Três ensaios sobre a estrutura do setor bancário e as políticas de Bancos Centrais

Tese apresentada ao Programa de Doutorado em Economia da Universidade de Brasília como requisito à obtenção do título de Doutor em Ciências Econômicas

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Brasília, 2019

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Praes, Caio Rangel
P P897t Três ensaios sobre a estrutura do setor bancário e as políticas de Bancos Centrais / Caio Rangel Praes; orientador Daniel Oliveira Cajueiro. -- Brasília, 2019.
84 p.

Tese (Doutorado - Doutorado em Economia) -- Universidade de Brasília, 2019.

1. Competição bancária. 2. Regulação bancária. 3. Política monetária. I. Cajueiro, Daniel Oliveira, orient. II. Título.

Trabalho aprovado, Brasília, 2 de outubro de 2019.

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Resumo: O objetivo do trabalho é entender aspectos das inter-relações entre a estrutura do setor bancário e políticas públicas típicas de bancos centrais. No primeiro artigo, analisamos a política monetária e o seu potencial impacto sobre a competição bancária. Argumentamos que a política monetária afeta a competição bancária na medida em que não afete todos os bancos igualmente. Bancos de varejo dispõem de fontes de recurso relativamente insensíveis à taxa básica de juros e, portanto, são mais eficientes em um contexto de taxas básicas de juros elevadas. Como o modelo de negócios de banco de varejo possui barreiras à entrada significativas, conjecturamos que taxa de juros básica condiciona, em algum grau, a competição bancária. Tal conjectura é investigada tanto teoricamente quanto empiricamente. No segundo artigo, analisamos teoricamente os potenciais impactos da estrutura do setor bancário sobre as políticas prudenciais. O racional é simples: o processo decisório dos agentes varia conforme a estrutura do mercado. Em particular, argumentamos que há diferentes restrições ligadas à estrutura de mercado que mudam a forma em que os requerimentos prudenciais são incorporados nas decisões de preço e de risco. No terceiro artigo, invertemos tal pergunta e analisamos empiricamente o impacto de políticas prudenciais que discriminam o tratamento de acordo com o porte sobre a estrutura do mercado bancário. Argumentamos que o regime de proporcionalidade introduzido no Brasil fomentou o crescimento das instituições menores.

Palavras-chave: Competição bancária, regulação bancária, política monetária

Abstract: This work seeks to understand features governing the relationship between bank market structure and Central Bank policies. In the first article, we analyze how monetary policy can impact bank competition. We argue that monetary policy may not affect all banks in the same manner. In fact, retail funded banks are not as sensitive to variations in the policy rate and are more efficient in a high policy rate environment. As the business model of a retail bank carries significant barriers to entry, we argue that the policy rate is a factor in the level of bank competition. Such conjecture is investigated both theoretically and empirically. In the second article, we investigate how bank market structure may affect prudential policies. The underlying hypothesis is straightforward: the decision-making is conditioned by the market structure. In particular, we argue that varying market structure constraints change the way prudential requirements are reflected in loan rates and in bank risk-taking. In the third article, we reverse this question and try to identify the empirical effects of prudential policies under a size-based proportionality framework on bank competition. We argue that the new proportionality regime introduced in Brazil fostered the growth of the smaller banks.

Key words: Bank competition, monetary policy, banking regulation

“We have not succeeded in answering all our problems. The answers we have found only serve to raise a whole set of new questions. In some ways we feel as confused as ever, but we believe we are confused on a higher level and about more important things.”

Posted outside the mathematics reading room

Tromsø University

Contents

Agradeço a Deus, por tudo, à minha família, pelo fundamental, ao meu orientador, pelo apoio dado em inúmeras formas, aos membros da banca, pelas contribuições e comentários, aos meus chefes, em especial o Ricardo Moura, pelo suporte inestimável e inesperado.

Introduction

This work contributes to the literature in three ways. First, by investigating how monetary policy may affect bank competition. While the literature has identified the beginning of our story, by establishing that bigger banks are less affected by monetary policy shocks (TABAK, LAIZ, and CAJUEIRO, 2013), and its end, by pointing out that spreads increase when the policy rate increase (GERTLER and KARADI, 2015), there is a void in between that we seek to fill.

Our starting point is that monetary policy does not seem to affect all banks in the same manner, and that funding strategies can go a long way in explaining differences in bank behavior (KHAN, SCHEULE, and WU, 2017). From the assumption that retail funded banks are not as sensitive to variations in the policy rate and are more efficient in a high policy rate environment, we argue that the policy rate is a factor in the level of bank competition using a simple theoretical model. Such reasoning is tested on large cross-country panels, both at the country-level and at the bank-level, and we find compatible results.

The second and the third contributions of this work are related to the study of prudential policies. We explore the effects of prudential policies under multiple market competition regimes using a theoretical model that allows us to compare how prudential polices fare in each environment. Our results contribute to the literature by enriching the model developed by ARPING (2017), enabling it to be a tool to evaluate prudential policies. By doing so, we reach novel conclusions regarding the effects of prudential policies. For instance, we show that capital and liquidity requirements may actually reduce credit spreads, a counterintuitive conclusion that, to the best of our knowledge, is original.

Last but not least, we open a new frontier in the study of prudential policies by focusing on the competition effects of size-based proportionality, that is, prudential policies whose requirements vary according to the size of the bank. Our main point underlying this contribution is that understanding size-based proportionality is fundamentally different, in terms of its effects on competition, from prudential requirements applied equally to all institutions or specifically to institutions on a case-by-case basis. As far as we are aware, no other work had this research question. Our work is centered on the empirical effects of size-based proportionality measures introduced in Brazil during the 2010s.

Chapter 1 – Differences in funding: how monetary policy may affect bank concentration and spreads

1. Introduction

This chapter offers empirical evidence that monetary policy influences both the banking sector structure, as measured by its concentration, and the banking lending spread. Using a large cross-country data set, we find that increases in the policy rate are associated with higher bank concentration and wider spreads. To make sense of the results, we posit a simple model that provides an explanation based on differences in funding strategies. Our model assumes that banks with retail funding are less sensitive to variations in the policy rate, a hypothesis we verify with bank-level data from BANKSCOPE.

We argue that a high policy rate environment favors funding strategies that entail significant entry costs, making them relatively efficient. Thus, when the policy rate increases, business is diverted to banks with policy rate insensitive funding strategies and away from banks with market-based funding strategies, which cannot seamlessly switch to these strategies due to the associated entry costs. Facing higher marginal costs, banks with market-based funding strategies reduce their output. As policy rate insensitive funding strategies have high fixed costs, they tend to be adopted by the largest banks[1], which now face relatively inefficient competitors. As a result, concentration might increase and spread might widen.

Our work circumvents more in-depth discussions on the contentious issue of what exactly characterizes the level of competition and whether it is always reflected by bank concentration and by lending spreads. In fact, although concentration and price margin measures alone may not determine the competitiveness of the banking sector, the scope of this work is not to ultimately discern other possible drivers of bank competition or, more importantly, to ascertain its level. Therefore, we argue that a more direct approach is warranted. For instance, the usual rationale for using structural metrics of competition instead of measures of performance or measures of concentration usually involves country-specific factors affecting entry (see CLAESSENS and

[1] Using the data from BANKSCOPE, we find that only in the United States of America and in Cape Verde the average correlation between loan market share and the proportion of deposit funding is negative. In the case of Cape Verde, some years have only two observations and they skew the results.

LAEVEN, 2004), issues we do not seek to investigate. We are interested solely in the marginal effects of monetary policy on bank competition. In other words, while it might be true that a concentrated banking sector can display intense competition that point is not relevant to this work unless simultaneous increases in concentration and in price margin reflect an unchanged degree of competition.

Establishing the empirical relevance of the effect of monetary policy on the banking sector market structure and conduct has broad implications. Besides the welfare effects inherent to wider spreads and less market depth, the monetary policy itself may be affected (see VAN LEUVENSTEIJN et al., 2008). For instance, a non-competitive banking sector may hinder the transmission of monetary policy, as LENSINK and STERKEN (2002) have argued. However, we argue that the main practical implication of this finding is that reductions in the monetary policy rate or in the reserve requirement rate on term deposits potentially amount to pro-competition policies for the banking sector.

This chapter is organized in the following manner. Section 2 discusses the related literature, presenting a brief review of the studies on the relationship between bank competition and monetary policy, and on how monetary policy may affect spreads. In section 3, we lay out the theoretical model and the accompanying results we take to the data, which is described in the next section. Sections 5 and 6 contain the methodology and the empirical results, respectively, while section 7 provides bank-level estimates. Section 8 ends the chapter.

2. Literature review

The literature has established that policy rates influence the behavior of banks. In fact, the efficacy of the monetary policy transmission mechanism hinges, to an important extent, on how banks pass the policy-induced changes in money market interest rates along to their customers, the so-called bank lending channel of monetary policy (see KASHYAP and STEIN, 1995 and 2000). However, the literature on how monetary policy affects banking sector market structure and conduct is scant.

That monetary policy can have a bearing on bank competition is a point first made by BAGLIANO, DALMAZZO, and MARINI (2000). Using the framework of ROTEMBERG and SALONER (1986), they show how monetary policy decisions can influence banks' incentives to collude. In fact, the policy rate can be viewed as the cost of adding capacity in the short-term and worthwhile deviations from an implicit collusion arrangement require either idle capacity or the ability to increase capacity in the short-term. Therefore, the stability of such anticompetitive arrangements is affected by the policy rate. BAGLIANO, DALMAZZO, and MARINI (2000) demonstrate that a countercyclical monetary policy may foster implicit collusion among banks, since the higher cost of funding during booms would erode capacity exactly when deviations would be otherwise more likely. Their conclusion is a new contribution to the literature concerned with the bank lending channel of monetary policy, as bank competition would function as an indirect amplification mechanism of movements in the policy rate.

TOOLSEMA (2004) develops a different model of competition to analyze how monetary policy may affect the degree of market power and reaches an opposing conclusion. TOOLSEMA (2004) applies the SALOP (1979) model of horizontal product differentiation and confirms the finding of BAGLIANO, DALMAZZO, and MARINI (2000) that monetary policy has consequences to the market power of banks. However, according to TOOLSEMA (2004), the LERNER (1934) index[2] is negatively related to the policy rate, while the implicit collusion model of BAGLIANO, DALMAZZO, and MARINI (2000) would lead to the opposite conclusion. The conclusion of TOOLSEMA (2004) rests on the fact that banks may not be able to fully incorporate the higher marginal cost represented by the higher policy rate into their lending rates, depressing their Lerner index.

Our work reinforces the conclusions of BAGLIANO, DALMAZZO, and MARINI (2000) and also provides an amplification mechanism to monetary policy based on bank competition. The usual tool for monetary policy, small movements in short term rates, appear to have a significant effect on economic activity. GERTLER and KARADI (2015) show that substantial movements in credit costs following modest changes in short rates are mainly because of term premium and credit spreads. In explaining their findings, they point to the various theories of the bank lending channel and argue that the tightening of the monetary policy carries a tightening of financial constraints. We, on the other hand, focus on the repercussions on competition but reach a similar conclusion, that is, spreads may amplify movements in the policy rate.

[2] The Lerner index is the mark-up over marginal cost, shown as a percentage.

3. A simple model of bank competition

We develop a simple model of bank competition to give a rigorous footing to our conjectures. Our model does not provide the direct specification of the equations we take to the data. In other words, we are not interested in estimating the specific parameters embedded in its formulation, but on clearly articulating our conjectures.

Following LEUVENSTEIJN et al. (2007), we consider a banking sector in which banks produce a single product (or portfolio of banking products) in a Cournot-Nash setting[3] and face a linear demand curve, that is, price p_i charged by bank i depends linearly on the output of bank i and of the other banks, as shown in equation 1 below:

$$p_i(q_i, q_{j\neq i}) = a - bq_i - d\Sigma_{j\neq i}q_j \quad \text{(eq. 1)}$$

However, unlike LEUVENSTEIJN et al. (2007), we assume that banks have a different marginal cost depending on their business model. In the model considered, banks can rely either on wholesale funding or on retail funding. We assume that the cost of funding of retail banks is lower than the cost of market-based wholesale funding and not as sensitive to the policy rate. That is, each bank has marginal cost mc_i which is assumed to be $\beta_R + \alpha_R r_{pol}$ for a retail-funded bank or $\beta_M + \alpha_M r_{pol}$ for a wholesale-funded bank, where $\beta_R \leq \beta_M$, $\alpha_R < \alpha_M$, r_{pol} stands for the short-term policy rate.

The assumption that banks are not equally affected by monetary policy is not new. Using data from European banks, FUNGÁČOVÁ, SOLANKO, and WEILL (2014) find that banks with more market power, as measured by the Lerner index, are less affected by monetary policy and point to funding advantages as a probable cause. Similarly, but using data from Brazilian banks, TABAK, LAIZ, and CAJUEIRO (2013) show that larger banks are less impacted by monetary policy shocks.

By distinguishing banks based on funding strategies, we acknowledge the findings of DEMIRGÜÇ-KUNT and HUIZINGA (2010), as they show that differences in funding are related to performance, with deposit funding being a driver for increased performance and stability. In a

[3] SCHLIEPHAKE and KIRSTEIN (2013) show that even if banks compete on prices, the existence of capital requirements provides a justification for the use of a Cournot-Nash setting.

similar vein, others have pointed that how much asset risk banks take, i.e. their output, depends on their source of funding. VAZQUEZ and FEDERICO (2015) show that banks with weaker structural liquidity, that is, more dependent on wholesale funding, were more vulnerable to failure during the Global Financial Crisis (GFC). KHAN, SCHEULE, and WU (2017) confirm that banks with higher deposit ratios took less risk during the GFC, but also found that they usually do the opposite, as evidenced by higher risk-weighted assets.

