mentioned.
		A - Economic capital or potential loss.
		B - Pricing.
5	Variable of interest.	C - PD.
		D - LGD.
		E - Other.
		A - New perspectives.
		B - Consistent with other paper(s).
6	Findings.	C - Old model and/or different data (source).
		D - Comparisons.
		E - Other.
		A - Less than 3 years.
		B - Between 3 and 5 years.
7	Period of analysis.	C - Between 6 and 10 years.
		D - More than 10 years.
		E - Not applicable.

The first category, Main Subject, identifies the topic and any subject considered as a subcategory. The following subcategories were considered:

Risk management: This subcategory includes articles that investigated risk in a more comprehensive or general manner, focusing on management.

Credit risk models: Articles in this subcategory addressed credit risk modelling.

Rating analysis: This subcategory includes papers on credit qualities of any nature, with an assessment or criticism of the category, focusing on attributes, criteria, and considerations. Notable features are prediction models and risk management, but these do not play a more

significant role than the category. In the case of predictions, it is worth noting the difference between this and other classifications. Since the category is Main Subject, almost all papers have some type of prediction; however, this does not mean that they qualify for the D subcategory. Thus, if the subject was better classified as risk management or a model of credit risk or rating, we ignored this qualification. Nevertheless, if there was a strong influence of econometric and statistical treatment for predictability, for instance, and this objective competed with other categories, the work was classified in both categories.

Credit derivatives: This subcategory comprises studies that involve derivatives such as Credit

Default Swap (CDS) and Collateralised Debt Obligation (CDO).

Other: This subcategory includes studies whose main subject did not fall into any of the previous options.

The Method category is related to the main method applied or used by the authors in their study. There are six options, and an article may be included in more than one category, as well as in all the other eight criteria investigated. It is important to remember that the most significant aspect in this item is the method used for the main subject in the paper. Thus, for instance, theoretical articles that used a regression or statistical technique in a small part of the study were not taken included in this subcategory. The subcategories for this category are as follows:

Theoretical Framework: This subcategory includes studies directly contributing to the theoretical framework for credit risk, which mainly involves criticizing or complementing conceptual aspects. These papers sometimes use sophisticated tools or mathematical abstractions.

Times Series Analysis: In this subcategory, the main study characteristics are a regression analysis, robust statistical tests and, if necessary, other analyses that are relevant to the validity of the research.

Multivariate Analysis: This subcategory comprises articles on research of a phenomenon using statistical techniques that do not fit a time series, such as probability and correlations.

Simulation and Computational Method: This subcategory includes articles that used more recent computer simulation techniques for empirical data, such as machine learning.

Empirical Analysis: This subcategory encompasses articles that address phenomena made evident by a small number of samples, such as case studies or samples represented by exceptions to a specific assumption in a population.

Note that articles using panel data analysis are classified as Time Series Analysis. Articles with multivariate or cross-sectional analysis carried out over time were also assigned to the same subcategory.

Type of Data Source is a very objective category, as are Analysis Period, with articles classified according to the type of data considered. For theoretical articles, the data source was identified as the one most often indicated or cited by the author in suggesting applications, even if it was not necessarily studied. The same approach was applied for studies that carried out a simulation. Again, taking into account banking data (economic capital, risk models, etc) and, simultaneously, other organizations classify the study in both options.

The Data Source Location or Geographic Location in which data were collected is the fourth category. In this case, the sources were quite clear in the papers. Studies involving countries apart from the USA, Europe, and Asia were classified as the fourth possibility.

The fifth category is the main Variable of Interest in the studies. This category was more comprehensive in cases in which the authors did not emphasize any of their results. The pricing

subcategory comprises studies focusing on return on assets, derivative spreads, and valuation, among other topics. It should be noted that the recovery rate variable was included in the LGD subcategory.

The Findings category was very well explored in the papers. Overall, authors were quite emphatic when presenting an innovation derived from their studies. In a broad sense, this category identifies the relationship between these more recent studies and previous studies. Therefore, its subcategories are self-explanatory.

The final category is the period covered by the data. This was separated into four size subcategories. There was no quantitative treatment of these data to avoid tendencies and errors of proportion in the analysis.

2. RESULTS AND DISCUSSION

Our searches identified more than 3000 scientific papers during 2000–2014. It was not feasible to investigate this amount of material, so objective selection of papers was necessary. Therefore, apart from the filters used in the primary search, other objective criteria were taken into account. The first one was to verify the number of citations per year since publication, and to analyse only those articles with an average of at least five citations. With this focus, recent articles were not excluded, outliers (potentially seminal articles) remained in the selection, and obsolete works (papers that were once a reference or not but became out-dated or do not effectively contribute to knowledge) were discarded. This reduced the sample to approximately 100 articles. During further collection of detailed information and analysis, other articles were excluded because they did not adhere to the credit risk topic. The final sample consisted of 83 papers.

To identify the origin of the research and the current main collaborators in this area of knowledge, we verified the main authors and the respective institutions with the greatest frequency in our database, as shown in Table 2 and Table 3.

The main articles on the topic of credit risk were concentrated in four journals, as shown in Table 5. However, articles of great importance appeared in other journals, such as studies by Hillegeist et al. (2004), Bielecki et al. (2005), and Ericsson et al. (2009) published in the *Review of Accounting Studies*, *Mathematical Finance*, and the *Journal of Financial & Quantitative Analysis*, respectively. For the journals listed in Table 5, the total number of citations during January 2000–December 2014 is shown in Figure 3. According to the *Scopus* database, the *Journal of Financial Economics* is the most-cited journal, even though it is not the journal with the greatest number of articles on credit risk.

Table 2. List of the main researchers in descending order of number of publications in the period 2000–2014

<i>Author</i>	<i>Papers</i>	<i>h-index</i>	<i>Citations (GQC)</i>	<i>Local Citations (NLC)</i>
<i>Darrel Duffie.</i>	3	17	1992	18
<i>Viral V. Acharya.</i>	2	17	1148	7
<i>Stefano Battiston.</i>	2	4	125	0
<i>Michael B. Gordy.</i>	2	6	390	5
<i>John M. Griffin.</i>	2	7	140	5
<i>J. Grunert.</i>	2	2	75	0
<i>Robert A. Jarrow.</i>	2	8	212	5
<i>Gabriel Jiménez.</i>	2	6	180	2
<i>Phillip Jorion.</i>	2	10	382	3
<i>Others.</i>	1	NA	NA	87
Total	83	-	-	132

Source: Web of Science.

Table 3. Number of articles published by institution

Institution	Papers
New York University.	4
University of California.	4
University of Mannheim.	3
Arizona State University.	2
Bank for International Settlements.	2
Board of Governors of the Federal Reserve System.	2
Cornell University.	2
ETH.	2
London Business School.	2
Massachusetts Institute of Technology.	2
Stanford University.	2
University of Chicago.	2
University of Toronto.	2
Washington University.	2
Total.	33

The list is less extensive for research location. Table 4 summarizes the data.

