University of Brasília

College of Economics, Business Management, and Accounting (FACE)
Postgraduate Program in Business Management

The influence of leverage in determining risk for the Brazilian banking system

Douglas da Rosa München

Thesis submitted in partial fulfillment of the requirements for the degree of
Master in Business Management

Advisor
Prof. Dr. Herbert Kimura

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Dedication

I dedicate this master thesis to my wife Daniela, for the unconditional support and love, and to my daughters Rafaela and Olívia, for teaching me to be a better person.

Acknowledgements

Thanks to my advisor, Prof. Tit. Herbert Kimura, for the dedication in corrections of this work and for the teachings transmitted throughout the course.

To the professors of the Postgraduate Program in Administration of UnB, for the dedication and the teachings.

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Abstract

The high leverage of financial institutions is seen as a relevant factor to explain the last global financial crisis. Risk's over-taking by banks has brought great costs to the economies of several countries. For this reason, the Basel Committee recommended the establishment of operational limits, including leverage. For the Brazilian case, it is important to know how leverage influences banks' risk taking and how it affects financial stability. Previous results for the US pointed out by Papanikolaou and Wolff (2014) show that, when the financial crisis of 2007 emerged, banks had to deleverage their positions, amplifying the downward pressure on assets price, especially for banks that were engaged in off-balance sheet operations. In the Brazilian case, the results show that the measurement of leverage carried out by the Basel Committee is relevant for the determination of institution risk as measured by z-score. Considering specific segments of banks, such as non-commercial ones, some types of transactions are riskier, such as derivative operations, or less risky, such as off-balance operations. For commercial banks, it was verified the importance of monitoring typical financial intermediation variables, such as the composition of assets and deposits of financial institutions, in order to mitigate the banking system's risk. Thus, the results of the study bring important insights to market agents and to banking regulation.

Keywords: leverage, banks, regulation, basel, risk

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Chapter 1

Introduction

The excessive leverage of financial institutions is indicated as being a relevant factor in explaining the last global financial crisis (Miele and Sales, 2011, p. 293). The 2007 crisis highlighted the impact that the banking sector can have on the economy in turbulent situations. Innovation in the banking sector and financial engineering led to the development of new products for the financial market; however, this also brought new forms of risk and greater challenges for regulating them.

Thus, the traditional form of banking intermediation between savers and borrowers has become more complex, making banks more exposed to and willing to take risks. However, given the financial innovations, the risks assumed were little known. Consequently, the inappropriate measurement of these new forms of financial intermediation increased the so-called leverage of the banks.

Papanikolaou and Wolff (2014, p. 3) argued that, in general, financial leverage is part of the underlying characteristic of banks. Traditionally, leverage came from formal debts; however, according to the authors, in the years before the crisis of 2007, banks were transferring part of their leverage off the balance sheets, due to the emergence of the use of financial engineering techniques that masked the real leverage of these institutions.

When the financial crisis of 2007 emerged, banks had to scrap their positions, expanding the process of depreciating asset prices. Thus, according to the authors, this procyclical process was most relevant for large and systemically important institutions that were engaged in off-balance sheet operations (Papanikolaou and Wolff, 2014, p. 3).

Banks that demonstrated more intense earnings management prior to the 2007 crisis also presented greater risk in the stock market. Thus, according to the authors, these movements should be warning signals for regulators to prevent future problems in the banking system (Cohen et al., 2014, p. 171). Gibson et al. (2018) use a measure of systemic vulnerability in european banking system and find evidence of rising vulnerability prior to 2007 crisis.

Additionally, the capital structure of the banking system differs from that of traditional firms. Banks are extremely leveraged. Accordingly, these institutions must maintain their own capital to support unforeseen losses that are consequently not provided for. Thus, the requirement of indicators that measure the minimum level of capital are important in the context of banking regulation.

Gjerde and Semmen (1995) analysed the effectiveness of risk-based capital indicators when bank deposits are fully insured. They specified an optimal set of asset risk weights, and the results show that when deviations from the optimal risk weights occurred, a combination of a leverage constraint and a risk-based capital indicator appears to be a more appropriate approach to risk control.

Blum (2008, p. 1699) suggested that banking regulation, within the scope of the Basel Accords, needs an indicator for leverage restriction and proposed the use of a leverage indicator in conjunction with risk-based capital requirements. According to the author, given that information about risk is provided by the banks themselves and that the authorities are limited in identifying and sanctioning non-honest banks, an additional risk-independent leverage indicator should be adopted to induce disclosure about risk that is free from bias by the banks.

According to Jarrow (2013), the leverage indicator controls the same risks as the capital adequacy rules based on the Value-at-Risk (VaR). Dermine (2015) stated that the Leverage Ratio establishes a floor for the risk-weighted capital indicator.

Kuzubaş. et al. (2016) used heterogeneous leverage (different leverage between banking institutions) to analyse systemic risk. The results showed that the presence of heterogeneous leverage markedly changes the systemic effects of default and the nature of the contagion in the interbank markets.

Studies published in the finance and economics literature support the adoption – via banking regulations – of mechanisms to limit the high level of leverage of such institutions. However, it is worth noting that the use of the leverage indicator is not new for certain countries (e.g., USA and Canada) that had already been using it in supervisory activity before *Basel III* (Miele and Sales, 2011, p. 293). Canadian banks are a good case study in this regard, as they have been subject to a regulatory leverage indicator since the early 1980s (Crawford et al., 2009).

Given the importance attributed to banking leverage in recent years, especially after the 2007 crisis, it is important to highlight how this issue is discussed in the literature, especially in the form of capital regulation. Many important works have been and are being conducted in relation to banking leverage – particularly, the great predominance of studies after the recent crisis, after which the number of publications has grown significantly.

Studies by Blum (2008); Chen and Mazumdar (1994); Evanoff and Wall (2001); Morgan (2002); Saunders and Wilson (2001) showed the importance of banking leverage before the financial crisis started in 2007, especially regarding the objects of study of asymmetric information and moral hazard. After the crisis, studies sought to relate leveraging to the following topics: business cycles (Aymanns et al., 2016; Aymanns and Farmer, 2015; Brei and Gambacorta, 2016; Valencia and Bolaños, 2018); monetary policy (Angeloni and Faia, 2013); systemic risk (Aymanns et al., 2016; Aymanns and Farmer, 2015; López-Espinosa et al., 2012; Papanikolaou and Wolff, 2014; Tasca et al., 2014); and financial stability (Kiema and Jokivuolle, 2014; Papanikolaou and Wolff, 2014).

Thus, the objective of this work is to identify the influence of leverage in determining risk for the Brazilian banking system. First of all, it presents a bibliographic review of studies of bank leverage within the context of the prudent regulation of capital. The research and systematic analysis of the main articles related to leverage in relation to banking institutions have made it possible to consolidate our knowledge and identify prospective areas for research. This work seeks to verify how leverage is being studied in the literature and linked to studies of bank and economic performance, and suggests other gaps that need to be explored in future studies. Secondly, based on the work of Papanikolaou and Wolff (2014), it verifies empirically that leverage influences risk taking by Brazilian banks and examines how it affects financial stability.

Our justification for the analysis of the banking system is the importance of verifying the degree of bank leverage within the context of the possible financial instability of these entities and the resulting alterations in the structure of capital which may lead to high costs for the economy and society.

The results of this bibliometric analysis point to financial stability as an important subject of study in relation to leverage, in addition to credit risk. There is a gap in studies of this subject for emerging nations and also a gap in the interaction of macroprudential and microprudential studies of this area. The results of a meta-analysis of the data indicate that the determinants of the capital structure of banking, for example the work of Gropp and Heider (2010), should be considered as well as the keywords banking, capital, regulation and Basel.

The results of this empirical study show that these insights matter to the regulators and agents of the financial market. The proxy of leverage for on-balance sheet, derivative, off-balance sheet and repo operations related to the individual risk of banks measured by the *zscore*, shows that the leverage for on-balance sheet operations and macroeconomic variables, such as *PIB*, influence the stability of the banking system. Considering the banking segment specifically as well as commercial banks, asset and liability composition variables (control variables) are important risk factors. For treasury or non-commercial

banks, derivative operations are riskier.

In this manner, this work presents the following contributions to the financial and economic literature:

(i) it gathers together published studies of capital leverage within the context of the banking system, which furthers the understanding and classification of leverage studies in finance and economics;

(ii) it verifies how leverage influences banks risk taking and how it affects financial stability.

The rest of this work is organized in the following manner. Chapter 2 consists of a review of the literature. Chapter 3 presents the empirical study. Chapter 4 presents the results of this empirical study, and Chapter 5 consists of the study's concluding remarks.

Chapter 2

Review of the literature

For the definition of the group of articles that represent banking leverage in the context of the regulatory and risk exposure environment, this literature review follows the research method suggested by Junior and Filho (2010, p. 14-15), Seuring (2013, p. 1513), Jabbour (2013, p. 144-145), and Silva et al. (2017, p. 92-93). The *Scopus* database was used, together with the search for the words *leverag* and basel or regulat* and bank* or financial institution* and risk**.

Association of Business Schools (ABS) in the areas of Finance and Economics, Econometrics, and Statistics was adopted to restrict the evaluation to important journals in the area of finance and economics. Furthermore, all the selected articles were written in the English language.

In the first evaluation, on August 17, 2017, 133 articles were found using the previously defined filters. On November 6, 2017, a new round of research was conducted with the same criteria, and no additional articles were found. On June 21, 2018, 155 articles were found - 22 articles in addition to those found previously. The following were not analysed for selection of the sample's final set: one article that had been duplicated in the database, one article that did not conform to the subject being studied (an article from the electric sector), and one article that was not available for download. A latest new round of research was conducted on January 10, 2019 and 8 articles more was found. Thus, the final sample consisted of 160 articles.

In relation to the categorization scheme of the articles, this present study follows the method of Silva et al. (2017, p. 94), who conducted a bibliometric review related to the topic of systemic risk.

Tables 2.1 and 2.2 illustrate the main features of the articles published on the topic, including, for example, the following: the specific study object and the type of focus institutions of the related articles; the types of studies done (theoretical or empirical); the type of approach (quantitative or qualitative); the method used; the type of data

analysed; and, in the case of quantitative studies, the scope (one country or more than one country), the context (developed or emerging countries), the time period studied, and if they offer new perspectives or are consistent with previously published studies.

Regarding the objects of study, based on the study of the literature and the researcher's evaluation, the themes that are related to banking leverage were listed. It should be emphasized that the resulting attribution of the object(s) of study to each article is linked to the analysis of the author, in accordance with the reading of the texts.

Additionally, in relation to the objects of Table 2.1, the groupings of microprudential and macroprudential objects (groups in which each object is located) – which are based on the banking regulation policy in practice since the last financial crisis – were assigned, in accordance with Vinais (2013) and Borio (2003).

According to Galati and Moessner (2011), prior to the financial crisis of 2007, macroeconomic policies – especially monetary policy – aimed for the stability of prices and products and were treated in a way not associated with the so-called microprudential policies, which basically individually analyse the minimum limits and provisions of financial institutions. After the financial crisis of 2007, it was necessary to analyse the macroeconomic policies that incorporate the behaviour of the financial system, which began being done through the implementation of macroprudential policies. According to this denomination, a macroprudential policy is that which, above all, aims for financial and systemic stability.

By contrast, microprudential policies are focused on individual stability (Caruana, 2010). According to Acharya and Thakor (2016, p. 4), because both forms of regulation ultimately aim to improve the stability of the financial system, microprudential and macroprudential regulation not only relate to each other, but there is, in fact, tension between them. For more information on macroprudential policies and their differences from microprudential policies, see for instance Galati and Moessner (2011).

It is important to highlight that the macroprudential regulation is crucial from a financial stability and a systemic risk perspectives (Bruno et al., 2017; Cerutti et al., 2017; de Haan et al., 2017; Karmakar, 2016). A broad stream of literature discusses macroprudential regulation related not only to leverage but also to stress testing (Buncic and Melecky, 2013), monetary transmission mechanisms (Agenor and da Silva, 2014), credit spreads (Tayler and Zilberman, 2016), risk communication and visualization (Sarlin, 2016)

Thus, for the purpose of this present study, the study objects of the Business Cycle (which has a strong connection to monetary policy), Systemic Risk, and Financial Stability are linked to the macroprudential approach. By contrast, the study objects related to the individual stability of institutions – Asymmetric Information, Moral Hazard (deposit insurance), Bank Runs, Business Models, Capital Markets, and Credit Risk / Distress

Risk / Default Risk – have a microprudential approach.

It should be noted that each article may have one or more objects of study and can address both the macroprudential and microprudential object level. This classification aims to facilitate the understanding of what types of risk the studies on the banking leverage topic are dealing with, in accordance with Table 2.1 of the proposed coding scheme.

Additionally, the articles may contain other objects of study not listed in Table 2.1 because the study seeks to list objects of studies related to regulatory banking leverage. Thus, other objects of study connected to leverage are classified as *Others*.

Regarding the focus of the studies, also in Table 2.1 of the coding scheme, the expectation from the results is that the *Banks* element be the main result found in the articles surveyed, given that the prudential regulation of banking leverage – disclosed by the Basel Committee – has this type of institution as the main focus.

Classification and coding used for the analysis of the articles		
Numeration	**Title**	**Description**
C1	Object of study	*microprudential*
		A - Asymmetric information
		B - Moral hazard (deposit insurance)
		C - Bank run
		D - Business model
		E - Capital market
		F - Credit risk / Distress risk / Default risk
		macroprudential
		G - Business cycle
		H - Systemic risk (contagion)
		I - Financial stability
		J - Others
C2	Focus	
		A - Financial institutions in general
		B - Banks
		C - Stock market
		D - Insurance companies
		E - Investment funds
		F - Mortgage / real estate market
		G - General market (non-financial)
		H - Countries / government securities
		I - Other segments

Table 2.1: Object and focus of the study.

With the codification proposed in Table 2.2, the idea was to understand how the topic of leverage is being studied, that is, which type of study was done (theoretical or empirical), which type of approach (quantitative or qualitative) and method were used, and, if the study was empirical, what types of data were analysed (market, financial statements, etc.), what was the scope and context of the articles, how many periods were studied in the articles of the sample, and what types of results were found. It should be noted that if the study used only simulated data or mathematical models, it is classified as theoretical. In relation to the C6 classification (Data types analysed) of Table 2.2, there is a difference in the option for the *Various* term compared to the *Others* term discussed in Silva et al. (2017, p. 94) to facilitate the annotation scheme and due to the expectation in this present work of the analysed articles using various data sources.

Additionally, in Table 2.2, the leverage metric used in the articles studied (classification

C7) is discussed. Two leverage metrics are mentioned in this study. Metric A represents the total assets of the banks over equity (or the inverse of this ratio) or the total debt over total assets. In other words, the first metric is an indicator that demonstrates the equity position. Metric B, which is the indicator promulgated by Basel III, comprises the ratio between Tier 1 Capital and Total Exposure. This second metric basically represents an indicator that comprises the quality equity of the banks over the total assets plus items not accounted for in the assets, which are considered to be off-balance sheet items. This indicator is presented in more detail in section 2.3.

Considering the characteristics of the leverage, the expectation regarding the evaluation of this metric is that most of the articles are situated in item A, given that metric B was promulgated by the Basel committee in 2013; therefore, only the studies conducted most recently were suitable to perform at least one proxy of this new indicator.

Classification and coding used for the analysis of the articles		
Numeration	**Title**	**Description**
C3	Type of study	A- Theoretical
		B-Empirical
		C- Both
C4	Type of approach	A- Quantitative
		B- Qualitative
		C- Quantitative and qualitative
		D- Review/Research
		E- Not applicable
C5	Methods used	A- Econometric / Statistical / Multivariate analysis
		B- Computational / Simulation
		C- Mathematical modelling
		D- Not applicable
C6	Types of data analysed	A- From the market
		B- From balance sheets
		C- Macroeconomic
		D- From regulators, IMF, and other entities
		E - Various
		F- Not applicable
C7	Metrics for leverage	A- Total assets / Net equity
		B- Level 1 capital / Total exposure
		C- Not applicable
C8	Scope	A- One country
		B- More than one country
		C- Region/Block
		D- Global
		E- Not specified / Not applicable
C9	Context	A- Developed countries
		B- Emerging countries
		C- Both
		D- Not applicable
C10	Periods studied	A- Up to 2 years
		B- From 2 to 5 years
		C- From 5 to 10 years
		D- More than 10 years
		E- Not applicable
C11	Results	A- New perspectives
		B- Consistent with studies previously published in the literature

Table 2.2: Type of study, approach, methods used, type of data, metrics for leverage, scope, context, period, and results.

Regarding the Scope item, the objective was to answer the following questions: Where is the focus of the articles? Does the study focus on a country or a region? Does the article have a global scope? Considering the context, one can also see the focus countries of the studies in Table 2.2 and whether they are developed or emerging or both. This Table also codifies the period of time studied in the articles. For the articles that do not use empirical data and, therefore, are only theoretical, the term *Not applicable* is adopted for the period of time studied. In relation to the Results item found in the articles of the sample (classification C11), two options were adopted in relation to the results analysed, as follows: if they have new perspectives, taking into account the authors' own mention; or if the studies are consistent with previous publications.

Given the set of articles in the sample, it was found that the main publication vehicle is the Journal of Banking and Finance, with 22 articles in the sample, representing 14% of the total. The sample was also found to have a large dispersion of publication vehicles - 40 journals had only 1 publication, which represents 25% of the total.

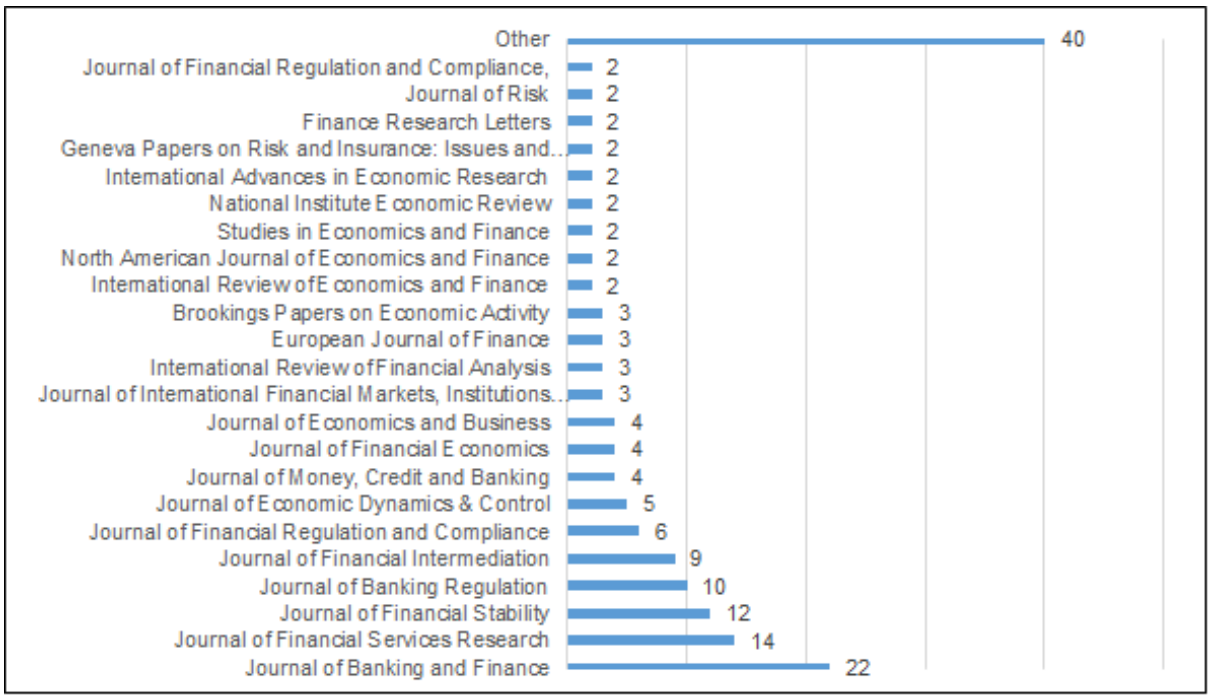

Figure 2.1: Number of articles per journal.