We also assume that there is a fixed number of retail-funded banks N_R and that the overall number of banks N is also constant. With symmetry, equation 1 becomes equations 2 and 3 below:

$$p_R(q_R, q_M) = a - bq_R - d\big((N_R - 1)q_R + (N - N_R)q_M\big) \quad \text{(eq. 2)}$$
$$p_M(q_R, q_M) = a - bq_M - d(N_R q_R + (N - N_R - 1)q_M) \quad \text{(eq. 3)}$$

That is, we have a symmetrical equilibrium given by four variables (p_R, q_R, p_M, q_M), and we show that an increase in r_{pol} leads to an increase in the market share of retail banks at the same time that it allows these banks to widen their spreads. In other words:

Proposition 1. *If the sensitivity of the marginal cost of the wholesale-funded banks to the monetary policy, α_M, is sufficiently greater than the sensitivity of the marginal cost of the retail-funded banks to the monetary policy, α_R, then the derivative of the output of a retail funded-bank q_R with respect to the policy rate r_{pol}, $\partial q_R/\partial r_{pol}$, is non-negative while the derivative of the output of a wholesale funded-bank q_M with respect to the policy rate r_{pol}, $\partial q_M/\partial r_{pol}$, is negative. In other words, if the larger banks are retail-funded, the derivative of bank concentration with respect to the policy rate r_{pol} is positive under such assumptions.*

Proposition 2. *If the overall number of banks, N, is sufficiently large and sufficiently greater than the number of retail-funded banks, N_R, then the derivative of the price charged by retail-funded banks $p_R(q_R, q_M)$ with respect to the policy rate r_{pol}, $\partial p_R(q_R, q_M)/\partial r_{pol}$, is bigger than one. In other words, an increase in the policy rate leads to a wider spread.*

We highlight that the agents we call banks may not be banks in the legal sense of a chartered bank. For instance, we include in our definition of wholesale-funded banks any credit granting entity which obtains funding at rates highly correlated to the policy rate. Therefore, a large number of “banks” is not a strong assumption for economies with developed capital markets. For instance, private credit funds and securitization structures are not wholesale-funded banks but may compete with retail-funded banks in the credit market as if they were.

Since Propositions 1 and 2 disregard entry and exit decisions, we interpreted them as short-term marginal effects. However, if we consider entry and exit decisions, monetary policy also has a clear implication in terms of bank competition in the long run. Assuming that the entry costs required for a retail funding operation are E_R while the entry costs for wholesale funding operation is E_M, $E_R > E_M$, then a very low policy rate, that is, $r_{pol} \sim 0$, would effectively undermine any funding advantage obtained by incurring E_R. Therefore, the effective entry cost to the credit market would be E_M. In other words, no entrant to the credit market would opt for a relatively costly commercial bank charter in a very low policy rate environment, even though the overall amount of credit granted would probably grow in this circumstance.

4. Data

Several datasets are combined for the estimations. We collect most of the variables the Global Financial Development Database (GFDD) of the World Bank (see ČIHÁK et al, 2012). For the monetary policy rate, we use the Central Bank policy rate as found in the International Financial Statistics (IFS) of the International Monetary Fund. The variables on reserve requirements are from the dataset of FEDERICO, VEGH, and VULETIN (2014). As for a list of the countries and periods in which monetary policy followed an inflation targeting regime, this information came from FAZIO, TABAK, and CAJUEIRO (2015). Contestability variables are from surveys by BARTH, CAPRIO, and LEVINE (2013) and there are also financial freedom indexes calculated by the Heritage Foundation, also as proxies for the presence of regulatory constraints on entry. Finally, the use of macroprudential instruments is from CERUTTI, CLAESSENS, and LAEVEN (2017), who devised a Macroprudential Index summing dummies for the application of 12 macroprudential policies. The variables and their main statistics are presented in Tables 1, 2, and 3 below. All variables represent country-year observations, of which the most recent year is 2014.

Table 1. Description and Definition of Variables

Variable name	
Bank concentration	Assets of three largest commercial banks as a share of total commercial banking assets. Source: Čihák et al, 2012 (GFDD).
Bank lending-deposit spread	Difference between lending rate and deposit rate. Lending rate is the rate charged by banks on loans to the private sector and deposit interest rate is the rate offered by commercial banks on three-month deposits. Source: Čihák et al, 2012 (GFDD).
Policy rate	Central bank policy rate, percent per annum. Source: International Financial Statistics (IFS)
Deposit money banks' assets to GDP	Total assets held by deposit money banks as a share of GDP. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Source: Čihák et al, 2012 (GFDD).
Nonbank financial institutions' assets to GDP	Total assets held by financial institutions that do not accept transferable deposits but that perform financial intermediation by accepting other types of deposits or by issuing securities or other liabilities that are close substitutes for deposits as a share of GDP. Source: Čihák et al, 2012 (GFDD).
Inflation targeting regime	Countries and periods in which monetary policy followed an inflation targeting regime. Source: Fazio, Tabak and Cajueiro, 2015.
Financial freedom	Financial freedom is a measure of banking efficiency as well as a measure of independence from government control and interference in the financial sector. Source: Heritage Foundation.
Divergence of reserve requirements rates based on term	For countries and periods in which there were different reserve requirements for term deposits and demand deposits, this variable is difference between rate for term deposits and demand deposits. In case there were multiple rates for either demand deposits or term deposits, the difference is calculated between averages. Source: Federico, Vegh, and Vuletin, 2014.
Entry into banking requirements	Entry into banking requirements. Higher values indicate greater stringency. Source: Barth, Caprio and Levine, 2013.
GDP per capita	GDP per capita is gross domestic product divided by midyear population. Data are in constant 2005 U.S. dollars. Source: Čihák et al, 2012 (GFDD).
Macroprudential Index	Use of macroprudential policies, covering 12 of them. Source: Cerutti, Claessens, and Laeven, 2017.

Based on the variables described in Table 1 above, we also design several dummies. There is a dummy for bank concentration, which is unity if the variable bank concentration is above 70% (57% of the sample). In the same fashion, there is a dummy for entry requirements, which is one if the average for the entry requirements metric in all four surveys (1999, 2002, 2006 and 2011) is above 7 (54% of the sample). There is a dummy for nonbanks participation, which is one if nonbank financial institutions' assets are over 40% of the total assets of nonbanks and banks combined (13% of the sample). We also have a dummy for rich countries, which is unity if GDP per capita is over thirty thousand 2005 US dollars (9% of the sample). Finally, a dummy for financial freedom is one if financial freedom is 60 or higher (32% of the sample).

Table 2. Descriptive Statistics

Variable name	Mean	Median	Std. Deviation	Min	Max
Bank concentration	72.76806	74.27375	20.0805	17.2872	100
Bank lending-deposit spread	7.890605	6.10833	7.379928	0.025001	91.7583
Policy rate	8.146759	5	13.08901	0.02	200
Deposit money banks' assets to GDP	42.23331	30.70035	37.25959	0.000026	263.126
Nonbank financial institutions' assets to GDP	14.26457	6.34133	24.29674	0.000448	174.427
Financial freedom	4.838321	5	1.976438	1	9
Divergence of reserve requirements rates based on term	-0.0225039	0	0.0711225	-0.72	0.095
Entry into banking requirements (2011 Survey)	7.708075	8	1.031641	0	8
GDP per capita	9206.248	2535.22	15329.66	69.5792	158603
Macroprudential Index	1.755102	1	1.544939	0	8

Table 3. Correlations

	Bank concentration	Bank lending-deposit spread	Financial freedom	GDP per capita	Entry into banking requirements (All Surveys)	Nonbank financial institutions' assets to GDP
Bank concentration	1					
Bank lending-deposit spread	-0.1227	1				
Financial freedom	0.0313	0.0557	1			
GDP per capita	0.2079	-0.2843	0.1733	1		
Entry into banking requirements (All Surveys)	0.1537	0.1437	-0.0569	0.0131	1	
Nonbank financial institutions' assets to GDP	-0.0345	-0.2221	0.1052	0.3375	-0.0541	1

5. Methodology

To investigate whether the conjectures put forth in section 3 hold, we carry out two sets of estimations, pooling OLS and fixed-effects, based on variants of the following equations:

$$Spread_{i,t} = Const + \beta_1 Policy\ Rate_{i,t}^2 + \beta_2 Policy\ Rate_{i,t}^2 I_{char.} + \varepsilon_{i,t} \quad \text{(eq. 4)}$$
$$Concentration_{i,t} = Const + \beta_3 Policy\ Rate_{i,t} + \beta_4 Policy\ Rate_{i,t} I_{char.} + \varepsilon_{i,t} \quad \text{(eq. 5)}$$

where $I_{char.}$ stands for the dummy variables described in the previous section. In eq. 4, we use the squared policy rate to account for possible short-term price rigidities, but the alternative regression considering the policy rate is also shown in the Annex.

Underlying these econometric specifications is the assumption that policy rate movements, $Policy\ Rate_{it}$, are not caused by variations in lending spreads, $Spread_{it}$, in bank concentration, $Concentration_{it}$, or by movements in common drivers. The hypothesis on which the validity of these regressions hinges is that changes in the policy rate are uncorrelated to the drivers of bank concentration and lending spreads with which they do not have a causality link starting in the policy rate. Assuming that lending spreads or bank concentration are not targets for monetary policy, the only remaining source of bias is simultaneity with other factors.

In fact, higher policy rates may be a reaction of the monetary authorities to increases in macroeconomic risks that are simultaneously but independently factored into the credit spreads. Such risks could be diversifiable to large, internationally active banks and, therefore, the more diversified portfolio of the biggest banks would render them more efficient. However, this narrative needs the assumption of the incompleteness of the financial system, that is, the inexistence of financial instruments that would afford small banks protection to a diversifiable risk, an assumption that is unlikely to hold in globalized markets. The GFC has shown that even small institutions can easily expose themselves to portfolios that bear no connection to their immediate economic environment.

Another possible narrative for simultaneity bias stems from the literature on financial accelerator and credit constraints (see, for instance, BERNANKE, 2007). If an increase in the policy rate leads to the devaluation of collaterals, loan spreads must increase to take into account the heightened credit risk. Also, if one assumes that smaller firms have higher financial constrains in this sense, then their credit availability is affected in a more significant proportion. Finally, if smaller credit institutions were specialized in granting loans to smaller firms, then there would be an ensuing increase in bank concentration. However, the results on bank concentration are similar when reserve requirements rates are used instead of policy rates.

We regress bank concentration on a measure of the reserve requirements that would affect the marginal costs of banks according to their funding base in a manner similar to the policy rate. The measure is the difference between the reserve requirements rates of term deposits and demand deposits, which is a measure that roughly captures a wedge on the marginal costs of banks with a retail funding base and of banks without it. Therefore, the propositions of section 3 would remain mostly unchanged when such measure is used instead of the policy rate, but the link of reserve requirement rates to firm's financial constraints is tenuous at best.

Finally, it could be the case that monetary policy is regularly used in conjunction with macroprudential instruments and we are unintentionally observing the effects of the latter. For instance, in the event of an overheating of the credit market, it is plausible that policy-makers would also introduce prudential requirements, especially after the GFC. Such countercyclical introduction of prudential requirements could be cause of the increase of bank concentration if larger banks cope better with their costs, and of the wider spreads if the costs of adhering to prudential requirements are incorporated into prices. We rule out this possibility by controlling for the introduction of macroprudential requirements, using the Macroprudential Index developed by CERUTTI, CLAESSENS, and LAEVEN (2017).

In any case, we also test the lag of the policy rate as an instrumental variable, which would clean the variation on the policy rate of any other simultaneity bias.

6. Empirical results

We find that the policy rate affects bank concentration, in ways that are compatible with proposition 1. As shown by regressions (2) and (7) in tables 4, 5 and 6 below, the effect is primarily due to economies in which the banking sector is heavily concentrated (bank concentration is above 70%) and is stronger in economies which nonbanks are a relevant part of the credit market.

The first finding could be interpreted in terms of Proposition 1 if economies with such concentrated banking sectors were more likely to have its biggest banks with retail funding or, by the same token, if economies with less concentrated banking sectors were more likely to have wholesale funded-banks among its biggest banks. The United States is a case in point, for its banking sector is relatively fragmented and there is a negative correlation between deposit funding and size in the American loan market.

As for economies in which nonbanks are a relevant part of the credit market, they are the markets where business could be diverted towards banks with retail funding at the highest intensity, for obvious reasons, since nonbanks by definition do not take deposits.

As can be seen in regression (6) in tables 4, 5 and 6 below, the effect is actually reversed in economies following inflation targeting regimes. Our theoretical framework is not equipped to deal with dynamic effects, but it seems plausible that a more transparent regime will lead to some anticipation and better planning on the part of the banks, weakening the short-term effect on concentration we posit, but that is a point worthy of further investigation and beyond the scope of this work.

