Financing Imbalances and Heterogeneous Effects of Monetary Policy *

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Abstract

This work documents the existence of a heterogeneous banking channel in Peru, where monetary policy actions have a differentiated effect on the credit market and which depends on the level of leverage of financial institutions. First, we characterize the symmetric aggregate response of the credit market to expansionary or contractionary shocks of monetary policy. At the financial entity level, we show that its financing structure, measured by its leverage level, mainly determines a heterogeneous monetary policy lending channel. To show causal effects of this channel of financing imbalances, we use microdata at the branch level, together with an econometric strategy that focuses on local credit markets and a measure that considers the geographic distribution of financing imbalances. We show that the dependence on external funding at the branch level determines the heterogeneity in the credit channel, for the monetary policy transmission, with two important margins: an amplifying effect and another attenuating effect, associated with a lower or higher level of leverage, or with a greater or lesser need for external funding, respectively. To rationalize our findings we build a theoretical model. In the model, the financing structure of a bank generates effects that amplify or attenuate the effects of monetary policy.

Keywords: Regional heterogeneity, monetary policy shocks, leverage, regional imbalances.

JEL Classification: E5, G21

Introduction

In Peru, the capital market is still underdeveloped; therefore, the depository financial system is the main institution for the mobilization of funds between saving agents and

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debtors. In particular, the credit market serves as the main source of financing for firms and families that carry out investment and consumption activities. That is why the credit market is important in economic activity and a relevant channel for the transmission of monetary policy.

Monetary policy actions influence the credit market in two ways. On the one hand, by altering the cost of funding, they affect the credit supply decisions made by financial entities, which is called the bank loan channel (Bernanke and Blinder, 1998). On the other hand, they also affect the demand for loans by altering the solvency of the firm equity, known as the balance sheet channel (Bernanke and Blinder, 1998; Kiyotaki and Moore, 1997). In equilibrium, the impact of a monetary policy shock on the credit market is corresponding to a credit contraction. But, the determination and final magnitude of the equilibrium depend on the relative importance of the supply and demand factors. Pozo and Rojas (2020b, 2021a) show that credit demand and supply factors are related in equilibrium, and a correct characterization of them is important for the design of policies. Quispe (2001), Carrera (2011), Viladegut and Cabello (2011), Bustamante et al. (2019) and Pozo and Rojas (2021a), are previous empirical studies that have documented the lending channel of monetary policy for Peru. However, none of these previous studies have characterized the heterogeneous equilibrium of the credit market, adequately controlling for supply and demand factors, and considering the credit and deposit structure.[1]

In particular, we seek to answer the following questions regarding the effects of monetary policy on the credit market: Is it the supply side or the demand side that guides the adjustment of the credit market? Are these adjustments non-linear and do they depend on the contractionary or expansionary stance of monetary policy? More importantly, are the effects of monetary policy on the credit market heterogeneous? What are the implications of the credit and deposit structure in the transmission of monetary policy? By answering these questions we can determine the macro adjustment of the credit market, differentiating it by relative components of supply and demand. In addition, it is possible to specify the differentiated impacts and describe the operating margins of the monetary policy actions in the credit market.

Specifically, we focus on the lending channel and examine the heterogeneities in the evolution of credit associated with changes in the monetary policy position. To do this, we use a two-pronged strategy. We first estimate empirical models at the bank and bank branch level, using publicly available data on loans and deposits for the period 2003:M1-2019:M12. Second, to rationalize our results we developed a simple model with heterogeneous banks or branches on the financing structure of the loans.

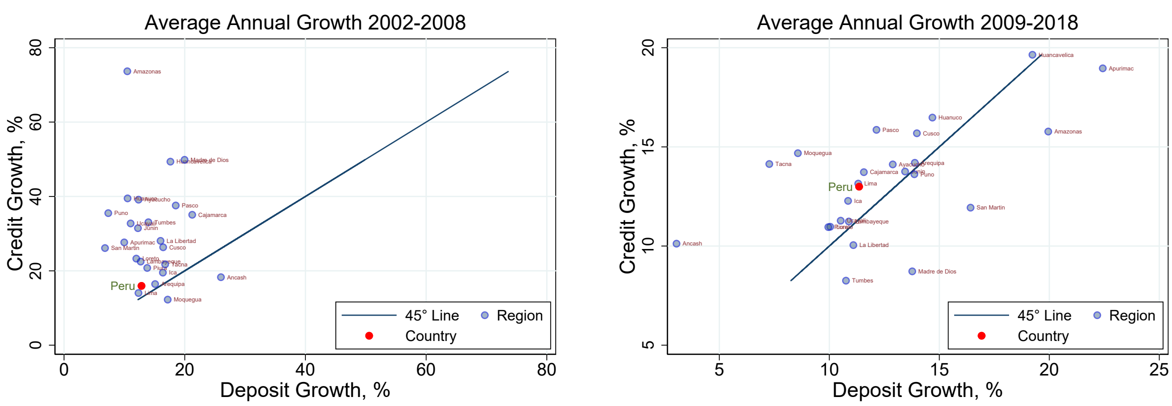
In our empirical exploration, to achieve identification, and to overcome the endogene-

[1]Exceptions are Bustamante et al. (2019) and Pozo and Rojas (2021a) that also differentiate between demand and supply factors of monetary policy, but the first seeks to explain the determinants of loan growth and the second documents the risk-taking channel.

ity problem of the monetary policy response to credit markets, first, we use a new time series of monetary policy shocks constructed by Pozo and Rojas (2022) for the Peruvian economy. As part of our initial results, at the aggregate level, we extend the results of Pozo and Rojas (2022) and show that contractionary or expansionary monetary policy shocks do not, on average, have asymmetric effects on the credit market. Second, similar to Pozo and Rojas (2021a, 2022), we use data at the bank branch level to compare the differential responses of branches to a monetary policy shock, in a specification that allows us to control for demand factors within a financial institution. An important assumption of our strategy is to consider that changes in the monetary policy rate affect the cost and/or the sources of credit financing and, therefore, the opportunity cost of deposits, which are the main source of funding for banks. However, at the local level, deposits, made for example in a district, do not necessarily coincide with credit financing needs. It is then that the reallocation of funds across different locations becomes important.

The mobilization of funds to finance credit does not occur in the same way in all regions of Peru. Figure 1 shows the differences in deposit and credit growth rates across regions for two periods: one before the international financial crisis, 2002-2008, and one after it, 2009-2018. In the 2002-2008 period, the acceleration of aggregate credit occurred at a faster rate than the expansion of deposits (with an average annual rate of 16% for loans, but 12.8% for deposits). In general, in all regions a greater acceleration of credit was observed in relation to deposits. In addition, a greater heterogeneity is documented in the dynamics of regional credit with respect to the dynamics of deposits. While average credit growth rates range from 12.3% to 73.7%, deposit rates only range from 6.8% to 26.0%.

Figura 1: *Regional dynamics of deposits and loans*



Note: Source: Superintendency of Banking, Insurance, and Private Pension Fund Administrators (SBS).

However, after the great international financial crisis, in the 2009-2018 period, the expansion of aggregate credit has moderated, with an average annual growth rate of 13%, but deposits grew at a slower pace, at a rate of 11.4% per year, which is similar to that of the 2002-2008 period. However, although there is less growth dispersion between deposits and loans, there is still great heterogeneity between them at the regional level. This heterogeneity in the credit financing structure is a relevant characteristic that would explain the differentiated impacts of monetary policy on the credit market.

In the remainder of the analysis we proceed as follows: First, we use segregation metrics used in sociology (Duncan and Duncan, 1955; White, 1983; Aguirregabiria, Clark and Wang, 2019) to descriptively document the existence of an unbalanced geographic structure between deposits and loans, both for individual banks and for all banks located in a district. We show that some districts have a higher share of total loans in the country, but a low share of total deposits, and vice versa for other districts. Although there is no specific geographic pattern, these distributions remain relatively constant over time. At the level of shares of branches of a bank in a district, there is a high degree of inequality in both the distribution of credit shares and the distribution of deposit shares, where the shape of the loan share distribution has a tail that is fatter than that of the distribution of deposit shares. 50% of the district branches of financial entities have shares below 1% (0.2% for credit shares, and 0.8% for deposit shares). However, 1% of bank branches hold shares of more than 65% and 77% of a bank's total deposits and loans, respectively. To capture this differentiation in the geographic financing structure of financial entities, we compute a geographic imbalance index.

Second, we estimate the heterogeneous effect of monetary policy at the bank level. This effect would be a function of the financing structure, measured by leverage and the geographic imbalance index. The first measure considers the overall balance sheet structure of a financial institution, and therefore characterizes its external financing needs. In general, in this work we call "external financing" the funding that does not come from local deposits. The second one measures the structure of deposit and loan networks within a financial entity. Our results indicate that the leverage is the most important variable to determine the monetary policy power in the credit market, with an amplifying margin and another that attenuates monetary policy shocks. In particular, the greater the leverage (or less dependence on external financing), the less positive it will be the impact of an expansionary monetary policy shock. On the other hand, we find that, although a higher imbalance index amplifies the impact of monetary policy, these effects are not significant, and probably converge with that of leverage. Additionally, our specification at the bank level does not allow us to identify the loan channel since we cannot differentiate this supply effect from demand factors.

Third, we exploit the geographic variation in the credit-to-deposit ratio induced by differences in the concentration of local credit and deposit markets. At the branch level of a financial institution, the credit-to-deposit ratio is an indicator of leverage or needs for external financing. To identify the imbalance channel, we need the variation of this indicator to be independent of the lending opportunities of the financial institution or the demand factors that influence the financial institution's decisions. To obtain this variation, we compare the loans between branches of the same financial entity located in different districts.[2] Under this strategy, we can control for loan demand opportunities that a bank faces, and we can identify the sensitivity induced by changes in monetary policy on the credit supply strategy of a bank branch. Our results indicate that the sensitivity of credit growth is negatively related to the credit-to-deposit ratio. This is indicative of the heterogeneity in the monetary policy transmission that depends on the relative size of external funding at the branch level and that it works in the expected direction from a given threshold.

Finally, we build a theoretical model to rationalize the results obtained about the non-linear monetary policy impact on credit at the bank and branch levels. According to the model, this is because the impact of the policy rate on bank profits and hence on the probability of bankruptcy, for a given level of credit, depends on the level of leverage or the financing structure.

In the model, the greater the leverage, the less positive impact of an expansive monetary policy. This is due to the greater leverage or greater dependence on local deposits amplifies the positive impact of a lower deposit rate, which leads to a stronger reduction of bank or branch default probability, ceteris paribus. In the general equilibrium, this reduces bank incentives to issue excessive loans. In addition, the heterogeneous impacts are better identified at the bank branch level due to the greater leverage variability by definition at the branch level.

The rest of this document is organized as follows: section 1 presents the literature review of the related research work. Section 2 presents aggregate evidence of the impact of the monetary policy stance on credit, and also discusses the importance of asymmetric effects. Section 3 describes data at the bank and branch levels. The section 4 shows descriptive evidence of the geographic imbalance in the structure of loans and deposits, at the level of local markets and banks. The section 5 shows estimates of the heterogeneous effect of monetary policy, but at the level of financial institutions. Section 6 presents the identification strategy and the estimates with granular information, and robustness exercises. Section 7 discusses the theoretical model with banks and with heterogeneity in the credit financing structure in order to rationalize the empirical results. Finally section 8 concludes.

[2] **Notice that we collapse information at the bank-district level, since it is not possible to track information of more than one bank branch in a district.** The districts of Peru are the third-level country subdivisions of Peru. They are subdivisions of the provinces, which in turn are subdivisions of the regions.

1 Literature Review

This document is related to the bank lending channel literature as in Bernanke and Blinder (1998); Kashyap and Stein (1994). In this literature, the bank lending channel depends on the supply of required reserves, which is under the control of the central bank, and through this, the central bank controls the size of bank balance sheets. However, as the monetary policy framework shifted from control of aggregates to control of the interest rate, the role of reserve requirements diminished (Galí, 2015). However, as Kashyap and Stein (200); Jiménez et al. (2017); Drechsler et al. (2017) shows, the central bank's market operations alter the opportunity cost of financing and influence the bank's lending decisions. Our contribution to this literature includes a set of empirical estimates on this channel in an emerging market economy where the monetary policy framework involves changes in the interest rate and the reserve requirement. We also provide theoretical results to rationalize our findings. Our work formalizes and extends the previously found evidence (Carrera (2011); Quispe (2001); Viladegut and Cabello (2011); Bustamante et al. (2019); Pozo and Rojas (2021a)) of a lending channel in Peru.

Our work is also related to empirical research that studies the impact of conditional monetary policy on the financing structure of credit. For their part Dell'Ariccia et al. (2016) using loan information at the bank level for the period 1997-2011 in the United States, find that the impact of monetary policy on bank risk taking is conditional at the level of bank capitalization. In particular, the less capitalized a bank is (or the higher its leverage level), the less negative the impact of the contractive monetary policy on risk taking. Unlike Dell'Ariccia et al. (2016) we focus on the credit volume and not only at the bank level but also at a bank branch level.

Recently, Li (2022) using monthly data for the 1994-2017 period, finds that monetary policy in the United States is more effective in reducing financing costs, when financial intermediaries are well capitalized (or have low leverage). This allows for a greater boost in actual activity. Likewise, the authors show that the lower effectiveness when in a state of nature with a low capital ratio would not necessarily be associated with the lower bound limit of the policy rate.