In relation to the year of publication, production increased after the financial crisis of 2007 - 86% of the sample's articles were published within this period.

Article	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Papanikolaou and Wolff (2014).	1G,1H,1I	2B	3B	4A	5A	6E	7B	8A	9A	10D	11A
Dermine (2015).	1A,1C,1F	2B	3A	4A	5C	6F	7A	8E	9D	10E	11A
Aymanns and Farmer (2015).	1G,1H	2A	3A	4A	5B	6F	7A	8E	9D	10E	11B
Aymanns et al. (2016).	1D,1F,1G,1H,1I	2B	3A	4A	5B	6F	7A	8E	9D	10E	11B
Angeloni and Faia (2013).	1C,1G,1J	2B	3A	4C	5A,5C	6E	7A	8E	9D	10E	11B
Demirguc-Kunt et al. (2013).	1E,1I	2B	3B	4A	5A	6E	7B	8B	9A	10B	11B
Vallascas and Keasey (2012).	1D.1F.1H	2B	3B	4A	5A	6E	7B	8C	9A	10D	11A
Kiema and Jokivuolle (2014).	1F,1I	2B	3A	4A	5B,5C	6F	7B	8E	9D	10E	11B
Cathcart et al. (2015).	1F,1I	2B	3C	4A	5A,5C	6D	7A	8A	9A	10B	11A
Blum (2008).	1A,1B,1D,1H,1J	2B	3A	4A	5C	6F	7A	8E	9D	10E	11A
Kalemli-Ozcan et al. (2012).	1D,1G	2B,2G	3B	4A	5A	6E	7B	8D	9C	10C	11A
Chen and Mazumdar (1994).	1B,1J	2B	3B	4A	5C	6F	7A	8A	9A	10E	11A
Morgan (2002).	1A,1J	2B,2D	3B	4A	5A	6D	7A	8A	9A	10C	11B
Beltratti and Stulz (2012).	1H,1I,1J	2B	3B	4A	5A	6E	7A	8D	9C	10B	11A
Carey et al. (1998).	1D	2B	3B	4A	5A	6E	7C	8A	9A	10C	11A
Hughes et al. (1999).	1D	2B	3B	4A	5A	6E	7C	8A	9A	10A	11B
Evanoff and Wall (2001).	1E	2B	3B	4A	5A	6E	7A	8A	9A	10D	11A

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
López-Espinosa et al. (2012).	1H,1I,1J	2B	3B	4A	5A	6E	7A	8B	9C	10C	11A
John et al. (2010).	1J	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Saunders and Wilson (2001).	1E,1G	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Poghosyan and Čihak (2011).	1F,1H,1I,1J	2B	3B	4A	5A	6E	7A	8C	9A	10D	11A
Episcopos (2008).	1B,1F	2B	3B	4A	5A	6E	7B	8A	9A	10B	11A
McAleer (2009).	1J	2B	3B	4A	5A	6E	7C	8B	9A	10D	11B
Riccetti et al. (2013).	1F,1G,1H,1I,1J	2G	3A	4A	5B	6F	7C	8E	9D	10E	11B
DeAngelo and Stulz (2015).	1F	2B	3A	4A	5B	6F	7A	8E	9D	10E	11A
Clarke (2010).	1F,1J	2A	3A	4B	5D	6D	7C	8C	9A	10E	11B
Gueyie and Lai (2003).	1B	2A	3B	4A	5A	6E	7A	8A	9A	10D	11B
Guidara et al. (2013).	1G,1I	2B	3B	4A	5A	6E	7A	8A	9A	10D	11A
Patro et al. (2013).	1E,1F,1H,1I	2B,2G	3B	4A	5A	6A	7C	8A	9A	10A	11B
Kane (2012).	1I	2A	3A	4B	5C	6F	7C	8A	9A	10E	11B
Braun and Raddatz (2010).	1J	2B	3B	4A	5A	6E	7A	8D	9C	10D	11B
Poledna et al. (2014).	1F,1G,1H	2A	3A	4A	5B	6F	7A	8E	9D	10E	11B
Weiß et al. (2014).	1H,1I	2B	3B	4A	5A	6E	7A	8D	9C	10D	11A
Kishan and Opiela (2012).	1I,1J	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Carbo-Valverde et al. (2008).	1D	2B	3B	4A	5A	6E	7A	8C	9A	10D	11B

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Calomiris and Nissim (2014).	1E,1I	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Gjerde and Semmen (1995).	1B	2B	3A	4A	5B	6F	7A	8E	9D	10E	11B
Black et al. (2016).	1F,1H,1I,1J	2B	3B	4A	5A	6E	7A	8C	9A	10D	11B
Lee and Chih (2013).	1F	2B	3B	4A	5A	6B	7A	8A	9B	10C	11A
Triantis (2000).	1J	2G	3A	4B	5D	6F	7C	8A	9A	10E	11A
Mingo (1976).	1D	2B	3B	4A	5A	6B	7A,7B	8A	9A	10A	11A
Vazquez and Federico (2015).	1F,1I	2B	3B	4A	5A	6E	7A	8B	9A	10C	11B
Chan-Lau et al. (2015).	1E,1I	2B	3B	4A	5A	6E	7A	8B	9A	10B	11B
Prasch (2012).	1I	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Mazumder and Ahmad (2010).	1E,1I	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Carson and Hoyt (2000).	1F,1J	2D	3B	4A	5A	6E	7C	8C	9A	10D	11B
Allen et al. (1996).	1B,1F,1J	2B	3C	4A	5A	6E	7A	8A	9A	10B	11A
Plantin (2015).	1A,1B,1D	2B	3A	4A	5C	6F	7A	8E	9D	10E	11B
Gabbi et al. (2015).	1G,1H,1I	2B	3A	4A	5B	6F	7A	8E	9D	10E	11A
Ratnovski (2013).	1J	2B	3A	4A	5C	6F	7C	8E	9D	10E	11A
Inderst and Mueller (2008).	1B,1F	2A	3A	4A	5C	6F	7A	8E	9D	10E	11A
Tasca et al. (2014).	1D,1F,1H	2B	3A	4A	5B	6F	7A	8E	9D	10E	11A
Geanakoplos (2014).	1G,1I	2A	3A	4B	5D	6F	7C	8C	9A	10E	11B

Continued in the next page.

Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Calmès and Théoret (2013).	1G,1I	2B	3B	4A	5A	6E	7B	8A	9A	10D	11B
Hagen and Fender (1998).	1J	2A	3A	4B	5D	6F	7C	8E	9D	10E	11B
Krug et al. (2015).	1H.1I	2B	3A	4A	5B	6F	7A	8E	9D	10E	11B
Mullineux (2014).	1B,1I,1J	2B	3A	4B	5D	6F	7C	8B	9A	10E	11B
Ellis et al. (2014).	1,H,1I,1J	2B	3A	4B	5D	6F	7C	8E	9D	10E	11B
Pennathur et al. (2014).	1E,1I	2A	3B	4A	5A	6E	7A	8A	9A	10A	11A
Cabral (2013).	1I	2B	3A	4C	5B	6F	7C	8A	9A	10E	11A
Chernykh and Cole (2015).	1F,1I	2B	3B	4A	5A	6E	7A	8A	9A	10C	11A
Lee and Lin (2012).	1F	2G	3B	4A	5A	6E	7C	8A	9A	10C	11B
Nieto and Garcia (2012).	1I,1J	2B	3A	4B	5D	6F	7C	8C	9A	10E	11B
Acharya and Thakor (2016).	1H,1J	2B	3A	4A	5C	6F	7C	8E	9D	10E	11B
Mohsni and Otchere (2015).	1I,1J	2B	3B	4A	5A	6E	7A	8A	9A	10C	11A
Valencia (2014).	1I,1J	2B	3A	4A	5B	6F	7A	8E	9D	10E	11B
Bernardo and Welch (2013).	1I,1J	2A	3A	4A	5B,5C	6F	7C	8E	9D	10E	11B
Harding et al. (2013).	1B,1F	2B	3A	4A	5B,5C	6F	7A	8E	9D	10E	11B
Blundell-Wignall et al. (2012).	1D,1H1I	2B	3A	4C	5D	6D	7C	8C	9A	10E	11B
Miele and Sales (2011).	1I	2B	3A	4C	5D	6D	7C	8D	9C	10E	11B
Heed (2010).	1D,1H,1I	2A	3A	4B	5D	6F	7C	8B	9A	10E	11B

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Bernard et al. (2005).	1B	2B	3A	4A	5B,5C	6F	7C	8A	9A	10E	11A
Wang et al. (2014).	1H	2A	3B	4A	5A	6E	7A	8A	9B	10C	11A
Koch (2014).	1D,1E1G.1I	2B	3B	4A	5A	6E	7A	8A	9A	10C	11A
Schmaltz et al. (2014).	1D	2B	3B	4A	5B	6B	7B	8A	9A	10A	11A
Agur (2013).	1A,1I	2B	3A	4A	5C	6F	7C	8B	9A	10E	11A
Glasser (2013).	1I	2A	3A	4B	5D	6F	7C	8A	9A	10E	11B
Mullineux (2011).	1B,1I,1J	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Handorf (2011).	1D,1E	2B	3B	4A	5A	6E	7A	8A	9A	10A	11B
Hugonnier and Morellec (2017).	1F	2B	3A	4A	5B,5C	6E	7A	8A	9A	10	11B
Osborne et al. (2017).	1G,1I	2B	3B	4A	5A	6E	7A,7B	8A	9A	10D	11A
Arayssi (2016).	1A,1D,1H,1J	2B	3A	4A	5C	6F	7A	8E	9D	10E	11A
Hasan et al. (2016).	1B,1D,1F,1I	2B	3B	4A	5A	6E	7A	8D	9C	10D	11A
Kuzubaş. et al. (2016).	1D,1H	2B	3C	4A	5A,5B	6B	7A	8A	9A	10A	11A
Bengtsson (2016).	1D,1G,1H	2E	3A	4B	5D	6F	7C	8E	9D	10E	11A
Admati (2016).	1F,1H,1I	2B	3A	4B	5D	6F	7C	8E	9D	10E	11B
Benhabib et al. (2016).	1B,1C,1G,1I	2B	3A	4A	5B,5C	6F	7C	8E	9D	10E	11B
Kupiec and Wallison (2015).	1F,1H,1I	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Elyasiani et al. (2015).	1E,1H,1I	2B,2D	3B	4A	5A	6E	7A	8B	9A	10C	11A
Fidrmuc et al. (2015).	1D,1F	2A	3B	4A	5A	6B	7A	8A	9A	10B	11B
Dubecq et al. (2015).	1A, 1J	2B	3A	4A	5C	6F	7C	8A	9A	10E	11A
Thimann (2015).	1H	2B,2D	3A	4B	5D	6F	7C	8C	9A	10E	11B

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Derviz (2014).	1F,1H,1I	2B	3A	4A	5B,5C	6F	7C	8E	9E	10E	11A
Pakravan (2014).	1H,1I	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Borri et al. (2014).	1H,1I	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Wilmarth (2014).	1D,1J	2B	3A	4B	5D	6F	7C	8E	9D	10E	11B
Cole and Cadogan (2014).	1F,1J	2G	3A	4A	5C	6F	7C	8E	9D	10E	11A
Eberlein et al. (2013).	1E,1G	2B	3B	4A	5A,5C	6A	7C	8A	9A	10D	11A
di Iasio (2013).	1F,1G,1I	2B	3A	4A	5C	6F	7C	8E	9D	10E	11A
Jarrow (2013).	1F,1G,1H,1I	2B	3A	4A	5C	6F	7C	8E	9D	10E	11B
Yang et al. (2012).	1B,1E,1F	2D	3B	4A	5B,5C	6A	7C	8A	9B	10C	11B
Moosa (2012).	1I,1J	2B	3A	4B	5D	6F	7C	8D	9C	10E	11B
Muradoglu (2010).	1I,1J	2B	3A	4B	5D	6F	7C	8A	9A	10E	11A
Covi (2017).	1F,1I,1J	2B	3C	4C	5A	6A	7A,7B	8C	9A	10C	11B
Haritchabalet et al. (2017).	1A,1H,1J	2B	3A	4A	5C	6F	7C	8D	9C	10E	11B
Miu and Ozdemir (2017).	1F,1G	2B	3C	4A	5A,5C	6E	7C	8E	9D	10D	11A
Sorokina et al. (2017).	1D,1G	2B	3B	4A	5A	6E	7A	8A	9A	10D	11A
Nesbitt (2017).	1D,1F	2G	3B	4A	5A	6D	7C	8A	9A	10D	11B
Krstevska et al. (2017).	1D	2B	3B	4A	5A	6E	7A	8A	9B	10D	11B
Falagiarda and Saia (2017).	1F,1G,1H,1I,1J	2B	3C	4A	5B,5C	6F	7C	8E	9D	10E	11A
Chen et al. (2017).	1D,1J	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Entrop et al. (2017).	1J	2B	3B	4A	5A	6E	7A	8A	9A	10D	11A

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Dandapani et al. (2017).	1D,1I	2B	3B	4A	5A	6E	7A,7B	8A	9A	10B	11A
Barucci et al. (2016).	1F	2B	3B	4A	5A	6E	7B	8C	9A	10A	11B
Wu and Zhao (2016).	1A	2B	3A	4A	5C	6F	7C	8E	9D	10E	11B
Dressler and Tauer (2016).	1D,1F	2A	3B	4A	5A	6E	7A	8A	9A	10C	11A
Klimenko and Moreno-Bromberg (2016).	1D,1J	2B	3A	4A	5B,5C	6F	7A	8E	9D	10E	11A
Schenck and Thornton (2016).	1B,1E,1I	2B	3C	4A	5A,5B	6E	7A	8A	9A	10D	11A
Walther (2016).	1F,1H,1J	2B	3A	4A	5C	6F	7C	8E	9D	10E	11B
Lengwiler and Maringer (2015).	1F,1H,1I	2A	3B	4A	5B	6F	7C	8E	9D	10E	11B
Kanas (2014).	1F	2B	3B	4A	5A	6D	7A,7B	8A	9A	10D	11A
Kellermann and Schlag (2013).	1I	2B	3C	4A	5A,5C	6B	7B	8A	9A	10B	11A
Bergevin et al. (2013).	1G,1H,1I	2B	3B	4A	5A	6A	7A,7B	8A	9A	10D	11A
Zamora-Mesinas et al. (2011).	1D,1I	2B	3B	4A	5B	6F	7C	8E	9D	10E	11B
Lee (2009a).	1J	2B	3B	4A	5A	6D	7A	8A	9B	10D	11B
Lee (2009b).	1B	2B	3B	4A	5A	6D	7A	8A	9B	10D	11B
Gavalas (2015).	1I,1J	2B	3B	4A	5A	6A	7A	8C	9A	10C	11B
Paris (2000).	1E	2B	3A	4A	5C	6F	7C	8E	9D	10E	11A
Chaigneau (2013).	1J	2B	3A	4A	5C	6F	7C	8E	9D	10E	11B
Imbierowicz et al. (2018).	1G,1H	2B	3B	4A	5A	6D	7A,7B	8A	9A	10C	11B

Continued in the next page.

Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Ghosh and Chatterjee (2018).	1D,1I,1J	2B	3B	4A	5A	6D	7A	8A	9B	10D	11B
Hossain et al. (2017).	1G,1I	2B	3B	4A	5A	6E	7A,7B	8C	9B	10C	11A
Kim et al. (2018).	1F,1I	2A	3B	4A	5A	6E	7C	8A	9A	10B	11B
Allahrakha et al. (2018).	1J	2A	3B	4A	5A	6D	7B	8A	9A	10B	11B
Barth and Seckinger (2018).	1B,1D,1J	2B	3A	4A	5C	6F	7C	8E	9D	10E	11A
Luciano and Wihlborg (2018).	1D,1F,1H	2B	3A	4A	5B,5C	6F	7C	8E	9D	10E	11B
Dreassi et al. (2017).	1D,1F,1H	2B,2D	3B	4A	5A	6A	7A,7B	8C	9A	10C	11A
Benbouzid et al. (2017a).	1F,1I	2B	3B	4A	5A	6A	7A	8B	9C	10C	11B
Mendonça and Silva (2017).	1H	2B	3B	4A	5A	6E	7A	8A	9B	10B	11B
Benbouzid et al. (2017b).	1F,1I	2B	3B	4A	5A	6E	7A	8B	9C	10C	11B
Cartwright and Sarraf (2005).	1F,1J	2B	3A	4B	5D	6F	7C	8E	9D	10E	11E
Lechner and Gatzert (2017).	1J	2G	3B	4A	5A	6E	7A	8A	9A	10B	11B
Herring (2018).	1J	2B	3A	4B	5D	6F	7C	8A	9A	10E	11B
Roukny et al. (2016).	1F.1H	2B	3A	4A	5C	6F	7C	8E	9D	10E	11A
Holland (2010).	1D,1I,1J	2B	3A	4B	5D	6F	7C	8A	9A	10E	11A
Goddard et al. (2009).	1I	2B	3A	4B	5D	6F	7C	8C	9A	10A	11B
Greenwood et al. (2017).	1I	2B	3C	4C	5C	6D	7B	8A	9A	10E	11A

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Artigo	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Sarin and Summers (2016).	1E,1I	2B	3C	4C	5A	6A	7A	8B	9C	10D	11B
Morris and Shin (2008).	1I	2B	3C	4C	5A	6B	7A	8A	9A	10D	11A
Leonard and Biswas (1998).	1B	2B	3B	4A	5A	6B	7A	8A	9A	10C	11A
Baker (2016).	1E	2A,2G	3C	4C	5A	6A	7A	8A	9A	10D	11B
Chen and Skoglund. (2014).	1J	2B	3A	4A	5B, 5C	6F	7C	8E	9D	10E	11A
Gong et al. (2018).	1D	2B	3B	4A	5A	6E	7A	8A	9A	10D	11A
Dewenter et al. (2018).	1B	2B	3B	4A	5A	6E	7A	8B	9A	10C	11B
Chami et al. (2018).	1B, 1I	2B	3C	4C	5A	6E	7A,7B	8A	9A	10A	11B
Barucci et al. (2018).	1H	2B	3B	4A	5A	6D	7B	8C	9A	10A	11B
Milonas (2018).	1J	2B	3B	4A	5A	6E	7A	8A	9A	10D	11B
Bharati and Jia (2018).	1J	2B	3B	4A	5A	6A	7A	8A	9A	10D	11B
Gornall and Strebulaev (2018).	1B,1J	2B,2G	3C	4A	5B	6D	7A	8E	9D	10E	11A
Adrian and Boyarchenko (2018).	1H, 1J	2B	3A	4A	5B,5C	6F	7C	8E	9D	10E	11A

Table 2.3: Articles in the sample.