Table 4. Country of origin of researchers and institutions in descending order of number of publications

<i>Country</i>	<i>1st author</i>	<i>2nd author</i>	<i>3rd author</i>	<i>4th author</i>	<i>5th author</i>	<i>All together</i>
USA.	46	44	20	6	2	118
Germany.	6	5	2	0	0	13
UK.	6	4	2	0	0	12
Canada.	5	4	2	0	0	11
Italy.	2	5	4	0	0	11
China.	4	3	1	1	0	9
Spain.	4	3	1	1	0	9
Switzerland.	5	1	1	0	0	7
Sweden.	1	1	1	1	0	4
Greece.	1	1	1	0	0	3
Netherlands.	1	1	0	0	0	2
Singapore.	0	1	1	0	0	2
Denmark.	0	1	0	0	0	1
Israel.	0	1	0	0	0	1
Paraguay.	0	0	1	0	0	1
Portugal.	1	0	0	0	0	1
Turkey.	1	0	0	0	0	1
Total.	83	75	37	9	2	206

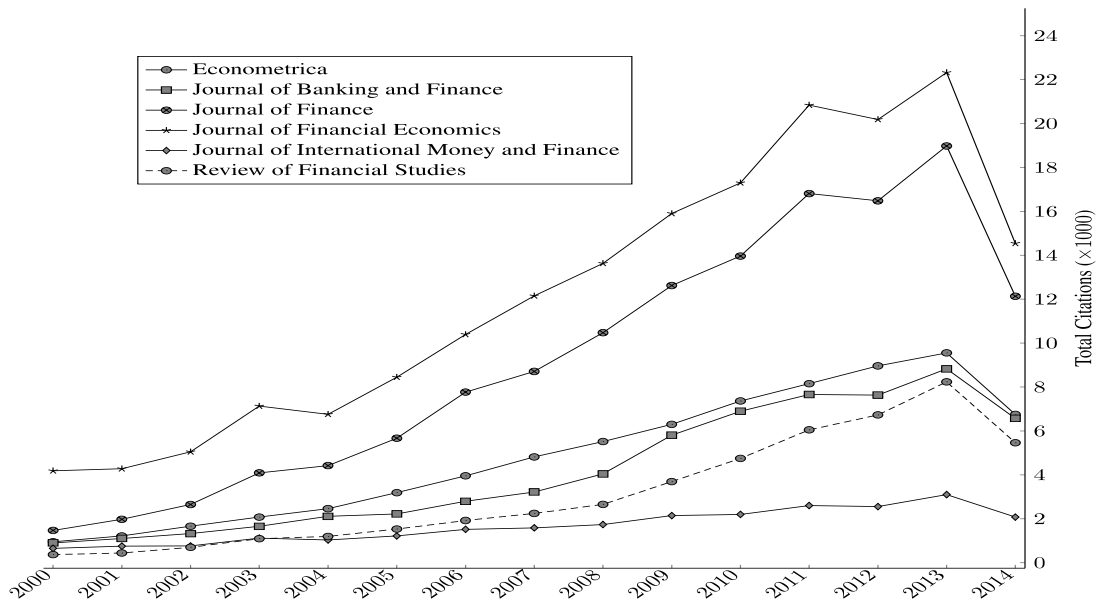
Table 5. Journals ordered according to their representation in the sample. Source: Scopus, Web of Science, and Proquest databases

Journal	Articles Published	Total Citations[†]
Journal of Banking & Finance.	22	62,768
Journal of Finance.	16	138,219
Journal of Financial Economics.	15	183,113
Review of Financial Studies.	10	47,061
Econometrica.	3	72,928
Journal of International Money & Finance.	2	25,054
Others (with 1 article published).	15	NA

Source: Scopus, Web of Science, and Proquest databases.

† The last column indicates the total number of citations in all papers from 2000 to December 19, 2014.

Figure 3. Total number of citations of the main journals taken into account in this research



Source: Scopus database

Table 6 shows the classification results for the articles, including the categories and subcategories identified in Table 1, and Table 7 provides a brief description of the objective, the conclusions, and the contribution of each study to the area of credit risk.

Overall, the studies we analysed were not concentrated on a single subject, but there was a strong tendency to focus on risk management, credit risk models, and statistical analysis of credit derivatives. Some articles fell into more than one classification because other subjects were equally addressed or were connected to the main subject. We also identified a small number of papers in the A-B, A-C, B-E, B-F, C-E, D-F, and A-C-D-E subcategories. For example, Jiménez and Saurina (2004) highlighted that the literature has been using data generated only in the USA. Gropp et al. (2006)

affirmed that there are difficulties in working with some stock market indicators. A possible explanation is the lack of skill among researchers and risk managers outside the USA in dealing with data scarcity and understanding the relation between macroeconomic measures and market information. Thus, we can identify the following gap that should be addressed in future research.

Gap1 : Analysis or extension of the work by Jiménez and Saurina (2004) and Gropp et al. (2006) should be further explored, because it is possible to analyse the risk for counterparts, as done by Jarrow and Yu (2001), or even to transfer risk through derivatives and its effects, providing alternative data to develop research on credit risk.

A new study about CDS and credit ratings have shown that it is possible to make interesting analysis.

Figure 5. Classification results for category 2, method applied

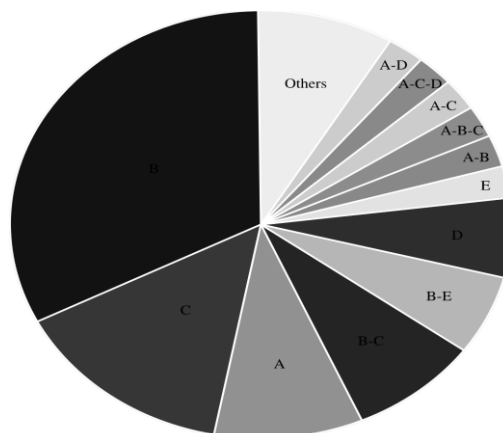


Table 6. Article classification according to categories 1-7 in Section 4.