Bräuer and Rünstler (2014) in an empirical study for 10 Eurozone countries in the 1982-2017 period, find that the credit channel of monetary policy is more important in periods where the bank leverage is higher. This is due to the relatively more important impact on bank equity. Similarly, De Groot (2014) in a general equilibrium model finds that highly leveraged banks experience a high change in equity after a monetary policy shock and therefore decide to adjust the supply of credit more aggressively. Unlike these authors, this paper explores the excessive risk taking channel, and we find evidence at bank and bank branch levels that the leverage or dependence on local funding (deposits) could diminish the monetary policy impact.

The theoretical model presented in this paper is related to the literature that models the interaction of limited liability and deposit insurance to explain excessive bank risk-taking (see, p. eg, Agur and Demertzis, 2012, 2019; Collard et al., 2017; De Nicolò et al., 2012; Pozo, 2019). Unlike Collard et al. (2017) and similar to Pozo (2019), the bank default probability is determined in general equilibrium, which allows us to measure the policy rate impact on bank excessive risk-taking' decisions.

In addition, this article is related to the literature that studies the different channels through which monetary policy can affect not only credit but also bank risk-taking (see, p. eg, Agur and Demertzis, 2012, 2019; Dell'Ariccia et al., 2014, 2016). Two main channels are suggested: the *profit channel* (or bank profit channel) and the *leverage channel* (or leverage channel). According to the *profit channel*, a lower policy rate increases bank profits in good states of nature and thus reduces bank incentives to take risk. The *leverage channel* suggests that a lower rate makes leverage less expensive. This means that the bank internalizes its risk-taking less and its incentives to assume more risks increase. Dell'Ariccia et al. (2014) conclude that when leverage is endogenous, low domestic interest rates lead to greater risk-taking by banks. However, if the level of leverage is exogenous, the effect depends on the level of leverage as follows: the higher the leverage, the higher the probability that a lower rate will reduce bank risk-taking. Our model also captures these two channels, but in a different setup. Thus, the monetary policy impact is non-linear on bank leverage, due to the *profit channel*, which has an impact not only on risk-taking incentives but also, unlike Dell'Ariccia et al. (2014), on the loan level. In this case, the higher the banks' leverage, the lower the positive impact on credit of an expansive monetary policy.

2 How does the credit market adjust to a monetary policy shock?

First, before documenting the heterogeneous effects of changes in monetary policy at the micro level, we present results documented in Pozo and Rojas (2022) and extend their estimates to differentiate between possible asymmetries of changes in monetary policy, between an expansive or contractive stance.

In particular, we adopt Pozo and Rojas (2022)'s estimation strategy that considers a flexible form that imposes few restrictions on the data to establish causal effects on the aggregate variables. However, since the monetary policy rate is endogenous to the economic cycle and credit market, an exogenous monetary policy shock is necessary. Therefore, from now on, we use the new series of monetary policy shocks constructed for the Peruvian economy by Pozo and Rojas (2022).[3]

[3] Pozo and Rojas (2022) construct a new time series of monetary policy shocks for Peru using the

Second, we use local projections (Jordà, 2005) to model the dynamic equilibrium response of credit and the lending rate after the monetary policy shock. Specifically, let y_t be the outcome variable at time t, we estimate a series of the following regressions:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h \, \epsilon_m^{MP} + \sum_{k=1}^{K} \gamma_k^h X_{t-k} + u_t^h \,, \tag{1}$$

where $h = 1, 2, ..., 16$. The coefficients β_h indicate the percentage change in the h horizon in response to a 100 basis point monetary policy shock. X_t denotes a vector of controls. Following the same specification as in Romer and Romer (2004), it includes three years of lagged values of the monetary policy shock and two years of lagged values of the dependent variable. In addition, we added a dummy variable for the period after the first quarter of 2009. After the Global Financial Crisis, the main macroeconomic variables began to show lower growth rates and higher volatility. It is important to note that the specification (1) leaves the contemporaneous response unrestricted, and differs from a typical Cholesky identification generally used in VAR specifications. Following Ramey and Zubairy (2018), local projections allow us to estimate non-linear effects using the same specification (1) but with dummies variables.

Results

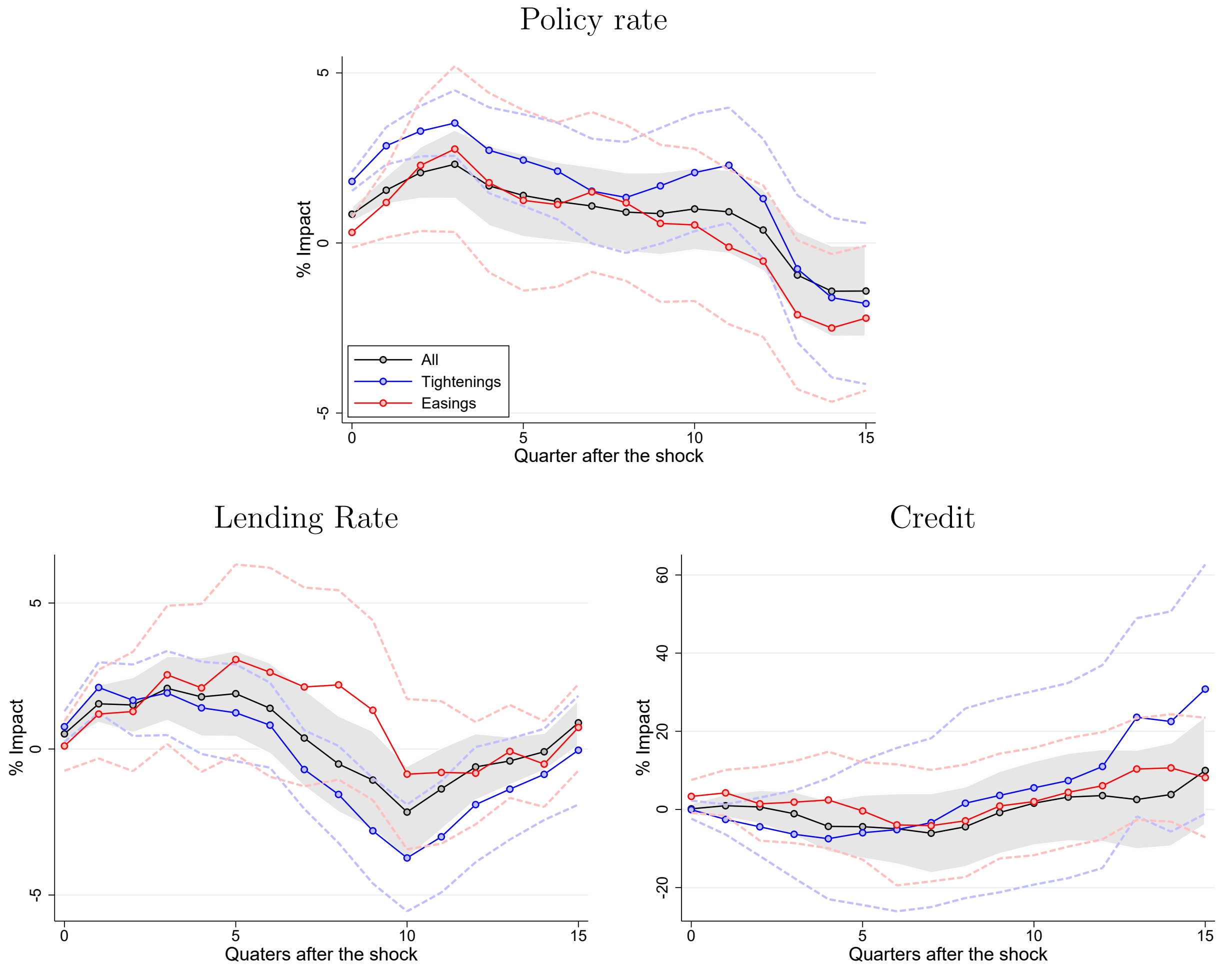
The local projections, in specification (1), are estimated with quarterly frequency data for the 2003:Q4-2019:Q4 period. We consider the impact of a contractionary monetary policy shock of 100 bps on the credit market at the aggregate level: total credit and the average lending rate[4].

The impulse responses of credit market outcomes after the tightening monetary policy shock are shown in Figure 2. Considering the base result reported in Pozo and Rojas (2022), an increase in lending rates is observed after a 100 bps increase in the monetary policy rate: the lending rate rises and reaches a maximum increase of 2% after two quarters and remains around this level a year later. There is also a negative, persistent and economically significant response in aggregate credit after a monetary policy shock: credit fell by around 3% four quarters after the shock, and reached a drop of around 5% in the next year. What is most important is that when considering different monetary

same approach as Romer and Romer (2004). To do this, they use annual GDP growth and inflation forecasts published by the Central Bank of Peru, and complement them with projections from professional forecasters, as in Holm et al. (2021), when the Central Bank's forecasts are not available. See Pozo and Rojas (2022) for a detailed explanation of the construction of these monetary policy shocks.

[4]The data was obtained from the repository of the Central Bank of Peru, BCRPData, available in https://estadisticas.bcrp.gob.pe/estadisticas/series/. Total credit (PN00505MM) measured by Total credit to the private sector of deposit institutions, in millions of S/. end of quarter. The average lending rate is constructed as a credit-weighted average between the series of flow interest rates in local currency (PN07808NM) and flow interest rates in foreign currency (PN07828NM).

Figura 2: *Monetary Policy and Credit Market Shock*



Note: This figure shows the impulse response functions to a monetary policy shock. Base: Indicates the impact of a contractionary monetary policy shock of 100 bps as reported in Pozo and Rojas (2022). Expansive: indicates the impact of an expansionary monetary policy shock of 100 bps, where the specification (1) considers only negative monetary policy shocks. Contractionary: indicates the impact of a contractionary monetary policy shock of 100 bps, where the specification (1) considers only positive monetary policy shocks. Confidence bands are of 68%, using Newey and West (1987) standard errors. Quarterly frequency for the 2003:Q4-2019:Q4 period.

policy regimes there is no considerable evidence to indicate asymmetric effects in credit markets after an expansionary or contractionary monetary policy stance. Based on these results, from now on, when we study the heterogeneous effects of monetary policy at the micro level, we do not distinguish between positive or negative monetary policy shocks.

This aggregate empirical evidence confirms that the supply-side adjustment mechanism in credit markets is important for credit market equilibrium after a monetary policy shock. Motivated by this added evidence, in the following sections we analyze the channel of imbalances between credits and deposits or external leverage at the branch level as a credit supply-side mechanism that determines the equilibrium after a monetary policy shock.

3 Data

In general, we use two levels of information. First, following the related literature, we use data at the bank level. Second, we use information at the branch level of a financial institution of the financial system[5] that is not very common to see in the literature, due to the limited availability of such information. The latter is more granular and hence allows us to better control demand characteristics that can bias our results. Both sets of information are publicly available on the website of the Superintendence of Banking, Insurance and Private Pension Fund Administrators (SBS).[6]

In the next subsection, we describe the time-bank level data set, the empirical model, and the results of our first bank-level regression. And in subsection 3.2 we focus on the more granular data that will be part of the input of the main estimates presented in the following sections.

3.1 Data at the bank level

We explore data at the bank level to assess the heterogeneous effects of monetary policy on credit.[7] In particular, we study its conditional effect on the bank leverage level (financing structure). Information on loans and other indicators of banking companies are provided by the (SBS). The variable we seek to explain is credit growth, Δy (calculated as the deviation of the logarithm of the bank's loan balance). We use the monetary policy shock measure identified for the Peruvian economy, ϵ_t^{MP}, presented in section 2.

In the analysis at the bank level, we include some variables to control for individual bank characteristics that vary over time, such as return on assets (ROA) and relative bank size or loan market share (SIZE). In addition, we include the risk-weighted asset-to-equity (RWA) ratio. The RWA ratio aims to control for the bank's resilience after a financial crisis, and for risk-taking incentives.[8]

Another control that we include is the non-performing loan (NPL) ratio defined as the ratio of loans in arrears to total loans under the same criteria defined by the Peruvian

[5]The financial system in Peru is divided in five financial groups: commercial banks (banks), *empresas financieras*, municipal credit and saving institutions (CMACs by its Spanish acronym), rural credit and savings institutions (CRACs by its Spanish acronym) and small business and microenterprises development institutions (EDPYMEs by its Spanish acronym). However, we do include EDPYMES in our analysis since they are not allowed to capture deposits.

[6]Available in `https://www.sbs.gob.pe/estadisticas-y-publicaciones/estadisticas-/sistema-financiero_`

[7]The banking system represents on average 88% of total credit in the financial system in our study period.

[8]See Agur and Demertzis (2012, 2019) and Dell'Ariccia et al. (2014) for a detailed explanation of the effect of bank leverage on risk-taking (i.e., the *leverage channel*). Intuitively, the higher the leverage, the lower the share of the owners' wealth in financing the bank's investment activities. For the time being, the lower the losses from bank duels if the banks fail (due to limited liability) and, therefore, the higher the preference for taking on more risk.

financial regulator, SBS.[9] It provides information of the non-performing loans at the institution-time level.

We use monthly data and the time period analyzed spans from 2003:M1 to 2019:M12. We start in 2003 to consider only the inflation targeting period in Peru and stop in December 2019 to avoid the Covid-19 pandemic period.