Table 4. Fixed-effects panel-data estimation with year dummies, bank concentration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate	0.187439 ***	-0.721379 ***	0.270088	0.286758 ***	0.184818 ***	0.156780 ***	0.269325 ***
Std. Err.	*0.039862*	*0.265801*	*0.284359*	*0.104527*	*0.042102*	*0.049772*	*0.061431*
Policy rate$I_{bank\ concentration}$*		1.022339 ***					
Std. Err.		*0.290096*					
Policy rate$I_{entry\ requirements}$*			-0.617498				
Std. Err.			*0.539063*				
Policy rate$I_{financial\ freedom}$*				-0.244743 *			
Std. Err.				*0.130999*			
Policy rate$I_{rich\ country}$*					-1.030048		
Std. Err.					*0.714116*		
Policy rate$I_{inflation\ targeting}$*						-1.482007 ***	
Std. Err.						*0.448502*	
Policy rate$I_{nonbanks\ participation}$*							1.486664 ***
Std. Err.							*0.542787*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES
Prob > F	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000
Number of groups	78	78	75	58	77	78	32
Average obs per group	12.8	12.8	7.9	13.0	13.0	12.8	10.1
Number of observations	1001	1001	595	756	998	1001	324

* 10%, ** 5%, *** 1%; Robust Std. Errors

Table 5. Fixed-effects panel-data estimation without year dummies, bank concentration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate	0,217483 ***	-0,719878 **	0,459466	0,328172 ***	0,221653 ***	0,183994 ***	0,129060 ***
Std. Err.	*0,038847*	*0,275508*	*0,313454*	*0,123593*	*0,040052*	*0,034657*	*0,046675*
*Policy rate*I $_{bank\ concentration}$*		1,063344 ***					
Std. Err.		*0,308190*					
*Policy rate*I $_{entry\ requirements}$*			-0,368524				
Std. Err.			*0,613860*				
*Policy rate*I $_{financial\ freedom}$*				-0,268929 *			
Std. Err.				*0,149653*			
*Policy rate*I $_{rich\ country}$*					-0,465095		
Std. Err.					*0,410992*		
*Policy rate*I $_{inflation\ targeting}$*						-1,432161 ***	
Std. Err.						*0,486691*	
*Policy rate*I $_{nonbanks\ participation}$*							-0,141800
Std. Err.							*0,425677*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	NO	NO	NO	NO	NO	NO	NO
Prob > F	0,0000	0,0007	0,3418	0,0257	0,0000	0,0000	0,0326
Number of groups	78	78	75	58	77	78	32
Average obs per group	12,8	12,8	7,9	13,0	13,0	12,8	10,1
Number of observations	1001	1001	595	756	998	1001	324

* 10%, ** 5%, *** 1%; Robust Std. Errors

Table 6. Pooling OLS estimation, bank concentration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate	0.092029 **	-1.431848 ***	0.153834	0.271061 ***	0.100671 **	0.124456 ***	0.120618 **
Std. Err.	*0.040845*	*0.281054*	*0.165516*	*0.073193*	*0.040918*	*0.042272*	*0.056206*
*Policy rate*I* $_{bank\ concentration}$		1.908466 ***					
Std. Err.		*0.286820*					
*Policy rate*I* $_{entry\ requirements}$			-0.347689				
Std. Err.			*0.234404*				
*Policy rate*I* $_{financial\ freedom}$				-0.335452 ***			
Std. Err.				*0.114314*			
*Policy rate*I* $_{rich\ country}$					0.450721		
Std. Err.					*0.441059*		
*Policy rate*I* $_{inflation\ targeting}$						-1.303447 ***	
Std. Err.						*0.161169*	
*Policy rate*I* $_{nonbanks\ participation}$							0.229675
Std. Err.							*0.419667*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	NO	NO	NO	NO	NO	NO	NO
Prob > F	0.0245	0.0000	0.3084	0.0005	0.0359	0.0000	0.0746
R-squared	0.0024	0.2661	0.0042	0.0187	0.0036	0.0454	0.0054
Number of observations	1001	1001	595	756	998	1001	324

* 10%, ** 5%, *** 1%; Robust Std. Errors

We found that the policy rate affects banks' lending spread in ways that are compatible with Proposition 2. As can be seen in regression (3) in tables 7, 8 and 9 below, the effect seems to be much stronger in jurisdictions where the entry requirements are more burdensome, thus, places where a transition to a strategy of retail funding is likely to carry higher fixed costs. Besides, as shown by regression (5) in tables 7, 8 and 9 below, the effect is also more significant in rich countries, which probably have a more mature capital market and, thus, a larger number of credit granting institution whose funding is obtained at rates highly correlated to the policy rate (a bigger N), as explicitly considered in section 3.

Table 7. Fixed-effects panel-data estimation with year dummies, bank lending-deposit spread

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate ^{2}	0.004159 ***	0.003965 **	0.001743 ***	0.004385 ***	0.004849 ***	0.004126 ***	0.001319
Std. Err.	*0.001361*	*0.001058*	*0.000491*	*0.000822*	*0.001201*	*0.001358*	*0.001967*
Policy rate ^{2} $*I_{bank\ concentration}$		0.000293					
Std. Err.		*0.001012*					
Policy rate ^{2} $*I_{entry\ requirements}$			0.012279 **				
Std. Err.			*0.005409*				
Policy rate ^{2} $*I_{financial\ freedom}$				-0.002806			
Std. Err.				*0.001865*			
Policy rate ^{2} $*I_{rich\ country}$					0.020568 **		
Std. Err.					*0.008071*		
Policy rate ^{2} $*I_{inflation\ targeting}$						0.017714 *	
Std. Err.						*0.009290*	
Policy rate ^{2} $*I_{nonbanks\ participation}$							0.001884
Std. Err.							*0.005444*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-
Number of groups	71	69	64	55	70	71	30
Average obs per group	12.8	10.2	6.9	13.1	12.8	12.8	11.5
Number of observations	910	702	442	720	896	910	344

* 10%, ** 5%, *** 1%; Robust Std. Errors

Table 8. Fixed-effects panel-data estimation without year dummies, bank lending-deposit spread

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate ^{2}	0.003950 ***	0.004162 ***	0.001962 ***	0.004736 ***	0.004774 ***	0.003925 ***	0.000839
Std. Err.	*0.001440*	*0.001094*	*0.000358*	*0.000985*	*0.001193*	*0.001443*	*0.002636*
Policy rate ^{2} *$I_{bank\ concentration}$		0.000357					
Std. Err.		*0.001004*					
Policy rate ^{2} *$I_{entry\ requirements}$			0.013075 **				
Std. Err.			*0.005589*				
Policy rate ^{2} *$I_{financial\ freedom}$				-0.002408			
Std. Err.				*0.001591*			
Policy rate ^{2} *$I_{rich\ country}$					0.006566		
Std. Err.					*0.007130*		
Policy rate ^{2} *$I_{inflation\ targeting}$						0.022254 ***	
Std. Err.						*0.008080*	
Policy rate ^{2} *$I_{nonbanks\ participation}$							0.001189
Std. Err.							*0.002654*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	NO	NO	NO	NO	NO	NO	NO
Prob > F	0.0077	0.0000	0.0000	0.0000	0.0003	0.0009	0.0000
Number of groups	71	69	64	55	70	71	30
Average obs per group	12.8	10.2	6.9	13.1	12.8	12.8	11.5
Number of observations	910	702	442	720	896	910	344

* 10%, ** 5%, *** 1%; Robust Std. Errors

Table 9. Pooling OLS estimation, bank lending-deposit spread

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Policy rate ^{2}	0.005707 ***	0.010595 ***	0.003097	0.005280 ***	0.006214 ***	0.005679 ***	0.008037 *
Std. Err.	*0.000964*	*0.002192*	*0.002784*	*0.001474*	*0.001103*	*0.000949*	*0.004565*
Policy rate ^{2} $*I_{bank\ concentration}$		-0.006672 ***					
Std. Err.		*0.002346*					
Policy rate ^{2} $*I_{entry\ requirements}$			0.048441 ***				
Std. Err.			*0.009073*				
Policy rate ^{2} $*I_{financial\ freedom}$				-0.001382			
Std. Err.				*0.001819*			
Policy rate ^{2} $*I_{rich\ country}$					-0.069774 ***		
Std. Err.					*0.009530*		
Policy rate ^{2} $*I_{inflation\ targeting}$						0.067510 ***	
Std. Err.						*0.009985*	
Policy rate ^{2} $*I_{nonbanks\ participation}$							-0.019650 ***
Std. Err.							*0.004513*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	NO	NO	NO	NO	NO	NO	NO
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.1501	0.1559	0.2535	0.0729	0.1791	0.3070	0.0481
Number of observations	910	702	442	720	896	910	344

* 10%, ** 5%, *** 1%; Robust Std. Errors

As we ponder the robustness of the results we found, we estimate a fixed-effects regression of bank concentration on the difference between the reserve requirements rates of term deposits and demand deposits. Increases in such difference alter the relative efficiency of demand deposits, the quintessential form of retail funding, to the advantage of banks with retail funding strategies. However, as not all credit granting entities can take deposits, whether term deposits or demand deposits, the effects are not expected to be the same as that in the case of the policy rate being considered. For instance, an overall increase in reserve requirements may cause all banks to lose market share to other credit-granting entities such as funds that do not need to hold such mandatory reserves. Therefore, Proposition 1 may not fully apply. In any event, controlling for the average reserve requirement[4], an increase in the difference of the reserve requirement rate applicable to term deposits to that applicable to demand deposits does increase bank concentration, as shown in table 10 below.

[4] Average in terms of the different types of deposits, not weighted by volume.

Table 10. Fixed-effects panel-data estimation, bank concentration

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Avg. RR	17.392520	20.087940	-2.629590	19.200970	19.009820	16.552960	15.865570
Std. Err.	*19.815120*	*19.990060*	*9.164372*	22.493440	*20.221200*	*20.226790*	*24.773800*
Div. RR	44.152410 ***	50.005810 ***	246.236400 ***	42.109090 ***	43.181840 ***	45.408830 ***	34.717200 **
Std. Err.	*11.619720*	*11.025690*	*71.999270*	*10.721590*	*11.901440*	*9.401673*	*13.529130*
*Div. RR*I* $_{bank\ concentration}$		-115.336700 ***					
Std. Err.		*41.231440*					
*Div. RR*I* $_{entry\ requirements}$			-166.332000 *				
Std. Err.			*92.486750*				
*Div. RR*I* $_{financial\ freedom}$				-49.853760			
Std. Err.				*34.329200*			
*Div. RR*I* $_{rich\ country}$					199.842900		
Std. Err.					*175.531700*		
*Div. RR*I* $_{inflation\ targeting}$						9.849455	
Std. Err.						*20.581960*	
*Div. RR*I* $_{nonbanks\ participation}$							6626.896000 *
Std. Err.							*3684.807000*
Constant	YES	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES
Prob > F	0.0000	0.0000	0.0082	0.0000	0.0000	0.0000	-
Number of groups	76	76	74	55	75	76	34
Average obs per group	15.8	15.8	9.1	16.5	15.8	15.8	12.4
Number of observations	1199	1199	676	906	1184	1199	421

* 10%, ** 5%, *** 1%; Robust Std. Errors

Table 11 below displays the results when the lag of the policy rate is used as an instrument in a fixed-effects regression with year dummies. When compared to the same regression without the use of the instrumental variable, the results appear to be stronger.

Table 11. Fixed-effects (within) IV regression with year dummies

Variable	Bank concentration	bank lending-deposit spread
Policy rate	0.749588 ***	
Std. Err.	*0.137242*	
Policy rate ^{2}		0.007071 ***
Std. Err.		*0.0005818*
Constant	YES	YES
Year dummies	YES	YES
Prob > Chi2	0.0000	0.0000
Number of groups	78	69
Average obs per group	12.2	12.2
Number of observations	948	841

* 10%, ** 5%, *** 1%; Std. Errors

Table 12. Fixed-effects panel-data estimation with year dummies

Econometric specification	Bank concentration	Bank lending-deposit spread
Policy rate	0.145645 ***	
Std. Err.	*0.0360092*	
Policy rate ^{2}		0.004310 ***
Std. Err.		*0.0004611*
Macroprudential Index	-1.149859	0.339588
Std. Err.	*1.442161*	*0.2484493*
Constant	YES	YES
Year dummies	YES	YES
Prob > F	0.0000	0.0000
Number of groups	67	58
Average obs per group	11.3	9.8
Number of observations	754	568

* 10%, ** 5%, *** 1%; Robust Std. Errors

Finally, table 12 above shows the result when we add the Macroprudential Index as a control for simultaneous policies of that nature. Again, the results remain significant.

7. Bank-level results

Using data from BANKSCOPE, we investigate whether our reasoning holds at a bank-level panel. We restrict our sample to commercial banks. It has over a hundred thousand bank-year observations spanning the years 1997-2014 in 54 countries. Based on this sample, we see how net loan growth of each bank is affected by variations in the policy rate. The impact of the policy rate is significantly smaller for the largest banks and for deposit-funded banks, as shown in table 13 below. However, this divergence may not appear in every sample, since it depends on country characteristics, as discussed in the previous section. For that end, the Appendix contains tables showing the impact of the United States, the jurisdiction most represented in the sample by far and one whose banking sector has distinct characteristics.

The basic equation estimated by fixed effects is:

$$\begin{gathered} Net\ Loan\ Growth_{i,t} = Const + \beta_5 \Delta Policy\ Rate_{i,t} + \beta_6 \Delta Policy\ Rate_{i,t-1} \\ + \beta_7 \Delta Policy\ Rate_{i,t} I_{5\%\ loan\ market\ share,i\ in\ t-1} + \beta_8 \Delta Policy\ Rate_{i,t-1} I_{5\%\ loan\ market\ share,i\ in\ t-1} \\ + \beta_9 \Delta Policy\ Rate_{i,t} Deposit\ Funding_{i,t} + \beta_{10} \Delta Policy\ Rate_{i,t-1} Deposit\ Funding_{i,t} \\ + \beta_{11} Liquidity\ Index_{i,t-1} + \beta_{12} Equity\ Index_{i,t-1} + \beta_{13} ROE_{i,t-1} + Controls + \varepsilon_{i,t} \end{gathered} \quad \text{(eq. 6)}$$

where $I_{5\%\ m.\ share,i\ in\ t-1}$ stands for the dummy variables that flashes whenever the bank had a market share of over 5% in the previous period. We characterize deposit funding as the relative importance of customer deposits for the bank funding, measured as a proportion of total liabilities. The liquidity index is a straightforward proportion of liquid assets to total assets, while the equity index is similarly defined as equity to total assets. The ROE is calculated as the net income over equity. We also include controls to reflect macroeconomic conditions, the GDP growth and the stock market return.