Study	Main subject	Method	Data source	Location	Variable	Findings	Period
Crouhy et al. (2000).	B	E	A	E	F	D	E
Gordy (2000).	B	D-E	A	E	C	D	E
Huang et al. (2009).	A	B-C	A-D-E	A	B-C	A	C
Rosenberg and Schuermann (2006).	A	B-C-E	A	A	A	A-D	C
Chatterjee et al. (2007).	B	D	B	B	D	C	B
George and Hwang (2010).	F	A-C	B	A	F	A	D
Angelini et al. (2008).	F	A-B	B	A	F	A-D	D
Yu (2005).	B	A-C	B-C-D	A	B	B	D
Gopalan et al. (2007).	D	B-E	B	C-D	F	A	D
Errais et al. (2010).	B-E-F	A-C-E	D	A	F	A	D
Gross (2002).	B-D	B	F	A	C	C	A
Zhu (2006).	B-E-F	B-E	C-D-E	A-B-C	B	A-D	B
Amato and Furfine (2004).	C	B	B	A	F	C	D
Hillegeist et al. (2004).	B	B	A	A	C	C-D	D
Ivashina (2009).	F	B	A	A	B	A	D
Griffin and Lemmon (2002).	F	B	B	A	F	E	D
Morellec (2003).	F	A-C-D	F	E	F	A-B	E
Hackbarth et al. (2006).	A	A-C-D	B-F	E	B-F	A-B	E
Jiménez and Saurina (2004).	A-B	C	A	B	C	A	D
Das et al. (2007).	A-B-D	B-C	B	A	C-F	A	D
Agarwal and Taffler (2008).	B-D	C-E	A	B	C-F	C-D	D
Bielecki et al. (2005).	A	A	F	E	F	A	E
Güntay and Hackbarth (2010).	D-E	B	C	A	F	A	D
Carling et al. (2007).	B-C	B	A-B-E	B	C	A-B-D	D
Jarrow and Yu (2001).	A-B-D	A	C-D	E	B	A-C	E
Battiston et al. (2007).	F	D	B	E	F	A	E
Jorion and Zhang (2009).	A-E	B	A-B-D-F	A	F	A-B-C	D
Bonfim (2009).	B-D	C	B-E	B	C	E	C
Allen and Carletti (2006).	A-D	D	A	E	F	B	E
Acharya et al. (2011).	A-F	B-C	B-E-F	E	F	A	D
Battiston et al. (2012).	A	A	F	E	F	A	E
Vassalou and Xing (2004).	B-F	B	B	A	B-C	B-C	D
Griffin and Tang (2012).	C-E	B	D	E	B-F	A	D
Davydenko and Franks (2008).	A-F	B	B	B	F	D	D
Mansi et al. (2004).	A-E	B	B	A	B	B	D
Acharya et al. (2007).	B-D-E	B	B	A	D	A-B-C	D
Gropp et al. (2006).	A-C-D-E	C	A-D	B	B	D-E	D
Brissimis et al. (2008).	A-D-F	B	A	B	F	A-C	D
Poon (2003).	F	C	B	A-B-C	B	A	D
Maudos and de Guevara (2004).	A-F	B	A	B	B	C	D
Bharath and Shumway (2008).	E	B	C	B	B	A	A
Duffie et al. (2009).	B-D	C	B	A	C	C-D	D
Jorion and Zhang (2007).	B-D-E	C	B	A	C	A	D
Jiménez et al. (2014).	A-E	B	D	A-E	B	B-C	B
Beber et al. (2007).	A-D-F	B	A	B	F	E	C
Hennessy and Whited (2007).	D-F	A-D	B	E	B	B-C	E
Campbell et al. (2008).	A-B-D	C	B	A	B-C	C-D	D
Jappelli and Pagano (2002).	A-D-F	B	A	E	F	E	A
Hertzel et al. (2008).	F	B	B	A	F	A	D
Chava and Purnanandam (2010).	A-D-F	B	B	A	B-C-F	C-E	D
Foos et al. (2010).	A	B	A	E	F	A	D
Chen (2010).	B-E	A	B-E	E	A-B	A	E
Tang and Yan (2010).	E	B-E	D-E	A	F	A	C
Altman and Sabato (2007).	B-D	C	B	A	C	B-C	C
Duffie et al. (2007).	B-D	B-E	B	A-E	C	D-E	D
Chen et al. (2008).	B	A-D	D	A	F	C-E	D
Lin et al. (2011).	A-F	B	B-E	E	F	A	D
Houweling and Vorst (2005).	A	A-E	A-D	A	B	A	A
Gordy and Howells (2006).	B-C	C	C-D	A-B	B	D	A
Tian et al. (2012).	A-D	D	A	E	A	A	E
Grunert and Weber (2009).	A-C	D	B-C-E	A-B-C-E	C-F	A-B	D
Bangia et al. (2002).	B	A	F	E	F	B-D	E
He and Xiong (2012).	B	B-E	B	B	F	B	D
Nickell et al. (2000).	B-D	A	B-C	E	B-F	A	E
Eom et al. (2003).	C	C	C	E	F	B-D	D
Schaefer and Strebulaev (2008).	B	C	B-C	A	B	D	D
Duffie and Lando (2001).	D-E	B-C	C	A	B	C	C
Veronesi and Zingales (2010).	E	C	C	E	F	B-C	E
Norden and Weber (2009).	E	B	B-C	A-B-C	B	B	B
Guiso et al. (2013).	F	E	B	A	F	E	A
Ericsson et al. (2009).	E	B	D	A	F	A	B
Collin-Dufresne et al. (2001).	E	B-D	B-C	A	F	A	C
Bao et al. (2011).	F	B-C	C	A	F	E	B
Goss and Roberts (2011).	A	B-C	A	A	F	A	D
Jarrow and Turnbull (2000).	A	A	F	E	F	E	E
Bhamra et al. (2009).	B	A-B-C	B-E	A	B-C	A	D
Hull et al. (2004).	C	A-B-C	C-D	A-B-C-E	F	B	B
Almeida and Philippon (2007).	C	A-B	C	E	B	A-B	E
Grunert et al. (2005).	B-C	C-D	A	B	C	C	B
Demiroglu and James (2010).	A-F	B	F	A	F	B	C
Zhou (2001).	F	A	F	E	B-C-D	A	E
Brown and Dinc (2009).	A	B-C	A	E	C	B-C	C
Dooley and Hutchison (2009).	D	B	D	A	F	E	A

Table 7. Brief descriptions of the main objective, conclusions, and contribution of each article considered in this study