The results found in relation to the components of each table presented in the methodology and respective coding are shown in what follows below. Considering the coding scheme proposed in Table 2.1, which addresses the object of study and focus, we can see from Table 2.4 that, considering only the microprudential approach, the Credit Risk / Distress Risk /Default Risk object was the object most encountered (48 articles or 30% of the sample). Given that the credit risk to which banks are subjected represents the greatest risk incurred by them, this result is somewhat expected, in accordance with the works of Poghosyan and Čihak (2011), Episcopos (2008), and DeAngelo and Stulz (2015),

who discussed the quality of the assets, regulatory limits, and debt issuance, respectively, as well as possible impacts on the credit risk of banking institutions.

Additionally, from the microprudential point of view, 22 articles in total were classified within the Moral Hazard object of study. For example, moral hazard with credit risk and also corporate governance were discussed in the works of Allen et al. (1996); Episcopos (2008); Harding et al. (2013); Inderst and Mueller (2008), and Mullineux (2011, 2014). The Business Model object of study is more strongly associated either with a macroprudential object of approach (Systemic Risk, 11 times), in works such as Blum (2008); Vallascas and Keasey (2012), or with a microprudential object (Credit Risk, 9 times), in works such as Aymanns et al. (2016); Tasca et al. (2014).

Considering the Capital Market object of study, which was found in 17 articles, it was associated with Financial Stability in 10 of the sample articles, in works such as Calomiris and Nissim (2014); Chan-Lau et al. (2015); Demirguc-Kunt et al. (2013), which assessed the behaviour of the stock value of the financial institutions before and during the last major financial depression.

Seven of the nine articles of Asymmetric Information object was found in the period after 2007 crisis, in works such as Dermine (2015); Plantin (2015), who studied imperfect information regarding banks' assets. It was also verified that only three articles had Bank Run as the object of study (Angeloni and Faia, 2013; Benhabib et al., 2016; Dermine, 2015), which can be regarded as an opportunity for future studies, given that the bank run - according to Diamond and Dybvig (1983) - is a common feature during a crisis.

The Financial Stability object of study was found to have the highest number of articles when considering only the macroprudential approach - 73 or 46% of the sample. This object is predominant in articles appearing after the financial crisis of 2007. It is interesting to note that in a joint analysis with other objects, the Financial Stability object was found in 24 articles in conjunction with the Systemic Risk object and in 21 articles in conjunction with the Credit Risk object - see Table 2.4. It can be said that this relationship is important, given that after the financial crisis of 2007, the concern with financial stability was discussed, mainly due to the contagion and consequent spread of systemic risk among large international banks, for example, in the studies of Beltratti and Stulz (2012) and López-Espinosa et al. (2012), which indicated that long-term debt deficits are a determining factor for the spread of systemic risk and the consequent fragile financial stability of large world banks. Furthermore, the discussion of financial stability with credit risk was addressed in the studies of Vazquez and Federico (2015) and Chernykh and Cole (2015), which dealt with the connection between default risk and financial stability.

Also from the macroprudential view, the Business Cycle object of study was found a higher number of times with the objects of study Financial Stability (15 times) and

Systemic Risk (11 times), which indicates the strong connection of the objects of study of this same approach. Except for the study of Saunders and Wilson (2001), for the other articles in the sample, the Business Cycle object of study became the target of study after the financial crisis of 2007, which indicates the concern of experts about placing the connection of the leverage with the real economy.

	Asymm. infor.	**Moral hazard**	**Bank run**	**Bus. model**	**Cap. market**	**Credit risk**	**Bus. cycle**	**Sys. risk**	**Financ. stab.**	**Others**
Asymm. infor.	9									
Moral hazard	2	22								
Bank run	1	1	3							
Business model	3	4	0	34						
Capital market	0	2	0	2	17					
Credit risk	1	6	1	9	2	48				
Business cycle	0	1	2	5	3	7	25			
Systemic risk	3	1	0	11	2	18	11	44		
Financ. stab.	1	6	1	8	10	21	15	24	73	
Others	5	6	1	7	0	11	3	13	17	48

Table 2.4: Connection of the objects of study.

The objects of study classified in the *Others* item - not directly explained in Table 2.1 - and their respective number of citations were as follows: Corporate Governance (twelve times); Liquidity (eleven times); Monetary Policy (eight times);, Agency Theory (seven times); Market Discipline and Monitoring or Supervision (six times each); Market Risk (four times); Banking Resolution and Trade-off Theory (twice each); and Regulation, Economic Policy, Safety Nets, and Behavioural Economics (once each). The object most cited in the *Others* category - Corporate Governance - was in line with the procedures promulgated by the Basel committee for good supervisory and regulatory practices, known as pillars two and three.

Also in relation to the results from Table 2.1 of the proposed coding scheme, with regard to the study's focus, most of the articles in the sample have *Banks* as the study's focus (125 of the 160 articles in the sample). Given that regulatory banking leverage has the banks as its main object, the result found was expected.

Regarding Table 2.2 of the proposed classification scheme, which addresses how banking leverage is being studied, the results of which are shown in Table 2.5 and Figures 2.2, 2.3, and 2.4, the categories of Theoretical and Empirical study types had 44% and 48% of the articles from the sample, respectively. The remainder (8%) used these categories together. Regarding the type of approach, 78% (125 articles) used a quantitative approach, with the following fitting into this category: empirical studies (coding C3-B and C3-C, representing 48% and 8% of the sample, respectively), theorists of mathematical methods (coding C5-C, representing 14%), and theorists of simulation methods (coding C5-B, representing 9%). Therefore, there is a possibility for future studies with a qualitative approach, as this approach represented only 16% (25 articles) of the sample. Regarding the methods used, 48% were of the Econometric / Statistical / Multivariate analysis type.

Classification	Number of articles	Proportion
C3 - A - Theoretical	70	44%
C3 - B - Empirical	76	48%
C3 - C - Both	14	9%
C5 - A - Econometric / Statistical	77	48%
C5 - B - Computational / Simulation	15	9%
C5 - C - Mathematical modelling	22	14%
C5 - D - Not applicable	26	16%
C5 - A e B	2	1%
C5 - A e C	5	3%
C5 - B e C	13	8%
C7 - A - Total assets/ Equity	73	46%
C7 - B - Tier 1 capital / Total exposure	13	8%
C7 - A e B	10	6%
C7 - C - Not applicable	64	40%
C8 - A - One country	75	47%
C8 - B - More than one country	13	8%
C8 - C - Region / bloc	17	11%
C8 - D - Global	8	5%
C8 - E - Not specified / Not applicable	47	29%
C10 - A - Up to 2 years	11	7%
C10 - B - From 2 to 5 years	13	8%
C10 - C - From 5 to 10 years	23	14%
C10 - D - More than 10 years	39	24%
C10 - E - Not applicable	74	46%
C11 - A - New perspectives	69	43%
C11 - B - Consistent with previous studies	91	57%

Table 2.5: Number of articles in accordance with the classification.

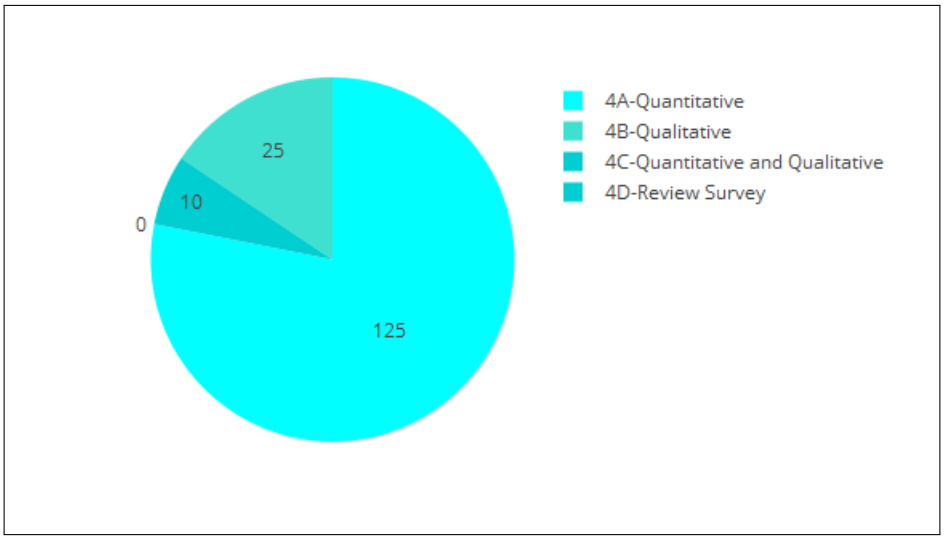

Figure 2.2: Type of approach.

Also in relation to Table 2.2 of the coding scheme, most of the analysed data are from various sources (36%, 58 articles), as seen in Figure 2.3. This result is feasible since, in empirical studies of financial system analysis, it is more likely that data are collected from various sources than just one location. When only one data source was used, market, balance sheet, and regulator data were chosen in the sample of articles. In relation to the results for the metrics used, according to Table 2.5, 46% of the articles in the sample used the traditional accounting metric (C7-A), which considers the assets and equity of the institutions, or variants very close to this metric. This result was expected because the regulatory leverage metric stipulated by the Basel committee was disclosed only in the year 2014.

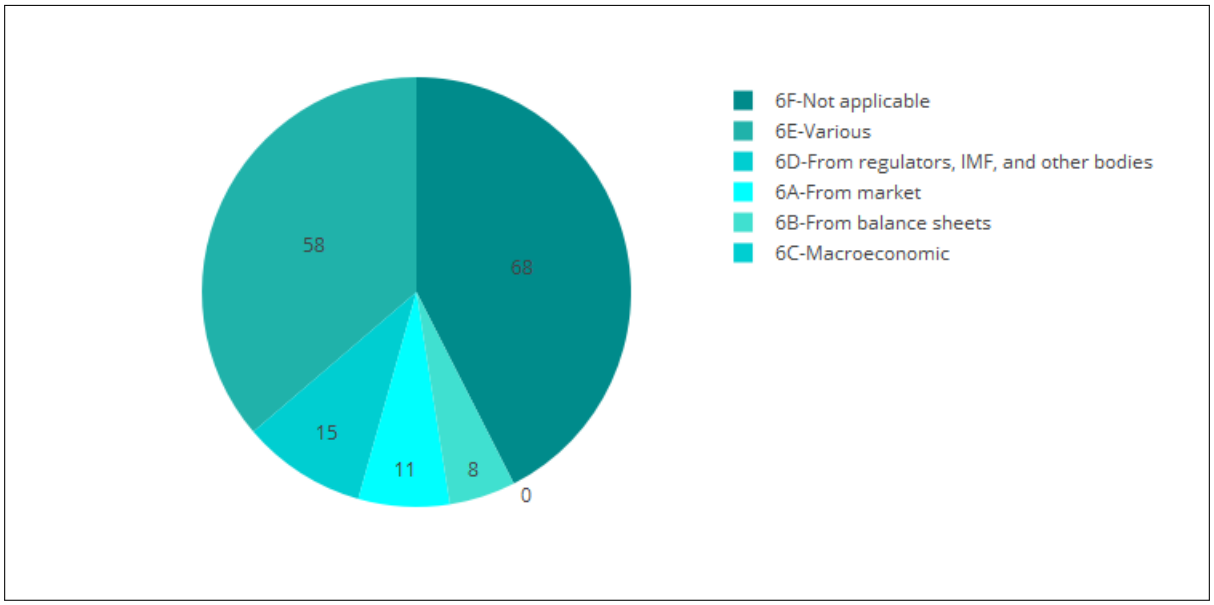

Figure 2.3: Type of data.

The results associated with Table 2.2 of the coding scheme indicated a gap for studies that involve emerging countries and address the topic of leverage - see Figure 2.4. Only 9 articles (6% of the sample) have emerging countries as the context - 92 studies (58% of the sample) performed were related to developed countries. In relation to the scope applied, according to Table 2.5, 47% of the studies apply to only one country - for example, the studies addressing the financial crisis that began in 2007 and related to the behaviour of American banks (Cathcart et al., 2015; Papanikolaou and Wolff, 2014) and Canadian banks Guidara et al. (2013).

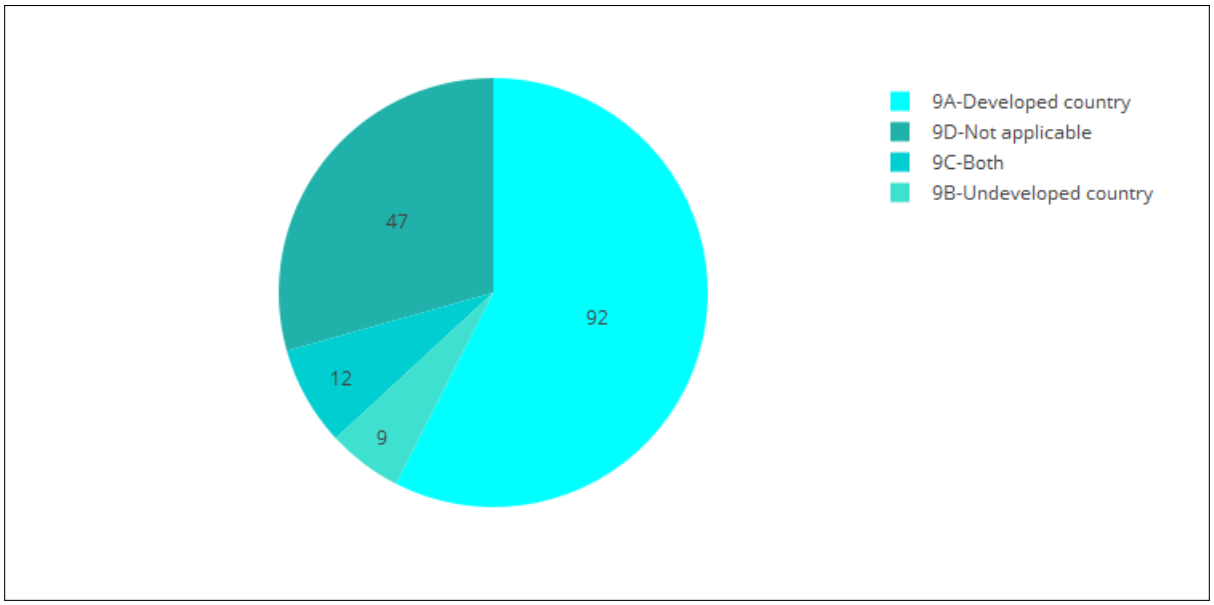

Figure 2.4: Context.

Regarding the C10-D coding from Table 2.5, the empirical articles with study periods longer than 10 years have the highest proportion in the sample, representing 24% of the total number of articles researched, which indicates a trend of longer-term empirical studies when addressing the topic of banking leverage. Studies with a macroprudential approach are predominant when a longer period of time is considered, for example, the studies by Papanikolaou and Wolff (2014), Poghosyan and Čihak (2011), Guidara et al. (2013), Weiß et al. (2014), Kishan and Opiela (2012), Calomiris and Nissim (2014), Black et al. (2016), and Calmès and Théoret (2013).

Regarding the *Results* item of the coding scheme in Table 2.5, it was found that 57% of the articles surveyed are consistent with results previously presented in the literature (C11-A) and approximately 43% present new perspectives in relation to previous results in the literature (C11-B), which shows that the subject of banking leverage provides a significant share of new approaches and an addition to existing theory. For example, the study by Papanikolaou and Wolff (2014) paid particular attention to the deleveraging process of banking institutions after the 2007 crisis, and the study of Dermine (2015) revealed new ideas by studying the leverage limit as an argument to reduce the risk of bank runs, given the asymmetric information about the values of bank assets.

2.1 Meta-analysis and network analysis

According to Wolf (1986, p. 10), the procedures used in data meta-analysis enable quantitative reviews and standardized summaries of academic research, which aim to establish guidelines for reliable and valid reviews.

Citation analysis has become an important indicator for assessing the impact of scholarly works (Garfield, 1983, p. 355). From bibliometric analysis, one can identify the most influential articles on a topic and obtain the links between articles that explore a certain topic.

The results of bibliometric analysis are useful not only to measure the popularity and influence of articles but also to identify key authors and their publications. According to van Raan (2003, p. 20-21), bibliometric analysis is based on the premise that authors publish their most important results in cutting-edge journals, and the application of citation analysis is, in many situations, a strong indicator of scientific performance.

Among the various types of bibliometric analysis, the study of networks is an important method for extracting relevant information about a particular topic. There are various forms of network evaluation involving different objects of study discussed in the literature on a particular topic. For Small (1973, p. 265), co-citation analysis and the identification of clusters of co-cited papers highlight a new way of studying specialties in science. Morris

et al. (2003, p. 413) established that the analysis of research fronts is done based on a large number of articles that reference fundamental articles, regardless of the time of the research.

The concept of network analysis has received attention lately due to the development of new forms of scientific collaboration provided by recent technological innovation. For the elaboration of network analysis, Zupic and Čater (2015, p. 436) proposed a flow of intellectual mapping composed of five stages, as follows: elaboration of the study, data collection, data analysis, data visualization, and interpretation.

In the *Elaboration of the Study* stage, the research question and the bibliometric methods to answer the proposed question are defined. According to Zupic and Čater (2015, p. 440), one of the main decisions made in scientific mapping is to limit the study scope. In an attempt to address this issue, the authors suggested the two following options: carefully selecting the keywords searched and limiting the scope to articles published in one or a small number of journals.