Table 13. Fixed-effects panel-data estimation with year dummies, net loans growth

Variable	(1)	(2)
ΔPolicy rate	-0.099634 **	-0.198551 ***
Std. Err.	*0.044427*	*0.040221*
ΔPolicy rate$I_{mkt\ share\ on\ loans\ 5\%,\ past\ year}$*	0.108873 **	
Std. Err.	*0.043829*	
ΔPolicy rate(Total Customer Deposits/Total Assets)*		0.225005 ***
Std. Err.		*0.067141*
Lagged ΔPolicy rate	-0.043164 **	-0.005424
Std. Err.	*0.017926*	*0.028654*
Lagged ΔPolicy rate$I_{mkt\ share\ on\ loans\ 5\%,\ past\ year}$*	0.055133 **	
Std. Err.	*0.021497*	
Lagged ΔPolicy rate(Total Customer Deposits/Total Assets)*		-0.030883
Std. Err.		*0.049290*
GDP growth	0.480816	0.596862
Std. Err.	*0.450894*	*0.357081*
Stock market return	-0.000616	0.000574
Std. Err.	*0.002731*	*0.001887*
Lagged equity index (Equity/Total Assets)	5.480610 ***	5.587434 **
Std. Err.	*2.036366*	*2.154327*
Lagged liquidity Index (Liquid Assets/Total Assets)	3.676212 *	3.684257 *
Std. Err.	*2.021984*	*2.050898*
Lagged ROE	-0.041178	-0.040675
Std. Err.	*0.028802*	*0.028785*
Constant	YES	YES
Year dummies	YES	YES
Prob > F	0.0000	0.0000
Number of groups	11411	11355
Average obs per group	9.8	9.8
Number of observations	111583	111177

* 10%, ** 5%, *** 1%; Cluster by Country Std. Errors (54 Countries)

The takeaway from the bank-level estimation is that after controlling for the equity and liquidity indexes, the effects of the policy rate on net loans growth is subdued in proportion to the relative importance of customer deposits for the bank funding, as seen in regression (2) in table 13 above. That is the empirical expression of the gist of our theoretical model. Everything else involving our conjectures follows from this finding. The other result, that the biggest banks are less affected, is a mere confirmation of the country-level finding that higher policy rates increase bank concentration.

8. Conclusion

We have investigated whether a theoretical possibility that monetary policy affects banks' competitive behavior, as laid out in a simple model, is compatible with the empirical evidence. With the use of an extensive cross-country data set spanning over a decade, we argue that the results of the theoretical propositions can be employed to explain the empirical findings that the monetary policy rate has a positive relationship with both bank concentration and the lending-deposit spread.

Banks are assumed to have different strategies regarding funding bases. Acquiring a retail funding base implies high fixed costs, but allows banks to have a deposit funding less sensitive to the policy rate. On the other hand, market-based funding is more easily obtainable, but is more sensitive to the policy rate. Therefore, when the policy rate increase, banks with a retail funding strategy gain an advantage. However, the fact that such a strategy has significant barriers to entry means that retail banks are in a more secure position in a high policy rate environment.

Following this reasoning, we argue that bank concentration increases when the biggest banks are retail funded, something that occurs in most countries. As retail funded banks become relatively more efficient in a high policy rate environment, they stand to get a larger market share at the expense of other entities with market-based funding, whose less aggressive behavior also allows retail banks to charge wider spreads unmolested.

Appendix

Proof of Proposition 1:

The outputs are given by:

$$q_R = \frac{a - d * (N - N_R) * q_M - mc_R}{\left(2 * b + d * (N_R - 1)\right)} \quad \text{(eq. 1a)}$$

$$q_M = \frac{a - d * (N_R) * q_R - mc_M}{\left(2 * b + d * (N - 1 - N_R)\right)} \quad \text{(eq. 2a)}$$

Combining equations 1a and 2a above:

$$q_R = \frac{a - \frac{d * (N - N_R) * (a - mc_M)}{(2 * b + d * (N - 1 - N_R))} - mc_R}{\left(2 * b + d * (N_R - 1) - \frac{d^2 * (N_R) * (N - N_R)}{(2 * b + d * (N - 1 - N_R))}\right)} \quad \text{(eq. 3a)}$$

Differentiating equation 3a concerning r_{pol}:

$$\frac{\partial q_R}{\partial r_{pol}} = \frac{\frac{d * (N - N_R)}{(2 * b + d * (N - 1 - N_R))} * \alpha_M - \alpha_R}{\left(2 * b + d * (N_R - 1) - \frac{d^2 * (N_R) * (N - N_R)}{(2 * b + d * (N - 1 - N_R))}\right)} \quad \text{(eq. 4a)}$$

A sufficient condition for the denominator of equation 4a to be positive is $2 * b > d$, that is the demand at the bank-level is at least as sensitive to the individual output when compared to the aggregate output, which is taken as an uncontroversial assumption, and the numerator is non-negative if:

$$\frac{2 * b + d}{d * (N - N_R)} + 1 \leq \frac{\alpha_M}{\alpha_R} \quad \text{(eq. 5a)}$$

As for q_M, both the increase in q_R and the increase in mc_M lead to its decrease.

Proof of Proposition 2:

The derivative of the price charged by retail-funded banks is given by:

$$\frac{\partial p_R(q_R, q_M)}{\partial r_{pol}} = -\left(b + d * (N_R - 1)\right) * \frac{\partial q_R}{\partial r_{pol}} - d * (N - N_R) * \frac{\partial q_M}{\partial r_{pol}} \quad \text{(eq. 1b)}$$

The derivative of the output of a retail funded-bank concerning the policy rate is outlined in equation 4a, while the same procedure obtains the derivative of the output of market funded-banks concerning the policy rate:

$$q_M = \frac{\left(1 - \frac{d * N_R}{(2 * b + d * (N_R - 1))}\right) * a + \left(\frac{d * N_R}{2 * b + d * (N_R - 1)}\right) * mc_R - mc_M}{\left(2 * b + d * (N - N_R - 1) - \frac{d^2 * N_R * (N - N_R)}{(2 * b + d * (N_R - 1))}\right)} \quad \text{(eq. 2b)}$$

$$\frac{\partial q_M}{\partial r_{pol}} = \frac{\frac{d * \frac{N_R}{N}}{\frac{2 * b}{N} + d * \left(\frac{N_R}{N} - \frac{1}{N}\right)} * \alpha_R - \alpha_M}{\left(2 * b + d * (N - N_R - 1) - \frac{d^2 * \frac{N_R}{N} * (N - N_R)}{\left(\frac{2 * b}{N} + d * \left(\frac{N_R}{N} - \frac{1}{N}\right)\right)}\right)} \quad \text{(eq. 3b)}$$

Combining equations 1b, 4a, and 3b yields:

$$\frac{\partial p_R(q_R, q_M)}{\partial r_{pol}} = -\big(b + d * (N_R - 1)\big) * \left(\frac{\left(\frac{d * \left(1 - \frac{N_R}{N}\right)}{\left(\frac{2 * b - d}{N} + d * \left(1 - \frac{N_R}{N}\right)\right)}\right) * \alpha_M - \alpha_R}{\left(\big(2 * b + d * (N_R - 1)\big) - \frac{d^2 * \left(1 - \frac{N_R}{N}\right) * N_R}{\left(\frac{2 * b - d}{N} + d * \left(1 - \frac{N_R}{N}\right)\right)}\right)}\right)$$

$$- d * (N - N_R) * \left(\frac{\frac{d * \frac{N_R}{N}}{\frac{2 * b - d}{N} + d * \frac{N_R}{N}} * \alpha_R - \alpha_M}{\left(2 * b + d * (N - N_R - 1) - \frac{d^2 * \frac{N_R}{N} * (N - N_R)}{\left(\frac{2 * b - d}{N} + d * \frac{N_R}{N}\right)}\right)}\right) \quad \text{(eq. 4b)}$$

If we assume that N is sufficiently large so that $\frac{2*b-d}{N}$ is approximately zero, then equation 4b can be simplified to:

$$\big(d * (N + 1 - 2 * N_R) - b\big) * \left(\frac{\alpha_M - \alpha_R}{2 * b - d}\right) \quad \text{(eq. 5b)}$$

Therefore $\frac{\partial p_R(q_R, q_M)}{\partial r_{pol}} > 1$ is equivalent to:

$$N - 2 * N_R > \frac{1}{d} * \left(\frac{2 * b - d}{\alpha_M - \alpha_R} + b\right) - 1 \quad \text{(eq. 6b)}$$

Alternative regression:

In table 14 below, we present the results on bank lending deposit spread considering the policy rate, for the sake of completeness.

Table 14. Results on bank-lending deposit spread

Econometric specification	OLS	Fixed-effects	Fixed-effects
Policy rate	*0.355689* ***	0.222803 **	0.258660 **
Std. Err.	*0.0477051*	*0.1006247*	*0.1008552*
Constant	YES	YES	YES
Year dummies	NO	NO	YES
Prob > F	0.0000	0.0301	0.0000
R-squared	0.2037	-	-
Number of groups	-	71	71
Average obs per group	-	12.8	12.8
Number of observations	910	910	910

* 10%, ** 5%, *** 1%; Robust Std. Errors

Impact of the United States on bank-level results:

In table 15 below, we exclude the American banks from the sample. We do that because of their weight, encompassing the majority of the observations. By excluding them we make sure that the results are not due to a quirk in that particular market. In that subsample, we still find that loan concentration increases in the same way and that deposit-funded banks are less affected by monetary policy.

Table 15. Fixed-effects panel-data estimation with year dummies, net loans growth, excluding American banks

Variable	(1)	(2)
ΔPolicy rate	-0.077946 **	-0.186554 ***
Std. Err.	*0.036799*	*0.036100*
*ΔPolicy rate*I* $_{mkt\ share\ on\ loans\ 5\%,\ past\ year}$	0.095061 **	
Std. Err.	*0.042543*	
ΔPolicy rate(Total Customer Deposits/Total Assets)*		0.270365 ***
Std. Err.		*0.071379*
Lagged ΔPolicy rate	-0.026858 *	-0.025557
Std. Err.	*0.013694*	*0.030229*
*Lagged ΔPolicy rate*I* $_{mkt\ share\ on\ loans\ 5\%,\ past\ year}$	0.042857 **	
Std. Err.	*0.020466*	
Lagged ΔPolicy rate(Total Customer Deposits/Total Assets)*		0.044261
Std. Err.		*0.049687*
GDP growth	1.535122 **	1.422847 ***
Std. Err.	*0.692829*	*0.495869*
Stock market return	-0.003498	-0.002872
Std. Err.	*0.003657*	*0.003231*
Lagged equity index (Equity/Total Assets)	7.446498 *	7.989279 **
Std. Err.	*4.254567*	*4.817153*
Lagged liquidity Index (Liquid Assets/Total Assets)	7.631167 *	7.946259 *
Std. Err.	*4.400580*	*4.624105*
Lagged ROE	-0.078559 *	-0.076424 *
Std. Err.	*0.040912*	*0.040310*
Constant	YES	YES
Year dummies	YES	YES
Prob > F	0.0000	0.0000
Number of groups	2408	2354
Average obs per group	5.2	5.2
Number of observations	12608	12219

* 10%, ** 5%, *** 1%; Cluster by Country Std. Errors (53 Countries)

Chapter 2 – Prudential regulation and bank competition: a model for various regimes

1. Introduction

Using the model with borrower moral hazard developed by ARPING (2017), we conclude that capital requirements do not always reduce risk-taking. In fact, only in a monopoly or a near-monopoly does the exogenous capital requirement improve loan quality. For the other cases, the capital requirement causes higher loan rates, thus, it negatively affects borrower incentives. As banks substitute risk-insensitive insured deposits for equity, their cost inevitably rises and so does the loan rate. Similarly, capital requirements do not alleviate the effects of deposit competition on risk-taking under all regimes and may actually aggravate them. Last but not least, the degree of competition in the loan market affects the efficacy of capital requirements on curbing risk-taking in a monopoly.

Although it is often assumed that capital requirements improve financial stability, the theoretical literature does not provide a clear-cut answer (VANHOOSE, 2007). In fact, while capital requirements provide a cushion against losses, they may incentivize risk-taking, thus, making such losses more likely and muddling the final picture. Given that risk-taking is intimately linked to competition, as many have argued (see VIVES, 2016, for an extensive review), it is only natural that the effects of capital requirements on risk-taking should be assessed against a backdrop of various competition regimes.

As for the other prudential requirement considered in this work, the liquidity requirement, the conclusions are also nuanced. Liquidity requirements can either increase or decrease bank risk-taking depending on the market structure. It goes without saying that liquidity requirements exist for reasons the model is not capable of grasping, but it should be noted that liquidity requirements always increase the effect of deposit competition on bank risk-taking in loan markets, a finding that might be relevant for policy making.

Several authors have dealt with the issue of how competition affects risk taking in banking. Some, such as KEELEY (1990), have argued that competition erodes banks' long-term profits, that is, the charter value of banking, making the prospect of failure less unsavory to bankers. Others, following BOYD and DE NICOLÓ (2005), point out that borrower incentives are such that the higher lending rates associated with less competition entails greater moral hazard. In other words, facing high lending rates, it is the borrower that may not care as much if his project fails and the loan is defaulted upon. Reconciling both views, we argue that ultimately the relation between bank competition and financial stability hinges on which decision is given more weight to and that, in turn, is something determined by the market structure. It is on this insight, developed in the seminal paper of ARPING (2017), that we build our work.

In the model designed by ARPING (2017) that we build upon, the competition in the loan market can follow three regimes: monopoly, perfect competition and imperfect competition. In a monopoly, the banker has the liberty to set loan rates taking into consideration the borrowers' decision making, while under a perfect competition regime, the banker is constrained to maximize borrower utility. Therefore, contingent on the market structure, the perspective of a different agent will prevail. We use this framework to understand how prudential requirements fare in the three regimes of competition in the loan market and how prudential requirements affect the way through which the degree of competition in the deposit market influences risk-taking.

This chapter is organized in the following manner. Section 2 discusses the related literature, presenting a brief review of the previous work on understanding the impact of prudential requirements. In section 3, we lay out the theoretical model and the aforementioned results. Section 4, the conclusion, ends the chapter.

2. Literature review

This work is primarily connected to the literature that seeks to understand the impact of prudential regulation on bank's decision making. This literature is relatively ample when capital requirements are concerned, but almost inexistent in the case of liquidity requirements (ALLEN et al., 2014). However, this fact does not imply universally established conclusions regarding the effects of capital requirements. On the contrary, VANHOOSE (2007) reviews the theoretical literature on bank behavior under capital regulation and finds that it produces mixed predictions on the effects of capital requirements on risk-taking. Similarly, there is relatively little empirical literature on estimating the overall net impact of capital requirements (DIAMOND and KASHYAP, 2016), and the effect on risk-taking seems to either small or non-existent, a finding that may be explained in several ways.

CALEM and ROB (1999) calibrate a portfolio choice problem and find a U-shaped relationship between capital and risk-taking. Their result that risk-taking first declines and then increases may account for the small aggregate impact found by RIME (2001). Another possible explanation may be that, as MILNE (2002) discussed, the effects of capital regulation bear relation to the *ex post* penalties for breaching the minimum requirements and not necessarily the level of such requirements. Finally, our result may also contribute to this debate, as different banks may be exposed to diverse niches even if in the same jurisdiction and, therefore, several distinct competitive environments may coexist, generating opposite effects that can cancel each other out in country-level studies. Under this reasoning, the consolidated impact is expected to be small or non-existent.