Table 1 presents the descriptive statistics. In our study period, we have an average of 15 banks and around 2700 observations. Average monthly credit growth is 1.2% with a relatively high dispersion. The risk-weighted assets to capital ratio is 6.8 and a relatively low dispersion considering. The average NPL ratio is 3.3% and there is a high dispersion. The average loan market share (SIZE) is 6.2%, with a relatively high dispersion. The return on assets (ROA) is the one with the highest relative dispersion. We also use a measure of the imbalance of deposits and loans at the bank level (GI). [10] Finally, we show the average of the monetary policy shock, very close to zero, with a standard deviation of 0.10%.

Tabla 1: *Descriptive statistics of the observations at the bank-time level*

Variables	N° Obs.	Mean	Standard deviation	Min	Max
Δy_{bt}	2933	0.012	0.06	-0.62	0.80
RWA_{bt}	2786	6.800	1.66	0.80	10.24
NPL_{bt} (%)	2786	3.300	3.42	0.00	34.28
SIZE_{bt} (%)	2933	6.176	8.63	0.00	32.55
ROA_{bt} (%)	2748	1.711	1.99	-12.51	8.06
GI_{bt}	2784	0.270	0.21	0.00	0.78
ϵ_t^{MP} (%)	196	0.000	0.10	-0.23	0.35

Source: SBS. Own Elaboration. SIZE_{bt} = (total loans of bank b at time t)/(total credit at time t). We omit extreme values and keep $-1 < \Delta y_{bt} < 1$. We drop 10 observations.

3.2 Data at financial institution branch level

Table 2 presents the descriptive statistics of the main variables of the analysis. It shows averages of time series and cross-sectional data. The empirical analysis uses the loan variations at the branch level. **Indeed, in this paper branch level data is built collapsing information of all branches of a bank at the district level, since it is not possible to track information of more than one branch in a district.** There are 3,682 branches located in 451 districts and 189 provinces.

[9] The definition of the non-performing loans ratio would be the following:

$$\frac{\text{arrears loans (big (15d), small (30d), mortgage (30d), personal (90d))}}{\text{Total Credit}} 100. \tag{2}$$

Big firms correspond to corporate, large-sized and mid-sized firms. Small firms refer to small-sized and micro-sized firms.

[10] The construction of this index will be seen in the 4 section.

Tabla 2: *Descriptive statistics*

	All		Low C/D		High C/D	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Panel A. Province Characteristics						
Population (thousands)	203.2	765.9	332.1	1,070.0	74.2	49.2
Area (sq. km.)	6,915.1	12,489	7,451	15,128	6,379.0	9,196.9
Formal Employment (%)	2.6	3.7	4.4	4.4	0.9	1.5
Cred-Dep ratio (%)	187584	1.1e+06	155	56	375013.5	1.6e+06
Obs.(Provinces)	154		77		77	
Panel B. Branch Characteristics						
Credit (thousands S/)	114.1	949.8	160.0	1,091.7	68.1	779.5
Credit growth (%)	8.0	24	7.8	26	8.2	20.9
Deposits (thousands S/)	111.4	826.2	199.6	1,114.4	22.9	326.6
Deposit growth (%)	10.9	32	7.7	24	14.1	37.5
Cred-Dep ratio (%)	1,072.8	3,786	83	59	2,065.2	5,170.2
Obs.(Branch × month)	91,390		45,744		45,646	

Note: This table provides summary statistics at the province and branch levels. All panels provide a breakdown by high and low loan-to-deposit (C/D) ratio, using as a break-point the median. Panel A presents the characteristics for all provinces with at least one branch. The underlying data is from the 2017 census. Data on employment comes from SUNAT (Peru's tax authority). Panel B presents data on total credit and loan and deposit growth at the branch level. Source: SBS. Own elaboration.

All panels in table 2, for presentation purposes, provide a breakdown by high and low Credit/Deposit (C/D) ratio using the median as the threshold.Panel A of table 2 shows data statistics for all provinces with at least one branch. It is notable that the low C/D ratio provinces are larger and have more formal employment than the high C/D provinces. The average population in the low C/D ratio provinces is 333.7 thousand compared to 72.7 thousand in the high C/D ratio provinces. The formal employment rate in markets with a low C/D ratio is more than 4 times that of markets with a low C/D ratio: 4.4 vs. 0.9.

Summary statistics at the branch level are shown in Panel B of 2 table. Branches in low C/D ratio provinces are larger. The average branch with a high C/D ratio has loans and deposits of 160 thousand soles and 199.6 thousand soles, respectively, which are well above 68 thousand soles and 22.8 thousand soles, respectively, from low C/D ratio branches. However, on average high C/D ratio branches show a higher rate of credit and deposit growth relative to high C/D ratio branches.

4 Evidence of Geographic Imbalances between Loans and Deposits

In this section, we provide evidence of how spatially unbalanced deposits and loans are. As in Aguirregabiria, Clark and Wang (2019), we use segregation metrics used in sociology (Duncan and Duncan, 1955; White, 1983) to identify variations in the geographic distributions of deposits and loans, both for individual banks and for all banks.

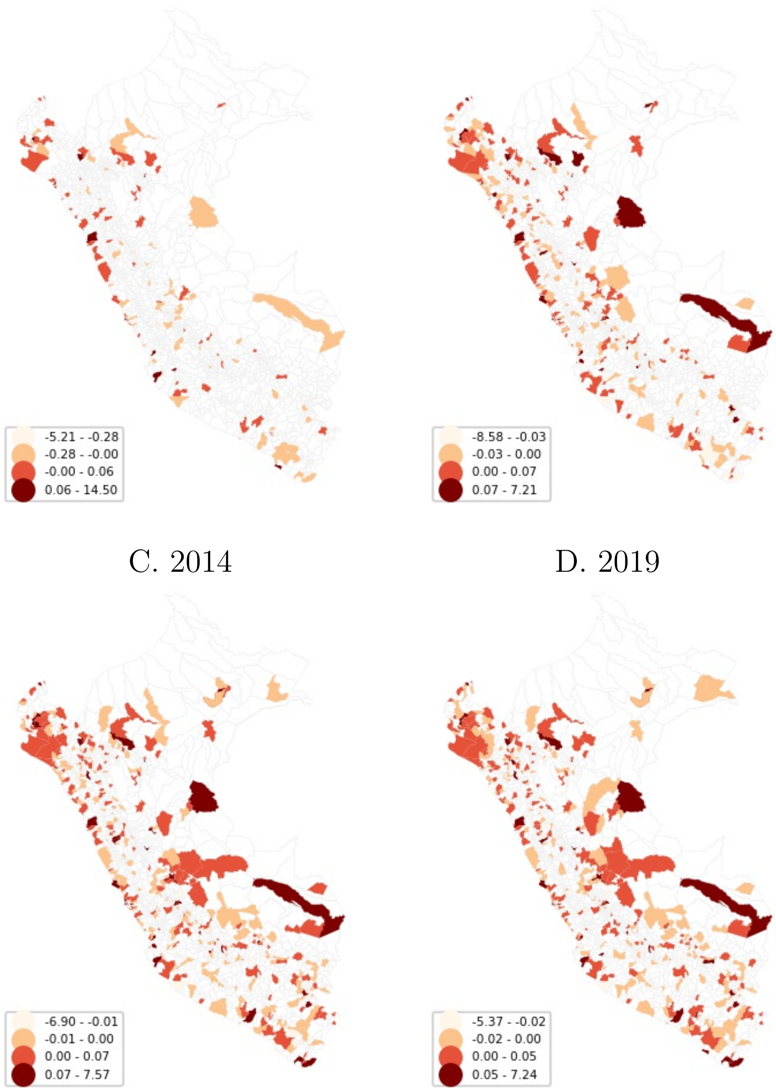
Figure 3 shows the geographic distribution of districts as net borrowers or net lenders, measured by the district-level geographic imbalance index $GI_{S_L - S_D}$, which is computed by the difference between a district's share of the country's deposits, dep_{dt}/Dep_t, and its share of the country's loans, cre_{dt}/Cre_t:

$$GI_{S_L - S_D} = \frac{dep_{dt}}{Dep_t} - \frac{cre_{dt}}{Cre_t}\,.$$

For each year (2002, 2008, 2014, or 2019), returns the distribution intervals divided by the 10th, 50th, and 90th percentiles of $GI_{S_L - S_D}$. From lightest to darkest red, these boundaries form four groups of districts: i) Districts belonging to the bottom 10 percentiles, with very low loan shares relative to deposit shares, ii) districts between the 10th and 50th percentiles, with low loan-to-equity deposit ratios; iii) districts between the 50th and 90th percentiles, with percentages of loans above their percentages of deposits and iv) districts belonging to the top 10 percentiles, with percentages of loans that are very high in relation to their percentages of deposits.

Figure 3 shows evidence of deposit and loan imbalance. Some districts present higher participation of total loans of the country, but a low level of participation of the total deposits, and the opposite is true for other districts. There is no regular regional pattern regarding the districts' concentration with net debtor position or net lender position. And it is interesting to see important changes over time. In 2002, mainly along the coast of the country were the net debtor districts. Consequently, the other districts financed these loans and concentrated the largest share of the deposits. In 2008, the figure changed and the imbalance map becomes more heterogeneous throughout the country. However, between 2008 and 2019 the geographical distribution of net borrowing and net lending districts remains relatively constant.

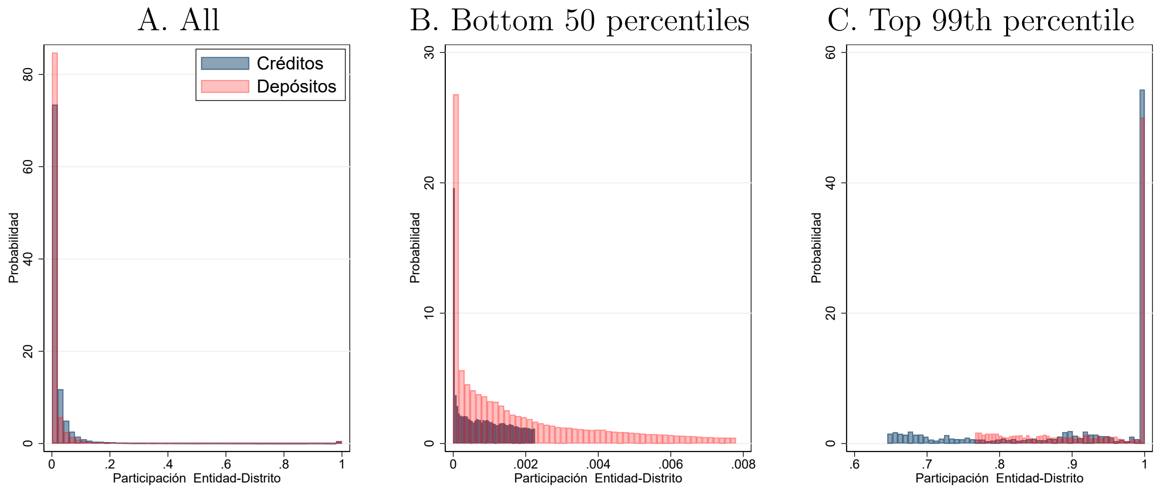
Figura 3: *Geographic distribution of districts as net borrowers or net lenders*



Note: The figure shows the geographic distribution of districts' position as net borrowers or net lenders as measured by the district-level geographic imbalance index $GI_{S_L - S_D}$, which is computed as the difference between the share of loans and their share of deposits, both of the national total. For each year (2002, 2008, 2014, or 2019) it shows the distribution intervals divided by the 10th, 50th, and 90th percentiles of $GI_{S_L - S_D}$. From lightest red to darkest red, these boundaries form four groups of districts: i) Districts that are in the bottom 10 percentiles, with very low loan rates relative to deposit rates, colorboxmyredlightii) districts between the 10th and 50th percentiles, with a low share of loans relative to share of deposits; iii) districts in the 50th to 90th percentiles, with loan percentages above their deposit percentages and iv) districts in the top 10 percentiles, with loan percentages very high in relation to deposit percentages.

To capture the impact on the behavior of the financial system of this regional imbalances between loans and deposits, using monthly data from all financial institutions from the 2002:M1-2019:M12 period figure 4 show that the distributions of deposit and loan shares in each district in a financial institution have wide tails. The credit and deposit shares are calculated as the ratio of the deposits or loans of an entity-district over the amount to the total loans or deposits of the financial institution in a given month-year.

Figura 4: *Distribution of the credit and deposit shares of financial institutions in a district*



Note: This graph shows the distribution of shares of deposits and loans of each financial entity in a district. The panel on the left shows the complete distribution. The middle panel widens the distribution of shares of the bottom 50 percentiles. The panel on the right zooms in on the top 99th percentile of shares. The participation of credits and deposits is calculated as the ratio of the amount of deposits or loans of an entity-district over the total amount of loans or deposits of the financial institution in a given month-year. The shares are shown grouped for all banks and months-years.

Panel A shows a high degree of inequality between the credit and deposit share distributions. The loan share distribution has a wider tail. Panel B and C confirm this high inequality. 50% of the district branches of financial entities have shares below 1% (0.2% for credit shares, and 0.8% for deposit shares). However, 1% of bank branches hold shares of more than 65% and 77% of total deposits and loans, respectively. Figure 8 in Appendix A shows that the shape of these distributions has not changed much over the years.