<i>Study</i>	<i>Main objective</i>	<i>Main conclusion</i>	<i>Main contribution</i>
Crouhy et al. (2000).	Compares KMV and credit portfolio view models.	The models have different approaches but it is not possible to identify which is the best.	Mathematically details the working process of the techniques analysed.
Gordy (2000).	Compares Credit Risk+ and Risk Metrics models.	The models are similar in managing loan portfolios if the volatility effect in Credit Risk+ is low; highlights that Credit Risk+ is more sensitive to credit quality, demonstrating a broader assessment of this risk factor.	Comprehensive study of the two models including the entire theoretical context.
Huang et al.(2009).	Modelling and stress testing to measure systematic risk in financial institutions using financial data and CDS spreads.	Systematic risk is greater when the average PD or exposure to common factors increases.	The model features advances in measuring the systematic risk of attaching a proxy to credit risk.
Rosenberg and Schuermann (2006).	Implements a method for applying copulas to measure operational, market, and credit risks.	Risks can be calculated separately and adjusted with the copulas technique.	Implementing copulas in risk management.
Chatterjee et al. (2007).	Uses the neural network technique for PD estimation.	The model was considered efficient in two application approaches.	The model uses neural networks for 15 financial variables in predicting PD for Italian companies.
George and Hwang (2010).	In-depth analysis of household credit risk in accordance with US bankruptcy legislation.	Demonstrates the existence of a balance between prices and defaults in households with the same characteristics.	The model reveals the sensitivity of macroeconomic factors.
Angelini et al.(2008).	Discusses the negative relation between returns and leverage.	Low asset returns are directly related to systematic risk, which also increases with the insolvency cost; by contrast, companies with high costs prefer smaller leverage, which generates a smaller PD value.	The book-to-market index is not a measure of the risk of financial difficulties, but captures exposure to price risk, which is not related to capital structure.
Yu(2005).	Examines the relation between the term structure of credit spreads and the quality of accounting information.	The quality of accounting information may result in an increase in financial costs.	Empirically proves the term structure effect (e.g., companies that publicize more precise information have lower credit spreads in the short term).
Gopalan et al. (2007).	Investigates the way corporate groups participate in the capital market.	Corporate groups in India initially exist to protect member companies against financial difficulties.	Highlights the positive and negative points of corporate groups.
Errais et al. (2010).	Presents a method rarely used in the literature, the affine point process, using a top-down approach applied to derivatives pricing.	A self-extracting technique for assessing credit portfolios can be applied to bonds and loans.	A mathematical tool demonstrates how the affine point process works in the analysis of credit risk.
Gross (2002).	Studies credit card clients to verify PD throughout the duration.	The relation between default and the economic basis changed during the period analysed.	Uses duration in a study of credit card consumers and assesses the stability of credit risk in these cases.
Zhu (2006).	Discusses the impact of development of the credit derivatives market in the pricing of credit risk.	The results indicate that CDS spreads are more likely to provide a precise indicator of the price of credit risk than spreads of financial obligations.	Compares bonds and CDS spreads to verify the sensitivity of credit risk associated with the derivatives market.
Amato and Furfine (2004).	Addresses the relation between credit ratings and business cycles using a probit model with financial and macroeconomic variables to determine credit rating.	The credit risk rating of a company varies with cyclical changes in business and with financial risks.	The results revealed pro-cycling in ratings for high-investment companies and change assessments, which indicates possible sensitivity to the business cycle.
Hillegeist et al. (2004).	Discusses positive and negative aspects of traditional models of bankruptcy prediction (Z-score and O-score) and the Merton model.	The Merton model shows better performance in predicting bankruptcy.	Compares the most commonly used prediction models in the market.
Ivashina (2009).	Examines shared ownership of a market leader bank and the impact of the stock on the banking charge spread.	Banks with larger and more competitive portfolios have a competitive advantage because they can offer lower financing costs.	Includes the effects of market dominance and unions in the analysis.
Griffin and Lemmon (2002).	Analyses the relation between the book-to-market index, insolvency risk, and stock prices.	The average return for companies with a high possibility of insolvency is low, and is affected by decreasing stock prices and the BM/ME rate.	The results confirm that companies with large information asymmetries are more likely to have unstable stock prices.
Morellec (2003).	Analyses the impact of a manager's opportunistic behaviour on asset prices, indebtedness decisions, and company value.	When the number of growth options in a company's investment group increases, the cost of overinvestment decreases, which reduces indebtedness.	Confirms that changes in the economy affect indebtedness.
Hackbarth et al. (2006).	Studies the sensitivity of credit risk to macroeconomic changes and to capital structure.	Confirms the hypothesis that credit risk is influenced by macroeconomic changes such as choice of capital structure, as evidenced by a high default rate in periods of crisis.	Builds a consistent theoretical framework for sophisticated credit risk management in terms of leverage and market perspectives.
Jiménez and Saurina (2004).	Analyses the impact of loan characteristics such as guarantees, type of creditor institution, and creditor-borrower relationships on credit risk.	Guarantees increase the probability of loan non-compliance; there are significant differences in credit risk assumed by different creditors; investment banks loans are more risky than those of commercial banks.	Credit risk model with European data that takes into account characteristics seldom considered in this area, with interesting results.
Das et al.(2007).	Proves the efficiency of a model formulated in a Poisson stochastic process to verify the intensity of defaults throughout time, and reviews research analysing default correlations with macroeconomic variables using copulas.	Joint hypotheses testing revealed that default intensities are properly measured and have a doubly stochastic property.	Introduces a credit risk model affected by default intensities using a Poisson process.
Agarwal and Taffler (2008).	Compares two credit risk models based on market information to the Z-score model proposed by Altman(1968).	The Z-score is more precise, but it does not have statistical significance; its advantage relies on better adjustment of incomes to risk, profit, return on invested capital, and risk-adjusted return on capital when compared to market-based credit risk assessment; tests reveal that all models collect information about bankruptcy, but no method replaces any other.	Analysis of credit risk using models based on accounting data is more robust than market variable models.
Bielecki et al.(2005).	Searches for the optimal solution for asset selection in an investment/asset portfolio.	The solution can be obtained via a risk management approach using European options.	A new optimisation model that takes into account aversion to bankruptcy.

Table 7. Brief descriptions of the main objective, conclusions, and contribution of each article considered in this study (Continued)