According to Aria and Cuccurullo (2017, p. 960), *Data Collection* is divided into three sub-stages. The first sub-stage involves obtaining the data. There are various online bibliographic databases, such as Web of Science, Scopus, Google Scholar, and Science Direct; however, they do not cover scientific fields and journals in the same way. Thus, each researcher must identify the most suitable database for their research. According toAria and Cuccurullo (2017, p. 961), the second sub-stage involves loading and converting the data into a format that is friendly to the bibliometric tools being used. The final sub-stage is data cleaning, in which the quality of the results depends on the quality of the data. Various reprocessing methods can be used, for example, detection of duplicate elements and misspellings. According to the authors, although most databases are reliable, cited references may contain multiple versions of the same publication and different spellings of an author's name. Additionally, cited journals may appear in many different ways and books may have different editions.

The *Data Analysis* phase begins with pre-processing, in which, to achieve better results, the data must be *clean* (Zupic and Čater, 2015, p. 442). This phase encompasses the descriptive analysis and identification of networks. According to Aria and Cuccurullo (2017), different approaches have been developed to identify networks using different units of analysis, as shown in Table 2.6.

Taxonomy of the bibliometric technique	**Unit of analysis used**	**Type of relationship**
Bibliographic coupling	Author	Common references in the authors' works
	Document	Common references in the documents
	Journal	Common references in the papers of the journals
Co-citation	Author	Co-cited authors
	Reference	Co-cited references
	Journal	Co-cited journals
Co-author	Author	Co-occurrence of authors in the author's list of a document
	Country per affiliation	Co-occurrence of countries in the address list of a document
	Institution per affiliation	Co-occurrence of institutions in the address list of a document
Co-word	Keyword, or term extracted from the title, abstract, or body of the document	Co-occurrence of terms in a document

Source: Aria and Cuccurullo (2017)

Table 2.6: Usual bibliometric techniques according to the unit of analysis.

According to Aria and Cuccurullo (2017, p. 961), the most common form of data analysis is citation analysis, which uses citation counting as a measure of similarity between documents, authors, and journals. Citation analysis can be divided into bibliographic coupling and co-citation. Bibliographic coupling was proposed by Kessler (1963), who verified that the greater the similarity between the content of the articles studied, the greater the similarity of the reference literature, which can be obtained by the general formula, as follows:

$$B_{coup} = AA^t \tag{2.1}$$

in which A is a document x cited reference matrix. Each element b_{ij} indicates how

many bibliographic couplings exist between documents i and j. The intensity of the bibliographic coupling between two articles i and j is defined simply by the number of references that the articles have in common.

The co-citation technique - proposed by Small (1973) – aims to analyse the basic articles and pioneers in a specific field of scientific research. According to Aria and Cuccurullo (2017, p. 961), bibliographic coupling is based on the documents searched and is used to map current research fronts. A co-citation study analyses the documents cited through the documents searched. According to the authors, a co-citation between two articles occurs when both are cited in a third article. A co-citation network can be obtained by general formula 2.1; however, in this case, element B_{ij} indicates how many co-citations exist between documents i and j.

According to Zupic and Čater (2015, p. 446), another taxonomy of the bibliometric technique, i.e., the co-author analysis, is used to identify the structure of scientific networks established in the collaborations of authors and their affiliations. In turn, co-word analysis is based on the most important words in the documents. According to Aria and Cuccurullo (2017, p. 961), co-word analysis facilitates the understanding of the cognitive structure by mapping and creating clusters of the terms extracted from the keywords, titles, or abstracts. A co-word network can be obtained by the general formula described in Equation 2.1, in which A is a document x word matrix.

According to Aria and Cuccurullo (2017, p. 961), once data analysis is constructed and the network of connections is established, a normalization process (e.g., Jaccard coefficient or Pearson correlation) can be performed. Additionally, the use of a data reduction technique is appropriate for identifying niches, such as the use of clustering algorithms.

For Zupic and Čater (2015, p. 446), the Data Visualization phase is the first stage of mapping a scientific field. According to the authors, network analysis results in visualizations of scientific fields in which the nodes show the units of analysis (documents, authors, etc.) and the ties signify the similarity between the connections.

Finally, the Interpretation of the Data - the last stage of the flow of intellectual mapping proposed by Zupic and Čater (2015) – has as a premise the need for the author to expand upon the theme to better interpret the results.

Thus, in this present study, the data collection for the network analysis followed the proposition via the Scopus database with 160 articles in the final sample.

For the data analysis in this article, two taxonomies of bibliometric techniques were used. The first is the co-citation by author taxonomy, which has the objective of analysing the basic articles on the topic of banking leverage, in accordance with Small (1973). Zamore et al. (2018) used the co-citation technique for bibliographic review and credit

risk agenda. Second, the co-word by keyword taxonomy was used to understand the cognitive structure of leverage, in accordance with Aria and Cuccurullo (2017, p. 961). The Bibliometrix package of the R software - developed by Aria and Cuccurullo (2017) and which supports a bibliometric analysis process compatible with that proposed by Zupic and Čater (2015) - was used as an automated tool for the analysis. Thus, the knowledge base as well as possible inflections in the field of scientific research were explored. In the case of banking leverage, these estimates are important for evaluating the intellectual structure of the literature on the topic.

For visualization and interpretation of the results found, the VosViewer software - which is useful for graphically constructing bibliometric maps - was used van Eck and Waltman (2010). It uses the Visualization of Similarities (VOS) mapping technique to generate views based on the distances from bibliometric networks. For the formation of clusters in the VosViewer program, the Pajek package was used (Mrvar and Batagelj, 2016).

Aiming to reinforce the results presented above from the bibliometric review, the technique of analysis through co-citation networks was also used for the 160 articles of the sample. For the analysis of co-citations, the main 60 references cited were selected to perform a content analysis of these articles. References related to the normative publications of regulatory agencies were excluded to restrict the sample to only include articles.

According to Small (2004), this technique measures the frequency with which two articles are cited simultaneously in a third article. The networks are represented by circles, in which each item represents an author, and the size is linked to the number of times the article participated in a co-citation, which demonstrates the strength of the links or the connectivity of the author. The lines represent the co-citations themselves.

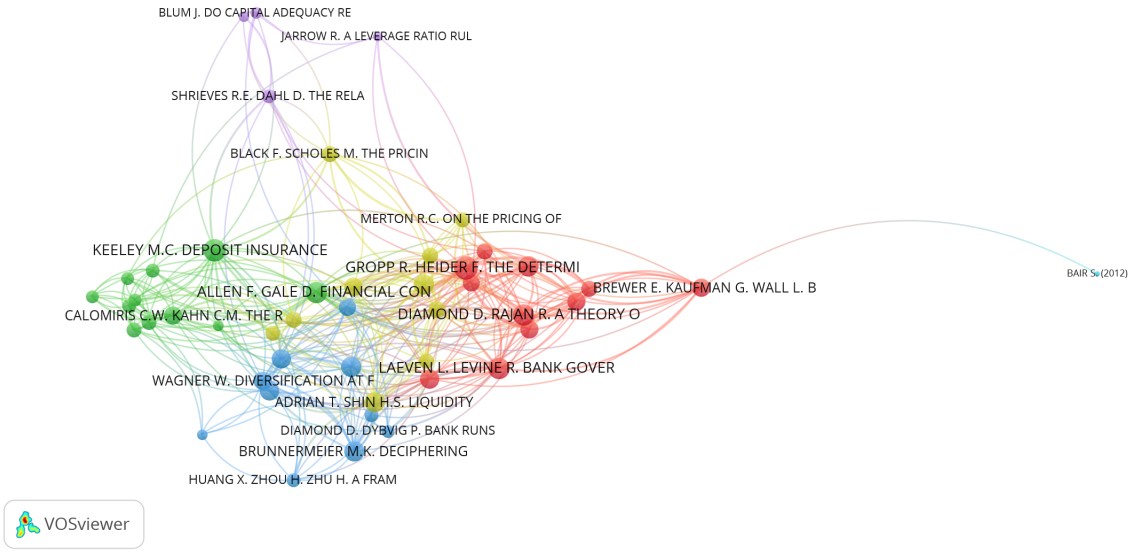

Figure 2.5: Co-citation Network.

Figure 2.5 is the result of the co-citation network of the articles used in the bibliometric review, and the creation of the five main clusters can be seen in it. The purple cluster includes the works of Blum (1999); Calem and Rob (1999); Jarrow (2013); Shrieves and Dahl (1992), who addressed the link between risk and banking capital.

In the yellow cluster, the works of Adrian and Shin (2010); Brunnermeier and Pedersen (2009); Kiyotaki and Moore (1997) are the ones with the greatest link strength (above 20) - they dealt with credit cycles, liquidity and the relationship with leverage. In the blue cluster, the authors Brunnermeier (2009); Demsetz and Strahan (1997); DeYoung and Roland (2001); Diamond (1984); Wagner (2010) also had link strengths above 20, and they addressed the theory of financial intermediation, more specifically, the monitoring and business model of banking institutions, with the risk incurred by these institutions. The most recent publications in this cluster also address liquidity, credit bubbles, and systemic risk.

The green cluster includes the authors Allen and Gale (2000); Calomiris and Kahn (1991); Keeley (1990), who had the greatest link strength (also above 20) and essentially addressed moral hazard, default risk, and contagion in the financial system. The red cluster has as its exponent the study of Gropp and Heider (2010), which analysed the determinants of the banking capital structure, considering elements of the classical theory of finance in the activity of financial intermediation. Thus, by analysing the network of co-citations and the construction of clusters, it can be seen that the theoretical framework used in the bibliometric revision uses more recent citations regarding the financial crisis of 2007, as well as classic financial theory.

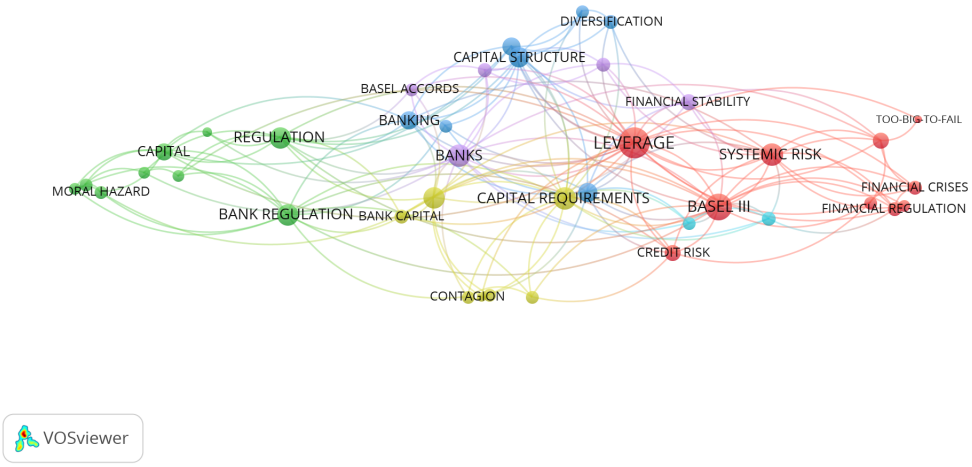

Figure 2.6: Co-word Network.

For the co-word analysis, using the keywords mentioned by the authors in the Scopus database, 40 main keyword connections were selected in the sample of articles.

Through the clusters formed, it could be seen that the keywords bank, capital, regulation, and Basel, and their variations, permeate the six clusters found, which was expected because they are basic words for the study of leverage, and, according to Galati and Moessner (2011), the main target of the Basel 3 proposals was the banking sector. Thus, the finding of these key terms in the articles of the sample is consistent with the concerns of the banking sector's regulating agencies.

In addition to these key terms, the most found words and their corresponding number of links are as follows: systemic risk (14), financial crisis (13), and liquidity (10).

In the red cluster, the evaluation of leverage in the macroprudential context is highlighted, which is associated with the systemic risk and credit risk objects of study. This association can be found in the studies by Vallascas and Keasey (2012) and Patro et al. (2013). This cluster shows the concern of the articles studied regarding the financial policies adopted by countries and regulatory bodies , which is the focus of the Basel 3 accord (BIS, 2010). In the green cluster, the regulation of capital structure and risk is represented by the study of objects related to moral hazard, deposit insurance, and corporate governance in studies such as those by Mullineux (2011, 2014). In the blue cluster, keywords that represent variations of the term banking are found, which are associated with capital structure and banking regulation (Basel) and also the terms diversification and liquidity. The studies of Allahrakha et al. (2018); Chen and Skoglund. (2014) are examples of articles in this cluster that are in line with the concerns of the regulatory

agencies about the ability of financial institutions to honour their deposits and funding, both in the short and long term, as advocated by BIS (2010).

In relation to the yellow cluster, the financial crisis and the corresponding capital requirements - including the Leverage Ratio - are associated with the contagion and market discipline objects of study in studies such as those by Acharya and Thakor (2016); Poghosyan and Čihak (2011). These works support the notion that both depositors and market participants play an important role in financial stability. In the purple cluster, the Basel accords and capital regulation are associated with the activity of financial intermediation and financial stability, in accordance with the study of Cabral (2013). Finally, the light blue cluster covers the keywords Basel II and private equity, which can be seen in the work of Arayssi (2016), which addresses the effect that private investment has on bank capital requirements.

2.2 Brief report on prudential banking regulation and leverage

Capital limits were originally dealt with in the first Basel Accord, *Basel I*, released in 1988. A new capital accord, known as *Basel II*, was published in 2004. A broad stream of literature on the the first Basel accords, taking into account financial stability, banking policy and impacts on the industry and economy, is extensively discussed (Andersen, 2011; Ayadi et al., 2016; Aymanns et al., 2016; Barakova and Palvia, 2014; Demirguc-Kunt and Detragiache, 2011; Hakenes and Schnabel, 2011; Herring, 2004; Rossignolo et al., 2012; Schmaltz et al., 2014). For more information on the *Basel I* and *Basel II*, Balin (2008) performed a descriptive analysis of both accords.

With the advent of the subprime market crisis in 2007, the Financial Stability Board (*FSB*) and the *G20* proposed a set of measures aimed at protecting the banking system against financial crises. These negotiations contributed greatly to the broader reform that culminated in the most recent capital accord named *Basel III* BIS (2010), which involves greater concern for the quality of the banks' capital, among other measures. In this new context, where liquidity plays a major role in financial crisis, various studies discusses different facets of *Basel III* (Dermine, 2015; Fidrmuc and Lind, 2018; Hessou and Lai, 2017; Hong et al., 2014; King, 2013; Petrella and Resti, 2017; Rubio and Carrasco-Gallego, 2016). Herring (2018) discusses the growing complexity in financial regulation, including an analysis of *Basel III*.

Most countries have gone through a process of disintermediation, that is, a large part of financial intermediation is taking the form of negotiable securities, rather than loans and bank deposits (Hausler, 2002). Due to regulatory incentives and capital requirements,

as well as the possibility of greater returns to shareholders and greater competitiveness, banks have moved financial risks, especially credit risk, from their balance sheets into the securities market. According Dubecq et al. (2015, p. 72), intermediaries use off-balance sheet conduits to adjust the level of capital. Those movements are related to shadow banking procedures (Pozsar et al., 2010).

One of the topics in this new accord relates to the excessive leverage of financial institutions. According to Demirguc-Kunt et al. (2013), many banks were apparently in compliance with the minimum regulatory capital both before and after the crisis; however, they did not actually have enough capital to absorb the unexpected losses.

Thus, the *Basel III* recommendations require that the Leverage Ratio and risk-based capital requirements function together (Brei and Gambacorta, 2016, p. 360). According to the authors, on the one hand, it is important to have risk-sensitive capital requirements because the charges for capital are higher for exposure to low probability of payment, and lower when the probability of payment of an asset is higher.

On the other hand, given that any estimate of the probability of loss depends on the assumptions of the underlying model, which may be wrong and lead to the sub-estimation of the associated risks, it is important to have a Leverage Ratio restriction that is independent of such risk assessments (Miele and Sales, 2011, p.293).

In particular, risk-based capital requirements refer to the banking institutions' potential loss, while the Leverage Ratio indicates the maximum loss that can be covered by the capital (Brei and Gambacorta, 2016, p. 360).

For this reason, BIS (2010) recommended the establishment of new operational limits to be followed by financial institutions, which meant additional requirements for global banks. BIS (2014) officialised the introduction of the new Leverage Ratio (LR) indicator.

2.3 Measuring regulatory banking leverage

BIS (2014) established a supplementary instrument to the capital requirements based on risk weighting by adopting a leverage cap in conjunction with the recently revised operational capital limits in BIS (2010). According to the agency, the LR leads to greater resilience for the banks and the financial system because such a restriction acts as a second layer of protection against possible errors in the measurement of the risks of financial intermediation operations. Additionally, imposing limits on banks' leveraging can reduce possible excess credit supply, thus reducing potential cyclical effects on the banks' capital requirements. The guideline of the said agency is that the leverage measure adopted by the national jurisdictions be simple, transparent, and easy to determine.

According to Gabbi et al. (2015, p. 118), one of the impacts of this new approach is that it broadens the definition of what constitutes leverage of a banking institution. Thus, it should lead to banks acting noticeably to increase their capital or to reduce their intermediation activity.

The Leverage Ratio (LR) is defined as the fraction of Tier 1 and Total Exposure, where Tier 1 corresponds to the sum of the Core Capital and the Additional Tier 1 Capital, whose portions are explicitly defined in the BIS (2010) document. In turn, according to BIS (2014), Total Exposure means the exposures recorded in the balance sheet added to the following items with specific treatment: exposure to derivatives, exposure to transferable securities, and items not recorded on the balance sheet.

2.4 Connection of regulatory banking leverage with objects of study from the literature on finance and economics

Main object of associated study	**Examples of important studies**
Moral hazard	Gjerde and Semmen (1995).
	Gueyie and Lai (2003).
	Blum (2008).
Asymmetric information	Morgan (2002).
	Blum (2008).
Bank run	Angeloni and Faia (2013).
Business model	Carey et al. (1998).
	Holland (2010).
	Kane (2012).
	Vallascas and Keasey (2012).
Credit risk	Blum (2008).
	Episcopos (2008).
	Poghosyan and Čihak (2011).
	Vallascas and Keasey (2012).
	Lee and Chih (2013).
	Patro et al. (2013).
	Vazquez and Federico (2015).
Business cycle	Kalemli-Ozcan et al. (2012).
	Angeloni and Faia (2013).
	Guidara et al. (2013).

Continued on the next page.

Main object of associated study	Examples of important studies
	Poledna et al. (2014).
Capital market	Saunders and Wilson (2001).
	Evanoff and Wall (2001).
	Beltratti and Stulz (2012).
	Demirguc-Kunt et al. (2013).
	Calomiris and Nissim (2014).
Systemic risk	López-Espinosa et al. (2012).
	Vallascas and Keasey (2012).
	Patro et al. (2013).
	Weiß et al. (2014).
	Black et al. (2016).
Financial stability	Morris and Shin (2008).
	Goddard et al. (2009).
	Holland (2010).
	Clarke (2010).
	Kane (2012).
	Patro et al. (2013).
	Vazquez and Federico (2015).
Others	Hughes et al. (1999).
	McAleer (2009).
	John et al. (2010).
	Clarke (2010).
	Braun and Raddatz (2010).
	Holland (2010).
	Kane (2012).
	Kishan and Opiela (2012).
	Angeloni and Faia (2013).
	Riccetti et al. (2013).
	DeAngelo and Stulz (2015).