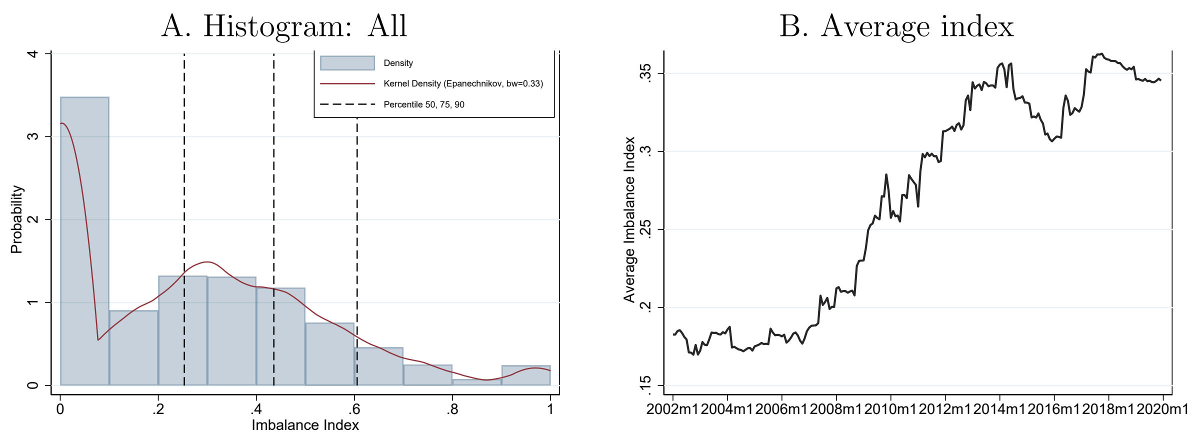
To account for this heterogeneity, we go further and compute an index that captures the imbalance of deposits and loans at the bank level, as in the sociology literature (Duncan and Duncan, 1955; White, 1983):

$$GI_{bt} = \frac{1}{2} \sum_{d=1}^{M} \left| \frac{dep_{dtb}}{Dep_{bt}} - \frac{cre_{dbt}}{Cre_{bt}} \right| \tag{3}$$

where dep_{dbt} and cre_{dbt} represent the amount of deposits and loans, respectively, in district d and month t for a bank b, and Cre^{d}_{bt} and Dep_{bt} represent the total amounts of the bank's deposits and loans. This ratio is a measure of a bank's deposit and loan imbalance or, alternatively, a measure of the bank's internal bias. For example, an index value of zero represents an extreme case of perfect internal balance at the district level, that is, the geographic distributions of bank loans and deposits are identical. At the other extreme, a ratio equal to one means that a bank takes all its deposits in markets where it does not make loans, and lends only in markets where it does not make deposits, which would be an extreme case of geographic segmentation of loans.

Figure 5 in Panel A shows that a significant number of financial entities have a strong local district bias, and they allocate loans mainly funded by the deposits they obtain in these same districts. In each period there is a significant mass of financial entities with an index close to zero. These are entities that operate exclusively in very few districts. In addition, most financial institutions transfer funds across geographic locations. At the other extreme, we find some entities with very high imbalance indices. In fact, the index is greater than 0.5 for more than 20% of financial entities. Figure 9 in Appendix A shows that over time this distribution has moved further to the right, with an increase in the mass of financial entities with a higher index. Panel B of Figure 5 precisely shows that since 2008 more financial entities have become involved in moving deposits and credits through geographic locations. But, as of 2014, these dynamics have stopped, and the average index has remained relatively constant. Figure 10, in Appendix A, shows that these trends are maintained or even more pronounced if we *empresas financieras*.

Figura 5: *Distribution of the imbalance index between credits and deposits at the level of financial entities*



Note: Panel A shows the bank-level histogram of the credit and deposit imbalance index, measured by the GI_{bt} specification in the equation 3, for all banks and all sample periods. 2002:M1-2019:M12. Panel B shows for each period the average imbalance index of all financial entities.

5 Leverage and imbalance channel at the bank level

In this section we seek to characterize the heterogeneous effect of monetary policy at the bank level, and that it depends on the financing structure, measured by leverage and the geographic imbalance index. The first measure considers the overall balance sheet structure of a financial institution, and therefore characterizes its external financing needs. The second measure measures the structure of the financing network and internal loans of a bank.

We empirically estimate the following model at the bank level for the 2003:M1-2019:M12 period using monthly frequency of the monetary policy shock and Ordinary Least Squares (OLS):

$$\Delta y_{bt} = \alpha + \beta_1 RWA_{bt-1}\epsilon_t^{MP} + \beta_2 GI_{bt-1}\epsilon_t^{MP} + \beta_3\epsilon_t^{MP} + \beta_4 RWA_{bt-1} + \beta_5 GI_{bt-1} + \beta_6 X_{bt} + \epsilon_{bt}, \tag{4}$$

where the subscript b refers to a bank, the subscript t refers to month, Δy_{bt} is the monthly credit growth and ϵ_t^{MP} is the monetary policy shock. If $\epsilon_t^{MP} > 0$, there is an unexpected contractionary policy; while if it is negative, the opposite holds.

The specification considers the interaction of the monetary policy shock with the level of leverage (RWA) and the geographic imbalance index (GI). These variables enter the specification with a lag to reduce endogeneity problems. The purpose of these variables is to measure the monetary policy impact conditional on the financing structure of bank loans.

Likewise, controls are incorporated to isolate unobservable bank characteristics that are invariant over time (bank fixed effects). Similarly, time-fixed effects can be incorporated. The latter allows controlling for fluctuations, for example, in the exchange rate, and the aggregate economy. Similarly, we control for some time-varying bank characteristics. These control variables are grouped in X_{bt} and include the return on assets (ROA), the non-performing loan ratio (NPL) and the bank's market share (SIZE). Finally, ϵ_{bt} is a random error that has a normal distribution.

By interacting the geographic imbalance index with the monetary policy shock, we seek to capture whether the impact of monetary policy may depend on the imbalance level, regardless of whether it is due to a greater or lesser relative presence of credits or deposits in a district.

Consistent with the results in aggregate analysis in section 2 and with the theoretical model that we discuss in section 7, it is expected that a contractionary monetary policy (a positive realization of ϵ_t^{MP}) also a negative impact on credit at the bank level. That is, we expect $\beta_1\overline{RWA} + \beta_2\overline{GI} + \beta_3 < 0$.[11] Also, in line with the theoretical model's results, due to the excessive risk-taking channel, it is expected that the leverage level is associated with a less effective monetary policy. That is, the positive impact on credit of policy rate reduction is less the higher the leverage (or the less dependence on external funding), i.e., it can be expected to find $\beta_1 > 0$.

Table 3 reports the results of the estimations with Ordinary Least Squares, for differ-

[11] The upper bar indicates the average across both time t and banks b.

ent specifications. In columns 1-3 the geographic imbalance index is not yet considered, while in columns (4)-(6) we do. Likewise, estimates without fixed effects are shown, columns (1) and (4), with bank fixed effects, columns (2) and (5), and time-fixed effects, columns (3) and (6).

According to Table 3 the monetary policy shock is statistically significant. In addition, considering the averages of 6.8 and 0.27 of the leverage (RWA) and the demographic imbalance index (GI) respectively, see table 1, we find that the shock has the expected direction. This is $\beta_1 \overline{RWA} + \beta_2 \overline{GI} + \beta_3 < 0$.

The novel result is to find that the interaction coefficient of the monetary policy shock with the lagged leverage is statistically significant and has the expected sign, in all the specifications, columns (1)-(6). This might suggest that the excessive risk-taking channel is at least statistically significant and might dominate other leverage-related channels. The coefficient can take values from 0.012 to 0.017. These results hold if we also add as control the interaction of the monetary policy shock with the lagged geographic imbalance index, which controls for the internal structure of the banks' deposit and loan network. Interestingly, if we do not exclude the extreme values of credit growth, this coefficient is still statistically significant, but quantitatively more important, so it could take values between 0.032 and 0.041 (see table 9 in Appendix B).

As a robustness exercise, table 4 shows the results including controls for some bank characteristics that vary over time, such as the NPL ratio, return on assets, and market share. Qualitatively, the results hold, although quantitatively it is found that the coefficients associated with the monetary policy impact and its interaction with leverage are larger. This time this interaction coefficient takes values between 0.020 and 0.025. Considering for example the interaction coefficient of 0.02 (see column 4) and the average leverage of 6.8, a negative monetary policy shock of 100 bps, without considering the effects of the structure of the loan and deposit network captured by the geographic imbalance index, implies an increase in credit growth of 2.5 bps. Note that if we do not consider the differential impact of leverage (i.e., leverage is zero), credit growth would be 16.3 bps. This indicates that the leverage level is quite important in determining the monetary policy power in the credit market.

To measure the importance of monetary policy heterogeneity induced by the leverage level, we apply the same change in the monetary policy shock to different values of the leverage ratio: one equal to one standard deviation below the mean (5.1) and the other to one standard deviation above the mean (8.5). This comparison in the distribution of leverage ratios shows increases in credit growth of 5.9 bps and -0.9 bps, respectively. Holding other characteristics constant, banks with less leverage (or with greater dependence on external financing) increase their credit to a greater extent in response to expansionary monetary policy shocks. An entity with a level of leverage with one standard deviation below the average increases credit by 3.4 bps more than an average bank. In contrast, banks with very high levels of leverage, one deviation above the average, increase their credit growth by 3.4 bps less than an average bank. These results are consistent with the theoretical model that we present in section 7.

If we consider the coefficients associated with the effects of the structure of the loan and deposit network captured by the geographic imbalance index, these are not statistically significant, and indicate that the internal financing structure of a financial institution would not affect the impact of monetary policy. However, if we consider columns (4) and (6) of Table 4 that does not control for the constant heterogeneity between banks, it shows that banks that tend to mobilize more funds between districts, or with a broader and more heterogeneous branch network (a higher imbalance index), amplify the impact of monetary policy. Although these impacts are not significant, since they probably converge with the leverage, in addition to the fact that the index does not distinguish whether the imbalance is due to a greater or lesser participation of credit and/or deposits in a district. Although at the bank level the imbalance between credits and deposits may not be significant, as we will see later, at the branch level, we will have a leverage indicator. Implicitly, it will indicate that greater or smaller participation of deposits in the funding structure will have different implications on the impact of monetary policy.

Although these results show that a monetary policy shock has the expected effect on the credit market at the bank level, these are limited. A monetary policy shock has an impact on both sides of the credit market, and we want to study the lending channel that only considers supply effects. But, in the previous specifications that we present, we cannot separate the supply effects from those of demand. Therefore, from now on, we use an identification strategy at the bank branch level to obtain a clearer signal of the heterogeneous effect caused by the leverage level when it interacts with the monetary policy shock.

Tabla 3: *Regression at bank level, monthly frequency, estimated with OLS*

	Dependent variable: Δy_{bt}					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{GI}_{bt-1}\epsilon_t^{MP}$				0.00233	0.0235	-0.00638
$\text{RWA}_{bt-1}\epsilon_t^{MP}$	0.0128*	0.0156**	0.0167**	0.0127*	0.0147**	0.0169**
ϵ_t^{MP}	-0.106**	-0.128***		-0.105**	-0.129***	
RWA_{bt-1}	-0.00177**	-0.00653***	-0.00365***	-0.00201***	-0.00610***	-0.00387***
GI_{bt-1}				0.00674	-0.0467**	0.00596
Obs.	2,680	2,680	2,680	2,680	2,680	2,680
R^2	0.005	0.086	0.122	0.005	0.088	0.122
F test (ρ-value)	0.00664	7.48e-09	3.28e-07	0.0192	6.62e-09	3.23e-06
Bank FE		✓			✓	
Time FE			✓			✓

*p<0.1, **p<0.05, ***p<0.01.

Tabla 4: *Bank level regression with additional controls, monthly frequency, estimated with OLS*

	Dependent variable: Δy_{bt}					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{GI}_{bt-1}\epsilon_t^{MP}$				-0.00903	0.00577	-0.0209
$\text{RWA}_{bt-1}\epsilon_t^{MP}$	0.0201***	0.0237***	0.0243***	0.0203***	0.0235***	0.0248***
ϵ_t^{MP}	-0.164***	-0.193***		-0.163***	-0.193***	
RWA_{bt-1}	0.00323***	0.00151	0.00246***	0.00266***	0.00168	0.00194**
GI_{bt-1}				0.0164***	-0.0187	0.0153**
NPL_{bt}	-0.00158***	-0.00215***	-0.00118***	-0.00206***	-0.00203***	-0.00170***
ROA_{bt}	0.000681	-0.000593	-1.50e-05	0.000162	-0.000351	-0.000467
SIZE_{bt}	-8.11e-05	0.00322**	-6.74e-06	-7.92e-05	0.00330**	-1.13e-05
Obs.	2,642	2,642	2,642	2,642	2,642	2,642
R^2	0.025	0.087	0.121	0.027	0.087	0.124
F test (ρ-value)	0	4.81e-10	8.66e-07	0	2.85e-09	4.49e-07
Bank FE		✓			✓	
Time FE			✓			✓

*p<0.1, **p<0.05, ***p<0.01.