This work is also linked to the literature that explicitly considers competition regimes to assess the impact of capital regulation on risk-taking. REPULLO (2004) and HELLMANN et al. (2000) build on a model of spatial monopolistic competition and find that capital regulation improves the banks' operating margin, thus, enhancing the incentive to be prudent, for the banker will have more of its wealth at stake. Our result also conveys aspects of this logic, but we find it to be conditional on the market structure, for in a perfectly competitive loan market or near-perfectly competitive loan market, banks' margins are not sensitive to capital requirements once the opportunity cost of equity is taken into account.

In a way, our work is also close to that of SCHLIEPHAKE (2016), since it analyzes the interferences of the competitive environment on the effects of capital regulation and concludes that the optimal level of capital requirements may depend on the market structure. She assumes that capital requirements change the competitive environment by negatively affecting entry and increasing the market power of incumbents. On the other hand, we take the market structure as a given and show that capital requirements have an ambiguous effect on stability precisely because bank competition differs *ex-ante*, a completely different foundation for a similar conclusion that intense competition may reverse the stability-enhancing effect of capital requirements[5].

[5] CHEN (2016) shows that credit market competition reduces banks' incentive to hold capital, but this conclusion is not related to ours, since we restrict our attention to capital requirements only. For a general review of reasons why banks hold excess capital see TABAK, NORONHA, and CAJUEIRO (2011).

3. The model

The structure of the model is that developed by ARPING (2017). The model is suited to analyze the impact of prudential policies under divergent scenarios concerning bank competition because it allows them to be integrated in a single comparable framework that also considers varying degrees of competition in the deposit market. The setting is a two-period economy in which two bankers, bank 1 and bank 2, compete over a single loan extended to an entrepreneur that faces a cost s to switch from bank 1 to bank 2. When $s = \infty$, bank 1 enjoys a monopoly, while $s = 0$ implies perfect competition à la Bertrand. Naturally, $s > 0$ accommodates the remaining intermediate cases that are referred to as imperfect competition.

The banks also compete for deposits. There are two of continua of families, each endowed with $1 that can either be taken to a riskless money market, in which the return is normalized to 1, or be deposited in a bank. Families only value consumption in the second period $t = 1$ and have no storing technology. Each bank has access to a separate continuum of families of a single unit of mass, which we refer to as the “local” deposit market. Families in the local deposit market 1 (2) find it more convenient to deposit their endowments in bank 1 (2), for otherwise they must incur in a cost $s^D > 0$. Thus, s^D is a measure of the degree of competition in the deposit market, for it conveys the spread banks can earn by simply taking deposits and investing them in the riskless money market. Banks cannot differentiate prices between the two continua of families.

The families are indifferent between obtaining a return of 1 in the money market and depositing their endowment in their respective local bank for a return of $1 - s^D$, as the deposits are fully insured. In addition, we assume that banks have a capacity constraint so that a bank cannot corner the deposit market by receiving all deposits from both continua of families. Under that assumption, the equilibrium in the deposit market is attained by each bank offering a return of $1 - s^D$ to its local depositors. If a bank offers a return high enough to attract entire deposit market, it will reach its capacity constraint and would be worse off, alternatively, if it offers a lower return, the families in its local market would take their endowments to the money market, also leaving the bank worse off.

The entrepreneur does not have access to sources of funding other than the bank loan to develop his project. His project generates $\Pi > 1$ if it succeeds, but yields nothing otherwise. The probability that the project succeeds is given by the unobservable effort e of the entrepreneur, who incurs in a private cost $\varphi(e) \equiv \beta e^2/2$ to exert effort e. As the bank charges R for the loan, the utility of the risk-neutral entrepreneur is given by $U_E = e(\Pi - R) - \varphi(e)$. Therefore, the model displays borrower moral hazard. Naturally, we assume the conditions for the existence of a level of effort such that the net expected return of the project enables it to be brought about and all results we discuss are restricted to the instances in which that occurs. Thus, we do not discuss output levels in this work.

We introduce a capital requirement as the exogenous percentage γ of the loan that must be funded with the banker's own equity. We assume that the banker has enough equity to face this requirement but otherwise would not be interested in funding the entrepreneur with its own resources, since it costs more to do so. The banker is risk-neutral and includes the opportunity cost of capital in its utility. In other words, the banker considers that his equity must have the same expected return of the risk-less financial market, as otherwise the banker would rather leave the business. Thus, the utility of the banker is given by $U_B \equiv e(R - (1 - s^D)(1 - \gamma)) - \gamma$ when the capital requirement is introduced.

We also consider a liquidity requirement τ. For each $\$1$ extended as a loan to the entrepreneur, the banker must set aside τ to fund a liquidity reserve. In this scenario, the local market for deposits is assumed to have enough endowments to provide the additional resources needed by the bank. Accordingly, the utility of the banker would then be $U_B \equiv e(R + \tau - (1 - s^D)(1 + \tau))$, since the liquidity reserve is held in the money market and yields 1.

3.1 Monopoly

Assuming $s = \infty$, bank 1 has a monopoly in the loan market. Under such circumstances, bank 1 can safely ignore the existence of bank 2, and maximize his utility when setting R and the equilibrium effort level e it entails given the incentive-compatibility (IC) constraint. As the outside option of the entrepreneur is the exclusion from the market, the only individual rationality (IR) constraint is that his utility is bigger or equal to zero.

$$\max_{(e,R)} U_B \text{ s.t.}$$
$$U_E(e,R) = e(\Pi - R) - \varphi(e) \geq 0 \; (IR)$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \; (IC)$$

Proposition 1. *In a monopoly in the loan market, the exogenous capital requirement increases the effort level e and reduces the loan rate R, the intensity of the effects is negatively affected by s^D.*

The most puzzling aspect of proposition 1 is its second part, that is, s^D negatively affecting the impact of the capital requirement on risk-taking. However, it should be noted that the capital requirement is similar, in its effects on risk-taking, to less competition in the deposit market. The higher the s^D, the more the funding from depositors resembles the banker's equity in determining the risk level. Thus, capital requirements do not make much of a difference at high levels of s^D. In fact, at the limit, $s^D = 1$, the depositors' funding is indistinguishable from equity, since, in effect, it is irrevocably given to the banker, and the capital requirement is therefore without effects. As for the effect on effort and on the loan rate, it follows from the fact that the bank becomes more sensitive to losses and a lower loan rate reduces losses.

Proposition 2. *In a monopoly in the loan market, the exogenous liquidity requirement increases the effort level e and decreases the loan rate R, the intensity of the effects is positively affected by s^D.*

The intuition to proposition 2 is akin to that of proposition 1. The liquidity requirement enables the bank to obtain a higher rent from its position in the deposit market. Thus, in this particular sense, the liquidity requirement increases the franchise value of the bank. However, as this increase in the franchise value of the bank is proportional to s^D, it is only natural that the intensity of the effect of the liquidity requirement depends on s^D.

Proposition 3. *In a monopoly in the loan market, the effect of the degree of competition in the deposit market on the effort level is reduced by the capital requirement but increased by the liquidity requirement.*

Proposition 3 is fairly straightforward. The capital requirement reduces the exposure of the bank to the deposit market, thus, it reduces the impact the deposit market competition has on risk-taking. On the other hand, the liquidity requirement does exactly the opposite. The higher the liquidity requirement the more important the deposit market becomes for the bank.

3.2 Perfect competition

Assuming $s = 0$, the entrepreneur's decision is based only on the loan rate R. As banks quote their offers simultaneously in $t = 0$, they compete à la Bertrand. For the mere sake of completeness, we assume that facing equal prices, the entrepreneur strictly prefers bank 1's offer. Therefore, in equilibrium, the utility of the entrepreneur is maximized subject to the constraint that banker 1 opts to take part in the arrangement, but has no economic profit (ZP) from extending the loan.

When the bank is subject to a capital requirement, the equilibrium is given by the solution to the following program:

$$\max_{(e,R)} U_E \text{ s.t.}$$
$$e(R - (1 - s^D)(1 - \gamma)) - \gamma - s^D(1 - \gamma) = 0 \ (ZP)$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \ \textit{(IC)}$$

Similarly, if there is an exogenous liquidity requirement, the program becomes:

$$\max_{(e,R)} U_E \text{ s.t.}$$
$$e(R + \tau - (1 - s^D)(1 + \tau)) - (1 + \tau)s^D = 0 \ (ZP)$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \ \textit{(IC)}$$

Proposition 4. *In a perfectly competitive loan market, the exogenous capital requirement decreases the effort level e and increases the loan rate R.*

Proposition 5. *In a perfectly competitive loan market, the exogenous liquidity requirement decreases the effort level e and increases the loan rate R.*

Propositions 4 and 5 tell the same story. The prudential requirement increases how much of the total surplus must be set aside to compensate the banker, which does not make any profit but must not suffer any economic loss in equilibrium. Thus, this dent in the utility of the entrepreneur negatively affects his incentive to exert effort. In a nutshell, the increased cost of funding is passed along to the entrepreneur, increasing moral hazard.

Proposition 6. *In a perfectly competitive loan market, the effect of the degree of competition in the deposit market on the effort level is increased by both the liquidity requirement and the capital requirement.*

Proposition 6 is not surprising when the liquidity requirement is considered, as it increases the amount of bank funding subject to the influence of the deposit market. However, even though the capital requirement does exactly the opposite it has an indirect effect on the equilibrium effort that predominates over this direct effect. At the same time that the surplus the entrepreneur has to set aside to the banker because of this position in deposit market shrinks because of the capital requirement, it also causes the total surplus attributable to the bank to increase, which worsens incentives. With less effort, the surplus to be shared between the entrepreneur and the banker is smaller, and therefore, the entrepreneur is more sensitive to any additional amount of utility it loses to the bank, which is precisely the consequence of less competition in the deposit market.

3.3 Imperfect competition

Assuming $s > 0$, bank 1 takes into consideration that the entrepreneur could opt to take the loan with bank 2 when deciding which loan rate to offer. Therefore, bank 1 now faces two individual rationality constraints, as the entrepreneur has two outside options to ponder. In addition to individual rationality constraint already mentioned, bank 1 has to offer a rate that the entrepreneur prefers over that of bank 2 (IR''), which is given by e^*, R^* in the program below.

$$\max_{(e,R)} U_B(e,R) \text{ s.t.}$$
$$U_E(e,R) = e\varphi'(e) - \varphi(e) \geq U_E(e^*,R^*) = e^*\varphi'(e^*) - \varphi(e^*) - s \; (IR")$$
$$U_E(e,R) = e(\Pi - R) - \varphi(e) \geq 0 \; (IR')$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \; \mathit{(IC)}$$

It should be noted that, in equilibrium, the only possible values for e^* and R^* are those that bank 2 would offer under perfect competition. Were they to assume any other value, bank 1 could easily undercut bank 2 of any additional utility its offer could possibly generate. Therefore, these are only values that could be part of a strategic equilibrium in imperfect competition, and the entrepreneur anticipates that before reaching out to bank 2 and igniting a bidding war.

Proposition 7. *In an imperfectly competitive loan market, propositions 4, 5 and 6 still apply. However, for a sufficiently large s, propositions 1, 2 and 3 apply instead.*

Proposition 7 simply says that the threshold between the polar cases we discussed is well-behaved. However, it has important policy implications, since the results we found for a monopoly could apply to market structures with more than a one bank. In fact, propositions 1, 2 and 3 depend only on a sufficiently large switching cost.

4. Conclusion

Our work has shown that it is not possible to reach unconditional results regarding the impact of prudential requirements on the banking activity. In particular, results vary widely depending on the market structure and on the type of the prudential regulation. Even in a relatively simple model such as ARPING's (2017), one can easily reach opposite conclusions regarding the effect of capital or liquidity requirements on bank risk-taking and loan rates or on the relationship between deposit competition and risk-taking. Therefore, our work is an attestation to the relevance of considering the market structure when assessing the implementation of prudential regulations.

Appendix

Proof of Proposition 1. *In a monopoly in the loan market, the exogenous capital requirement increases the effort level e and reduces the loan rate R, the intensity of the effects is negatively affected by s^D.*

The program is given by:

$$\max_{(e,R)} U_B(e,R,\gamma) = e(R-(1-s^D)(1-\gamma))-\gamma \text{ s.t.}$$
$$U_E(e,R) = e(\Pi - R) - \varphi(e) \geq 0 \textit{ (IR)}$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \textit{ (IC)}$$

However, we know that the IR constraint is not binding. Were it the case, the entrepreneur would not choose a positive effort. Therefore, we can safely ignore the IR constraint and find a solution considering only the IC constraint.

$$\max_{(e,R)} U_B(e,R,\gamma) = e(R-(1-s^D)(1-\gamma))-\gamma \text{ s.t}$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \textit{ (IC)}$$

Combining the IC and U_B:

$$e(\Pi - \varphi'(e) - (1 - s^D)(1 - \gamma)) - \gamma$$

Differentiating the expression above with respect to e, we find the first-order condition below:

$$(\Pi - \varphi'(e) - (1 - s^D)(1 - \gamma)) - e\varphi''(e) = 0 \text{ (eq. 1)}$$

Solving for e and substituting $\varphi(e)$:

$$e^{M_\gamma} = \frac{\Pi - (1 - s^D)(1 - \gamma)}{2\beta} \text{ (eq. 2)}$$

Equation 2 gives the level of effort in a monopoly in the loan market when there is an exogenous capital requirement, e^{M_γ}. Differentiating with respect to γ yields:

$$\frac{\partial e^{M_\gamma}}{\partial \gamma} = \frac{(1 - s^D)}{2\beta} > 0 \text{ (eq. 3)}$$

Therefore, the effort exerted by the entrepreneur is increasing in the exogenous capital requirement. However, this effect is decreasing in s^D. As for the loan rate, it is implicitly defined by the IC constraint:

$$\Pi - R - \varphi'(e) = 0 \rightarrow R = \Pi - \beta e \text{ (eq. 4)}$$

Thus, as there is inverse linear relationship between the loan rate and the effort level, the loan rate is decreasing in γ.