Table 2.7: Objects of study table.

Table 2.7 shows the studies described in this section, with more than 15 citations on the date of the last study done in the sample, contemplating the objects of studies associated with banking leverage.

The association between **asymmetric information, moral hazard**, and capital ratios that limit the banks' leverage was done in important studies in the 1990s and 2000s, before the financial crisis of 2007.

Gjerde and Semmen (1995) analysed the effectiveness of risk-based capital indicators when bank deposits are fully insured, and the results showed that, when diverted from the optimal weightings of risk, a combination of leverage restriction and a risk-based capital indicator appears to be a more suitable approach.

In the case of official deposit insurance in Canada, Gueyie and Lai (2003, p. 249) found no evidence of moral hazard in the banking industry after the introduction of deposit insurance in this country. The authors found that the total capital risk, market risk, and implied volatility of bank assets increased. However, these conditions are necessary, but not sufficient, to complete the change in behaviour of banks in the midst of the implementation of deposit insurance.

Blum (2008, p. 1700) found that without capital regulation, banks have an incentive to inefficiently incur high risks, both in the presence of deposit insurance not properly priced and in externalities that result in banking collapses. However, as risk is not directly observable, due to privacy and unobservable information from the banks, capital requirements cannot precisely control the level of risk to which banks are exposed.

Morgan (2002, p. 874) associated asymmetric information in relation to the opacity about the information available from the banks, indicating the disagreement in certain evaluations of the American rating agencies and emphasizing that the uncertainty about the banks comes from their assets, loans, and securities in particular, which are risks that are difficult to observe and change. In addition to the uncertainty about their assets, the leverage of the banks can also result in problems of agency.

Regarding bank runs, Angeloni and Faia (2013) constructed a macroeconomic model to study the transmission of monetary policy and the relationship with capital, and they indicated that risk-based capital indicators are bad for financial well-being.

Regarding the Business model object of study and its relationship with leverage, Carey et al. (1998) highlighted the specialization in the North American corporate credit market by comparing corporate lending by banks and other financial institutions. The results showed that financial institutions tend to lend to riskier companies, particularly those that are more leveraged.

Holland (2010) reviewed the literature on business models and compared the cases of bankrupt and non-bankrupt banks and found evidence that the lack of basic knowledge about the risks and values of the banking business by managers and the administration of the institutions in the failed banks had an effect on the recent banking crisis.

Kane (2012) studied the tax benefits received by financial institutions in the safety net contracts in the United States and concluded that a key factor in achieving robust financial reform is to develop an effective statistical metric for measuring the ex-ante value of the support given, both in aggregate form and by individual institution.

Increased risk-taking by banks can lead to financial problems for these institutions - the so-called financial distress - or even to banking collapse. Without a capital requirement appropriately chosen by the regulation, banks can increase risk-taking and also increase the likelihood of collapse (Blum, 2008, p. 1700).

To encourage banks to reliably report their risks, Blum (2008, p. 1700) proposed a banking leverage model that combines two types of situations, as follows: banks' risks are ex ante private information, but the regulator can discover the risk incurred ex post. An optimal combination of capital requirements is, therefore, formed by the following two bits of information: the information made available by the banks and the information measured by a leverage constraint independent of the risk assessment.

Additionally, in the context of the likelihood of a banking collapse, the relationship of this issue and prudential regulation of capital was seen in the work of Episcopos (2008). The author used barrier options to study contingency claims. According to the author, barrier options are similar to the standardized options for buying and selling stocks; however, they start or stop when the value of the underlying asset reaches a predetermined level before the date for exercising the option. The regulator or the administrator of the bank deposit insurance has an option over the assets of the banks, which can be counterbalanced with the expectation of coverage costs (Episcopos, 2008, p. 1677). The results found showed that regulatory barriers are priced into the stock market and are inversely proportional to the leverage indicator.

Poghosyan and Čihak (2011, p. 163) analysed the determinants of problematic banking situations in Europe, and the results showed that leverage is an important determinant of the risk situations of banks as well as the asset quality and profitability profile. Additionally, Lee and Chih (2013) examine whether Chinese banks have met standard regulations and analysis how previous regulations have impacted bank risk.

To reduce the possibility of a banking collapse, Vallascas and Keasey (2012) suggest the adoption of a ceiling in the absolute size of a bank, which would be an effective measure and complement the measures of liquidity and leverage. The authors also suggested adopting portions of non-interest revenue (service revenue) and the growth of assets, which are important indicators in regulatory actions disclosed by the Basel Committee.

Vazquez and Federico (2015, p. 1) analyze the evolution of banks' financing structures in the course of the global financial crisis, as well as the implications for financial stability. According to the authors, the emphasis of *Basel III* should be on the leverage of the banks, particularly for systematically important institutions.

It should be noted that, besides the determinants of the performance profile of the banks already cited (e.g., profitability, quality, size, and growth of assets), institutions are affected by the economic context they are subjected to – these external determinants are

analysed in important studies related to the leverage of banking institutions.

In a study conducted with data before and after the 2007 crisis, Kalemli-Ozcan et al. (2012) found evidence of the pro-cyclicity of leverage for large commercial banks and investment banks in the United States. The study also covered emerging market countries, and the results showed that tighter banking regulations may have contributed to less deleveraging during the crisis of 2007. According to these authors, excessive risk-taking before the crisis was related to the quality, not quantity, of the assets.

Angeloni and Faia (2013, p. 311) studied the connection between monetary policy and capital regulation, and the results showed that a monetary expansion and a positive productivity shock increase the risk and leverage of the banks. According to the authors, risk-based capital requirements amplify the economic cycle. Thus, within simple prudential rules, the best combination includes anti-cyclical capital ratios and a response to monetary policy for asset prices or for leveraging of the banks.

Guidara et al. (2013, p. 3374) found countercyclical effects between the capital buffer of six large Canadian banks and the business cycle, with a larger capital buffer in economic expansions than in recessions, which can be explained – among others results – by the Canadian experience of implementing both the risk-based capital requirement and the non-risk-based capital requirement (Leverage Ratio).

Poledna et al. (2014) considered the leverage cycle to be a process that is dependent on investor heterogeneity. The authors used three regulatory credit policies, as follows: the case of non-regulation, the Basel II accord, and a hypothetical alternative using options to hedge risk operations. When compared to the unregulated case, both the Basel II accord and the perfect hedge policy reduce the risk of default when the leverage is low, but increase the risk when the leverage is high. This is because both regulatory policies increase the level of buying and selling of assets necessary to achieve deleveraging, which may destabilize the market (Poledna et al., 2014, p. 199).

The relationship between **capital markets** and leverage was considered in important studies conducted by Beltratti and Stulz (2012); Calomiris and Nissim (2014); Demirguc-Kunt et al. (2013); Evanoff and Wall (2001); Saunders and Wilson (2001), which compared the behaviour of instruments issued by banks (stocks or subordinated debt) and the level of capital held by these institutions, especially in crisis situations.

Saunders and Wilson (2001, p. 185) mention self-regulatory incentives generated by valuable bank charters to constrain their risk taking and presents evidence that charter value itself may emerge from high-risk intermediation. During economic expansions, bank charter values rise to reflect growth opportunities and banks gain easier access to equity capital sources. However, the relationship may invert during economic contractions, demonstrating that the charter value and bank leverage relationship is sensitive to

market conditions.

Evanoff and Wall (2001, p. 121) performed an empirical analysis of the effectiveness of some capital ratios as well as subordinated debt spreads to predict the economic conditions of banks. The results showed that some capital ratios have no predictive power. However, the leverage ratio performs much like the sound predictive power of the spreads of subordinated debts.

Beltratti and Stulz (2012, p. 1) used the significant variations in the share returns of major world banks during the period from July 2007 to December 2008 to evaluate the poor performance of these banks' shares during this period. Among other results, they found that the banks with better performance had lower leverage and lower returns just before the crisis.

Demirguc-Kunt et al. (2013, p. 1147) studied the situations in which the best capitalized banks obtained higher stock returns during the financial crisis. The authors distinguished various types of capital ratios, as follows: risk-based capital ratio, leverage indicator, level 1 and level 2 capital ratios, and the tangible capital ratio. Among the results found, before the crisis, the difference between capital ratios did not have much impact on stock returns. During the crisis, a stronger capital position was associated with better stock market performance, especially for large banks. The strongest capital position was notably better when using the leverage indicator rather than the risk-based capital indicator.

Calomiris and Nissim (2014) studied changes in the market indicators of US banks during the financial crisis, and the results showed that the declines in intangible assets coupled with unrecognized contingent liabilities may explain the extent and persistence of the decline of market indicators and indicators of equity value.

In the context of the financial crisis of 2007, the subject of **systemic risk** became very important, especially after the aid given to the financial institutions that were systematically important at that time, which caused an increased expenditure of public resources - especially in developed countries - to avoid the collapse of large institutions and the consequent spread to the entire financial system.

Using the $CoVaR$ approach to identify the determining factors of systemic risk, López-Espinosa et al. (2012, p. 3150) did not find strong evidence that either size or leverage contributes to increasing systemic risk in the context of internationally active banks.

Patro et al. (2013) presented a systemic risk indicator based on the correlation of the return on stocks of financial institutions. They indicated that the increase in systemic risk is highly influenced by the increase in the correlation between the idiosyncratic risks of the banks, which tend to predict or coincide with important economic events such as the crisis of 2007.

Similarly, Weiß et al. (2014, p. 78) found no empirical evidence that bank size, leverage, non-interest revenue, or bank asset quality are persevering determinants of systemic risk in financial crises. The results show that global systemic risk is predominantly guided by the characteristics of the regulatory regime.

Black et al. (2016, p. 107) calculated a distress insurance premium to determine the systemic risks of European banks. This measure includes characteristics of the banks, such as size, likelihood of default, and correlation. The results showed that the risk of default on sovereign securities has a strong influence on systemic risk and that the specific indicators of the banks (e.g., leverage) predict the systemic risk a year ahead.

In the context of the financial crisis of 2007, to verify the **stability of the financial system**, Morris and Shin (2008, p. 229) presented the idea of a leverage constraint, not from the traditional viewpoint of a buffer against the loss of assets, but as a result of the stabilization of the institutions' liabilities in a highly connected financial system.

Goddard et al. (2009) analysed the government measures taken in western Europe to address problem banks during the crisis, and, under the new regulatory framework, banks in the region should be less leveraged.

Clarke (2010) determined that the recent financial crisis called for a detailed analysis of how some financial institutions had taken such high risks and how risk management, governance, and the ethical environment allowed such risky situations for the institutions.

Furthermore, the relationship between leverage and other banking issues can be mentioned. Hughes et al. (1999, p. 292) studied the **banking consolidation and mergers** of US banks and found evidence that the economic benefits of the consolidation are greater for those banks engaged in inter-state expansion and, in particular, that which diversifies the macroeconomic risks of the banks.

McAleer (2009, p. 831) studied the monitoring of market risk from the perspective of the Basel II accord and found evidence that it encourages excessive risk-taking, due to the high costs of accurate measures and risk projections.

Studies like the one by John et al. (2010, p. 383) examine **CEO compensation** and the existence of two types of problems of agency, as follows: the classic owner-manager agency problem and the problem of the change in risk between shareholders and creditors. The results show that the sensitivity regarding the payment for CEO performance decreases with the increase in the leverage indicator.

Braun and Raddatz (2010, p. 234) analysed when former politicians become directors of banks, and they found that, at a micro level, banks that are politically connected are larger and more profitable than other banks, despite being less leveraged.

Kishan and Opiela (2012, p. 573) analyze a monetary policy channel through the risk pricing of bank debt in the market for jumbo certificates of deposit and the results show

that contractionary policy boosts the sensitivity of jumbo-CD spreads to leverage and asset risk for small banks, and to leverage for large banks.

Using the **classic capital structure classification** between pecking order theory and trade-off theory, Riccetti et al. (2013) used the dynamic trade-off theory to model the leverage and financial structure of firms and the possible impact, in the case of default, on the financial and equity situation of banks, as well as the impact on the stability of the financial system, also covering the systemic risk and monetary policy of central banks. Among other things, the results showed that if the leverage increases, the economy becomes riskier, with a higher pro-cyclical leverage having a destabilizing effect that could weaken the effect of the monetary policy.

Also resorting to the classical capital structure, from the perspective of Modigliani and Miller (1958) and Diamond and Dybvig (1983), DeAngelo and Stulz (2015) explained that high leverage is optimal for banks using a model that has enough friction to explain a significant role in the production of liquidity claims. The model used has a market premium for secured/net debt. Due to secured debt leading to a liquidity premium, risk management plays an important role in the capital structure and leverage of the banks.

Chapter 3

Measuring Bank Leverage and its Impact on Risk for Financial Institutions

The banking system plays a fundamental role in the world economy. Any imbalance in financial institutions can cause unprecedented systemic risk, as was witnessed by the financial crisis of 2007.

One of the causes of this world crisis, as pointed out by the Basel Committee, was the excessive leverage of financial institutions. According to Demirguc-Kunt et al. (2013), before and after the crisis many banks apparently were in compliance with the minimum capital requirements. However, considering the real scenario of the crisis, it was observed that these banks did not have sufficient capital to absorb their unexpected losses, especially due to the adoption of new forms of financial intermediation adopted in the years prior to the crisis such as, for example, the securitization of credit portfolios and derivative transactions which made it difficult to identify the true leverage of the banking system.

Thus, mechanisms that limit the excessive degree of leverage of these institutions should be adopted as part of banking regulations as suggested by (Dermine, 2015; Jarrow, 2013; Keeley, 1990; Wang, 2013). On the other hand, according to Papanikolaou and Wolff (2014), a great reduction in the leverage of banks would be detrimental to the prices of the system's financial assets, given the smaller offer of financial resources.

In order to establish more appropriate capital requirements for banks, the capital agreement defined in BIS (2010), known as *Basel III*, stipulated new demands announced in 2014 including the introduction of a capital indicator known as the Leverage Ratio (LR).

According to the Basel guidelines, the Leverage Ratio is given by the fraction of Tier I Capital over Total Exposure. *Tier I* Capital corresponds to the sum of Common Equity

Tier 1 and Additional Tier 1 Capital, whose composition is defined explicitly in Brazil by the Central Bank (Banco Central do Brasil, 2013). *Total Exposure*, on the other hand, measures the on-balance sheet exposure as well as the off-balance sheet exposure of banks which, for example, includes various forms of guarantees (Banco Central do Brasil, 2014).

The *LR* is a simple metric that also contemplates traditional risk indicators such as the Basel Index *(*BI).

The dominant vision of the literature is that the structure of banking capital is different from the traditional structure of firms. Banks use their liabilities to obtain resources and make loans and other intermediation operations. Debt is part of banking. In this manner, banks are extremely leveraged when compared to non-financial firms. According to Matthews and Thompson (2005), the leverage of traditional firms is roughly 0.6 times their equity while banks typically operate with a leverage of 9.0 times their equity.

According to Ayuso et al. (2004), the decision-making model that banks adopt in relation to capital is the result of a trade-off between three different types of costs related to capital levels. First of all, there are the costs of remuneration, which are probably more expensive than the costs of a bank's alternative liabilities, such as deposits or debts, as argued by Campbell (1979) and Myers and Majluf (1984).

Secondly, there are costs of adjustment which are due to changes in the levels of capital and which are related to asymmetry of information problems in the capital markets. Since those who make an initial stock offering have an informational advantage as opposed to potential buyers, a stock offering or stock buyback can be viewed as a signal that the company considers the market price to be out of keeping with the stock's true value, which will increase the pertinent adjustments (Ayuso et al., 2004).

Finally, there are the costs of bankruptcy, which include the loss of market value, reputational risk and legal costs in the bankruptcy process (Acharya, 1996). In addition to these costs are those related to capital requirements as stipulated by the Basel agreements. It is important to point out that, if banks adopt the decision-making guidelines for capital structure, according to the trade-off model banking capital will be stable over time, which is a result that was not found to be true by Gropp and Heider (2010).

This study will analyze the influence of leverage in determining risk for financial institutions in Brazil. This leverage will be measured by a proxy of 4 (four) main leverage components promulgated by the Basel Committee (on-balance sheet, derivative, repo operations and off-balance sheet leverage) and risk will be measured by the risk indicator *zscore*, according to Papanikolaou and Wolff (2014).

Thus, this section presents the data used for the empirical analysis, the model utilized to solve the research question, the method of estimation of the parameters, and the measurements of the goodness of the model's fit.

3.1 Data

This study follows the model used by Papanikolaou and Wolff (2014) which through an analysis of panel data measures the risks to which financial institutions are subjected. The authors analyze the operations of the current banking system and especially the operations that do not appear on banking institution balance sheets.

In Papanikolaou and Wolff (2014), important findings were reported in relation to the American banking system, in terms of the separation of on-balance sheet and off-balance sheet leverage. In the current study, the objective is to observe the behavior of leverage for on-balance sheet and off-balance sheet operations within the Brazilian banking system, in order to verify possible impacts on the individual risks to banking institutions.

Considering data similar to the used in Papanikolaou and Wolff (2014), specific accounting information from financial institutions has been collected as well as Brazilian macro-economic variables. In particular, the following sources of information have been utilized: the financial institutions report data on the Brazilian Central Bank's website, information from the balance sheets of the Accounting Plan for Institutions of the National Financial System (Cosif), the Risk Management Report - Pillar 3 (RGR-P3), available on the internet websites of financial institutions, and macroeconomic data from the IBGE (Brazilian Institute of Geography and Statistics).

The data used in this study was collected from accounting information from July 2001 to June 2018, and from December 2015 to June 2018 for information on leverage following the guidance of BIS (2010). It's important to point out that the leverage information, according to the calculation defined by BIS (2010) was only published by Brazilian banking institutions beginning in December 2015. For the macroeconomic data, the data used covers the period from January 2002 to June 2018.

As established by BIS2010 and according to Brazilian legislation, the leverage variables are measured by:

Row number	**Leverage Ratio**		
	Instruction	Billions Reais	% da L21
On-balance sheet items			
L1	On-balance sheet items (excluding derivatives and SFTs, but including collateral)	6,473	79.0%
L2	Regulatory adjustments in determining Basel III Tier 1 capital)	(171)	-2.1%
L3	Total exposure on-balance sheet items	6,302	76.9%
Derivative Exposures			
L4	Replacement cost associated with all derivatives transactions	105	1.3%

Continuous in the next page.