6 Transmission of Monetary Policy at Bank Branch Level: The Imbalances Channel

6.1 Identification Strategy

We exploit the geographic variation in the credit-to-deposit ratio induced by differences in the concentration of local credit and deposit markets. At the branch level of a financial institution, the credit-to-deposit ratio is an indicator of leverage or the need for external financing. This is, the higher the credit-to-deposit ratio, the greater the need for external financing. As we will show later, this ratio allows us to capture the heterogeneous impact of monetary policy induced by differences in leverage ratios or external financing needs. An important assumption in our analysis is that credit markets are local. In general, the process of granting loans is an information-intensive activity, where a financial entity must filter among potential borrowers, due to information asymmetries. In general, geographic proximity reduces the costs of transmitting and processing information (Nguyen, 2019). Therefore, the relationships between clients and local financial entities become crucial.

We use the credit-to-deposit ratio as a measure of the composition of balance sheet liabilities or leverage within a bank branch (Agénor, Alper and Pereira, 2018). The key idea is that this ratio, which captures the bank branch leverage, is important for bank lending strategies (Gertler and Karadi, 2011). Although banks can internally allocate funds between branches, this is not a costless process between districts. In particular, we rely on the administrative cost assumption to allocate resources across the district, which implies that it is preferable for a bank branch to collect local deposits to fund loans. If a bank branch has a high credit-to-deposit ratio, financing additional liquidity on top of deposits is expensive. The increase in the funding cost comes from changes in the allocation of assets and liabilities within a bank and costly liquidity transactions in the intrabank and/or interbank markets. This is a credit supply channel induced by the imbalance structure between credits and deposits within a bank.

To identify this channel of imbalances, it is important to have a variation in the composition of liabilities that is independent of the bank's lending opportunities or the demand factors that influence the bank's decisions. To obtain that variation, we compare the loans between branches of the same bank located in different districts. Under this strategy, we can control for loan demand opportunities that a bank faces, and we can identify the sensitivity induced by monetary policy changes on the credit supply strategy of a bank branch.

6.2 Reduced form estimation: Sensitivity of loans of a bank branch

Before any assumptions of causal identification, we first characterize the behavior of the credit change of all bank branches. In particular, we run the following time series regression for each branch j:

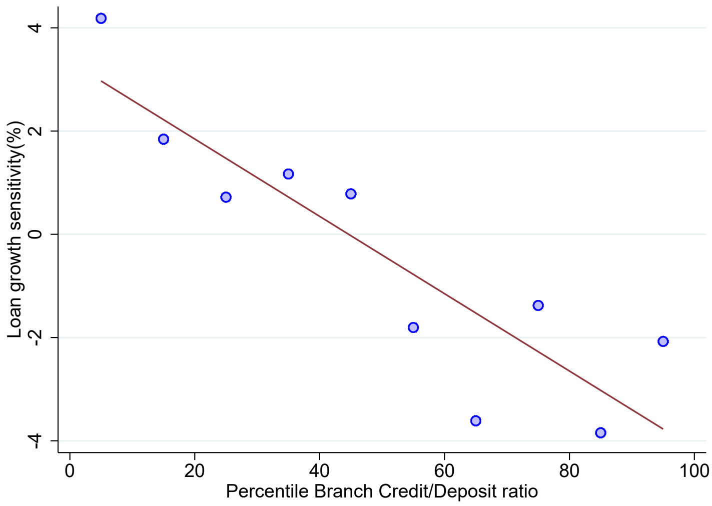
$$\Delta y_{jt} = \alpha_j + \beta_j \Delta i_t + \epsilon_{jt}\,, \tag{5}$$

where Δy_{jt} is the absolute deviation of the log of credit supplied by branch j at time t, Δi_t is the contemporaneous variation of the interbank interest rate, which is our measure of the monetary policy rate, β_j measures the sensitivity of the credit of branch j to changes in monetary policy. This is a branch credit beta.[12].

Next, we relate the credit beta, β_j, to the district's credit-to-deposit ratio. The latter measures the composition of external financing observed in a given district. We average the credit betas of all branches within a district, winsorizing at 1% to minimize the influence of outliers. We then classify all the branches into 10 equally sized partitions, according to the external financing composition (credit-to-deposit ratio)

Figure 6 shows that the sensitivity of credit growth is negatively related to the credit-to-deposit ratio. This is indicative of heterogeneity in monetary policy transmission depending on the relative size of external funding at the branch level and working in the intended direction from a given threshold.

Figura 6: *Credit growth sensitivity and the credit-to-deposit ratio*



Note: This figure shows the relationship between the credit-to-deposit ratio and the sensitivity of credit growth to changes in the monetary policy rate. This figure is built in two steps. In the first step, we estimate a time series regression for each branch $\Delta y_{jt} = \alpha_j + \beta_j \Delta i_t + \epsilon_{jt}$, where Δy_{jt} is credit growth and Δi_t is the policy rate change. In the second step, we average the credit betas of all branches within a district, winsorizing at 1 percent. We then rank all branches into 10 equal-sized bins by external funding composition and calculate the bin averages. Sample period 2003:M1-2019:M12. This includes all branches of banks, *cajas* and other loan-issuing branches.

On the one hand, the sensitivities to credit growth of branches that have a credit-to-deposit ratio above the 50th percentile become more negative and, therefore, amplify the impact of a change in the monetary policy stance on aggregate credit growth. On average, the credit beta is -2.75 in this group.

[12]Following the same spirit of the capital asset pricing model (CAPM) literature, this beta measures whether credit flows (credit change) at a given branch j they move in the same or opposite direction as the aggregate market, which is led by changes in the monetary policy rate.

On the other hand, those branches that have a loan-to-deposit ratio below the 50th percentile have positive or near-zero beta credit factors and, for example, when faced with a tight monetary policy stance, make more loans, rather than to reduce loans. These branches mitigate any impact of monetary policy on the credit market. These branches have an average credit beta factor of 1.74 percent.

6.3 Branch level estimation

Equation 6 shows the main specification at the branch level in a specific district that implements our identification strategy. The dependent variable, Δy_{bdt}, is the growth rate of loans granted by the branches of the bank b in district d at time t. $\left(\frac{Cred}{Dep}\right)_{bd,t-1}$ is the credit-to-deposit ratio and is our measure of funding frictions at the branch level. $\mathbb{1}_{\frac{Cred}{Dep}}$ is an indicator variable that takes 1 if the credit-to-deposit ratio is greater than the district median. This threshold captures our previous analysis of the sensitivity of monetary policy at the branch level. With this variable we intend to capture the heterogeneity in the credit response between banks due to supply frictions. ϵ_t^{MP} is the monetary policy shock. All these regressors (except the policy shock) enter the regression with a delay to control for endogeneity issues. We also include fixed effects (FE) that control for trends at the branch and local market factor level, at the region or district level, represented by α_{bt} and α_{rt} or α_{dt}. We also include district-bank fixed effect, α_{bd}, to capture unobserved time-invariant district-bank relationships.

$$\begin{aligned}\Delta y_{bdt} = \alpha_{bt} + \alpha_{rt} + \alpha_{dt} + \beta_0 \left(\frac{Cred}{Dep}\right)_{bdt-1} \epsilon_t^{MP} \\ + \beta_1 \left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP} + \gamma_x X_{bdt-1} + \epsilon_{bdt}\end{aligned} \tag{6}$$

The bank-time fixed effects, α_{bt}, are key in our identification as it absorbs all time differences between banks, and allow us to control for the lending opportunities that a particular bank faces. So, we compare between branches of the same bank. $\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP}$ captures the channel of imbalances and/or external financing of the monetary policy at the bank branch level. Consequently, if $\beta_1 < 0$, after an expansionary monetary policy shock, the branches that operate with a high credit-to-deposit ratio grant more loans than branches with lower external financing needs.

To control for initial credit conditions or observation-specific variance, we add a lag of all loans made by a branch, y_{bdt-1}. We also test different sets of controls in X_{bdt-1}, such as the lags of the dependent variables and the lags of the monetary policy shock that interact with the credit-to-deposit ratio at the branch level, to control for the mean reversion property of the endogenous variable at the branch level and the shock diffusion, respectively. We also include interactions and intermediate components to avoid misspecification issues, such as $\left(\frac{Cred}{Dep}\right)_{bdt-1}$, $\mathbb{1}_{\frac{Cred}{Dep}}$, $\left(\frac{Cred}{Rip}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}}$.

Results

The table 5 shows the results of the estimation of the equation (6), which formally implements our identification strategy. The sample includes all branches of all financial, banking and non-banking companies. The quarterly sample covers the 2003:Q1-2019:Q4 period. Credit data was winsorized at 2% to control for biased results due to outliers. In general, we intend to control for variables that could influence the lender's decision and that may also be correlated with finance company ownership, financial institution size, regional economic conditions, management decisions, or initial trends of the branches.

Columns (1)-(4) show various specifications for adding or removing controls. Column (1) is our preferred specification, as it includes fewer restrictions on the data. Column (1) shows that the monetary policy channel of leverage at the bank branch level is statistically and economically significant. It confirms that loan sensitivity to monetary policy changes is non-linear and increases as the credit-to-deposit ratio of a bank branch is higher, even within a financial company. ~~Numerically, after a 100 bps expansionary monetary policy shock, financial institutions increase loan growth rates by 13.2 bps more at their branches where the loan-to-deposit (C/D) ratio is above its median. Meanwhile, for the group of branches with C/D ratios below its median, after the same policy shock, loan growth rates increase by only 0.35 bps, which is not statistically significant.~~ **Numerically, after a 100 bps expansionary monetary policy shock, financial institutions with a loan-to-deposit (C/D) ratio below its median increase on average loan growth rates by only 0.29 (=$\overline{C/D}$*0.0035*100) bps. Meanwhile, for the group of branches with C/D ratios above its median, after the same policy shock, loan growth rates increase on average by 273 (=$\overline{C/D}$*0.13*100) bps more. For an aggregate perspective, this latter response is numerically higher; however, it might be explained since this average effect is not weighted by the relevance of branch credit or deposits.**

Similar to the bank level analysis (section 5), to measure the importance of monetary policy heterogeneity induced by the C/D ratio, we apply the same monetary policy shock to a different value of the leverage ratio but to only the group of branches with a C/D ratio above its mean: one standard deviation above the leverage mean (72.35). It results in an increase of credit growth of 955 bps by more.

Column (2) omits region-time fixed effects, but considers district-time fixed effects, so identification occurs in a smaller geographic space, by comparing only bank branches that operate within the same district. Column (3) includes longer lags for monetary policy shocks and the dependent variable to account for more persistent mean reversion and propagation effects. Column (4) is like the specification in column (3) but omits bank-time fixed effects. The leverage channel coefficients in all these columns remain similar to those in column (1). These results confirm that the sensitivity of loans to changes in the monetary policy rate increases with the loan-to-deposit ratio, but they are significant and more important for branches with very high loan-to-deposit imbalances. These results are also complementary to the monetary policy risk channel documented in Pozo and Rojas (2020a, 2022). In general, as can be seen in Table 2, branches with a high C/D ratio are those that tend to display similar characteristics to branches that operate in riskier markets.

Tabla 5: *Estimation results at the level of banking branches*

	Dependent variable: Δy_{bdt}			
	(1)	(2)	(3)	(4)
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \epsilon_t^{MP}$	-0.00354	0.0686	0.119	-0.0585
	(0.111)	(0.145)	(0.216)	(0.135)
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP}$	-0.132*	-0.174*	-0.238*	-0.306**
	(0.0777)	(0.0893)	(0.145)	(0.146)
y_{bdt-1}	-0.588***	-0.693***	-0.0275	-0.769
	(0.0763)	(0.0949)	(0.208)	(0.624)
R^2	0.642	0.676	0.581	0.508
Obs.	86093	81974	58220	58544
Controls	✓	✓	✓	✓
Control Long lags			✓	✓
Bank-Time FE	✓	✓	✓	
Region-Time FE	✓		✓	
Distric-Time FE		✓		
Branch FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓
Time FE				✓

Note: It shows the estimated effects of Peruvian monetary policy shocks on credit growth at the branch level. The dependent variable is the log change in credit at the branch level, Δy_{bdt}. Loan growth is the logarithmic change in credit at the branch level. Quarterly Sample: 2004:Q1 to 2019:Q12. The sample includes only banks with branches in two or more provinces. Cred/Dep measures the degree of resource dependency of a bank branch. ϵ_t^{MP} is the monetary policy shock. Fixed effects are described at the bottom of the table. Standard errors clustered at time and bank level in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Robustness

Table 6 shows that the result of our base specification is robust to sample selection problems or omitted variables, such as bank concentration or market risk, which are documented in Pozo and Rojas (2021a), and that can bias the results. The effect of the leverage channel or financing imbalance continues to be economically and statistically significant in all specifications.