Proof of Proposition 2. *In a monopoly in the loan market, the exogenous liquidity requirement increases the effort level e and decreases the loan rate R, the intensity of the effects is positively affected by s^D.*

The program is given by:

$$\max_{(e,R)} U_B(e, R, \tau) = e(R + \tau - (1 - s^D)(1 + \tau)) \text{ s.t.}$$
$$U_E(e, R) = e(\Pi - R) - \varphi(e) \geq 0 \textit{ (IR)}$$
$$\frac{\partial U_E(e, R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \textit{ (IC)}$$

Following the same steps of the previous proof, we find:

$$e^{M_\tau} = \frac{\Pi + \tau - (1 - s^D)(1 + \tau)}{2\beta} \text{(eq. 5)}$$

Differentiating with respect to τ yields:

$$\frac{\partial e^{M_\tau}}{\partial \tau} = \frac{s^D}{2\beta} > 0 \text{ (eq. 6)}$$

Proof of Proposition 3. *In a monopoly in the loan market, the effect of the degree of competition in the deposit market on the effort level is reduced by the capital requirement but increased by the liquidity requirement.*

Differentiating equation 2 with respect to s^D yields:

$$\frac{\partial e^{M_\gamma}}{\partial s^D} = \frac{(1-\gamma)}{2\beta} \text{ (eq. 7)}$$

Therefore, even though an increase in the level of competition in the deposit market reduces effort, the capital requirement softens that relationship.

Similarly, differentiating equation 5 with respect to s^D yields:

$$\frac{\partial e^{M_\tau}}{\partial s^D} = \frac{(1+\tau)}{2\beta} \text{ (eq. 8)}$$

Consequently, we reach the opposite conclusion regarding the liquidity requirement.

Proof of Proposition 4. *In a perfectly competitive loan market, the exogenous capital requirement decreases the effort level e and increases the loan rate R.*

The program is given by:

$$\max_{(e,R)} U_E(e,R) = e(\Pi - R) - \varphi(e) \text{ s.t.}$$
$$e(R - (1-s^D)(1-\gamma)) - \gamma - s^D(1-\gamma) = 0 \ (ZP)$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \ \textit{(IC)}$$

Since both constraints are binding, we face a two-equation system whose solutions are given by the roots of the following equation:

$$e(\Pi - \beta e - (1-s^D)(1-\gamma)) - \gamma - s^D(1-\gamma) = 0 \text{ (eq. 9)}$$

Implicitly differentiating equation 9 with respect to the capital requirement, we find:

$$\frac{\partial e^{B_\gamma}}{\partial \gamma} = \frac{(1-s^D)(1-e^{B_\gamma})}{(\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma))} \text{ (eq. 10)}$$

As $e^{B_\gamma} \in (0,1]$, we know that the numerator is a positive number. To find whether the denominator is also a positive number, we follow ARPING (2017) and consider a slightly different program that is given in terms of the joint surplus of the entrepreneur and the bank, $S(e)$, and in which the IC constraint incorporates the ZP constraint and the resulting combined constraint is multiplied by the effort e.

$$S(e) \equiv U_E(e, R(e)) + U_B(e, R(e), \gamma) = e\Pi - \varphi(e) - e(1-s^D)(1-\gamma) \text{ (eq. 11)}$$

The ZP constraint implies $U_B(e, R(e), \gamma) = \gamma + s^D(1-\gamma)$, thus:

$$\max_{(e,R)} U_E(e,R) = S(e) - \gamma - s^D(1-\gamma) = e\Pi - \varphi(e) - e(1-s^D)(1-\gamma) - \gamma - s^D(1-\gamma) \text{ s.t.}$$
$$\theta(e) \equiv e\Pi - \gamma - s^D(1-\gamma) - (1-s^D)(1-\gamma)e - e\varphi'(e) = 0$$

In an unconstrained program, we know that $S'(e) = 0$, thus:

$$eS'(e) = e\Pi - e\varphi'(e) - e(1-s^D)(1-\gamma) = 0 \text{ (eq. 12)}$$

However, at the optimum of the constrained program, e^*, we have:

$$e^*S'(e^*) = \theta(e^*) + \gamma + s^D(1-\gamma) = \gamma + s^D(1-\gamma) > 0 \text{ (eq. 13)}$$

Consequently, by the concavity of $S(e)$, the equilibrium effort e^* is strictly inferior to the unconstrained optimum. Thus, the equilibrium effort is given by the largest solution of the program, thus, $\theta(e) = 0$ and:

$$\theta'(e^{B_\gamma}) = \Pi - (1-s^D)(1-\gamma) - 2\beta e^{B_\gamma} < 0$$

Which means that the denominator of equation 10 is negative and therefore the derivative of the equilibrium effort with respect to the capital requirement is also negative.

Proof of Proposition 5. *In a perfectly competitive loan market, the exogenous liquidity requirement decreases the effort level e and increases the loan rate R.*

The proof of proposition 5 closely follows that of proposition 4, but the program is given by:

$$\max_{(e,R)} U_E(e,R) = e(\Pi - R) - \varphi(e) \text{ s.t.}$$
$$e(R + \tau - (1 - s^D)(1 + \tau)) - (1 + \tau)s^D = 0 \ (ZP)$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \ \textit{(IC)}$$

By implicitly differentiating the combined constraints, we obtain:

$$\frac{\partial e^{B_\tau}}{\partial \tau} = \frac{(1 - e^{B_\tau})s^D}{(\Pi - 2\beta e^{B_\tau} + \tau - (1 - s^D)(1 + \tau))} \text{ (eq. 14)}$$

Finding the sign of the denominator requires the same reasoning as before, from which we can conclude that it is negative, as shown below.

$$\max_{(e,R)} U_E(e,R) = S(e) - (1 + \tau)s^D = e\Pi - \varphi(e) + \tau e - e(1 - s^D)(1 + \tau) - (1 + \tau)s^D \text{ s.t.}$$
$$\theta(e) \equiv e\Pi + e\tau - s^D(1 + \tau) - (1 - s^D)(1 + \tau)e - e\varphi'(e) = 0$$

Again, we know that the optimum in an unconstrained program implies $S'(e)$=0*,* thus,

$$eS'(e) = e\Pi - e\varphi'(e) + e\tau - e(1 - s^D)(1 + \tau) = 0 \text{ (eq. 15)}$$

However, at the optimum of the constrained program, e^*, we have:

$$e^*S'(e^*) = \theta(e^*) + s^D(1 + \tau) = s^D(1 + \tau) > 0 \text{ (eq. 16)}$$

Which implies $\theta'(e^{B_\tau}) < 0$, then:

$$\Pi + \tau - (1 - s^D)(1 + \tau)e^{B_\tau} - 2\beta e^{B_\tau} < 0$$

Proof of Proposition 6. *In a perfectly competitive loan market, the effect of the degree of competition in the deposit market on the effort level is increased by the liquidity requirement and the capital requirement.*

By implicitly differentiating equation 9 with respect to s^D:

$$\frac{\partial e^{B_\gamma}}{\partial s^D} = \frac{(1 - e^{B_\gamma})(1 - \gamma)}{\Pi - 2\beta e^{B_\gamma} - (1 - s^D)(1 - \gamma)} < 0$$

It is straightforward that γ decreases the numerator and increases the denominator, but we need to further differentiate the expression with respect to γ to find a precise answer on how $\partial e^{B_\gamma}/\partial s^D$ is affected by γ:

$$\frac{\partial e^{B_\gamma}}{\partial s^D \partial \gamma} =$$

$$\frac{\left(\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma)\right)\left(e^{B_\gamma} - 1 - (1-\gamma)\frac{\partial e^{B_\gamma}}{\partial \gamma}\right) + \left(2\beta\frac{\partial e^{B_\gamma}}{\partial \gamma} - (1-s^D)\right)(1-e^{B_\gamma})(1-\gamma)}{\left(\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma)\right)^2}$$

(eq. 17)

Equation 17 can be simplified in different ways, for instance, tackling the first expression in the numerator:

$$\left(\Pi - 2\beta e - (1-s^D)(1-\gamma)\right)\left(e - 1 - (1-\gamma)\frac{\partial e^{B_\gamma}}{\partial \gamma}\right) = -(1-e)(\Pi - 2\beta e) = (1-e)(2\beta e - \Pi) < 0$$

Since,

$$\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma) < 0 \rightarrow 2\beta e^{B_\gamma} > \Pi - (1-s^D)(1-\gamma)$$

$$2\beta e^{B_\gamma} - \Pi < -(1-s^D)(1-\gamma) < 0$$

While the second expression in the numerator can be similarly simplified:

$$\left(2\beta\frac{\partial e^{B_\gamma}}{\partial \gamma} - (1-s^D)\right)(1-e^{B_\gamma})(1-\gamma) = \left(\frac{2\beta + (1-s^D)(1-\gamma) - \Pi}{\left(\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma)\right)}\right)(1-e^{B_\gamma})(1-\gamma)(1-s^D) < 0$$

Since,

$$\Pi - 2\beta e^{B_\gamma} - (1-s^D)(1-\gamma) < 0 \rightarrow 2\beta + (1-s^D)(1-\gamma) - \Pi > 0$$

Therefore, we can conclude that $\frac{\partial e^{B_\gamma}}{\partial s^D \partial \gamma} < 0$.

Differentiating equation 14 with respect to s^D:

$$\frac{\partial e^{B_\tau}}{\partial \tau \partial s^D} = \frac{\left(\Pi - 2\beta e^{B_\tau} + \tau - (1-s^D)(1+\tau)\right)\left(1 - e^{B_\tau} - \frac{\partial e^{B_\tau}}{\partial s^D}s^D\right) - (1-e^{B_\tau})s^D\left(1 + \tau - 2\beta\frac{\partial e^{B_\tau}}{\partial s^D}\right)}{\left(\Pi - 2\beta e^{B_\tau} + \tau - (1-s^D)(1+\tau)\right)^2}$$

(eq. 18)

By knowing that $\Pi - 2\beta e^{B_\tau} + \tau - (1 - s^D)(1 + \tau) < 0$ and that $\partial e^{B_\gamma}/\partial s^D < 0$, we can conclude that equation 18 is negative.

As $\partial e^{B_\gamma}/\partial s^D < 0$, it becomes more negative with both γ and τ.

Proof of Proposition 7. *In an imperfectly competitive loan market, propositions 4, 5 and 6 still apply. However, for a sufficiently large s, propositions 1, 2 and 3 apply instead.*

The problem of solving the program below can be divided in two cases.

$$\max_{(e,R)} U_B(e,R) \text{ s.t.}$$
$$U_E(e,R) = e\varphi'(e) - \varphi(e) \ \geq U_E(e^*,R^*) = e^*\varphi'(e^*) - \varphi(e^*) - s \ (IR")$$
$$U_E(e,R) = e(\Pi - R) - \varphi(e) \ \geq 0 \ (IR')$$
$$\frac{\partial U_E(e,R)}{\partial e} = \Pi - R - \varphi'(e) = 0 \ \textit{(IC)}$$

For a sufficiently large s, the IR'' constraint is not binding and can be assumed away. In this case, the program becomes that of a monopoly. Therefore, propositions 1, 2 and 3 are valid if s is large enough.

However, for an insufficiently large s, the IR'' constraint is binding and cannot be assumed away. If IR'' is binding, we have:

$$e\varphi'(e) - \varphi(e) = e^*\varphi'(e^*) - \varphi(e^*) - s \text{ (eq. 19)}$$

As $\varphi(e) \equiv \beta e^2/2$, equation 19 is equivalent to:

$$\frac{\beta e^2}{2} = \frac{\beta (e^*)^2}{2} - s \text{ (eq. 20)}$$

Therefore, the equilibrium effort in an imperfect competition with a sufficiently small s is given by:

$$e^I = +\sqrt{(e^B)^2 - \frac{2}{\beta}s} \text{ (eq. 21)}$$

In other words, the relationship between the effort in imperfect competition e^I and in perfect competition e^B is monotonic, thus, propositions 4, 5 and 6 still apply.

Chapter 3 – Prudential regulation in Brazil: the effects of size-based proportionality on market structure

1. Introduction

This chapter explores the introduction of size-based proportionality in the prudential regulatory framework in Brazil to investigate how such policies affected banks' growth, and if the pattern of such growth impacted concentration. From a competition point of view, size-based proportionality has the defining feature of being akin to an artificial capacity constraint, a speed bump on growth in the form of prudential requirements only triggered at certain thresholds. Since the proportionality thresholds are based on observable characteristics, mainly size as measured by total assets or by total exposures, we apply a difference-in-differences matching estimator on a comprehensive public dataset maintained by the Central Bank of Brazil. We consider three separate prudential rules with embedded size-based proportionality, dealing with liquidity requirements, capital requirements and an overall requirement on risk management structures that entails variations in supervisory intensity.

There are two key results. Contrarily to our expectations, the new rules regarding risk management structures and supervisory intensity seem to have fostered the relative growth of the smaller financial institutions. Similarly, we find some evidence that such differentiation in prudential treatment of the institutions at the other end of the spectrum, those greater systemic importance and subject to heaviest regulatory burden, had an adverse effect on their growth. However, we did not find the same result in respect to the introduction of the capital buffers[6] for systemically important banks (SIBs) and of the short-term liquidity requirement, over which our estimations are inconclusive. Our interpretation of this apparent puzzle is that we are actually observing the effects of a simultaneous regime-change in terms of size-based proportionality and not of the new requirements on risk management structures, a topic we further discuss in the next section.

We posit that there are two possible effects from the introduction of size-based proportionality in terms of growth and market structure. Either it confers a competitive advantage

[6] A buffer differs from a traditional requirement by being a soft restriction. Banks can breach a buffer on occasion, provided they addhere to a set of limitations, usually a cap on dividends.

to the smaller institutions by relieving them of costs incurred by larger competitors or it creates a moat protecting the largest banks, giving them an edge in the form of higher marginal costs on the growth of their competitors not in their peer-group. Furthermore, we conjecture that the occurrence of each outcome depends on the nature of the proportionality measure in terms of cost. If the measure affects a variable cost, such as a higher capital or liquidity requirement, then it is more likely that smaller institutions acquire an advantage, at least in the range until the treatment is triggered. On the other hand, if the proportionality policy imposes a mix sunk of costs and fixed costs to bigger institutions, such as the need for a more complex risk management structure or a new information technology system, then we argue that it is to their benefit in terms of competition and may not hinder their growth.