Row number	Leverage Ratio		
L5	Add-on amounts for potential future exposure associated with all derivatives transactions	86	1.0%
L6	Gross-up for derivatives collateral provided	0	0.0%
L7	Deductions of receivables assets for cash variation margin provided	(0)	0.0%
L8	Exempted central counterparty leg of client-cleared trade exposures	(12)	-0.1%
L9	Adjusted effective notional amount of written credit derivatives	14	0.2%
L10	Adjusted effective notional offsets and add-on deductions for written credit derivatives	(1)	0.0%
L11	Total Derivative Exposures	191	2.3%
Securities Financing Transactions (SFT)			
L12	Repo and securities lending	964	11.8%
L13	Netted amounts of cash payable and cash receivables of gross SFT assets)	(16)	-0.2%
L14	Counterparty credit risk exposure for SFT assets	65	0.8%
L15	Counterparty credit risk in agent transaction exposures	83	1.0%
L16	Total SFT exposure	1,096	13.4%
Off-balance sheet Exposures			
L17	Off-balance sheet exposure at gross notional amount	1,389	17.0%
L18	Adjustments for conversion to credit equivalent amounts	(786)	-9.6%
L19	Total off-balance sheet exposures	603	7.4%
Basel III Tier 1 Capital and Total Exposure			
L20	Tier 1 Capital	664	8.1%
L21	Total Exposure	8,192	100.0%

Table 3.1: Leverage Ratio Disclosure Template

The absolute values and percentages of Total Exposure are described in the Table 3.1, according to the data for the Leverage Ratio for June 2018, considering the macro-segments B1, B2 and B4 of the Brazilian banking system, which consist of: commercial, non-commercial or investment and development banks, thus covering in a complete

manner all of the segment types of the Brazilian banking system. Table 3.2 shows the distribution of the frequency in relation to Total Exposure for information on the exposure in terms of derivatives, SFT's, on-balance sheet and off-balance sheet leverage for the period with available data for the regulatory Leverage Ratio (December 2015 to June 2018, with quarterly data), considering the data published by the Risk Management Report – Pillar 3 (RGPR-3), published by Brazilian banks on their respective websites which follow the normative guidelines of the Basel Committee and the Brazilian Central Bank, revealing the risk management process and the appropriate controls adopted.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
L3/L21(levreg)	1,463	0.448	0.414	0.000	0.000	0.860	1.000
L11/L21(derreg)	1,463	0.017	0.052	0.000	0.000	0.0004	0.327
L16/L21(comproreg)	1,463	0.072	0.126	0.000	0.000	0.095	0.706
L19/L21(offreg)	1,463	0.027	0.071	0.000	0.000	0.020	0.456

Table 3.2: Frequency Distribution - Leverage Ratio Disclosure Template

Time delimited data of leverage statements, which include information since December 2015 and also consider the criterion of pertinence, in which some risk figures in the Table 3.1 represented 0% of the Total Exposure of the banking system, was opted to use an accounting proxy for the leverage information of Brazilian banking institutions, with data beginning in January 2001.

Thus, the regulatory indicators described in the Table 3.2 will be represented by the accounting indicators described in Table 3.3, as follows: *levreg* for *lev*, *derreg* for *der*, *comproreg* for *compro* and *offreg* for *off*. These *proxy* variables represent the Leverage data in a significant manner, with the exception of the unavailability of the Cosif data for variables L2 and L18 in Table 3.1.

In addition, to estimate the econometric model described in Section 3.2, the result variables for the banking institutions have been used as instrumental variables for the proposed model, representing the revenues derived from non-traditional banking business operations as *recder*, *recaplic* and *recserv*. Papanikolaou and Wolff (2014) use the same logic to establish instrumental variables in their proposed model. These variables are listed also in Table 3.3.

Variable	**Abbreviation**	**Definition**	**Formula**
Dependent variable			

Continuous in the next page.

Variable	Abbreviation	Definition	Formula
	Zscore	The sum of returns on assets and book equity ratio divided by the standard deviation of return of assets.	Equation 3.1
Independent variables			
On-balance sheet leverage	lev	The ratio of total assets to book equity capital.	$\frac{TotalAssets}{PL}$
Derivative Leverage	der	The ratio of credit equivalent amount of derivatives to book equity capital.	$\frac{13300001}{PL}$
	recder	The ratio of trading revenue from derivative activities to total trading revenue.	$\frac{71500003}{71000008}$
SFT leverage	compro	The principal amount of loans and other assets sold and securitised with servicing retained or with recourse divided by total assets.	$\frac{12100008+42200002+42300005}{TotalAssets}$
	recaplic	The ratio of trading revenue from SFT activities to total trading revenue.	$\frac{71400000}{71000008}$
Off-balance sheet leverage	off	The sum of commitments, direct credit substitutes and acceptances divided by total equity.	$\frac{30100004}{PL}$
	recserv	The ratio of revenue from no interest activities to total trading revenue.	$\frac{71700009}{71000008}$

Table 3.3: Accounting Variables

The dependent and independent variables utilized for the econometric model described in Section 3.2 are listed in Table 3.3. The independent variables utilized are the leverage variables, given that according to Demirguc-Kunt et al. (2013), the relationship between the return on stocks compared to capital is stronger when the capital is measured by a

leverage indicator instead of a risk-based capital indicator. In Papanikolaou and Wolff (2014), the authors use on-balance sheet and off-balance sheet leverage variables and revenue variables for these operations as instruments for these variables. We have followed the same logic in this study.

To calculate the independent variable *zscore*, the measurement component of the individual risk of financial institutions follows the Equation 3.1 as used by Papanikolaou and Wolff (2014) and Beltratti and Stulz (2012).

$$Z_{iq} = \frac{\frac{PL_{iq}}{Ativo_{iq}} + ROA_{iq}}{\sigma_{ROA_iq}} \tag{3.1}$$

where PL is equal to the equity of the banks as measured by the Cosif data fields 60000002 + 70000009 + 80000006, ROA is obtained by dividing an institution's profits (fields 70000009 + 800000060) by its total assets (Cosif data fields 10000007 + 20000004). On the other hand, ROA is the annual standard deviation of the return on assets considering a window of 12 months.

Thus, the *Zscore* is composed of the sum of the returns on assets and the equity divided by the standard deviation of the return on assets, turning it into a measure of the risk of a bank's insolvency. According to Papanikolaou and Wolff (2014, p.17), this indicator combines profitability, capital risk and return volatility in a single metric. The greater the indicator, the lower the probability of a bank failure.

In this study, in terms of the independent variables, the leverage variable *lev* is a simple and traditional accounting measure that considers the total assets of institutions divided by their equity according to Beltratti and Stulz (2012). In this measure of *lev*, the total assets have been subtracted from the Cosif data fields 13300001 and 12100008, which make up the leverage of the derivatives and repo operations, respectively. According to the Table 3.1, this metric has an important proportional participation within the composition of the leverage of Brazilian banking institutions.

Considering the leverage of derivatives in Brazil, over the counter derivatives make up a small proportion of the market. Thus, instead of using the derivative variables *der* and *recder* just for over the counter derivatives like Papanikolaou and Wolff (2014), for the Brazilian case the total of derivative operations has been used.

In this way, *der* corresponds to the equivalent value of derivative credits divided by the equity and *recder* corresponds to securities and derivatives revenues divided by the total of these institutions' operational revenues. This indicator refers to the best effort to collect quality information from the Cosif chart of accounts to reflect the concepts of derivative leverage. Thus, the result of this indicator is data field Cosif 71500003 (securities and derivatives revenues) divided by total operational revenues, represented by the data field

Cosif 71000008.

The variables that represent the leverage of repo operations and securities lending (*compro* and *recaplic*) are associated with some type of retention of risk or guarantee. While *compro* consists of the repo operations of financial institutions, *recaplic* consists of the revenues from interfinancial applications. The original Basel variable and the one used by Papanikolaou and Wolff (2014) also use securities lending, however in the Brazilian case this type of operation is relatively rare in the banking system.

Thus, in this study are used the variable *compro*, which consists of the data fields Cosif 12100008, 42200002 and 42300005 divided by the total assets, defined as the sum of data fields Cosif 10000007 and 20000004, as well as the variable *recaplic*, represented by data field Cosif 71400000 divided by the total of operational revenues given by data field Cosif 71000008.

The variables *off* and *recserv* constitute the limits of guarantees given by institutions and service revenues respectively, which also appear in the accounting information. The accounting information on credit limits are not represented in the variable *off*, due to limitations in terms of the public accounting information that is available. However, this variable represents well the variable conceived of by Basel, as can be seen in the Table 3.4.

Thus, the variable *off* consists of data field Cosif 30100004 (commitments) divided by equity. The variable *recserv* consists of the result in the data field Cosif 71700009 (revenue from services), divided by the operational revenues in data field 71000008.

For greater robustness in the consideration of the accounting variables used as a proxy for the leverage variables considered in this study, the *Pearson* correlation coefficient was determined, which generated satisfactory results in terms of the representativeness of the accounting variables as well as the leverage of Brazilian banks. In this test, was compared the Cosif variables used and the original leverage variables. The results are displayed in the Table 3.4. Thus, since the Pearson coefficient presents a satisfactory correlation between the Cosif and leverage variables, one proxy of the variables originally proposed by Basel was constructed, which corroborated the use of these indicators in the Table 3.3, as in Papanikolaou and Wolff (2014).

3.2 The model

The functional relationship which is established in this work follows the example of Papanikolaou and Wolff (2014), which was one of the pioneering articles in evaluating banking leverage both on-balance sheet and off-balance sheet within the regulatory framework of Basel 3. The work of these authors was designed to determine how modern banking leverage affects the risk profile of banks. The authors studied American banks through

	L1	L11	L16	L19	L11 cosif	L16 cosif	L19 cosif	L1 cosif
L1	1	0.192	0.750	0.886	0.197	0.838	0.819	0.997
L11	0.192	1	0.226	0.172	0.875	0.141	0.139	0.146
L16	0.750	0.226	1	0.490	0.201	0.951	0.953	0.753
L19	0.886	0.172	0.490	1	0.175	0.539	0.510	0.883
L11_cosif	0.197	0.875	0.201	0.175	1	0.129	0.126	0.170
L16_cosif	0.838	0.141	0.951	0.539	0.129	1	0.999	0.839
L19_cosif	0.819	0.139	0.953	0.510	0.126	0.999	1	0.820
L1_cosif	0.997	0.146	0.753	0.883	0.170	0.839	0.820	1

Table 3.4: Regulatory and Cosif variables correlation

the construction of a data panel for the period from the first quarter of 2002 through the third quarter of 2012.

According to Ozkan (2001, p.176), compared with *cross sections* data, panel data is more flexible in terms of the choice of instruments used to control endogeneity. Also according to Hsiao (1985, p.163), the use of panel data depends on the extent and reliability of the data, as well as the validity of the restrictions that apply to the construction of the statistical methods. In this work, the dynamic panel has been used to study leverage and its impact on risk. According to Andrade and Tiryaki (2017, p.345), banking regulation is one of the areas of economics and finance that justifies the use of dynamic panel data, because current regulation depends on past measures. Thus, the functional relationship to evaluate the effects of leverage on the individual risk to banks is represented by the equation below:

$$\begin{aligned} Y_{it} = Y_{it-1} + \alpha_i + \beta_{1,it}\Delta lev_{i,t} + \beta_{2,it}\Delta der_{i,t} + \beta_{3,it}\Delta compro_{i,t} \\ +\beta_{4,it}\Delta off_{i,t} + \gamma_{1,it} atcomp_{i,t} + \gamma_{2,it} pascomp_{i,t} + \delta PIB_t + \delta IPCA_t + \varepsilon_{it} \end{aligned} \tag{3.2}$$

where $i = 1, 2, ...N = 71, t = 2002S1, ..., T = 33$.

In the model, Y_{iq} is equal to the *zscore* in its logarithmic form, as in Papanikolaou and Wolff (2014) and Hossain et al. (2017). Δlev_{iq}, Δder_{iq}, $\Delta compro_{iq}$, Δoff_{iq} are the average semester changes in *lev*, *der*, *compro* and *off*, respectively.

According to Andrade and Tiryaki (2017, p. 344-345), the inclusion of the lagged dependent variable as an explanatory variable makes model persistence possible and verifies shocks that have continuous effects over time, minimizing the serial correlation in terms of error. According to the authors, the coefficient of this lagged variable can indicate whether the impact of shocks increases or decreases over time. In the model, the lagged

dependent variable is also used in a logarithmic form.

According to Papanikolaou and Wolff (2014), the reason why on and off-balance sheet leverage variables are introduced in the model in first differences rather than levels is to capture the effects of increasing (positive) and decreasing (negative) trends in terms of bank risk.

Within this context, $atcomp_{it}$ and $pascomp_{it}$ are the specific control variables for the banks, which seek to capture possible alterations in traditional banking services, according to Berger et al. (2008), Uhde and Heimeshoff (2009) and González (2005). $atcomp_{it}$ captures possible changes in bank loan activity. This measure is calculated by the net loan and leasing divided by total assets. $Pascomp_{it}$ captures possible changes in traditional sources of bank financing, measured by banks' total deposits over total liabilities. PIB_t and $IPCA_t$ are two macroeconomic variables. $IPCA_t$ measures the semester variation in inflation, measured by *IPCA*, and PIB_t measures the gross domestic product (*PIB*) and market prices to evaluate the effects of business cycles on the process of adjustments to the degree of banking leverage. The *PIB* variable is used in its logarithmic form.ε_{it} is the error term , and α represents individual unobservable factors, while β, γ and δ are the parameters to be estimated.

According to Andrade and Tiryaki (2017, p.345), the inclusion of the lagged variable can create problems of endogeneity. Since Y_t is a function of α, therefore Y_{t-1} is also a function of α, where Y_{t-1} will be correlated with the error term, which makes the *OLS* (*ordinary least squares*) estimator skewed and inconsistent. According to authors, fixed and random effects models are not indicated for dynamic models with panel data.

Papanikolaou and Wolff (2014) estimate the model by the *two-stage least squares instrumental variables* (*2SLS* IV) model to deal with the potential problem of endogeneity, given that covariates could be related as dependent variables. However, the regression based on this method can generate skewed parameters when endogeneity exists, which could lead to erroneous statistical inferences. The most recent literature advocates the use of the estimation method for dynamic panel data *system GMM*, which has been prioritized by this study. The expected results are displayed in Table 3.5.

The relationship between *atcomp* and risk is considered positive by Papanikolaou and Wolff (2014), when both stable economic periods and crises are evaluated. However, the same relationship is expected to be negative by Weiß et al. (2014), when periods of financial crises are considered. In the present analysis, given that the larger the *zscore*, the smaller the risk incurred by a given banking institution, a positive relationship is expected between *atcomp* and *zscore* during periods of economic stability. Or in other words, the larger the proportion of credit operations in a banking institution, considering these operations to be typical of banking business, the lower the individual risk to the

Independent variable	Expected result with dependent variable
at_comp	(+) Papanikolaou and Wolff (2014) (-) Weiß et al. (2014) (crise)
pas_comp	(+) Papanikolaou and Wolff (2014) e Mendonça and Silva (2017)
lev e off	(-) Papanikolaou and Wolff (2014) e Vallascas and Keasey (2012)
der e compro	(-) Papanikolaou and Wolff (2014)
Inflation (IPCA)	(+) Papanikolaou and Wolff (2014) (-) Vallascas and Keasey (2012) (-) ou (+) Weiß et al. (2014)
PIB	(+) Papanikolaou and Wolff (2014) (-) Mendonça and Silva (2017), Marques Pereira and Saito (2015) e Vallascas and Keasey (2012) (-) ou (+) Weiß et al. (2014)

Table 3.5: Expected results

institution.

The expected result between *pascomp* and risk shows the positive relationship in not only Papanikolaou and Wolff (2014) but also an applied study of the Brazilian banking system where Mendonça and Silva (2017) analyze the effect of banking and macroeconomic variables on systemic risk. In these studies, the findings show that an increase in the proportion of deposits in banking liabilities reduces this risk.

The leverage, derivative exposure, repo operations and off-balance sheet variables have a negative relationship with the *zscore* variable in Papanikolaou and Wolff (2014), considering periods of financial stability. These results are similar to those found by Vallascas and Keasey (2012), considering the relationship between on-balance sheet and off-balance sheet variables and the resilience of banks to systemic shocks. In this sense, both authors found results that indicated that the greater the exposure to these operations, the greater the risk incurred.

In relation to the macroeconomic variables *IPCA* and *PIB*, the results and the relationship with risk depend on their context. Papanikolaou and Wolff (2014) find a positive relationship between these variables and the *zscore*, independent of whether it is a period of crisis or not, which implies a lower risk of bank insolvency with the increase of these variables.

Meanwhile Vallascas and Keasey (2012) finds a relationship between the growth of

these variables and an increase in systemic risk, as Marques Pereira and Saito (2015) and Mendonça and Silva (2017) find a relation to the growth of *PIB* and an increase in bank risk in Brazil. Weiß et al. (2014) on the other hand, in an applied study of financial crises, emphasizes that the behavior of these variables depends on the type of crisis that has occurred.

3.3 Estimation of the parameters

To evaluate the relationship between banking leverage and the risk indicator, the parameters will be estimated using the estimator used by Arellano and Bover (1995) and Blundell and Bond (1998), known as the *system GMM*, which is designed to correct the problem of weak instruments. According to these authors, variables with lagged levels are weak instruments for first difference variables, considering the stationarity of these variables. The estimation strategy is similar to that used by Brei and Gambacorta (2016) in studying leverage in relation to the business cycle in a panel for fourteen countries.

Arellano and Bover (1995) suggest the utilization of *GMM* with future orthogonal deviations. According to Andrade and Tiryaki (2017, p.354), this procedure subtracts the average of all future observations for units in *cross section*, which means that the last unit of time's observation is lost instead of the first, as occurs with *difference GMM* (Arellano and Bond, 1991), eliminating the individual effect in cross section.

Blundell and Bond (1998) shows the use of conditions of additional moments in relation to the original estimator used by Arellano and Bond (1991). According to Blundell and Bond (1998), this version of the system estimator tends to be better than the *difference GMM* estimator due to the use of the level and difference equation, where lagged level variables are instruments for difference variables and the difference variables are instruments for the level variables.

Also, as demonstrated by Arellano and Bond (1991) and Blundell and Bond (1998), the estimator of the two stage system coefficient is more efficient compared to the one stage system. However, one problem that comes with the two stage estimator is that the asymptotic standard errors can be overestimated especially when the number of instruments is equal to or greater than the number of *cross sections* (Beck and Levine, 2004). One adjustment that can be made is to reduce the number of instruments, limiting to the number of observations, which is what we have done in this work. It also uses the finite sample correction for the two stage variation matrix calculation as suggested by Windmeijer (2005), in order to generate more robust estimates.

Thus, the parameters were estimated for the R software through the *PLM* package. The parameterization used for the *system GMM* was: (a) oneway, individual effect, which

makes it possible to use unobservable individual effects, (b) two steps model, in which this model changes the weighting matrix in order to achieve more consistent estimates, (c) collapse instruments, which make the clusterization of instruments possible, as mentioned by Roodman (2009) and (d) a robust covariance matrix, mentioned by Windmeijer (2005), which makes it possible to generate more accurate estimates.