<i>Study</i>	<i>Main objective</i>	<i>Main conclusion</i>	<i>Main contribution</i>
Güntay and Hackbarth (2010).	Analyses whether variations in prediction lead to changes in bond markets similar to those in the stock market.	Bonds of companies with different return predictions have significantly higher credit spreads and more elevated future returns than similar bonds.	Institutional differences between stock and securities markets are worth studying in more details.
Carling et al.(2007).	Proposes a model based on duration to explain the survival time to borrower default in a credit portfolio.	Macroeconomic variables show significant explanatory power for default risk, and for a series of common financial indexes.	The model takes into account the macro effect and can explain the absolute level of risk.
Jarrow and Yu(2001).	Proposes the generalization of existing reducedform models to include default intensity.	Risk factors in the entire market and counterpart risks specific to companies interact to create a variety of form for the term structure of credit spreads.	New perspective for reduced-form models.
Battiston et al.(2007).	Identifies the minimum group of mechanisms that qualitatively reproduce a company and its standards for production, growth, and bankruptcy.	Theoretical model that takes into account local interactions and what creates a serial bankruptcy effect.	Analysis of the correlation between space-time, growth, and bankruptcy.
Jorion and Zhang (2009).	Development of a credit risk model that captures the interference caused by relations with bankrupt counterparts.	Stock prices react negatively and the CDS spread increases when the company has direct relationships with bankrupt debtors.	The authors state that this is the first study that uses a direct and clear company-counterpart connection to measure risk.
Bonfim(2009).	Simultaneous assessment of the effects of some dimensions of corporate credit risk, taking into account the company's accounting information, as well as macroeconomic and financial data, to understand how idiosyncratic and systematic risk factors determine default.	The results reveal that the macroeconomic dynamic has an important additional (and independent) contribution in explaining what leads companies to default.	Confirms that economy is a determining factor in default; an excessive risk assumption of companies in periods of economic expansion is noted.
Allen and Carletti (2006).	Shows the effect of credit risk transferences made by banks and insurance companies.	The result can be positive diversification; otherwise, it can cause contagion as a result of credit risk.	Detailed assessment of financial innovation processes that lead to positive outcomes or risk contagion.
Acharya et al.(2011).	Investigates the connection between creditors' rights and companies' investment policies.	Companies tend to reduce their risks in countries where creditors are strongly protected by the law.	Discusses creditors' rights and the benefits of a corporation in a more protected environment.
Battiston et al.(2012).	Presents a network model based on the borrower-creditor relationship for financial institutions, taking into account inter-relations in accounting data.	Diversification of individual risk can have an ambiguous effect at the system level.	Highlights the effects of risk diversification on systemic risk via a new model of cascading default.
Vassalou and Xing (2004).	Studies the relation between default risk and stock returns, using the Merton model as a measure.	Small companies have higher returns than larger companies if they assume high default risks; stocks generate higher returns instead of increasing their value.	The author states that this is the first study that uses the Merton model to measure credit risk for individual companies and evaluate their effect on stock returns.
Griffin and Tang (2012).	Proposes an empirical analysis and criticises credit classifications applied to CDOs.	Correlation between model and real classifications is low for the better classified group, so adjustments are necessary; adaptations that include additional factors do not have informational power.	Applies recent theoretical models of credit classification to real data and discusses norms defined by the models and practiced in the market.
Davydenko and Franks (2008).	Empirically assesses the nature of adjustments in loan contracts and the extent to which they mitigate the effect of the bankruptcy code on default results.	Banks adjust their financing and reorganisation practices in response to the bankruptcy code of a country.	No publications on default in different countries were found for comparison of data.
Mansi et al. (2004).	Discuss the relationship between auditor characteristics and debt financing.	The better qualified the auditor, the smaller the return for bondholders; more evident for firms with a low credit classification.	Highlights relevant aspects of auditor influence and the cost of third-party capital.
Acharya et al. (2007).	Assesses how sector difficulties affect the creditors of a company close to default recovery.	The economic situation of the sector plays an important role and affects the creditor recovery rate at the time of default.	Addresses the implications of assessment models for corporate bonds.
Gropp et al. (2006).	Examines the financial difficulties of banks using credit risk determinants.	The distance to default has small explanatory power and spreads are good indicators of bank fragility.	Uses derivative spreads combined with asset prices to address market discipline.
Brissimis et al. (2008).	Analyses the relation between bank performance and sector reform.	Greater regulation induces banks to improve their performance.	Empirical study of the entire reform period that pinpoints the main performance indicators for financial institutions.
Poon (2003).	Uses several mathematical tools to show return correlation in the stock market.	Uses several mathematical tools and applies a model that can show return correlation in the stock market.	New multivariate model that assesses the dependency structure among markets.
Maudos and de Guevara(2004).	Proposes an empirical model to compute the interest margin and its determinants for European banks in the 1990s.	In the period analysed, the concentration index was high for the banking sector, which decreased competitiveness and increased interest margins.	The model can determine interest margins involving competitiveness and operational costs.
Bharath and Shumway (2008).	Investigates how investors apply resources and assess corporate bonds.	Investors assess the default possibility and the liquidity of bonds from which they plan to obtain a return.	Reveals that the European securities market shows similar behaviour to the US market in terms of investor concern regarding credit quality and liquidity.
Duffie et al. (2009).	Analyses development of the Merton model in relation to factors associated with the distance to default.	The model cannot measure <i>PD</i> , but works as an information source to predict default.	Modifications of the traditional Merton model may offer greater explanatory power.
Jorion and Zhang (2007).	Examines the conditional probability distribution for losses in a credit portfolio.	Ignoring nonobservable aspects may cause biased VaR estimates for higher-volume credit portfolios.	The method used is more efficient in measuring losses in corporate bond portfolios and can be applied to other types of analysis.

Table 7. Brief descriptions of the main objective, conclusions, and contribution of each article considered in this study (Continued)

<i>Study</i>	<i>Main objective</i>	<i>Main conclusion</i>	<i>Main contribution</i>
Jiménez et al. (2014).	Studies the contagion effect in a sector with a default event on the prices of assets and derivatives.	A bankruptcy event impacts the bonds of companies in the same sector, whereas liquidation affects the stock price of firms in corresponding sectors because of competitiveness.	Proposes a connection between contagion effects, sector characteristics, and default.
Beber et al. (2007).	Applies a two-stage model to determine the credit quality of companies and its impact on financial institutions.	Low overnight interest rates cause an increase in bank risk, reflected by a larger number of lending transactions, because less capitalized banks will risk even more, which is evidenced by a larger volume of non-guaranteed concessions.	Pinpoints the aspects of risk taken that are connected to a monetary policy.
Hennessy and Whited (2007).	A structural model based on investment, cash, leverage, and default is to estimate financing costs in simulations.	Analyses confirm that the simulated outcomes are close to reality; corporate financing costs can be explained by bankruptcy costs and other rates.	The effect of choice of financing costs is very subtle because the context is fundamental.
Campbell et al. (2008).	Investigates factors connected to bankruptcy events and the stock prices of companies with high PD.	High PD assets are likely to yield low returns on average.	Reduced-form model that has very few errors.
Jappelli and Pagano (2002).	Uses primary data to study information sharing among financial institutions in the credit market.	Information sharing and the volume of loans follow the same trend.	Evidence from different countries indicates that banks share information to mitigate credit risk.
Hertzel et al. (2008).	Investigates contagion effects derived from bankruptcy events in sector terms and collaborators.	There are abnormal negative returns in supplier companies and there are signs of intersectoral contagion when the market receives default indicators or petitions for bankruptcy.	A bankruptcy event affects collaborators as well as companies in the same sector.
Chava and Purnanandam(2010).	Assesses the impact of default risk on stock prices.	Reveals a strong relation between the expected return and default risk.	Stock returns are estimated using ex ante data for the implied cost of capital via a proxy.
Foos et al. (2010).	Examines the relation between increases in loan losses and bank performance.	An abnormal increase in loan volume leads to greater institutional losses.	Sudden growth in a specific activity may lead to undesirable results.
Chen(2010).	Develops a structural model that includes macroeconomic variables.	The model meets its goal and is presented in a consistent way.	Model focuses on the effects of a risk premium in financing decisions and corporate bonds prices.
Tang and Yan(2010).	Studies the correlation between market risk and credit risk for derivatives.	Macroeconomic swings, growth rates, growth volatility, investor sentiment, and jump risk contribute to good model performance.	Risk model that includes growth measures and rates in analysing credit derivatives.
Beber et al. (2007).	Applies a two-stage model to determine the credit quality of companies and its impact on financial institutions.	Low overnight interest rates cause an increase in bank risk, reflected by a larger number of lending transactions, because less capitalized banks will risk even more, which is evidenced by a larger volume of non-guaranteed concessions.	Pinpoints the aspects of risk taken that are connected to a monetary policy.
Hennessy and Whited (2007).	A structural model based on investment, cash, leverage, and default is to estimate financing costs in simulations.	Analyses confirm that the simulated outcomes are close to reality; corporate financing costs can be explained by bankruptcy costs and other rates.	The effect of choice of financing costs is very subtle because the context is fundamental.
Campbell et al. (2008).	Investigates factors connected to bankruptcy events and the stock prices of companies with high PD.	High PD assets are likely to yield low returns on average.	Reduced-form model that has very few errors.
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Hertzel et al. (2008).	Investigates contagion effects derived from bankruptcy events in sector terms and collaborators.	There are abnormal negative returns in supplier companies and there are signs of intersectoral contagion when the market receives default indicators or petitions for bankruptcy.	A bankruptcy event affects collaborators as well as companies in the same sector.
Chava and Purnanandam(2010).	Assesses the impact of default risk on stock prices.	Reveals a strong relation between the expected return and default risk.	Stock returns are estimated using ex ante data for the implied cost of capital via a proxy.
Foos et al. (2010).	Examines the relation between increases in loan losses and bank performance.	An abnormal increase in loan volume leads to greater institutional losses.	Sudden growth in a specific activity may lead to undesirable results.
Chen(2010).	Develops a structural model that includes macroeconomic variables.	The model meets its goal and is presented in a consistent way.	Model focuses on the effects of a risk premium in financing decisions and corporate bonds prices.
Tang and Yan(2010).	Studies the correlation between market risk and credit risk for derivatives.	Macroeconomic swings, growth rates, growth volatility, investor sentiment, and jump risk contribute to good model performance.	Risk model that includes growth measures and rates in analysing credit derivatives.
Altman and Sabato (2007).	Assesses the performance of a model in measuring PD in small and medium Italian companies.	The model is more precise than a generic model.	Applies logistic regression to measure PD for SMEs using only financial variables.
Duffie et al. (2007).	Proposes a multiperiod credit risk model using macroeconomic covariates and firm-specific dynamics.	In some industries, the term structure of default risk rates is strongly associated with the economic situation and capital structure of the firms.	Analysis of a predictive PD model using time and macroeconomic covariate measures.
Chen et al. (2008).	Discusses how the stock price may contain information and its influence on future returns.	BAA-AAA bond spreads are explained from a pure credit perspective.	Identifies possible ways of determining spread.