According to LAUTENSCHLÄGER (2017), the rationale of size-based proportionality is the assumption that small banks face greater difficulties in complying with complex regulation. By allowing small and medium banks to thrive, she argues that size-based proportionality foster a diverse banking sector, which is more stable, as TABAK, FAZIO, and CAJUEIRO (2013) have shown using data from Latin American banks. They conclude that a highly unequal banking sector is detrimental for the performance of smaller banks and it also decreases the stability of the whole system. In fact, some size-based measures were specifically designed to discourage the dominance of the so-called too big to fail (TBTF) banks, see, for instance, the framework for dealing with domestic SIBs by the BASEL COMMITTEE ON BANKING SUPERVISION (2012). Therefore, even though we distance ourselves from the discussion on financial stability, one should not lose sight of its entanglement with competition in evaluating such policies.

The importance of understanding the competition effects of size-based proportionality is due to the fact that it has become a cornerstone of prudential regulation in several jurisdictions. A recent survey of the BASEL COMMITTEE ON BANKING SUPERVISION (2019) indicated that 85% of its member jurisdictions apply proportionality measures in some form. CARVALHO et al. (2017) list examples of proportional approaches in banking regulation and all of them include a prominent size dimension in how they are applied.

In addition to having become a ubiquitous feature of prudential frameworks, pro-competition policies for the financial sector often assume the analogous form of a regulatory sandbox. In this sort of policy, pioneered by the Financial Conduct Authority (FCA), a British regulator, early-stage technologically innovative financial firms, usually called “fintechs”, are allowed to operate in a controlled environment that waivers several prudential requirements and may even suspend the need of an authorization altogether before they reach a certain scale, as TRELEAVEN (2015) discusses. We argue that regulatory sandboxes are an extreme form of size-based proportionality, for they cleave the prudential framework into two separate domains whose threshold is linked to the size of the entity. Therefore, the same considerations may apply.

2. Proportionality in Brazil

Beginning in 2017 with the issuance of National Monetary Council Resolution 4,553, all financial institutions supervised by the Brazilian Central Bank are to be assigned to one of five segments, and both their prudential requirements and the intensity of supervisory procedures applied on them varies accordingly. The main driver of segment allocation is the size of the financial institution relative to Brazilian GDP. For instance, institutions whose total exposures exceed 10% of the Brazilian GDP, roughly the Segment 1, are subject to increased capital and liquidity requirements. At the other extreme of the spectrum, Segment 5, comprised of institutions whose total assets are less than 0,1% of the Brazilian GDP that adhere to some restrictions on activities, has a distinct body of rules with a simplified capital requirements framework that is entirely based on accounting rules. Of particular importance to this discussion is the concurrent issuance of National Monetary Council Resolution 4,557. According to this rule, the complexity of the risk and capital management structures Central Bank supervisors expect to find during inspections varies in line with the segment to which the supervised entity belongs, and the steepest changes arguably occurs in the transition to Segments 1 and 2. For instance, the leverage ratio requirement only applies to these two segments.

The taxonomy used by CARVALHO et al. (2017) divides the proportionality measures into two branches, the categorization approach, according to which banks are segmented in a single way for all banking rules, and the specific standard approach, which grants exemptions in each prudential standard following some idiosyncratic proportionality criterion. Our understanding is that National Monetary Council Resolution 4,553 marked the start of a transition, in the Brazilian prudential framework, from a specific standard approach to a categorization approach, that is, it was a regime switch. According to CARVALHO et al (2017), the categorization approach is also adopted in Japan and Switzerland.

In fact, size-based proportionality could be found in the Brazilian prudential framework before National Monetary Council Resolution 4,553, but under the specific standard approach. Under the specific standard approach then prevailing, each different rule could have its own criteria for proportionality and they were not introduced simultaneously. By using this feature, we can hope to distinguish variations in their effects on growth and test our conjectures.

In particular, we try to estimate the effects of National Monetary Council Resolution 4,401, issued in February 2015, which brought about a short-term liquidity requirement to banks whose total assets surpassed 100 billion Brazilian Reais, and of National Monetary Council Resolution 4,443, issued in conjunction with Central Bank of Brazil Circular 3,768 in October 2015, that established an additional capital buffer to systemic banks, that is, those whose total exposure is above 10% of GDP, approximately 500 billion Brazilian Reais at the time.

3. Related literature

Our work is connected to the literature that investigates how prudential requirements affects banks' lending growth and, in particular, how that may affect the credit market structure. In this regard, CARLSON et al. (2013) find evidence that relationship between the capital ratio and lending is affected by bank size, while KIM and SOHN (2017) find that the liquidity level interacts differently with the capital ratio on the effects of the latter on net loans growth depending on the size of the bank. However, our main point underlying this work is that understanding size-based proportionality is fundamentally different, in terms of its effects on competition, from prudential requirements applied equally to all institutions or specifically to institutions on a case-by-case basis, such as Basel Pillar 2 requirements that reflect the supervisory review of the capital adequacy of a given institution (e.g. DE JONGHE et al., 2019), a point that, to best of our knowledge, has not been addressed by the literature.

As BRIDGES et al. (2014) argue, idiosyncratic variations in individual bank capital requirements might not be comparable to variations affecting all banks. Individual requirements are not applied randomly, but are assigned to banks that supervisors deem to have insufficient loss-absorbing capacity, thus, their reaction might not be the same of other banks that are not undercapitalized. Besides, the fact that not all banks are subject to same requirement may constrain the response of the affected bank through competitive pressures emanating from non-affected banks. Therefore, our work is in the strand of the literature that investigates prudential requirements that differentiate the treatment of banks based on their size.

GROPP et al. (2018) provide the framework upon which this work is developed, as we follow the same empirical strategy. Their strategy is to use the fact that European banks are subject to different capital requirements based on their country-specific relative size to implement the nearest neighbor matching estimator developed by ABADIE and GUIDO (2002), obtaining average treatment effects. They show that treated banks increase their capital ratios not by raising equity, but by curbing their supply of credit, a finding we corroborate when analyzing capital buffers.

In addition, we also contribute to the incipient literature that explicitly seeks to understand how prudential requirements may affect bank competition, of which the work of SCHARGRODSKY and STURZENEGGER (2000) is a noteworthy example. They provide a theoretical model in which tighter capital requirements decrease product differentiation, leading to higher levels of bank competition. SCHLIEPHAKE and KIRSTEIN (2013) show that capital requirements can act like a capacity constraint and change the regime of competition from Bertrand to Cournot, in the manner of KREPS and SCHEINKMAN (1983).

3. Data

Our data comes from one source, the public IF.DATA database maintained by the Central Bank of Brazil. The database follows all Brazilian financial institutions, in three distinct forms of consolidation: non-consolidated individual entities, prudential conglomerates and financial conglomerates. In this work, we consider the last two forms of consolidation, their differences being limited mainly to the incorporation of funds managed by the bank in the prudential consolidation. However, while the data on the credit portfolios is more detailed in the financial consolidation, the information on prudential requirements is restricted to the prudential consolidation, which only began in 2015. Therefore, we cannot run regressions that simultaneously consider details of the credit portfolios and of variations in prudential requirements, neither can we consider prudential conglomerates in estimating effects of National

Monetary Council Resolution 4,401, because there is no observation in that form of consolidation prior to its announcement for us to compare. Thus, we focus on the financial consolidation, it is used unless noted otherwise.

The variables used are listed on table 1 below.

Table 1. Description and Definition of Variables

Variable name	
Credit growth	Variantion in accounting balances pertaining to credit and leasing operations, gross of provisions.
Asset growth	Variation in total assets, as reported for accounting purposes.
Liquidity index	Variations in the proportion of the sum of cash and short-term investments over total assets.
Equity index	Variations in the proportion of equity over total liabilities.
Retail Portfolio %	Percentage of credit granted to natural persons.
Trading Assets %	Percentage of total assets composed of securities (bonds, equities and derivatives).
SME Corporates, %	Ratio of credit granted to small and medium enterprises over total credit to legal entities.
Non-performing loans %	Percentage of credit classified by institution in the rating for over 90 days past due loans.
HHI Retail Lines	Herfindahl-Hirschman Index of the credit portfolio encompassing retail lines (e.g. vehicle financing, house financing, credit cards, rural credit).
HHI Corporate Lines	Herfindahl-Hirschman Index of the credit portfolio encompassing corporate lines (e.g. working capital, investments, receivables, trade finance, revolving lines).
HHI Geographic Region	Herfindahl-Hirschman Index of the credit portfolio encompassing all credit by geographic region (e.g. south, southeast, northeast, north, center-east).
Demand Deposit Funding %	Demand deposits (including "Poupança") as a percentage of total liabilities.
Wholesale Funding, %	Ratio of the sum of interbank deposits and securities-financed transactions over total liabilities.
Equity Funding, %	Porpotion of equity over total liabilities.
Total Assets	Total assets, as reported for accounting purposes.
Credit RWA growth	Variations in risk-weighted assets pertaining to credit risk, as reported for regulatory purposes.
Total RWA growth	Variations in total risk-weighted assets, as reported for regulatory purposes.
Basel Index	Ratio of regulatory capital to total risk-weighted assets, as reported for regulatory purposes.
CET1 Index	Ratio of common equity capital to total risk-weighted assets, as reported for regulatory purposes.

4. Results

We apply the nearest-neighbor matching estimator implemented by ABADIE et al. (2004) to obtain the average treatment effect of being placed under different prudential treatments. This technique imputes the missing potential outcome for each treated observation by using an average of the outcomes of untreated observations closest to the treated observation. The closeness between observations is measured by a weighted function of the covariates for each observation, the Mahalanobis distance metric. The Mahalanobis distance metric has the advantage of accounting for covariances between variables while reverting to Euclidean distance for uncorrelated variables with unit variance. When using categorical variables, we do not force the chosen untreated observations to conform to the same value displayed by the treated observation.

In pairing similar banks, we consider three sets of characteristics: the credit portfolio, the funding profile and ownership. In terms of credit portfolio, we include variables that reflect how it is distributed and its quality. As for funding profile, the proportion of retail funding is probably the key variable, but we also add the proportion of wholesale funding and of equity funding. Finally, we distinguish government-owned banks, since they could have distinct objectives, and banks that are subsidiaries of foreign banks. Subsidiaries of large banking groups could potentially tap resources outside of their balance sheet that may not be available to otherwise comparable banks. All variables are from the end of the quarter prior to the announcement of the measure.

However, given the size-based nature of the treatment, we face a peculiar difficulty in pairings that explicitly consider total assets. For instance, suppose there are three banks, A, B and C. Bank A is barely left out of the treatment, that is, its size is almost that of the threshold, while Bank B is left out the treatment by an ample margin. Finally, Bank C is subject to the prudential treatment. Comparing Banks A and C might yield contrasting results to those of a match between Banks B and C. Bank A may restrain his growth not to incur in the prudential treatment or it may simply anticipate the prudential treatment as if already applicable. In the second case, we would not observe an effect, even if exists, for there would be no distinction between the treatment group and the control group. Therefore, in order to differentiate two possible scenarios we run a separate estimation considering size only.

Therefore, we will consider four estimations in the following sections. In the first, characteristics relating to the credit portfolio are considered. Separately, a second estimation uses as input statistics on funding, excluding those pertaining to the credit portfolio. In the third, both the credit portfolio and the funding profile are jointly considered. Finally, the fourth estimate only uses the total assets criterion.

The liquidity requirement was issued in February 2015, thus, we observe the differences arising throughout 2015, comparing statistics at the end of 2015 to these of the end of 2014. Similarly, we assume that the additional capital buffer applicable to systemic institutions announced in October 2015 will have produced effects when the end of the third quarter of 2016 is examined in contrast to the end of the third quarter of 2015. Finally, for the effects of the introduction of the categorization approach in proportionality and the associated requirements on risk management structures we consider the differences that might have arisen between the last quarter of 2017 and the last quarter of 2016, since those measures were made public in final form in the first quarter of 2017.

4.1 Liquidity Requirements

As mentioned, the liquidity requirement was established by National Monetary Council Resolution 4,401. This requirement is the so-called Liquidity Coverage Ratio (LCR), part of the Basel III framework, and it seeks to guarantee that banks have high-quality liquid assets in sufficient quantity to withstand a 30-day stress scenario. The requirement was announced in final form in February 2015 and entered into force in October 2015.

Table 2. Nearest-neighbor matching estimator for average treatment effect, LCR requirement, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.189719	0.064655	-0.017750	0.007496
Std. Err.	*0.208044*	*0.048501*	*0.020339*	*0.009019*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	159	159	159	159

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 3. Nearest-neighbor matching estimator for average treatment effect, LCR requirement, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.067425	0.007699	-0.003786	0.002413
Std. Err.	*0.137414*	*0.038422*	*0.020137*	*0.010064*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	159	159	159	159

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 4. Nearest-neighbor matching estimator for average treatment effect, LCR requirement, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.063187	0.012209	-0.010925	0.007781
Std. Err.	*0.058564*	*0.030339*	*0.016385*	*0.009295*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	158	158	158	158

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 5. Nearest-neighbor matching estimator for average treatment effect, LCR requirement, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.422258	0.096576	-0.019046	0.002339
Std. Err.	*0.338929*	*0.076055*	*0.030126*	*0.009742*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	159	159	159	159

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

The results, as shown in tables 2 through 5 above, are inconclusive in the sense that no estimative is different from nil in a statistically significant way. Since we do not have the data on prudential conglomerates, we cannot explore it further in that dimension. It should be noted that our liquidity index is calculated using balance-sheet data, unlike the regulatory liquidity requirement, which is calculated using data on financial resources outflow that is not publicly available.