Tabla 6: *Branch level estimation: Robustness I*

	Dependent variable : Δy_{bdt}				
	(1) After 2006Q1	(2) Before GCF	(3) After GCF	(4) Control HH, Mor	(5) Ctrl. HH, Mor + Cluster
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \epsilon_t^{MP}$	-0.0162	-1.848**	-0.147	0.0123	0.0672
	(0.108)	(0.865)	(0.110)	(0.113)	(0.185)
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP}$	-0.144*	0.0538	-0.222***	-0.139*	-0.198**
	(0.0755)	(0.528)	(0.0760)	(0.0777)	(0.0862)
$\text{HH}_p \times \epsilon_t^{MP}$				-2.935	-3.501
				(2.559)	(3.893)
$\text{NPL}_p \times \epsilon_t^{MP}$				-0.0272	-0.0611
				(0.0435)	(0.0545)
y_{bdt-1}	-0.646***	-5.093***	-0.660***	-0.588***	-0.231
	(0.0794)	(1.307)	(0.0872)	(0.0762)	(0.259)
R^2	0.661	0.698	0.674	0.639	0.526
Obs.	78918	6696	65358	85881	87963
Control lags	✓	✓	✓	✓	✓
Bank-Tiempo FE	✓	✓	✓	✓	✓
Region-Time FE	✓	✓	✓	✓	✓
Branch FE	✓	✓	✓	✓	✓
Province FE	✓	✓	✓	✓	✓

Note: This table estimates the effect of Peruvian monetary policy shocks on credit growth, Δy_{bdt}. Loan growth is the logarithmic change in credit at the branch level. Quarterly Sample: 2004:Q1 to 2019:Q12. The sample includes only banks with branches in two or more provinces. ϵ_t^{MP} is the monetary policy shock. Fixed effects are described at the bottom of the table. Cred/Dep measures the degree of resource dependency of a bank branch. After the first quarter of 2006, the sample removes the observations from 2004 to 2005. Before the GCF (Great Financial Crisis) sample, the sample corresponds to the period from the first quarter of 2004 to the fourth quarter of 2008. The sample after the GCF corresponds to the period 2009Q4-2019Q4. NPL measures the market risk in the province where a branch is located (see Pozo and Rojas (2021a)). HH is the standard Herfindahl index of the province where a branch is located. HH and NPL are obtained by averaging all the years for each province (p). In Cluster, standard errors are clustered at the time and bank level. *p<0.1, **p<0.05, ***p<0.01.

Column (1) removes observations for the period before 2006. The early years of our sample have measurement problems and are underrepresented in aggregate credit dynamics. The result does not show a significant difference from our base estimate.

In columns (2) and (3) we try to control for the effects of variations in the amount of international liquidity, low international interest rates and the expansive stance of monetary policy. In particular, before the Great Financial Crisis (GCF) the monetary policy rates, both local and international, were not low. Likewise, in this previous period the rates of economic growth in Peru were also higher. After the GFC, with an expansionary monetary policy stance by almost all the central banks of developed countries, international liquidity has been high and interest rates have been lower. Consistently, the monetary policy rates also in Peru, on average, have been lower during this period. In this context, the behavior of the level of financing imbalance could be the result of international macroeconomic trends. In column (2) we only consider the sample period before the Great Financial Crisis (GFC). While in column (3) we restrict the sample to the period after the GFC, starting in 2019:Q4. Results holds for the sample period after the GCF, but no for the sample period before the GFC. After the GCF, this channel has been concentrated in those branches with higher levels of leverage, above the median.

Column (4) controls for other factors of the local markets where the financial branches operate. Pozo and Rojas (2021a,b) show that the degree of banking concentration or competition in the credit market or market risk influence the credit supply policies of financial institutions. For this purpose we use similar measures as in Pozo and Rojas (2021a): we use the standard Herfindahl (HH) index at the province level, to measure the degree of market concentration, and as a measure of risk at the local financial market level we use the non-performing loan (NPL) ratio at the province level as in Pozo and Rojas (2021b). HH and NPL ratio are obtained by averaging these measures for all years and for each province. These market characteristics could be part of our results, since more leveraged branches could operate in markets where they take more risk and where there is more concentration. The results in columns (4) and (5) show that the degree of leverage at the level of financial institution branch is still significant and very similar to our baseline estimate, even after controlling for these local market factors, column (4), or by controlling for the correlation of loans at the bank level and time, column (5).

Table 7 shows the robustness of the main specification in the equation (6) for different samples of financial institutions and geographic areas. In particular, we show evidence of the heterogeneity of the imbalance or leverage channel at the branch level for different types of financial institutions and local credit markets. Column (1) considers the branches of all financial institutions, column (2) restricts the sample to bank branches, column (3) considers branches of the four largest banks in Peru, and column (4) considers branches of non-banking institutions. Panel A reports the results for branches from all Peruvian local markets; while Panel B shows the results excluding branches operating in the metropolitan area, which accounts for most of the credit in the country.[13]

Panel A of table 7 shows that the base specification results hold in the same direction for the sample of banks, but with a doubling of sensitivity. The impacts are economically and statistically significant at the top of the distribution of C/D ratios. This differentiated impact of the monetary policy effect conditional on the size of the external leverage dependency, or high C/D ratio, between branches is even much higher for the sample of the largest banks. For the four largest banks in Peru, which have a more extensive geographic network of branches, covering almost all of the country's provinces, this sensitivity is almost 7 times. In this sense, the largest banks are sensitive to changes in monetary policy, via the imbalance channel, given that they have to mobilize a greater volume of funds to cover the various credit financing needs of their different branches.

Panel A of table 7 also indicates that for the sample of non-banks this imbalance channel is not present. However, Panel B, which analyzes more closely the sample of financial institutions and the difference between geographic areas that do not include the metropolitan area, shows that the channel of monetary policy imbalances is weak for the sample of banks, but significant and statistically significant. significant for the sample of non-banks. The metropolitan area represents approximately 75% of the credit in the sample and is mainly concentrated in credit for safer borrowers, such as corporations and large companies (Pozo and Rojas, 2021b) where banks tend to have more participation and whose branches tend to be more unbalanced. However, non-bank entities that are concentrated in geographical areas outside the metropolitan area tend to be less unbalanced and therefore have low credit-to-deposit ratios. In these bank branches, the imbalance channel is located in the lower part of the distribution of the need for leverage ratio.

[13] Pozo and Rojas (2021b) show that branches in the metropolitan area (regions of Lima and Callao) represent around 75% of total credit, and is mainly concentrated in credit to corporate and large firms.

Tabla 7: *Branch level estimation: Robustness II*

	Dependent variable: Δy_{bdt}			
	(1)	(2)	(3)	(4)
	All	Banks	Large banks	No banks
	Panel A: Full sample			
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \epsilon_t^{MP}$	-0.00354	0.0456	0.0976	-0.133
	(0.111)	(0.172)	(0.265)	(0.0814)
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP}$	-0.132*	-0.312**	-0.910*	0.0186
	(0.0777)	(0.152)	(0.521)	(0.0406)
y_{bdt-1}	-0.588***	-0.441***	-0.0492	-1.067***
	(0.0763)	(0.133)	(0.335)	(0.0503)
Observations	68969	30965	17703	34244
R^2	0.346	0.342	0.311	0.427
	Panel B: Non-Metropolitan Area sample			
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \epsilon_t^{MP}$	-0.113	0.0295	0.0620	-0.522**
	(0.101)	(0.168)	(0.172)	(0.256)
$\left(\frac{Cred}{Dep}\right)_{bdt-1} \times \mathbb{1}_{\frac{Cred}{Dep}} \times \epsilon_t^{MP}$	-0.0456	-0.0678	0.520	0.0375
	(0.0665)	(0.118)	(1.087)	(0.0490)
y_{bdt-1}	-0.733***	-0.761**	-0.433	-0.940***
	(0.0723)	(0.277)	(0.406)	(0.217)
Observations	59115	26457	14722	32514
R^2	0.599	0.601	0.606	0.618
Controls	✓	✓	✓	✓
Bank-Time FE	✓	✓	✓	✓
Region-Time FE	✓	✓	✓	✓
Branch FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓

Note: It shows the estimated effects of Peruvian monetary policy shocks on credit growth at the branch level. The dependent variable is the log change in credit at the branch level, Δy_{bdt}. Quarterly Sample: 2004Q1 to 2019Q12. The sample includes only banks with branches in two or more provinces. Cred/Dep measures the degree of resource dependency of a bank branch. ϵ_t^{MP} is the monetary policy shock. Fixed effects are described at the bottom of the table. The large bank sample considers only the four largest banks in Peru. Non-banking includes CAMCs, CRACs and financial companies. Non-Metropolitan Area Sample: excludes Lima and Callao, which form the largest metropolitan area in Peru. Standard errors clustered at time and bank level in parentheses. *p<0.1, **p<0.05, ***p<0.01.

These findings support the robustness of the imbalance or leverage channel at the branch level, and demonstrate that it operates across all financial institutions but across various sections of the C/D ratio distribution. The effects of monetary policy are precisely stronger and more significant in those branches that have a greater need for financing, and in particular for the sample of banks, and to an even greater extent for the largest banks.

However, the local markets where financial institutions operate matter. The financial imbalance channel operates in non-bank entities only for branches that are located in the lower half of the C/D ratio distribution and outside the metropolitan area.

6.4 Discussion

In principle, these results, both in a reduced form (section 6.2) and in the causal estimation (section 6.3) show that there is a heterogeneous banking channel in Peru, where the Monetary policy actions have an amplifying and a dampening effect on the credit market. The importance of these effects depends, at a granular level, on whether a bank branch is more or less dependent on external funding, defined as others than local deposits.

However, at the aggregate credit response (section 2), the amplifying margin for credit-to-deposit ratio heterogeneity must be stronger than the attenuating margin. This is also consistent with the results of the empirical model at the bank level (section 5). Also, at the bank level, we find that the impact of monetary policy may be conditional on the level of leverage in the same direction found in the branch analysis.

Note that our results are based on the fact that there are heterogeneous local credit markets across the country. Therefore, the monetary policy supply channel varies between regions, and depends on the actions of financial institutions, which depend on funding and opportunity costs. In particular, a relevant variable for local credit decisions could be the credit-to-deposit ratio. This variable could determine the heterogeneity of the monetary policy transmission mechanism toward the credit market. Thus, in principle, those branches that depend less on local deposits as a source of funding (that is, have a high credit-to-deposit ratio) may be less exposed to an increase in the interest rate of the monetary policy that is transferred to higher deposit interest rates. However, these same branches require more external funding. As a result, results suggest that the cost of this external funding increases much faster than the cost of local funding (local deposits). Therefore, the greater the dependence on external funding sources, the more positive the impact of the policy rate on the credit funding cost.

7 Theoretical model

The motivation of the theoretical model is to rationalize the heterogeneous effects of monetary policy on credit at the aggregate bank level and bank branch level. To do this, we propose a theoretical framework with specifications for each approach: aggregate and micro.

Whereas, in the first specification, the model seeks to shed light on the response of credit to the monetary policy rate conditional to the leverage level of the financial institution (credit to capital ratio); in the second specification, it seeks to understand the impact of the monetary policy conditional to the credit financing composition of a bank branch. Therefore, the specifications can complement each other, since the first seeks to help understand what happens across heterogeneous banks, while the second would help us understand what happens across heterogeneous branches of the same bank.

For both cases we develop a two-period banking model, where banks or banking branches grant loans to firms, which invest in a risky project. Banks or branches finance their investments with local deposits and other funds. To simplify the model, it is assumed that all agents are risk neutral. In addition, we assume that banks have limited liability and deposits are insured by government, through lump-sum taxes on households.

Motivated by the research question and empirical results, the model focuses on characterizing the heterogeneity that may exist in banks regarding their level of leverage. Although this measure reflects the capacity of a bank to absorb negative shocks, it can also capture bank incentives to take risk or excessive risk.

7.1 Banks with different levels of leverage

We develop a two-period model with a continuum of heterogeneous banks, firms, and households (depositors). Both firms and households are identical. Banks are heterogeneous in their exogenous level of initial net worth (capitalization).[14] Households own banks and firms. They also make bank deposits and supply labor to firms. Banks use their net worth and deposits to finance loans. Due to the nature of the business activity, loans are risky. Firms use loans to buy capital that, in combination with labor, is used in the production of goods. All agents are risk neutral and the unit of measurement is given by the final good.

It is assumed that loan risk is systematic (aggregate). It can be understood that it is the risk of a loan portfolio after having eliminated all idiosyncratic risk. Finally, it is assumed, for simplicity, that a bank is associated with a single company and vice versa.

In period $t{=}0$, firm i buys capital, k_0^i, financed entirely by bank loans, $l_0^i{=}k_0^i$. For simplicity and because it is not the purpose of this research to study the role of firm leverage in monetary policy, we assume that firm net worth is zero.[15] Firms use capital

[14] We assume in this two-period model that equity (capital of banks) is exogenous without abstracting too much from reality, since we know that raising new capital is a long-term process. For example, if the bank will face higher capital requirements, it will mainly reduce lending rather than increase its level of equity.