According to Hausman (2001), the statistic instruments implemented in the econometric analysis are variations of the same theme. The variables *recder*, *recaplic*, *recserv* and the lagged variable *zscore* are considered to be instruments in the estimation of the parameters by the *GMM system* method, considering a range from 2 to 6 *lags*. These utilized instruments follow the instruments proposed by Papanikolaou and Wolff (2014), which are variants of the same theme of the variables *der*, *compro* and *off* in the model presented in this work.

Thus, *recder* expresses bank activities in the derivative and securities markets, in the same line as the *der* variable, but from the perspective of the results of these types of operations. In turn, *recaplic* represents the revenues from financial applications and *recserv* the revenues of services, in which these variables represent the variables generated through repo operations and also financial institution services, and thus they constitute variables related to the same theme, but presented in a different manner.

The other model variables were not considered as *GMM* instruments but rather normal instruments with one lag: *der*, *compro*, *off*, *lev*, *atcomp*, *pascomp*, *PIB* and *IPCA*.

3.4 The model's goodness of fit

The *system GMM* estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998) requires stationarity data to produce consistent estimates. To verify the fulfillment of this condition, we performed unit root tests as proposed by Levin et al. (2002) and Im et al. (2003), which are abbreviated as *LLC* and *IPS*.

According to Baltagi (2008, p.240), the *LLC* test performs individual unit tests for each cross-section and assumes that there is independence among the individuals in the panel data. The null hypothesis is that each series contains a unit root, while the alternative hypothesis is that the series are stationary. This test is indicated for panel data of moderate size with values of N between [10; 250] and T between [25; 250]. The basic hypothesis is:

$$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \Theta_{iL} \Delta y_{i,t-L} + \alpha_{mi} d_{mt} + \varepsilon_{it}. \tag{3.3}$$

in which d_{mt} indicates the vector of the deterministic variables and α_{mi} corresponds to the coefficient vector for the model $m = 1,\ 2\ e\ 3$. Specifically, $d_{1t} = \emptyset$, $d_{2t} = 1$ and $d_{3t} = 1, t$.

According to Baltagi (2008, p.240), since the lag order is unknown, a regression is estimated for each *cross-section* separately. The lag order p_i can vary among individual banks. For a given T, choose the $p_{máx}$ and examine through the t statistic $\hat{\Theta}_{iL}$ whether the lag order of the previous cross section is a better fit. Once p_i is defined, two auxiliary regressions are realized Δy_{it} on $\Delta y_{i,t-L}$ and d_{mt}; and $y_{i,t-1}$ on $\Delta y_{i,t-L}$ and d_{mt} to obtain $\hat{e}_{it}$ and $\hat{\nu}_{it-1}$, respectively, where $L = 1, ...p_i$.

According to Baltagi (2008, p.242), the LLC test is restrictive to the extent that it requires that ρ is homogeneous in relation to the different i. Thus, the test proposed by Im et al. (2003) (IPS) permits the heterogeneity of the coefficients $y_{i,t-1}$ and proposes a procedure for an alternative test based on individual statistics of the unit root tests.

According to Baltagi (2008, p.242), the (IPS) test possesses the null hypothesis that each panel series contains a unit root, because it permits heterogeneity in the autoregressive parameter of the first order under the alternative hypothesis that there is a unit root for some (but not all) individual banks in the panel:

$$H_1 = \rho_i < 0 para i = 1, 2, \ldots N_1; e \rho_i = 0 para i = N_1 + 1, ...N. \tag{3.4}$$

The auto-correlation test of the residuals in Arellano and Bond (1991) proposes the hypothesis that there will not be an auto-correlation of the second order for first difference equations in the specifications of the proposed model. Therefore, it should fulfill the following hypotheses: 1) the non-correlation of lagged data (above the second) of the regressors in level with the first differences between errors; 2) the non-correlation of the first differences of regressors with an error in level.

In addition, Arellano and Bond (1991) suggests using the Sargan test of the above-mentioned restrictions, where one can verify the null hypothesis whether the group of instruments used is informative, thus testing the validity of the instruments.

Chapter 4

Results

In this chapter we will present the most relevant results in reference to the analyzed data and the estimation of the parameters, indicating the main impacts of leverage on the risk in the Brazilian banking system.

First, we will realize a descriptive analysis of the leverage of the banking system, exploring the variables used in this study, their statistical measurements and the correlation between the variables.

Second, we will present the results of the estimation of the parameters, considering the methods of estimation *OLS*, fixed effects and *system GMM* and its specifications, such as the placement of model variables using differences and also separating banks by their type of activity (commercial and non-commercial banks), in order to verify the leverage factors which generate risk for the banking system, with it being important that the regulatory authorities adopt appropriate prudent measures so that financial market agents are aware of the risks they are incurring.

Finally, we analyze the quality of the used model using the robustness and unit root tests *LLC* and *IPS*.

4.1 Descriptive analysis of the leverage of the banking system

The descriptive statistics of the study variables are presented in Table 4.1, including the variables used in the econometric model (*der*, *compro*, *off*, *lev*, *atcomp*, *pascomp*, *PIB* and *IPCA*), in accordance with Section 3.2, the instrumental variables applied in the *GMM* estimation method and the variables *roa* and *volroa*, which are components of the *zscore* variable.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
roa	2,343	0.006	0.024	−0.242	0.001	0.011	0.185
der	2,343	0.165	0.464	0.000	0.000	0.091	6.112
compro	2,343	0.195	0.210	0.000	0.040	0.282	1.435
off	2,343	0.560	1.122	0.000	0.007	0.546	18.741
lev	2,343	7.063	5.952	0.084	3.002	9.254	43.529
recder	2,343	0.312	0.275	0.000	0.067	0.502	0.994
recaplic	2,343	0.094	0.134	0.000	0.019	0.104	0.947
recserv	2,343	0.049	0.087	0.000	0.005	0.060	0.804
atcomp	2,343	0.368	0.256	0.000	0.141	0.548	0.983
pascomp	2,343	0.423	0.290	0.000	0.169	0.657	0.989
volroa	2,343	0.024	0.039	0.0002	0.005	0.026	0.368
zscore	2,343	22.521	24.984	−0.911	8.089	27.297	289.177
pib (bi)	2,343	1,972	863	709	1,136	2,769	3,350
ipca (perc)	2,343	3.114	1.548	1.180	2.300	3.590	8.990

Table 4.1: Descriptive analysis of the model's variables

In the descriptive analysis of these variables, a few outliers were observed such as, for example, a maximum leverage of 43.529, which refers to a bank which had successive losses for 5 (five) semesters. These losses substantially decreased the equity of this institution, making its leverage extremely high. After these losses, the shareholders of this bank invested new financial resources and its leverage became stable again.

In relation to the *zscore* variable, the minimum negative value refers to the same bank with maximum leverage, which presented negative *roa* during this period. On the other hand, the maximum value of the *zscore* refers to a bank with little activity in financial operations which has a equity close to the size of its assets.

To avoid the effects of outliers in the proposed estimation models, the component variables of the model were winsorized at 5% of the minimum and maximum levels.

Finally, in the Table 4.2, a Pearson correlation test was realized for the variables utilized in this model.

4.2 Results of the estimation of the parameters

The Tables 4.3 and 4.4 show the results of the estimation of the parameters considering the regressions used in the *OLS* method, panel data with fixed effects and the *system GMM* method. The results obtained comparing different estimators are designed to give more robustness to the presented results, according to Mendonça and Silva (2017) and Marques Pereira and Saito (2015). It's important to point out that all of the regressions

	der	compro	off	lev	rec der	rec aplic	rec serv	at comp	pas comp	z_score
der	1	0.024	0.059	0.229	0.411	-0.125	-0.059	-0.257	-0.214	-0.087
compro	0.024	1	-0.046	-0.014	0.021	0.554	0.022	-0.387	-0.047	0.035
off	0.059	-0.046	1	0.184	0.011	-0.147	0.104	0.037	-0.082	-0.040
lev	0.229	-0.014	0.184	1	0.060	-0.093	0.117	0.044	-0.008	-0.032
rec_der	0.411	0.021	0.011	0.060	1	-0.305	-0.127	-0.540	-0.463	-0.151
rec_aplic	-0.125	0.554	-0.147	-0.093	-0.305	1	-0.064	-0.242	0.104	0.228
rec_serv	-0.059	0.022	0.104	0.117	-0.127	-0.064	1	-0.136	0.058	-0.048
at_comp	-0.257	-0.387	0.037	0.044	-0.540	-0.242	-0.136	1	0.361	0.091
pas_comp	-0.214	-0.047	-0.082	-0.008	-0.463	0.104	0.058	0.361	1	-0.005
z_score	-0.087	0.035	-0.040	-0.032	-0.151	0.228	-0.048	0.091	-0.005	1

Table 4.2: Model's variables - Pearson correlation

used in the *system GMM* estimation method do not reject the null hypothesis of the Sargan (J-statistic) test and, in this manner, the overidentifying restrictions are valid. In addition, the serial auto-correlation *AR1* and *AR2* tests do not indicate the presence of serial auto-correlation.

The specification denoted by *1-OLS* in the Table 4.3 is compose of the control variables, as in Papanikolaou and Wolff (2014). The *2-OLS* specification, on the other hand, is made up of control variables along with other variables from the Section 3.2. The fixed effects *3-FE* specification displays the parameters found with this method of estimation, except for the macro-economic variables. The results for the Table 4.3 are in line with those found in the 1-GMM specification of the Table 4.4, which represents an overall sample of banks, except for the statistical significance of the *compro* and *off* variables, which represent repo operations and off-balance sheet operations.

Meanwhile the Table 4.4 is presented by the *system GMM two steps* model with the following specifications: an overall sample of the banks, (denoted by *1-GMM*), commercial banks (*2-GMM*), non-commercial or treasury banks (*3-GMM*) and foreign banks (*4-GMM*). It seeks, with this analysis, to identify specific leverage profiles within this group of banks, according to the classification proposed by Capelleto (2006).

In these models, the variables der, *compro*, *off* and *lev* are placed in first differences, in accordance with Papanikolaou and Wolff (2014), in order to verify a dynamic relationship between these variables and the *zscore* variable.

According to Mendonça and Silva (2017), the number of instruments utilized in the specifications that use the *system GMM* method were limited by the number of observations, in this case, to the total number of banks in the sample, to avoid the excessive use of instruments (Roodman, 2009). Thus, the GMM instruments used were the variables

	Dependent variable: z_score		
	(1-OLS)	(2-OLS)	(3-FE)
der		−0.616***	−0.591***
		(0.088)	(0.089)
compro		0.748***	0.765***
		(0.114)	(0.114)
off		−0.043**	−0.048***
		(0.018)	(0.018)
lev	−0.016***	−0.009**	−0.008**
	(0.004)	(0.004)	(0.004)
at_comp	0.758***	0.856***	0.866***
	(0.086)	(0.094)	(0.094)
pas_comp	−0.226***	−0.441***	−0.455***
	(0.075)	(0.073)	(0.073)
ipca		−0.032**	
		(0.015)	
pib		0.423***	
		(0.040)	
Constant	2.600***	−3.418***	
	(0.049)	(0.585)	
Observations	2,340	2,340	2,340
R^2	0.037	0.129	0.082
Adjusted R^2	0.036	0.126	0.067
F Statistic	29.866*** (df = 3; 2336)	43.163*** (df = 8; 2331)	34.136*** (df = 6; 2301)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 4.3: Regression Results 1

	Dependent variable:			
	z_score			
	(1-GMM)	(2-GMM)	(3-GMM)	(4-GMM)
lag(z_score, 1)	0.054**	0.093**	0.137*	−0.047
	(0.025)	(0.039)	(0.073)	(0.031)
der	−0.322***	−0.089	−0.429***	−0.399***
	(0.055)	(0.094)	(0.067)	(0.099)
compro	0.069	0.190*	−0.228*	−0.053
	(0.068)	(0.105)	(0.138)	(0.125)
off	−0.013	−0.022	0.098***	0.138***
	(0.017)	(0.023)	(0.025)	(0.024)
lev	−0.018***	−0.012***	−0.056***	−0.054***
	(0.003)	(0.004)	(0.006)	(0.005)
at_comp	0.669***	0.622***	−0.393**	0.549***
	(0.066)	(0.110)	(0.189)	(0.120)
pas_comp	−0.309***	−0.222***	−0.043	0.163
	(0.085)	(0.081)	(0.162)	(0.132)
ipca	−0.055*	−0.042	−0.106**	−0.120**
	(0.031)	(0.027)	(0.045)	(0.061)
pib	0.180***	0.173***	0.177***	0.202***
	(0.005)	(0.010)	(0.019)	(0.014)
Bancos	71	55	16	24
Períodos	33	33	33	33
Observations	2343	1815	528	792
J-stat and p-value	32.247 (0.404)	32.711 (0.383)	31.453 (0.443)	31.841 (0.424)
AR(1) and p-value	−6.305 (0.000)	−4.568 (0.000)	−3.927 (0.000)	−6.649 (0.000)
AR(2) and p-value	−1.371 (0.170)	0.481 (0.630)	0.380 (0.703)	0.798 (0.425)
Wald test and p-value	18.604 (0.000)	26.396 (0.000)	3.681 (0.000)	3.264 (0.000)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4.4: Regression Results 2

zscore (*lag*), *recder*, *recaplic* and *recserv* and the number of *lags* used by these instruments were limited to a range of 2 (two) to 6 (six).

Considering the parameters of the control variables *atcomp*, a positive and statistically significant relationship was found, as in Papanikolaou and Wolff (2014) during periods of financial stability (without crises), except for the 3-GMM model (treasury banks).

Thus, the expected result is found for the overall total sample of the banks and for the groups consisting of commercial banks and foreign banks (specifications 1-GMM, 2-GMM and 4-GMM), demonstrating that, the larger the proportion of credit operations in financial institutions, the greater the predominance of typical banking activity operations and the lesser the presence of those deemed to be unusual banking business operations. In this way, leverage through traditional loan activities presents less risk to the stability of Brazilian banking institutions.

For the 3-GMM specification, the relationship between *atcomp* and the *zscore* is negative and statistically significant at a 5% level, which may signify that within the treasury banking segment, the greater the proportion of credit operations, the riskier the financial institution is, given that this group's main focus is not typical commercial credit operations. This is an important study point: leverage in terms of traditional loans has different impacts depending on the type of financial institution.

Considering the control variable *pascomp*, it is negative and statistically significant at a 1% level obtained for the general sample (specification 1-GMM) and the commercial bank sample (specification 2-GMM), which is different from the findings of Papanikolaou and Wolff (2014) and Mendonça and Silva (2017). This later study found *pascomp* to be an important factor in the stability of Brazilian banking institutions in relation to systemic risk, given that the proportion of deposits over the total liabilities of the institutions is seen as a cushion against the appetite of banks for risk to increase their credit portfolio, reinforcing the perception that the use of fundraising from unusual sources could be a possible weakness of these banking institutions. Bearing in mind that the measurement of systemic risk is different from the measurement of individual bank risk, the results of the regressions may have a differential impact when the institutions are analyzed in an isolated manner.

It should be noted that this negative relationship was not found in a statistically significant manner for specifications 3-GMM and 4-GMM, which may mean that the proportion of deposits in the liabilities of these banks is not a significant source of risk, given that these institutions receive few deposits from individuals, the traditional form of funding for commercial banks.

Considering the variables that present on and off-balance sheet leverage (*lev*, der, *compro*, *off*), the variable *compro* presents a positive and significant relationship at a

10% level in the specification presented for commercial banks (2-GMM). In Brazilian commercial banks, this variable is concentrated on repo operations with federal securities guarantees, which thus constitute a lower source of risk for these institutions. For the specification of non-commercial banks (3-GMM), this relationship has been found to be statistically significant also at a 10% level, however in this case with a negative sign. The results suggest that these repo operations for treasury banks are riskier, possibly because they involve private securities guarantees rather than federal securities. The results for Brazilian treasury banks are in line with those found by Papanikolaou and Wolff (2014) for the American banking system during the period before the financial crisis of 2007. Meanwhile for foreign banks (specification 4-GMM), this relationship did not present statistical significance.

The *lev* variable, on the other hand, presented significance at a 1% level for all of the specifications, in line with the findings of Vallascas and Keasey (2012) and Papanikolaou and Wolff (2014) for the period before the 2007 crisis. Thus, this relationship shows that the greater the leverage of institutions, the greater the risk that is incurred. Given that the leverage of financial institutions, for the most part, contains an element of risk of defaults occurring in these operations, which would have a potential negative impact on banking results, the study's findings are to be expected.

The *der* variable presented a negative significant relationship at a 1% level for the specifications of treasury and foreign banks, as was obtained by Papanikolaou and Wolff (2014). Given that these segments usually perform more structured financial operations which are less conventional than commercial banks, there is a need to have greater protection for these operations. In addition, foreign banks realize transactions in foreign currency with their head offices, making it necessary to *hedge* against these operations.

The *off* variable presents a positive significant relationship at a 1% level in the specifications for treasury and foreign banks which suggests that for these segments an increase in off-balance sheet operations is less risky. More specifically, the results are compatible with this type of business for these segments which realize various forms of guarantees with their headquarters or foreign affiliates, which tend to be less risky for business. Our findings for this variable differ from Papanikolaou and Wolff (2014), which presented a negative relationship between the *off* variable and the *zscore* variable before the crisis of 2007.

These results demonstrate the relevance of these variables for the Brazilian case, even though the financial market for derivatives and off-balance sheet operations is not as robust as the American market studied by Papanikolaou and Wolff (2014). However, the Brazilian derivative market is considerably more transparent and regulated than the American market. The results may suggest that the impact of off-balance sheet operations

could be influenced by the particular characteristics of the banking environment in each country.

For Brazil, the study indicates that depending on the segment analyzed, no typical banking operations represented by *der* and *off*, as well as typical banking operations represented by the *lev* and *compro* variables have relevant weights in explaining banking risk.

The results of the macroeconomic parameters *PIB* and *IPCA* display a statistically relevant relationship in the presented specifications, especially, with significance at a 1% level for the *PIB* level and significance at a 5% level for the *IPCA* variable for treasury (3-GMM) and foreign (4-GMM) banks, in line with the results of Papanikolaou and Wolff (2014) for the *PIB* variable and in line with the results of Vallascas and Keasey (2012) for the inflation variable.

It can be inferred from these results that, for the individual stability of Brazilian banking institutions, the macroeconomic variables presented possess a significant contribution to individual risk. For the *PIB* variable, a positive adjustment to the level of bank risk in relation to business cycle effects can be noted. On the other hand, the *IPCA* variable shows that an increase in a country's inflation can increase the individual risk of banking institutions in the treasury and foreign segments.