4.2 Capital buffers

National Monetary Council Resolution 4,443, issued in conjunction with Central Bank of Brazil Circular 3,768 in October 2015, created a capital buffer applicable to SIBs. The norm defines as SIBs commercial banks with total exposures above 10% of the Brazilian GDP of the year two years previous. The requirement entered into force in January 2017. As mentioned, we consider the effects produced until September 2016, assuming that banks would not wait until the requirement becomes enforceable to adjust their operations. In fact, we deliberately made the option of focusing on announcement dates under that assumption.

Table 6. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.089575	-0.019755	0.017327	-0.002508
Std. Err.	*0.072303*	*0.063348*	*0.013892*	*0.008374*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	163	163	163	163

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 7. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.107960	-0.031458	0.022922	-0.002265
Std. Err.	*0.073127*	*0.066974*	*0.014172*	*0.008410*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	163	163	163	163

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 8. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.102439	-0.025850	0.021424	-0.002328
Std. Err.	*0.072356*	*0.061575*	*0.013769*	*0.008490*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	163	163	163	163

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 9. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.079655	-0.021510	0.012170	-0.003505
Std. Err.	*0.073536*	*0.057759*	*0.015638*	*0.008111*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	163	163	163	163

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Even though the results of tables 6 through 9 above do not point to a statistically significant reduction in credit growth relative to unaffected banks, banks could be rebalancing their portfolio growth towards a reduction in their risk-weighted density, that is, channeling resources to exposures with lighter risk-weight factors, as found by GROPP et al. (2018). Based on their results, we test this scenario using the prudential conglomerate data and find the results displayed in tables 10 and 11 below.

Table 10. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit RWA growth	(2) Total RWA growth	(3) Basel Index	(4) CET1 Index
Treatment Effect	-1.069609 ***	-4.086142	0.039058 *	0.039402 *
Std. Err.	*0.404604*	*3.407441*	*0.022069*	*0.022743*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	348	348	383	383

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 11. Nearest-neighbor matching estimator for average treatment effect, systemic buffer, same quarter past year

	(1) Credit RWA growth	(2) Total RWA growth	(3) Basel Index	(4) CET1 Index
Treatment Effect	-1.037784 ***	-4.038391	0.036392 *	0.038042 *
Std. Err.	*0.404410*	*3.407410*	*0.021830*	*0.022431*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	348	348	383	383

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

As expected, banks affected by the higher capital buffer did show a difference in their indexes pertaining to the measure and, in particular, their risk-weighted assets (RWA) pertaining to credit risk grew slower than those of their competitors, pointing to a portfolio being rebalanced, a finding convergent to those of GROPP et al. (2018).

4.3 Risk management structures/ supervisory intensity

We consider next the allocation to a particular segment defined by National Monetary Council Resolutions 4,553 and, thus, being subject to different prudential treatment in terms of risk management structures and, possibly, general supervisory intensity. For Segments 1 through 4, the only criteria for allocation is size relative to GDP, with the exception of a policy bank, BNDES, that is excluded from Segment 1. Segment 5 is comprised of Segment 4 institutions that abstain from some activities in return of a simplified prudential framework. However, not every type of institution can opt for Segment 5, banks, for instance, are ineligible, and a kind of financial institution, Microcredit Societies, is compulsorily in Segment 5. We exclude cooperatives from the sample, as they represent the bulk of institutions that could effectively choose to follow a simplified regime. Therefore, issues relating to self-allocating treatments can be safely ignored, at least immediately after the announcement of the measure, a period in which there was no significant migration to Segment 5, the only Segment for which such an explicit option exists.

National Monetary Council Resolutions 4,553 was issued in January 2017, almost simultaneously with National Monetary Council Resolutions 4,557, published in February 2017. National Monetary Council Resolutions 4,557 fleshed out what the newly established sized-based proportionality framework meant in terms of structures for risk management and for capital management. National Monetary Council Resolutions 4,557 is mostly a principle-based rule, but there are specific exemptions by Segment. For instance, the stress test methodology required varies in complexity according to each Segment. More generally, it says that such structures must be adequate to the institution's systemic importance, a principle we interpret as a general link to variations in supervisory intensity.

However, the importance of National Monetary Council Resolutions 4,553 goes well beyond National Monetary Council Resolutions 4,557. In fact, it set the building blocks with which future prudential requirements will mold their own proportionality. Therefore, financial institutions could be factoring in the expectations of future treatment in relation to other norms. In this sense, it is hard to ascribe any change we find only to structures for risk management and for capital management. Instead, we argue that it could be seen as the effect of size-based proportionality under the categorization approach, encompassing all aspects of prudential regulation and even supervision.

Table 12. Nearest-neighbor matching estimator for average treatment effect, Segment 1, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.083221	-0.085123 ***	0.023638 *	0.002192
Std. Err.	*0.071702*	*0.038897*	*0.013214*	*0.008889*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 13. Nearest-neighbor matching estimator for average treatment effect, Segment 1, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.053884	-0.077227 *	0.028582 **	0.000260
Std. Err.	*0.079870*	*0.042003*	*0.014530*	*0.009390*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 14. Nearest-neighbor matching estimator for average treatment effect, Segment 1, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.064214	-0.079518 **	0.027140 **	0.000335
Std. Err.	*0.061574*	*0.035464*	*0.011558*	*0.008482*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 15. Nearest-neighbor matching estimator for average treatment effect, Segment 1, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.045414	-0.078859 *	0.026532 *	0.001807
Std. Err.	*0.078201*	*0.047050*	*0.014695*	*0.009701*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Tables 12 through 15 above consider as treatment the categorization into Segment 1. The results presented in them seem to indicate that the treatment impacted the growth of the affected institutions, albeit the conclusion regarding credit growth is muddled. However, considering the categorization into Segment 1 or Segment 2 as the treatment provides a clearer conclusion, as shown in tables 16 through 19 below. Under that framework, we see a consistent impacts on credit growth.

Table 16. Nearest-neighbor matching estimator for average treatment effect, Segments 1 and 2, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.151929 **	-0.087822 ***	0.025965	0.003698
Std. Err.	*0.060619*	*0.033946*	*0.017035*	*0.007522*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 17. Nearest-neighbor matching estimator for average treatment effect, Segments 1 and 2, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.154605 **	-0.092724 **	0.049594 **	0.001996
Std. Err.	*0.072423*	*0.044660*	*0.022195*	*0.008771*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 18. Nearest-neighbor matching estimator for average treatment effect, Segments 1 and 2, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.142290 **	-0.073164 **	0.035279 **	0.002049
Std. Err.	*0.068429*	*0.036473*	*0.017111*	*0.007976*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 19. Nearest-neighbor matching estimator for average treatment effect, Segments 1 and 2, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	-0.326430 ***	-0.126959	0.071721 ***	0.005057
Std. Err.	*0.111530*	*0.078617*	*0.023665*	*0.007780*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 20. Nearest-neighbor matching estimator for average treatment effect, Segment 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.182420	0.135610	-0.028036	-0.035346
Std. Err.	*0.161209*	*0.113971*	*0.054151*	*0.031249*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 21. Nearest-neighbor matching estimator for average treatment effect, Segment 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.163332	0.321833 ***	0.049106	-0.079973
Std. Err.	*0.262805*	*0.090766*	*0.066823*	*0.056237*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 22. Nearest-neighbor matching estimator for average treatment effect, Segment 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.167396	0.169391 *	-0.021446	-0.047483
Std. Err.	*0.180535*	*0.099774*	*0.056569*	*0.043506*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 23. Nearest-neighbor matching estimator for average treatment effect, Segment 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.255564	0.217697 *	0.003880	-0.003527
Std. Err.	*0.220985*	*0.123959*	*0.030165*	*0.060711*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Similarly to what we saw before, we see some evidence of higher growth when the categorization into Segment 5 is considered the treatment, as can be viewed in tables 20 through 23 above, but most robust results are found if two adjacent segments are grouped together. In fact, tables 24 through 27 below allow us to draw a clearer picture, as every specification point to the same direction regarding credit and asset growth. In fact, when we define as treatment the opposite blocks of the two Segments of the biggest banks and of the smallest banks, the results consistently point to a statistically significant higher relative growth of the institutions under the simpler prudential frameworks.

Table 24. Nearest-neighbor matching estimator for average treatment effect, Segments 4 and 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.190326 ***	0.088521 **	-0.002734	-0.007598
Std. Err.	*0.059870*	*0.036970*	*0.012157*	*0.007758*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 25. Nearest-neighbor matching estimator for average treatment effect, Segments 4 and 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.154253 ***	0.086625 **	-0.020130 *	-0.005578
Std. Err.	*0.056001*	*0.037722*	*0.011474*	*0.008508*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 26. Nearest-neighbor matching estimator for average treatment effect, Segments 4 and 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.146742 ***	0.076376 **	-0.010101	-0.005630
Std. Err.	*0.050543*	*0.035136*	*0.013965*	*0.007811*
Variables Included Matching Estimator:				
Retail Portfolio %	*Yes*	*Yes*	*Yes*	*Yes*
Trading Assets %	*Yes*	*Yes*	*Yes*	*Yes*
SME Corporates, %	*Yes*	*Yes*	*Yes*	*Yes*
Non-performing loans %	*Yes*	*Yes*	*Yes*	*Yes*
HHI Retail Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Corporate Lines	*Yes*	*Yes*	*Yes*	*Yes*
HHI Geographic Region	*Yes*	*Yes*	*Yes*	*Yes*
Demand Deposit Funding %	*Yes*	*Yes*	*Yes*	*Yes*
Wholesale Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Equity Funding, %	*Yes*	*Yes*	*Yes*	*Yes*
Total Assets	*No*	*No*	*No*	*No*
Government-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Foreign-owned dummy	*Yes*	*Yes*	*Yes*	*Yes*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	156	156	156	156

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

Table 27. Nearest-neighbor matching estimator for average treatment effect, Segments 4 and 5, same quarter past year

	(1) Credit growth	(2) Asset growth	(3) Liquidity index	(4) Equity index
Treatment Effect	0.146110 **	0.111459 **	-0.003851	-0.001917
Std. Err.	*0.057527*	*0.050517*	*0.016270*	*0.009676*
Variables Included Matching Estimator:				
Retail Portfolio %	*No*	*No*	*No*	*No*
Trading Assets %	*No*	*No*	*No*	*No*
SME Corporates, %	*No*	*No*	*No*	*No*
Non-performing loans %	*No*	*No*	*No*	*No*
HHI Retail Lines	*No*	*No*	*No*	*No*
HHI Corporate Lines	*No*	*No*	*No*	*No*
HHI Geographic Region	*No*	*No*	*No*	*No*
Demand Deposit Funding %	*No*	*No*	*No*	*No*
Wholesale Funding, %	*No*	*No*	*No*	*No*
Equity Funding, %	*No*	*No*	*No*	*No*
Total Assets	*Yes*	*Yes*	*Yes*	*Yes*
Government-owned dummy	*No*	*No*	*No*	*No*
Foreign-owned dummy	*No*	*No*	*No*	*No*
Matches	4	4	4	4
Distance metric	Mahalanobis	Mahalanobis	Mahalanobis	Mahalanobis
Number of observations	157	157	157	157

* 10%, ** 5%, *** 1%; AI Robust Std. Errors

5. Conclusion

We find robust empirical evidence that the introduction of a categorization approach in the Brazilian prudential framework has been associated with higher relative growth of the financial institutions assigned to Segments with simpler, albeit not necessarily lighter, requirements. We do not find similar results in the specific standard approach that existed before. Our interpretation of the results is that before National Monetary Council Resolution 4,553, proportionality was not well defined nor uniform across regulations, and, thus, it was not feasible for financial institutions to make long-term plans based on it. In fact, as we have seen, each different rule could have its own criteria for proportionality, with limited overlaps and no clear expectation of their continuity in future regulations. By establishing an all-encompassing criterion, National Monetary Council Resolution 4,553 seem to have influenced banks' behavior in a stronger way.

Conclusion

The main takeaway of this work is that Central Bank policies can shape the market structure of the bank sector. We find that assertion unsurprising, since a very important cost for banks is a reflex of monetary policy and the way banks operate is constrained by prudential policies. However, we argue that this topic has received insufficient attention from the literature and that we were able to contribute to its understanding.

We have concluded that monetary policy can affect bank concentration as long as there is a relationship between the size of the bank and the sensitivity of its variable costs to the policy rate. In particular, we have verified, using bank-level data, that deposit-funded banks' loan growth is more impervious to variations in the policy rate. We developed a model aligned with this observation that allowed us to interpret the compatible empirical results we have found.

Similarly, we have shown that monetary policy can affect the bank lending spread when the policy rate determines which business model is more advantageous. If the level of the policy rate favors business models with high barriers of entry, then there would be an effect on bank lending spread. We explored this question in the same model and again found empirical results compatible with our theoretical reasoning. By doing so, we have provided a new explanation to an established phenomenon, that policy rates affect bank lending spreads.

However, we also find that the market structure of the bank sector can influence the effects of Central Bank policies. In investigating prudential policies, we have demonstrated that the effects of prudential policies are conditioned by the market structure in a fundamental way. We analyzed the issue using a theoretical model that integrates several competition regimes and that displays moral hazard. In the model, higher rates worsen borrower incentives. Thus, as capital requirement enhance the bankers' responsiveness to losses, there is the possibility that spreads will be reduced to minimize them. Whether this possibility would bear fruits is intrinsically a matter of the competition regime.

In a monopoly, bankers have both the incentive and the room to cut rates in face of higher capital requirements. Under intense competition, the dominant effect is the increased funding cost, which is necessarily passed along to the borrower.

Finally, we have studied the market structure effects of prudential policies that distinguish the treatment of banks based on their size. Our study is circumscribed by the specificities involving the introduction of Brazilian norms, but we have found evidence that the transition to a framework in which all rules are bound to the same criteria has fostered the growth of the smaller institutions. That effect potentially reduces bank concentration.

Bringing together our findings regarding prudential policies, we conclude that the effects of prudential policies on bank lending spreads and on market structure is far from preordained. In fact, we argue that it is wrong to assume that higher requirements will always lead to wider spreads and more bank concentration. The effect on bank lending spreads is contingent on the competition regime and the effect on bank concentration depends on the design of the requirement and especially on its scope of application.

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