Table 7. Brief descriptions of the main objective, conclusions, and contribution of each article considered in this study (Continued)

Study	Main objective	Main conclusion	Main contribution
Lin et al. (2011).	Examines the impact of control rights on a company's value.	Identifies possible ways of determining spread.	Perception of the influence of control rights on the capital cost.
Houweling and Vorst (2005).	Examines the impact of control rights on a company's value.	Use of European and Asian data reveals that inconsistencies between cash flow and control rights lead to higher debt-financing costs.	Assesses the financial performance of banks before and after the plan via credit derivatives.
Gordy and Howells (2006).	Evaluates the effect of the revised Paulson plan on the market.	The plan met its goal and was able to achieve efficient redistribution of resources.	Evaluation of the financial performance of banks before and after the plan via credit derivatives.
Tian et al. (2012).	Applies reduced-form models to price CDS premia.	Reduced-form models are more objective and more precise in CDS pricing.	The study is based on over 10,000 bonds, including sovereign bonds.
Grunert and Weber (2009).	Analyses the rating interdependence between macroeconomic variables and US companies and their business cycles.	The probability of a rating change is significantly supported by the business cycle.	Uses a business cycle when assessing ratings and proves the results via stress tests.
Bangia et al. (2002).	Reviews classification methods based on machine learning and proposes several formats and applications.	Support vector machines achieve good results in finance and economics.	Clarifies important points for the technique used.
He and Xiong(2012).	Tests four hypotheses on the credit quality of borrowers and the recovery rate.	Confirms the four hypotheses proposed.	Calculates the recovery rate using macroeconomic variables.
Nickell et al. (2000).	Examines a model that verifies the interaction between debt liquidity and credit risk.	A decrease in debt market liquidity induces an increase in the default liquidity premium.	Mathematically demonstrates a model that meets its goal taking into account the possibility of debt rollover.
Eom et al. (2003).	Assesses the evolution of a rating transition matrix for long-term bonds.	There is no strong relation between risk classification attributed by rating agencies and PD.	PD is associated with the stage of the business cycle.
Schaefer and Strebulaev (2008).	Compares the empirical performance of five models in pricing bonds.	The models exhibit wide variation in prediction errors and substantial differences in direction and intensity.	Theoretical demonstration of the mathematical and statistical context of each of the models.
Duffie and Lando (2001).	Uses a structural model to predict the hedge proportion for bonds strictly linked to the credit risk of a firm.	Returns on the company's equity and risk-free bonds explain approximately half of bond returns of the same investment grade.	Critical analysis of the model performance.
Veronesi and Zingales (2010).	Applies a reduced-form model to compute the term structure for company bonds in the case of information asymmetry.	Considering the lack of transparency, the model can verify the fall in bond prices when an issuer defaults.	Building of the Z model is evaluated stepwise, which provides an overview of the model.
Norden and Weber (2009).	Examines the behaviour of stock prices in relation to movements for CDS and bonds.	Stock prices react in the opposite direction to changes in derivative prices.	Contributes to investigation of market efficiency involving credit derivatives.
Guiso et al. (2013).	Investigates the impact of default costs for individuals and their assets.	Such costs increase with wealth and are linked to both financial and sentimental factors; there is also the possibility of contagion.	Very few papers take this strategic view when discussing default.
	Notes the sensitivity of a company's derivatives		
Ericsson et al. (2009).	Notes the sensitivity of a company's derivatives in deformation of the capital structure, taking into account volatility and the risk-free interest rate.	Confirms the theoretically supposed effect via statistical validation.	Applies default risk variables to study spreads.
Collin-Dufresne et al. (2001).	Investigates the impacts of contingent-claim and no-arbitrage standpoints on credit spreads.	A ratio of 25% was observed for movements in credit spreads associated with the probability of default and the recovery rate.	Changes in credit spreads for bonds cannot be explained by considering only financial data measures for companies or information for the securities market.
Bao et al. (2011).	Discusses the relationship between asset pricing and bond liquidity.	Illiquid bonds are strongly linked to lower asset prices and are associated with factors such as maturity, rating, and amount.	Liquidity may be explained by fluctuations in asset prices.
Jarrow and Turnbull (2000).	Tests macroeconomic variables for inclusion in a reduced-form model.	Some models are not able to observe the risk associated with derivatives; reduced-form models are sensitive to credit risk and the market, and are suitable for pricing and risk management.	Suggests that inclusion of economic variables can improve predictions of credit spreads by reduced-form models.