[15] In the same spirit of understanding the transmission mechanism of monetary policy Pozo and Rojas (2020b) present empirical evidence for Peru on the risk-taking channel of monetary policy. In this case,

and labor, h_1, the latter demanded at t=1, for the production of goods, y_1^i, using a Cobb-Douglas technology,

$$y_1^i = Z_1(k_0^i)^\alpha (h_1)^{1-\alpha},$$

where 0<α<1, and Z_1 is the multiplicative aggregate productivity shock. Z_1 is assumed to have a lognormal distribution, $ln(Z_1) \sim N(\mu_z, \sigma_z^2)$. F and f are the cumulative and probability density function of Z_1, respectively. The profits of the firm i at t=1 are:

$$\Pi_1^i = (1-\delta)k_0^i + y_1^i - r_1^{l,i} l_0^i - w_1 h_1,$$

where δ <1 is the capital depreciation rate, $r_1^{l,i}$ is the loan interest rate. To capture the risk associated with the firm's activities, it is assumed that the interest rate $r_1^{l,i}$ is contingent to the realization of Z_1. Firms' demand for loans is obtained by maximizing discounted future earnings at t=0, $\mathbb{E}_0\{\beta \Pi_1^i\}$, where l_0^i=k_0^i. The first order condition for k_0^i is,

$$0 = \mathbb{E}_0 \left\{ \beta \left(r_1^{k,i} - r_1^{l,i} \right) \right\},$$

where $r_1^{k,i}$=$1 - \delta + \alpha Z_1 (k_0^i)^{\alpha-1}(h_1)^{1-\alpha}$ is the marginal productivity of capital. In the period t=1 the level of productivity is known and companies demand labor until the marginal product of labor is equal to the wage, that is, w_1=$(1-\alpha)Z_1(k_0^i)^\alpha (h_1)^{-\alpha}$. A non-negative condition is assumed for realized benefits, that is, $0 \leq \Pi_1^i$. This implies that the first-order condition for capital is:

$$r_1^{k,i} = r_1^{l,i}.$$

For simplicity, it is assumed that households inelastically supply a unit of labor. So, in equilibrium, the demand curve for bank loans yields,

$$r_1^{l,i} = 1 - \delta + \alpha Z_1 (l_0^i)^{\alpha-1}.$$

The problem of the representative household is simple. Since it is risk neutral, the household maximizes utility, U_0=$C_0 + \beta E_0\{C_1\}$, where C_0 and C_1, respectively, denote the levels of consumption of the household at t=0 and t=1, subject to budget constraints at t=0, C_0=$Y_0 - D_0 + \Pi_0$, and at t=1 , $C_1 = r_0 D_0 + \Pi_1 + w_1 - T_1$, where β, Y_0, D_0, r_0, Π_0, Π_1, and T_1, respectively, represent the exogenous household discount factor, the exogenous initial endowment, deposits in banks, the gross rate of return on deposits, dividends from banks in the period t=0, dividends from banks at t=1, and government lump sum taxes.[16]

attention is not paid to monetary policy conditional on the level of leverage of financial institutions, but to bank incentives to offer loans between portfolios located in regions that might have different levels of risk.

[16]In equilibrium, Π_0 captures the net cash flow at t=0. In particular, at t=0 banks invest in risky

Since deposits are fully insured, these are risk-free and therefore their gross rate of return will be the same as the risk-free interest rate, i.e. $r_0 = \frac{1}{\beta}$. It follows that the supply of deposits faced by banks is perfectly elastic at the interest rate of r_0.

In the case of financial intermediaries, they are heterogeneous in their exogenous initial level of equity. A bank i finances its risky loans, l_0^i, with deposits, d_0^i, and with an exogenous initial equity, n_0^i. That is,

$$l_0^i = d_0^i + n_0^i. \tag{7}$$

As the literature suggests, the interaction of limited liability and deposit insurance leads to excessive risk taking (see, for example, Collard et al. 2017; Pozo 2019).[17]

To clearly explain this distortion, we first abstract from limited liability. The equilibrium thus leads to the socially efficient allocation. The future earnings of the bank are the difference between the income received from the loans and the payments for their deposits:

$$r_1^{l,i} l_0^i - r_0 d_0^i. \tag{8}$$

If future earnings are negative, $n_1^i < 0$, the bank transfers negative dividends to its owners (households); otherwise, it transfers positive dividends.[18] The bank optimally chooses the level of deposits to maximize $\mathbb{E}_0\{\beta n_1^i\}$, where β is the household discount factor, subject to the equation (7). The first order condition yields,

$$1 - \delta + \alpha \bar{Z} (l_0^i)^{1-\alpha} = r_0, \tag{9}$$

where $\bar{Z} = \mathbb{E}_0\{Z_1\}$. This result, equation (9), is not new. In equilibrium, the return on loans (marginal product of capital) is equal to the marginal cost of borrowing, r_0. Clearly, the interest rate (risk-free rate) directly affects the marginal cost of borrowing. As a result, a lower rate increases the incentives of banks to lend due to the assumption of diminishing marginal returns to capital.

When the bank faces limited liability, bank profits (dividends) cannot take negative values, that is,

$$N_1 = max\{0, r_1^{l,i} l_0^i - r_0 d_0^i\}.$$

For a given level of loans l_0^i, there will be a loan return r_1^{L*} such that bank profits will be zero,

$$0 = r_1^{l,i*} l_0^i - r_0 d_0^i, \tag{10}$$

projects the amount of K_0 (negative cash flow) and receive internal deposits, D_0 (positive cash flow). In other words, in equilibrium $\Pi_0 = -K_0 + D_0$.

[17] In both works, bank risk taking involves the volume of credit and not the type of credit. This is in line with the current literature, in particular the monetary policy literature which commonly views excessive bank risk-taking in terms of the aggregate volume of credit (see, p. eg, Borio and Zhu, 2012).

[18] Negative dividends means the bank owner needs to put up his own money to pay off all deposits

where in equilibrium,

$$r_1^{l,i*} = 1 - \delta + \alpha Z^{i*}(l_0^i)^{\alpha-1}. \tag{11}$$

This means that if $Z_1 \geq Z^{i*}$, bank i does not default; otherwise, it cannot fully repay deposits and, consequently, default. It follows that the endogenous probability of bank default is,

$$p_0^i = F(Z^{i*}),$$

where for convenience using (10) and (11), we rewrite Z^{i*} as,

$$Z^{i*} = \left[r_0 \frac{d_0^i}{l_0^i} - (1-\delta) \right] \frac{1}{\alpha} (l_0^i)^{1-\alpha}. \tag{12}$$

Since we are interested in the case that the probability of bankruptcy is positive, we parameterize the model such that in equilibrium $Z^{i*}>0$ holds. From (12) it is easy to verify that, *ceteris paribus*, bank leverage increases bank default probability. That is, the greater d_0^i/l_0^i, the greater $Z^{i,*}$. Also, *ceteris paribus*, the higher the risk-free interest rate, the higher the probability of bank default. This time the expected present value of future earnings is,

$$V_0 = \mathbb{E}_0 \left\{ \beta \left(max\{0, r_1^{l,i} l_0^i - r_0 d_0^i\} \right) \right\}. \tag{13}$$

With limited liability the bank only cares about the states of nature where its income is greater than its liabilities. Since the returns on bank deposits are insensitive to risk due to deposit insurance, the bank does not internalize the effects of its decision on the risk-taking. The bank seeks to maximize (13) subject to (7). For convenience we rewrite (13) as,[19]

$$V_0 = \int_{r_1^{l,i*}}^{+\infty} \beta(r_1^{l,i} l_0^i - r_0 d_0^i) dF^{r^l}(r_1^l), \tag{14}$$

The first-order condition for d_0^i yields,

$$\int_{r_1^{l,i*}}^{+\infty} \beta(r_1^{l,i} - r_0) dF^{r^l}(r_1^l) + \beta(r_1^{l,i*} l_0^i - r_0 d_0^i) F^{r^l}(r_1^{l,i*}) \frac{\partial r_1^{l,i*}}{\partial d_0^i} = 0.$$

Using (10), the optimality condition becomes,

$$\int_{r_1^{l,i*}}^{+\infty} \beta(r_1^{l,i} - r_0) dF^{r^l}(r_1^l) = 0,$$

and then it is held that, in equilibrium,

$$1 - \delta + \alpha \bar{Z}^{i,+}(l_0^i)^{\alpha-1} = r_0, \tag{15}$$

[19]where F^{r^l} is the cumulative distribution function of r_1^l, which inherits the distributive properties of Z_1.

where $\bar{Z}^{i,+}$=$\mathbb{E}_0\{Z_1|Z_1 > Z^{i,*}\}$.

From the equations (9) and (15), we see that the interaction of limited liability and deposit insurance leads banks to overestimate the marginal benefit of borrowing, since $\bar{Z}^{i,+} > \bar{Z}$. In other words, since banks do not absorb negative losses and the deposit interest rate is risk insensitive, banks take excessive risk leading to inefficiently high loan allocation.

From the equation (15) *ceteris paribus*, the probability of bank default increases bank incentives to take excessive risk and hence to excessively lend. We call the impact on risk taking and credit through the bank default probability as *excessive bank risk taking channel*.

Our measure of inefficiency or measure of excess bank risk, which involves the volume of credit, is the relative difference in loans under unlimited liability (UL) and under limited liability (LL), that is, $l_0^{i,LL}/l_0^{i,UL}-1$.

Under unlimited liability, as suggested by (9) a higher interest rate increases the marginal cost of deposits and reduces bank lending. Under limited liability and deposit insurance, according to (15), in addition to the direct impact there is also an indirect impact of the interest rate on the marginal benefit of loans, through the probability of bank default, in addition to the general equilibrium effect of credit on the probability of default.

Regarding the indirect impact, on the one hand, for a given level of loans, a lower interest rate reduces bank obligations, increases bank profits and, therefore, reduces the probability of bank default; while, on the other hand, higher credit (caused by the direct impact of the rate on the marginal cost of borrowing) produces the opposite effect on the probability of bank default.

According to equation (12), for the same level of loans l_0^i, the negative impact of a lower risk-free rate (funding cost of deposits) in the probability of bank default, it will be more important the greater the share of deposits as a source of credit funding, or the greater the leverage, which we can define as the ratio d_0^i/l_0^i. In other words, due to the excessive risk-taking channel, according to equation (12), the impact of expansionary monetary policy (captured by a reduction in the risk-free interest rate) on credit should be relatively less positive in those banks with relatively high levels of leverage.

The intuition is that lower financing costs increase profits for banks (*profit channel*). Therefore, banks, in order to guarantee these higher profits, take less risk. So, the greater the share of deposits, the incentives for less risk in the face of a reduction in the risk-free rate are stronger. What amplifies the negative impact on the granting of credit through the channel of excessive risk taking.

Next, we parameterize the model (with limited liability and deposit insurance) and present numerical solutions since analytical solutions are not straightforward. The parameter of capital participation in production, α, is set at 0.33, which is a standard value in the literature. We set our quarterly capital depreciation rate at 20%, which is higher than the literature, to avoid an explosive credit response.[20] The household's discount factor, β, is set at 0.98, which is a relatively standard value. We say that $\mu_z = -0.5\sigma_z^2$ so the unconditional mean of productivity is zero. Therefore, σ_z will mainly affect productivity volatility and help us to set the size of the bank default probability.

The other two parameters, $\{n_0, \sigma_z\}$, are established so that the bank leverage ratio (l_0/n_0) and the annual bank default probability are 6.0 and 1.5, respectively.[21] The level of leverage is slightly below the levels observed in Peru. In general, in many countries bank leverage has been reduced, albeit slowly since the 2008 global financial crisis. The level of default probability is a conservative, considering the probability of a banking crisis in emerging economies built with the data of Laeven and Valencia (2020). The table 8 summarizes the values of the parameters.

Tabla 8: *Parameters*

Description	Parameter	Value	
Capital share	α	0.33	Standard value
Capital depreciation rate	δ	0.20	
HHs discount factor	β	0.984	Standard value
			Target
Initial bank net worth	n_0	0.353	Bank leverage of 6.0
Volatility of $\ln(Z_1)$	σ_z	0.724	Annualized default probability 1.5%

The figure 7 shows us the numerical results of the impact of the monetary policy (changes in r_0) on the level of leverage, credit and bank default probability. To see the impact of the monetary policy conditional on the leverage level, results are reported for three different levels of leverage (low, medium and high).[22] According to the figure, 7 we see that at a higher leverage, the impact of the expansionary policy on credit is less positive. However, the difference in terms of the heterogeneous response to monetary

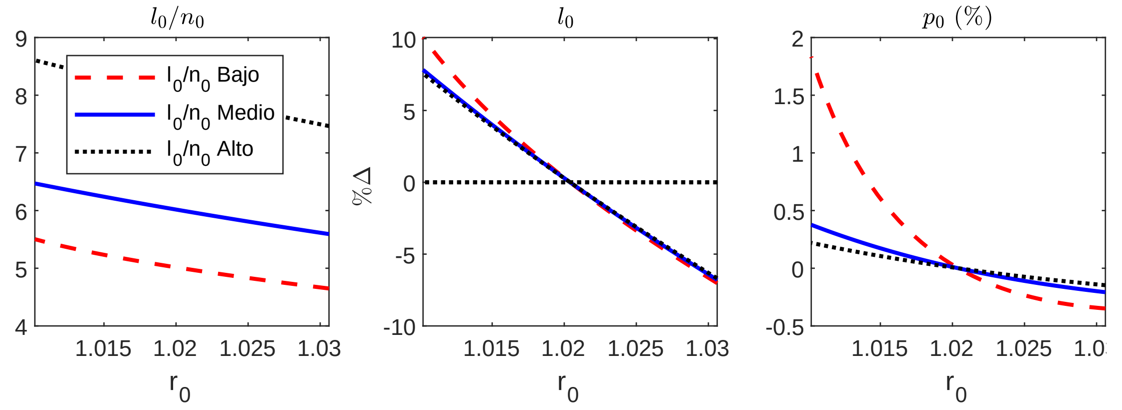
[20]The lower δ, the more explosive the credit response to the rate of interest. If the principal does not fully depreciate, one part of the loan payments is risk-free, $(1-\delta)l_0^i$, and the other part is risky, $\alpha Z_1 (l_0^i)^{\ alpha}$. Capital that does not depreciate reduces the relative importance of venture bank income. Technically, it means that after a change in bank liabilities (driven by interest rate changes) large adjustments of Z^* are required to keep earnings unchanged (or equal to zero). As a result, the probability of bank and credit default is more sensitive to changes in the interest rate. To guarantee a positive probability of default, in the worst state of nature, bank revenues must be less than bank liabilities, that is, $\delta > 1 - r_0(1 - n_0^i/l_0^i)$. This produces a lower bound for δ. In fact, the lower bound for our annualized δ turns out to be higher than that observed in the data.