Considering the lag *zscore* variable in the *GMM system* specifications, the results of the parameters show a positive relationship with this variable which is significant at a 5% level for the specifications 1-GMM and 2-GMM and at a 10% level for the 3-GMM specification. Given that the dynamic models for panel data use this variable to verify its relationship with the current variable, in these cases we found that the individual risk was dependent on the risk during the previous period. However, the parameters found have values close to zero, indicating that the variable is not persistent, or in other words, adjustments in terms of banking institution risk occur quickly.

4.3 Results of the model's goodness of fit

As robustness test, the method of estimation and the respective results found in the specifications of the Table 4.4 were obtained considering alterations in the estimation procedures. To accomplish this, we considered: the *system GMM one step* estimation model, according to the results of the Table 4.5, estimation results for the variables *der*, *compro*, *off* and *lev* in levels and not in differences, as in Papanikolaou and Wolff (2014), whose results are demonstrated in the Table 4.6 and also, in order to use a smaller number of instrument variables, we utilized a range from 2 to 5 *lags* for the instrument variables *GMM recder*, *recaplic*, *recserv* and the lagged *zscore* variable, and also considered the

variables *der*, *compro*, *off* and *lev* using in levels and not in differences, according to the Table 4.7.

In the comparison of the Tables 4.5 and 4.4, the results produced were very similar to those found by the *two-steps* method cited by (Arellano and Bond, 1991) (Blundell and Bond, 1998). For the presented specifications, the signs of the parameters remain the same. In relation to the statistical significance of the parameters, in general using the *one-step* method, the parameters present greater significance. In the 2-GMM-1ST specification for commercial banks, the macro-economic variable *IPCA* has statistical significance at a 5% level and for the 4-GMM-1ST specification, the outdated *zscore* variable has significance to a 10% level.

According to the results of the Table 4.6, using the variables der, *compro*, *off* and *lev* in levels, it may be observed that the signs of the parameters remain the same, except for the variable *compro* for specification 4-GMM-L, but this does not have statistical significance. In relation to the statistically significant alterations compared to the results of the Table 4.4, the *compro* variable has statistical significance in relation to the dependent variable *zscore*, as well as the *off* variable, considering the overall banking sample (specification 1-GMM-L). Meanwhile, the lagged *zscore* variable does not have statistical significance in terms of levels for this specification, which shows that when the leverage variables are used in differences there is a dependent relationship with past risk, which is not found when these variables are examined in terms of levels. Considering the 2-GMM-L specification for commercial banks, the variables der, *off* and *IPCA* have statistical significance, while the variable *lev* is not statistically significant. For the 3-GMM-L specification for non-commercial banks, the lagged *zscore*, *compro* and *atcomp* variables do not have statistical significance while the *pascomp* variable does. Lastly, for the 4-GMM-L specification, the *pascomp* variable has statistical significance while the *IPCA* variable is not statistically significant.

Also, as can be seen in the Table 4.7, the *GMM system* estimation method was tested using *lags* ranging from 2 to 5 for *GMM* instrument variables, in order to use the fewest number of instruments, as in Roodman (2009), and the variables der, *compro*, *off* and *lev* using in levels. The findings were similar to those for 2 to 6 *lags*, as in Table 4.6. The specifications presented did not display alterations in the signs of the parameters with the change in the number of *lags* used. In relation to the significance of the parameters obtained compared to the results of the Table 4.6 for the specifications 1-GMM-L5 and 4-GMM-L5, the variables *off* and *atcomp* had statistical significance at a 10% level respectively. For the specification 2-GMM-L5, on the other hand, the parameters of the variable *IPCA* did not present statistical significance.

To ensure greater reliability for the econometric estimations, unit root tests were

	Dependent variable:			
	z_score			
	(1-GMM-1ST)	(2-GMM-1ST)	(3-GMM-1ST)	(4-GMM-1ST)
lag(z_score, 1)	0.053***	0.094***	0.141**	−0.047*
	(0.020)	(0.031)	(0.058)	(0.028)
der	−0.318***	−0.090	−0.431***	−0.385***
	(0.048)	(0.076)	(0.057)	(0.091)
compro	0.067	0.189**	−0.267**	−0.060
	(0.057)	(0.075)	(0.108)	(0.122)
off	−0.014	−0.023	0.096***	0.137***
	(0.016)	(0.020)	(0.024)	(0.021)
lev	−0.018***	−0.012***	−0.056***	−0.055***
	(0.002)	(0.003)	(0.005)	(0.004)
at_comp	0.665***	0.617***	−0.344**	0.551***
	(0.055)	(0.086)	(0.164)	(0.111)
pas_comp	−0.311***	−0.220***	−0.041	0.144
	(0.080)	(0.073)	(0.156)	(0.107)
ipca	−0.055***	−0.037**	−0.097***	−0.104**
	(0.021)	(0.018)	(0.036)	(0.049)
pib	0.181***	0.172***	0.173***	0.199***
	(0.004)	(0.008)	(0.016)	(0.012)
Bancos	71	55	16	24
Períodos	33	33	33	33
Observations	2343	1815	528	792
J-stat and p-value	33 (0.369)	32.954 (0.371)	33 (0.369)	32.966 (0.371)
AR(1) and p-value	−5.935 (0.000)	−4.191 (0.000)	−4.006 (0.000)	−5.885 (0.000)
AR(2) and p-value	−1.340 (0.180)	0.543 (0.587)	0.581 (0.561)	0.729 (0.466)
Wald test and p-value	30.394 (0.000)	48.671 (0.000)	5.033 (0.000)	3.822 (0.000)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4.5: Regression Results 3

	Dependent variable:			
	z_score			
	(1-GMM-L)	(2-GMM-L)	(3-GMM-L)	(4-GMM-L)
lag(z_score, 1)	0.020	0.057*	0.035	−0.014
	(0.026)	(0.033)	(0.067)	(0.032)
der	−0.544***	−0.359*	−0.411***	−0.481***
	(0.104)	(0.203)	(0.103)	(0.149)
compro	0.646***	0.803***	−0.155	0.122
	(0.103)	(0.129)	(0.156)	(0.221)
off	−0.049**	−0.049*	0.144***	0.318***
	(0.025)	(0.029)	(0.054)	(0.046)
lev	−0.008**	−0.003	−0.068***	−0.061***
	(0.004)	(0.005)	(0.011)	(0.011)
at_comp	0.770***	0.814***	−0.266	0.459**
	(0.075)	(0.097)	(0.261)	(0.187)
pas_comp	−0.375***	−0.263***	−0.400*	0.484***
	(0.091)	(0.081)	(0.229)	(0.114)
ipca	−0.052*	−0.034*	−0.125***	−0.093
	(0.029)	(0.020)	(0.048)	(0.069)
pib	0.187***	0.169***	0.233***	0.207***
	(0.007)	(0.010)	(0.019)	(0.015)
Bancos	71	55	16	24
Períodos	33	33	33	33
Observations	2343	1815	528	792
J-stat and p-value	32.411 (0.397)	32.749 (0.381)	31.517 (0.440)	31.831 (0.424)
AR(1) and p-value	−6.394 (0.000)	−11.657 (0.000)	−5.551 (0.000)	−4.710 (0.000)
AR(2) and p-value	−1.500 (0.133)	−0.527 (0.597)	0.100 (0.920)	0.919 (0.357)
Wald test and p-value	17416 (0.000)	20290 (0.000)	4205 (0.000)	3943 (0.000)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4.6: Regression Results 4

	Dependent variable:			
	z_score			
	(1-GMM-L5)	(2-GMM-L5)	(3-GMM-L5)	(4-GMM-L5)
lag(z_score, 1)	0.024	0.058*	0.018	−0.015
	(0.028)	(0.033)	(0.066)	(0.036)
der	−0.544***	−0.353*	−0.421***	−0.517***
	(0.101)	(0.204)	(0.106)	(0.182)
compro	0.658***	0.804***	−0.153	0.127
	(0.109)	(0.136)	(0.148)	(0.242)
off	−0.048*	−0.051*	0.151***	0.324***
	(0.027)	(0.030)	(0.056)	(0.051)
lev	−0.008**	−0.003	−0.068***	−0.059***
	(0.004)	(0.005)	(0.011)	(0.011)
at_comp	0.765***	0.813***	−0.272	0.404*
	(0.075)	(0.111)	(0.250)	(0.241)
pas_comp	−0.372***	−0.273***	−0.377*	0.503***
	(0.097)	(0.087)	(0.216)	(0.127)
ipca	−0.053*	−0.031	−0.127**	−0.082
	(0.030)	(0.025)	(0.052)	(0.078)
pib	0.186***	0.168***	0.236***	0.206***
	(0.006)	(0.011)	(0.021)	(0.015)
Bancos	71	55	16	24
Períodos	33	33	33	33
Observations	2343	1815	528	792
J-stat and p-value	32.250 (0.223)	32.551 (0.212)	30.925 (0.274)	31.498 (0.251)
AR(1) and p-value	−5.785 (0.000)	−2.671 (0.007)	−2.797 (0.005)	−4.789 (0.000)
AR(2) and p-value	−0.940 (0.347)	−0.162 (0.871)	0.037 (0.970)	0.660 (0.508)
Wald test and p-value	17037 (0.000)	19678 (0.000)	3874 (0.000)	3361 (0.000)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4.7: Regression Results 5

conducted, as described in Section 3.4. The unit root tests conducted by Levin et al. (2002) and Im et al. (2003) were performed using the *purtest* function of the *PLM* package for the R *software*. The parameters presented were obtained using intercepts as well as intercepts and trend lines. As verified by the Table 4.8 , the null hypothesis that temporal series have unit roots was rejected. Therefore, the stationarity of the panel is verified, which makes the application of the econometric model and the appropriate statistical inferences possible.

	LLC	IPS
z_score	-66,98***	-63,509***
der	-66,609***	-63,462***
compro	-67,258***	-64,185***
off	-70,348***	-66,527***
lev	-50,547***	-49,721***
rec_der	-63,874***	-61,078***
rec_aplic	-70,961***	-67,073***
rec_serv	-55,887***	-53,324***
at_comp	-63,247***	-60,62***
pas_comp	-86,16***	-81,955***

Table 4.8: Unit root tests results- model's variables

4.4 Implications of the Findings

The study has relevant implications for the stability of the Brazilian banking system. For example, the result that traditional accounting (*on-balance*) sheet leverage is an important source of individual risk for Brazilian banks, has been corroborated for most of the specifications. The macro-economic variables linked to inflation (*IPCA*) and economic growth (*PIB*), also influence the risk for Brazilian banking institutions. For commercial institutions, the adjustment of individual risk occurs quickly, as indicated by the lagged *zscore* variable. Within this context, the Brazilian case is significant, considering its highly uncertain environment with widely varying rates of growth and inflation.

The results of the specification of commercial banks are very close to the specification of the sample as a whole, which can reflects the concentration of the Brazilian banking industry among a few commercial banks. For this segment, the control variables that measure the composition of the assets and liabilities have statistical significance in relation to the individual risk of banks, indicating that the variation of these activities implies greater or lesser risk. Thus, commercial financial institutions should be attentive to their portfolios of assets and liabilities and their respective risks in terms of credit and banks runs, in order to maintain stability in their operations. For this segment, derivative

operations and *off-balance* sheet items did not present evidence of sources of risk. For the Brazilian market, these operations are not usual banking business, are little explored by commercial banks, and are usually used for more specific goals in other business niches.

In this sense, for treasury or non commercial banks a negative relationship has been found between derivative operations and the incurred risk. It should be noted that in this segment this type of operation is riskier given that these banks generally operate in this market not just to protect possible operational losses as well as increasing the returns of their security portfolios. On the other hand, the relation between *off-balance* sheet operations with risk is positive, indicating that these operations do not raise great concerns among market agents and regulatory bodies. It should be noted that the relationship between the composition of the assets and individual risk is negative for treasury banks unlike the findings for commercial banks. In this way, for this segment it displays a relationship that is different from the composition of portfolio for the commercial banks, given that this segment does not have a large proportion of credit operations. Thus, this segment possesses a negative relationship between repo operations in several of the specifications, which could indicate a source of risk for this type of operation and possible interest on the part of regulatory bodies.

In terms of foreign banks, the business model for this segment will generally subsidize the relationship between the headquarters and a Brazilian affiliate, with the operations of these banks generally displaying behavior that is different from domestic banks. It may be due to the fact that this segment receives funds from the headquarters and few deposits from individuals that there is a positive relationship between individual bank risk and the composition of the institution's liabilities, which is significant for several specifications. Also, just as for treasury banks, foreign banks possess an important source of risk in the form of derivative operations, which are essentially designed to protect against oscillations in foreign currency rates. Looking at off-balance sheet operations, the positive relationship found with the individual risk of banks indicates lesser concern on the part of market agents and regulatory bodies, given that often these operations deal with a variety of types of guarantees provided by the foreign headquarters to subsidize the operations of the Brazilian affiliate.

However, we should emphasize the limitations of the empirical analysis that we have conducted. The choice of the time period for the data, the number of sample observations and the selected variables, as well as the estimation method itself, are results of the best efforts devoted to this study of Brazil, and unlike Papanikolaou and Wolff (2014), it concerns an emerging financial market as compared to a developed (American) financial market. Also, Papanikolaou and Wolff (2014) analyzes systemic risk as well as the individual risk for institutions. The present work, given the limitations of the market

information available, measures just the individual risk for institutions.

In this way, these findings are important for market participants to evaluate the costs and benefits of the operations that they are subject to, given that some types of operations are riskier than others, and also for regulators so that they may apply norms that are pertinent to the evaluation and correction of risks that various banking segments are incurring.

Chapter 5

Concluding Remarks

Excessive leverage on the part of world banking institutions has been of concern to regulatory bodies and has now led to new regulations. Thus, those who research banking leverage now associate this subject with various types of risks that institutions face.

In this study, we have sought to identify the influence of leverage on the determination of risk for the Brazilian banking system. First of all, we conducted a bibliographic review of the area, gathering together the main studies concerning bank leverage within the context of the prudential regulation of capital. Secondly, we have constructed an accounting *proxy* to measure the influence of Brazilian banking leverage on the risks faced by these institutions.

In relation to the bibliographic review, based on the *ranking* of the *Association of Business Schools*, the selected references display clear results that relate the subject of banking leverage regulation to important objects of study within the fields of finance and economics, such as Financial Stability, Credit Risk and Systemic Risk.

Considering the bibliometric metric used, the literature review has its limitations. By changing criteria, articles can be included or excluded from the sample. The categories of the objects of study can also be modified, depending on the researcher's interests and approach. That being said, the structure of the metric for the bibliometric revision utilized offers important results and possibilities for future studies.

Of the sample of articles, 46% have financial stability as their objects of study, and it is interesting to note that these articles were published after the 2007 crisis. Before the financial crisis of 2007, important works mainly examined Moral Risk featuring the use of deposit insurance on the part of financial institutions.

It should be emphasized that Credit Risk considering the microprudential approach was the most often cited object of study, which is an important and expected result, given that it is one of the greatest risks to which financial institutions are exposed.

A gap in the studies of leverage was identified in terms of emerging countries, which represent the context for only 6% of the articles studied.

Given the analysis conducted of network, in terms of the size of its circumferences, in which the articles are measured by the largest number of co-citations (measured by the number of links), we observe that the articles by Gropp and Heider (2010) and Keeley (1990) are the most relevant in this analysis, which makes them references in researching the subject of banking leverage, which vary in accordance with the specific *cluster* to be studied. In terms of the co-word analysis results, conducted through the keywords selected by the authors, they indicate potential terms to be considered by researchers and potential future studies related to the subject of banking leverage. In addition to the central terms *banking*, *capital*, *regulation*, *basel* and their variations, the keywords *systemic risk*, *financial crisis* and *liquidity* were the most often used, which demonstrates the force of the macroprudential approach to studies related to bank leverage along the lines advocated by BIS (2010).

Given that Financial Stability was the most often found object of study, it should be emphasized that, according to Acharya and Thakor (2016), microprudential and macroprudential regulation do not only act in an independent manner, but also display a certain amount of tension between them. Thus, it may be considered important to not only examine macroprudential studies, which were the dominant approach in the literature before the 2007 financial crisis, but also microprudential studies beyond those linked to Credit Risk, which were well represented in the sample of articles studied. As an example, we can consider studies of Bank Runs as well as other microprudential objects of study and their relation to macroprudential objects of study, which the current work establishes as a suggestion for future research.

In relation to econometric estimations, the results offer interesting *insights* for supervision and banking regulation. Considering the overall sample of banks, derivative and on-balance sheet operations are the riskiest for Brazilian financial institutions. However, considering this specific segment, it has been verified that derivative operations are the riskiest for non-commercial banks, and on the other hand, *off balance* sheet operations have a positive relationship with risk in these banking institutions. Given that the focus of this type of segment is not typical banking operations of financial intermediation, such as credit operations and deposits, these results seem compatible with the business model of these institutions.

For commercial banks on the other hand, the parameters found for the control variables of traditional banking businesses composed of assets and liabilities indicate the importance of monitoring this type of operation for this segment, given that these banks realize their activities focused on typical operations of financial intermediation, such as

credit operations and raising funds through deposits by individuals. The findings for this segment indicate that the greater the proportion of credit operations among its assets, the lower the risk that these institutions will incur, and they also indicate that there is greater risk when there is a predominance of short-term funding in the liabilities of this banking segment. Considering that the Brazilian market is vulnerable to crises and instability, these results are in line with the country's economic environment.

For foreign banks, the results point out that derivative operations are a source of risk for this segment, as they are also for treasury banks. In this sense, given that foreign banks realize, in a general manner, currency hedging operations due to their exposure to foreign currencies with their headquarters and that they seek potential gains from this type of operation, these results provide important information for banking supervision and regulation, and the monitoring of these activities.

For the specifications examined, the macroeconomic variables have an impact on the risk for individual banking institutions, with the *PIB* variable being the most significant. Thus, public policy and the macroeconomic environment have a significant relationship with banks' appetite for risk, which should be considered when analyzing the banking environment.

Finally, the supervision of banking regulation should take into account the type of segment which banks operate in to monitor the risks incurred due to banking leverage in the most assertive way. Possible financial intermediation operations which are part of the business model of a given bank do not exactly fit into the activity of a bank within another segment, which makes these particularities important to the monitoring of risk diversification policy and any possible instability in the banking system.

Future studies, given the complexity of the banking system and the diversity of risks that banking institutions are subject to, could work with other metrics and indicators of the risk exposure of these institutions. For example, they could measure the impact of leverage on the systemic risk of the Brazilian market or utilize other measures of the risks for individual financial institutions which are different from those used in this work.

The regulatory information regarding leverage that has been promulgated by the Basel Committee under the guidance of the Central Bank of Brazil, will be available in greater quantity, given that it began to be publicized in December 2015. We suggest the utilization of this official information for risk analyses of Brazilian banks in future studies.

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