Table 7. Brief descriptions of the main objective, conclusions, and contribution of each article considered in this study (Continued)

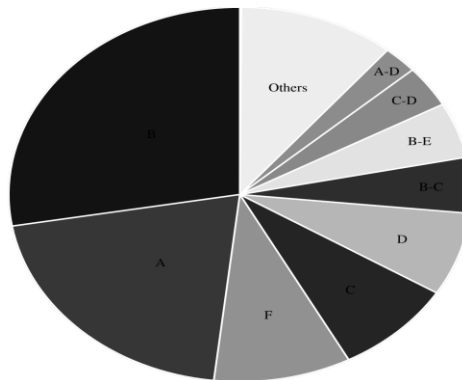
Study	Main objective	Main conclusion	Main contribution
Bhamra et al.(2009).	Develops a theoretical analysis of third-party capital costs and equity to verify the impact of macroeconomic variables on risk premia and credit spreads.	The model can determine <i>PD</i> and credit spread and simultaneously calculate premium equity and stock prices.	Proposes a relation between asset pricing and corporate finance.
Hull et al.(2004).	Evaluates the sensitivity of credit spreads to bond yields and announcements by rating agencies.	Confirms a negative relationship between credit spreads and the credit rating of firms.	Theoretical model used to study the link between credit spreads and spreads on the bond interest rate.
Almeida and Philippon (2007).	Examines the impact of corporate bond prices on the credit risk of firms.	The marginal risk-adjusted costs of financial distress and the marginal tax benefits of debt have similar volumes.	Capital structure can be influenced by insolvency costs.
Grunert et al.(2005).	Investigates the involvement of non-financial factors in internal credit ratings.	More precise prediction of the probability of default prediction when non-financial factors are included in the model.	Inclusion of non-financial measures in credit risk assessment.
Demiroglu and James (2010).	Investigates common features in <i>LBO</i> financing deals involving private equity groups.	Private equity groups with poor <i>LBO</i> reputation have a negative influence on credit spreads and financing structure.	The authors related private equity groups to <i>LBO</i> financing costs.
Zhou(2001).	Develops a reduced-form model addressing diffusion aspects from structural models.	The structural model used can be adjusted for credit spreads and reveals patterns in credit risk variables.	Risk linked to debt and credit derivatives can be assessed through default risk and interest rate risk.
Brown and Dinc(2009).	Examines the 'too big to fail' phenomenon for banks in emerging markets.	In fragile sectors, ailing banks tend to be protected by regulatory forbearance.	Role of the banking regulator in countries with an emergent market.
Dooley and Hutchison (2009).	Search for information on changes in emerging markets and credit spread default trends when default events occur in the USA.	US defaults have a significant impact on emerging markets.	Analysis based on VaR to verify links between markets.

Regarding the method used, it is noteworthy that econometrics has often been applied to time series, representing 38% of the methods used in the articles. Nevertheless, the abstract nature of theoretical studies did not affect the importance of their impact, demonstrating the need for this type of literature. We noted that computing methods and/or simulations are seldom used in studies on credit risk or even cited. A possible answer for this is the uncertainty in the outputs, i.e., there is no measure for validation or a confidence interval, as in statistical analysis. The main issue in the computing models is overfitting (When the model presents a large number of parameters and the performance does not increase or, in some cases, decreases

instead). Based on this argument, we can identify the following gap.

Gap2 : Apart from work by Chatterjee et al. (2007), Battiston et al. (2007), Allen and Carletti (2006), Tian et al. (2012), Collin-Dufresne et al. (2001), and Grunert and Weber (2009), there is a shortage of studies on credit risk that address the use of computing methods and/or simulations in depth and including validation analyses. There is indication of an increase in studies featuring this approach, but they still do not stand out as research references. It is possible that the abstract nature and innovative method, combined with the tendency for empiricism in economics and finance, are inhibitory factors.

Figure 6. Classification results for category 3, type of data source.



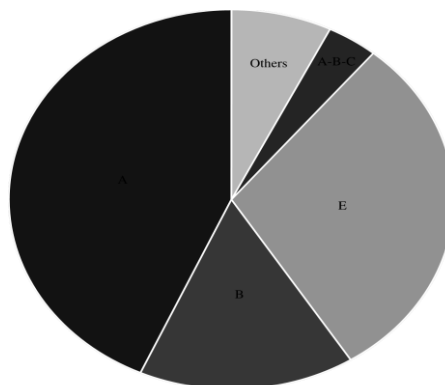
We noted a scattered distribution for the types of data applied in research, with the exception of research into companies that controls this variable. This is probably because of data availability and the difficulty in analysing data derived from financial institutions. For instance, SEE COCPAPERS. This study, if extended to many countries, might be an auspicious empirical analysis.

By contrast, macroeconomic variables are often cited in credit risk models, but they are still very

rarely applied to other subjects, even with the increase in transparency of governmental institution accounts. Therefore, the following gap is apparent.

Gap3 : The work carried out by Chen (2010) and Bonfim (2009) in analyzing macroeconomic variables when considering credit risk should be extended, especially for countries that have already made account information available.

Figure 7. Classification results for category 4, origin of the data



Results for the data origin show large concentration of research in the USA and some results for Europe, but other countries are practically unexplored. Although emerging markets may contribute more to our understanding of credit risk in the coming years, especially because they are a great source of credit risk in any situation, studies on these countries, such as Gopalan et al. (2007), are scarce. One purpose that could be more explored by

peers is a reference research involving emerging markets that have common culture and the recent crisis.

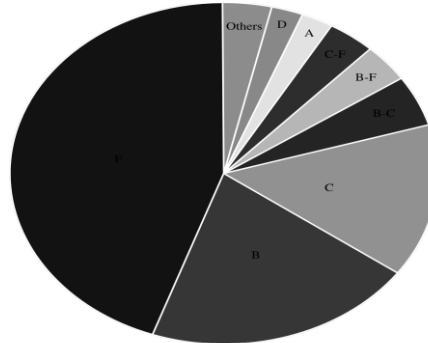
It is important to highlight that the greater collection of US data is probably explained by the intensity of the national market, the number of companies in the financial market, and the greater interest of US researchers in studying their country's characteristics, while emerging economies are very

constrained. In this sense, more research about credit risk in these markets are constantly necessary.

In the case of variables of interest, we noted that authors worked with several measures and that

the study objective was not always closely related to credit risk. However, some studies developed analyses in which some dimensions had a strategic role.

Figure 8. Classification results for category 5, variable of interest



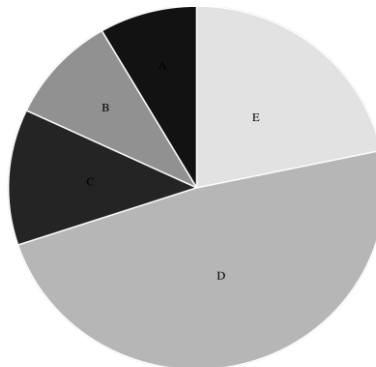
At the same time, variables were often associated to greater complexity models, demanding an attentive and sometimes subjective search. It is evident that there is a lack of publications on exposure to default in large-impact studies. Therefore, we can identify the following gap.

Gap4 : Studies on exposure to default are required that take into account the other gaps identified.

In addition, very few articles discussed LGD or the recovery rate, which is another issue that

requires research attention. It is very likely that the justification for this lack of works is associated with difficulties in obtaining data. Even in the USA, where there are a large number of data and databases, empirical results for the recovery rate are not fully publicised or widely known. In the same way, the topics of expected losses and economic capital are rarely addressed, even after the Basel II accord began to encourage banks to develop their own models to calculate capital requirements and more discussion of its implementation is required.