[21]The quarterly bank default probability p_0 of the model is found in the following equation $3.5\% = p_0\left[1 + (1-p_0) + (1-p_0)^2 + (1-p_0)^3\right]$.

[22]The medium level is the one used in the baseline parameterization. Every time the target level of leverage is changed, the parameters n_0 and σ_z are recalculated.

policy is not very significant. The latter may be associated with the simplicity of the model, and the difficulty involved in its parameterization.

Figura 7: *Monetary policy conditional to the bank leverage level*



%Δ: Percentage change with respect to the base level of the interest rate $r_0 = 1/\beta = 1/0.98 = 1.02$.

7.2 Results at bank branch level

Although the previous results are associated with the heterogeneous response of credit at bank level, under some assumptions, we can extrapolate them to also conclude the same at the branch level. Therefore, in what follows we focus on branches of the same bank. In that case, i now refers to a branch.

We assume that lending decisions are made at the branch level. In this specification, a bank branch i that can take local deposits as d_0^i and issue loans as l_0^i, requires external financing as $b_0^i = l_0^i - d_0^i$. If $l_0^i > d_0^i$, the branch requires positive external financing; otherwise, the branch is lending rather than borrowing funds. As at the bank level, the profit of the branch i is:

$$max \left\{0, r^{l,i} l_0^i - r_0 d_0^i \right\}.$$

As before, we can get:

$$Z^{i*} = \left[r_0 \frac{d_0^i}{l_0^i} - (1-\delta) \right] \frac{1}{\alpha} (l_0^i)^{1-\alpha}, \tag{16}$$

and,

$$1 - \delta + \alpha \bar{Z}^{i,+} (l_0^i)^{\alpha - 1} = r_0. \tag{17}$$

An additional difference with the bank-level model is that d_0^i could be greater than l_0^i, so higher levels of heterogeneity on $\frac{d_0^i}{l_0^i}$ could be observed at branch level.

As a result, we could find that for those branches with a relatively high ratio $\frac{d_0^i}{l_0^i}$ (or with a relatively low dependence on external funding), the indirect impact of r_0 on credit, through the branch default probability, might be more important. So, at the branch level, the heterogeneous impact of the monetary policy condition on bank (branch) leverage should be more marked.

Finally, the model rationalizes the results found in the data at bank level and at branch or district level, that the impact of monetary policy can be conditional on the leverage level. In particular, the greater the branches' dependence on external financing (or the less bank leverage, $\frac{d_0^i}{l_0^i}$) the more positive will be the impact of expansionary monetary policy on credit, amplifying its impact . Consequently, the lower the dependence on external funding (the higher $\frac{d_0^i}{l_0^i}$) we would see an attenuating effect on the impact of monetary policy.

8 Conclusion

In this research work we document the existence of a heterogeneous banking channel in Peru, where monetary policy actions have an amplifying and a dampening effect on the credit market, and depend on the leverage level of financial institutions. To show causal effects of this mechanism, we use a more granular level of data, and we show that monetary policy actions also affect supply decisions in a bank branch, but that effect will depend on the greater or lesser dependence of this branch on external funding that are not local deposits. In the aggregate, it is the amplifying margin, due to the heterogeneity of the funding, that determines the credit market corrections after monetary policy actions.

Our results, to our knowledge, are the first effort to understand how the micro dynamics of the financing structure of financial institutions impacts the transmission mechanisms of monetary policy. However, our work can still be extended to explain the reasons for our findings. For example, it is possible that those bank branches that depend less on local deposits as a source of funding (that is, they have a high ratio of loans to deposits) are less exposed to an increase in the interest rate of the monetary policy that is passed on to higher interest rates on deposits. However, these same branches require more external funding and the results we show suggest that the cost of this external financing increases much faster than the cost of funding local deposits. Therefore, the greater the dependence on external financing sources, the more positive is the impact of the policy rate on the cost of financing. Although this may be a plausible explanation, it is also necessary to document a deposit channel, and study the behavior of interest rates in the deposit and credit markets together.

Although we study the impacts of monetary policy conditional on a characteristic of the credit market, there are other elements of the Peruvian financial market that could also be important, such as the relatively high level of financial frictions, the relatively high market power of banks and the existence of underdeveloped capital markets. Although these are also important supply channels, we leave their exploration for a future research agenda.

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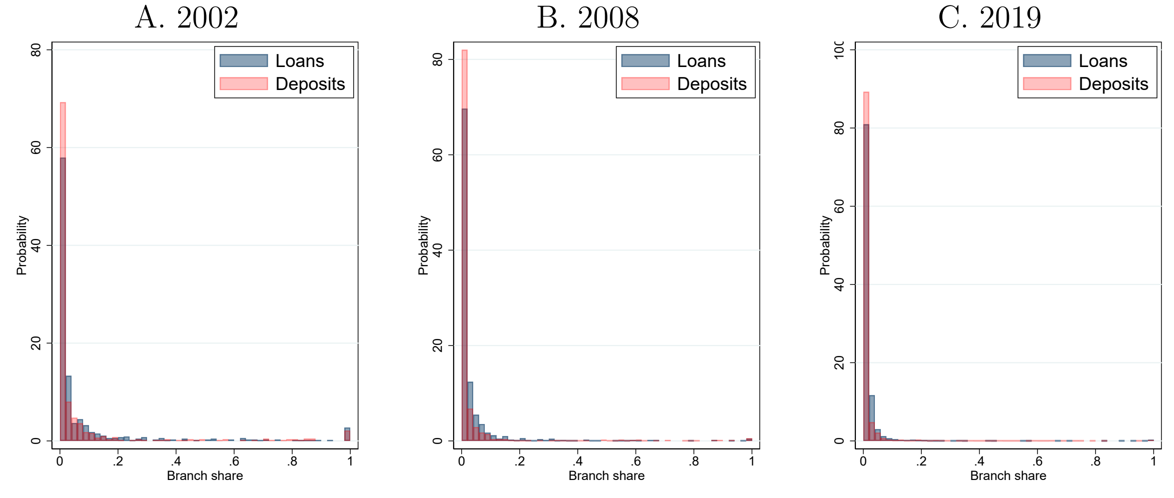
Appendices

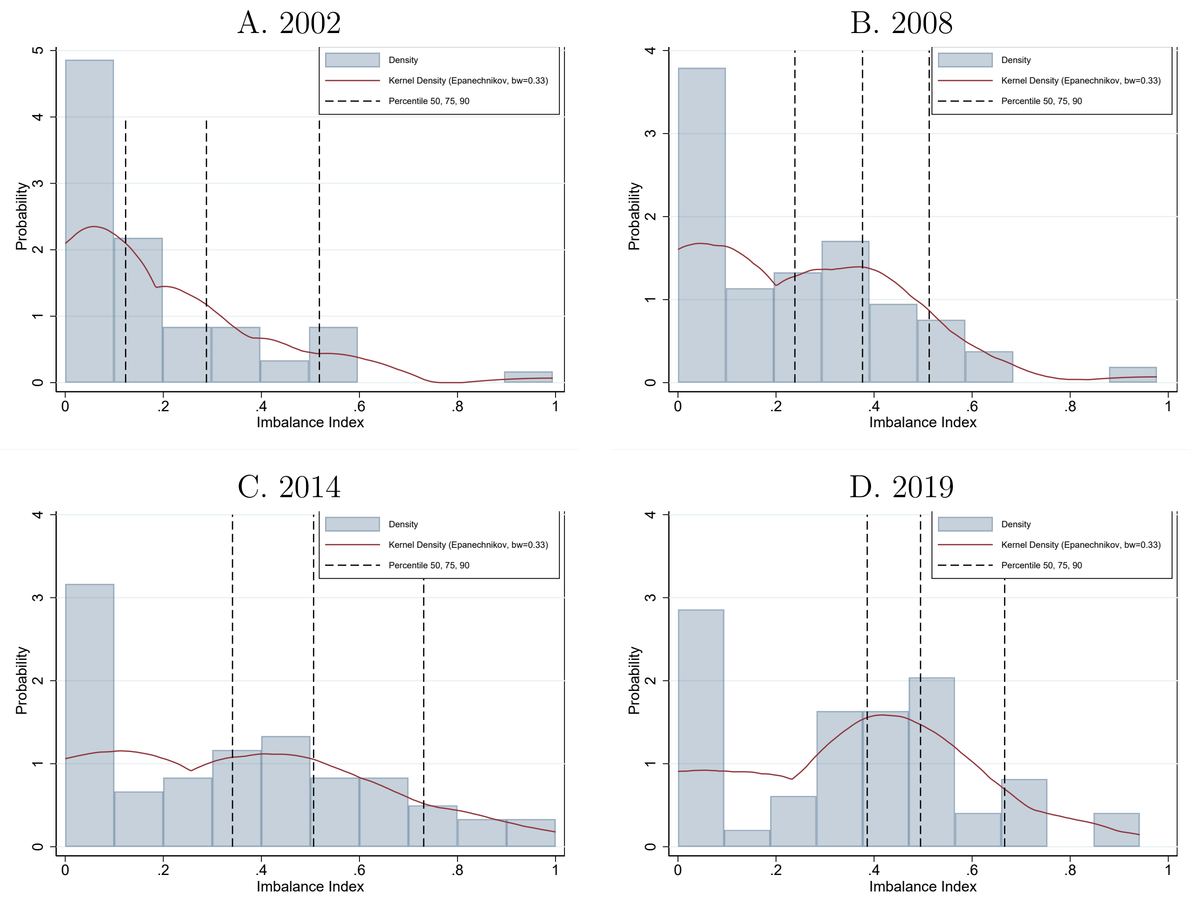
A Other figures

Figura 8: *Distribution of the participation of credits and deposits of financial entities in a district*



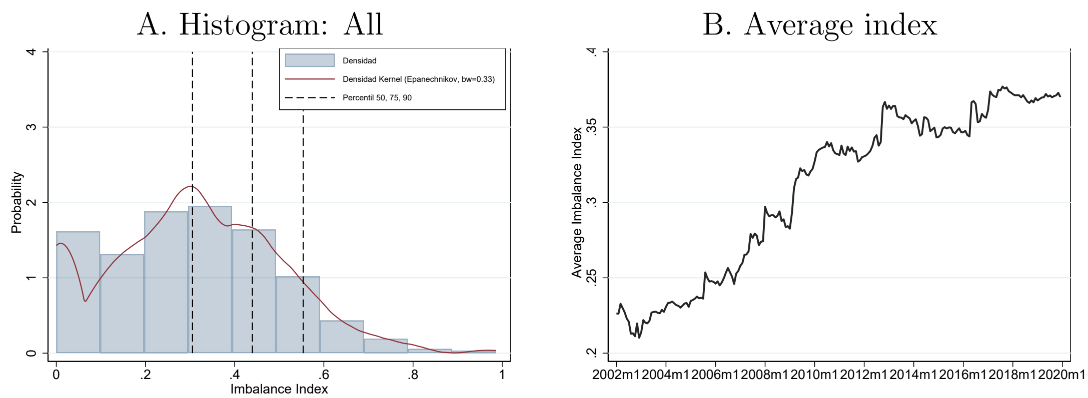
Note: This graph shows the distribution of shares of deposits and loans of each financial institution in a district. The participation of credits and deposits is calculated as the ratio of the amount of deposits or loans of an entity-district over the total amount of loans or deposits of the financial institution in December of each year. The shares are shown grouped for all banks and a given year.

Figura 9: *Distribution of the imbalance index between loans and deposits at the bank level*



Note: The figure shows the histogram at the bank level of the credit and deposit imbalance index, measured by the specification GI_{bt} in the equation 3, for the years 2002, 2008, 2014 or 2019.

Figura 10: *Distribution of the imbalance index between credits and deposits at the level of depository entities*



Note: These graphs consider the sample of depository entities, and therefore exclude financial companies. Panel A shows the bank-level histogram of the credit and deposit imbalance index, measured by the GI_{bt} specification in the equation 3, for all banks and all sample periods. 2002.1-2019.12. Panel B shows for each time period the average imbalance index of all financial entities.

B Robustness: regression at the bank level

Tabla 9: *Regression at bank level, monthly frequency, estimated with OLS: include extreme values of credit growth*

	Dependent variable: Δy_{bt}					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{GI}_{bt-1}\epsilon_t^{MP}$				0.0662	0.135	0.0461
$\text{RWA}_{bt-1}\epsilon_t^{MP}$	0.0346**	0.0405***	0.0412***	0.0322**	0.0361**	0.0395**
ϵ_t^{MP}	-0.265**	-0.316***		-0.267**	-0.323***	
RWA_{bt-1}	-0.00336**	-0.0109***	-0.00647***	-0.00447***	-0.0111***	-0.00751***
GI_{bt-1}				0.0314**	0.0191	0.0285**
Obs.	2,686	2,686	2,686	2,686	2,686	2,686
R^2	0.004	0.101	0.101	0.007	0.101	0.102
F test (ρ-value)	0.00746	8.47e-07	6.35e-06	0.00278	4.83e-06	7.82e-06
Bank FE		✓			✓	
Time FE			✓			✓

*p<0.1, **p<0.05, ***p<0.01.