Figure 9. Classification results for category 9, period of analysis.



The final category is the period of analysis. The majority of articles used a data analysis period of >10 years, which indicates a tendency towards long-term analysis. Analysis over a longer time horizon allows more robust results, because statistical inferences will be more reliable and patterns that should be taken into account in future work on credit risk may become apparent.

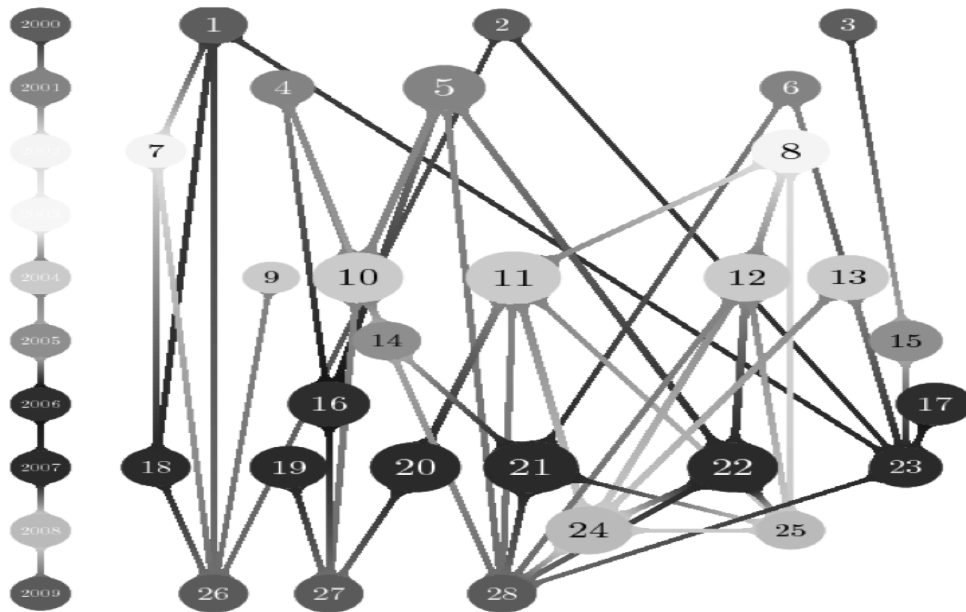
Besides our systematization to identify directions for future studies, we investigated the bibliographic references in each article using a citation-based approach. Our aim was to identify literature patterns, especially for articles that can lead to new research dimensions in the area of credit risk. The results are shown in Figure 10.

It should be noted that articles published after 2009 are not included in Figure 10. These papers are still very recent, and new studies probably chose one of the 28 articles mentioned in Table 7, as a

reference. This also indicates that the most relevant papers demonstrate greater concern regarding reference quality; thus, tools measuring the performance of scientific publications, such as the h-index and impact factor, are taken into account. This is a feature of well-elaborated, cohesive, and consistent research.

Many papers have demonstrated in the last years concerns about financial crises. Bank risks was another commented topic, and coupled to crises periods was strongly analysed. Shocks in Economy/Financial framework were also commented in the newest studies. In essence, observing in critical periods linked to particular influences provides the most of papers today. Consistent theories were not produced credit risk in the last years and seminal articles like Modigliani and Miller (1958) still persist fundamental concepts for new research.

Figure 10. Map of the references cited in the 83 articles in our database for papers with two or more citations. The size of the nodes is given by the number of selected citations, such described in Table 7.



We noted 52 connections identifying local citations, and 28 papers cited by the studies in our database had more than five annual citations. Table 8 lists the articles shown in Figure 10 and the

Number of Local Citations (NLC) and total citations (Global Number of Citations, GQC) according to the Scopus database.

Table 8. Study articles with at least two citations of other papers also included in our research (i.e., NLC ≥ 2). The last column shows the Global Number of Citations (GQC)

#	Num. Artic	Article	NLC	GQC
1	1	Crouhy et al. (2000).	2	153
2	2	Gordy (2000).	5	151
3	3	Jarrow and Turnbull (2000).	2	56
4	4	Duffie and Lando (2001).	9	201
5	5	Jarrow and Yu (2001).	3	104
6	6	Zhou (2001).	4	104
7	8	Bangia et al. (2002).	3	92
8	11	Griffin and Lemmon (2002).	5	88
9	12	Hillegeist et al. (2004).	6	176
10	13	Vassalou and Xing (2004).	8	259
11	15	Eom et al. (2003).	7	134
12	18	Jiménez and Saurina (2004).	2	45
13	21	Hull et al. (2004).	5	110
14	23	Yu (2005).	2	60
15	26	Houweling and Vorst (2005).	3	53
16	30	Zhu (2006).	4	65
17	32	Hackbarth et al. (2006).	5	69
18	33	Das et al. (2007).	7	98
19	34	Carling et al. (2007).	2	34
20	35	Duffie et al. (2007).	7	135
21	37	Jorion and Zhang (2007).	3	62
22	40	Acharya et al. (2007).	7	82
23	42	Almeida and Philippon (2007).	4	46
24	46	Bharath and Shumway (2008).	6	143
25	50	Campbell et al. (2008).	2	136
26	52	Bonfim (2009).	2	31
27	58	Chen et al. (2008).	2	38
28	60	Duffie et al. (2009).	2	60
		Sum	119	2785

Source: Scopus database

3. CONCLUSIONS

Credit risk has been increasingly studied by researchers and market practitioners. Interest in the subject is clearly justified, since financial losses of any intensity are undesirable and can cause

perspective changes, contagion, default events, and even bankruptcy in high-volume scenarios. Our study involved a systematic analysis of articles on credit risk published in the literature in the last 15 years.

Our results highlight relevant aspects of the 83 articles considered, in particular their similarities, contextualisation, and applicability in terms of the abstract, methodological analysis, and study scope. We conclude that interest in credit risk is growing (Figure 1), but applications remain concentrated on predictive modelling and credit derivatives. Economic capital, exposure to default, and LGD are areas for potential research, especially the latter, which authors consider the most relevant subject. However, the lack of data limits the consideration of LGD in empirical studies. By contrast, theoretical studies are mathematically sophisticated and their arguments create interest in future research, so they are cited very often.

This work adds important results to the academic literature and indicates some gaps that should be addressed (Section 5). These can be summarised as follows:

The concept of credit risk is highly associated with contagion. Nowadays, it has connected to economic shocks and crises.

There has been very little study of loss quantification, either as capital requirements or capital recuperated, or of the magnitude of exposure for default events. Models for predicting defaults are more frequent in the literature.

Computational models seem to be the future for studies on credit risk models in many ways, but they need more consistent results and validation measures.

Although we have contributed with a systematic review of the literature on credit risk and pointed out directions for future studies, future systematic reviews could be carried out to identify true connection networks in citation maps or bibliometric analyses, since we did not address the issue of self-citation. Tools such as the area diffusion of complex networks could be used for this purpose.

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