Bank Regulatory Capital Arbitrage: Evidence from Housing Overappraisals*

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Abstract

The overstatement of asset collateral values reduces bank capital requirements. We identify this novel form of regulatory arbitrage by studying housing overappraisals, the difference between housing collateral values computed by appraisers and transaction prices. We leverage both a discontinuity in mortgage capital risk weights and a reform that eliminated a discontinuity in mortgage provisions to show that tighter regulatory requirements cause larger overappraisals. On average, overappraisals lower risk-weighted mortgages by 9%, and free up capital that banks partially use to back up their lending to small and medium-sized enterprises. These loans are highly profitable, but also rather risky and capital-intensive.

Key Words: Risk-weighted Assets, Mortgages, Collateral, Credit Supply, SMEs.

JEL Classification Codes: G21, G28, R31.

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1 Introduction

The aftermath of the last financial crisis has led to a wave of regulation to limit the risks in bank balance sheets. The discussion among policy-makers, economists, and commentators has emphasized the pivotal role of loan-to-value (LTV) ratios for measuring expected credit losses (Crowe et al., 2011; Hanson et al., 2011; IMF, 2013; Claessens, 2015). Even if nowadays bank regulation depends explicitly on LTV ratios, these rules are challenged by the incentives of financial institutions to circumvent capital requirements (Huizinga and Laeven, 2012; Acharya et al., 2013; Acharya and Steffen, 2015; Behn et al., 2016).

This paper uncovers a novel form of regulatory arbitrage: the overstatement of asset collateral values. We focus on residential mortgages and show that regulatory requirements raise housing overappraisals, defined as the difference between housing collateral values computed by the appraisers and actual transaction prices. To identify the average treatment effect of regulatory requirements, we leverage two features of mortgage regulation. First, we exploit a discontinuity in capital risk weights which implies a jump in overappraisal-based capital reliefs at the 80% LTV ratio. Second, we study a regulatory reform that eliminated a discontinuity in mortgage provisions around the same LTV threshold. We find that overappraisals jump by 3.5 percentage points (p.p.) at the regulatory cutoff. This discontinuity was even larger before the reform, at around 4 p.p.

The appraisal bias depends crucially on the bank-appraiser relationship, as appraisers inflate the collateral values only if the bank granting the mortgage is their major business partner. This tight relationship between financial institutions and appraisers is rooted in the fact that banks used to own majority stakes in the appraisal companies. While these direct stakes were banned in 2013, on average 75% of the turnover of each appraisal company is still concentrated in just one bank. Thus, appraisers inflate the evaluations for their most important customer, either because they internalize the incentives of their relevant customers (Calem et al., 2018), or to build long-term relationships with the lenders (Agarwal et al., 2017). These findings resemble closely the channels highlighted by the literature on credit rating shopping (Sangiorgi et al., 2009; Bolton et al., 2012).

Overappraisals imply a substantial reduction in capital requirements, by lowering risk-weighted mortgages by 9% on average. We then leverage the heterogeneity in these capital reliefs across financial institutions to evaluate how overappraisals alter bank corporate lending policies. To identify the variation in corporate credit supply, we saturate a bank-firm-time regression with firm-time fixed effects (Khwaja and Mian, 2008). We find that overappraisal-based capital reliefs allow banks to raise their small and medium-sized enterprise (SME) lending. These loans are highly profitable, but also relatively riskier and thus require severe capital requirements.

Residential mortgages are a relevant component of bank balance sheets: they account for 20% of total assets and represent the asset class that originated the last financial crisis (Mian and Sufi, 2011; Acharya et al., 2014). In our analysis, mortgages serve as an ideal case study for two further reasons. First, the process through which appraisers assess the collateral value of each mortgage is very transparent, as it is regulated by law. When a bank grants a mortgage to an individual, a third party – called the appraiser – estimates the collateral value of the underlying property, by comparing it to at least six similar dwellings. The collateral value is then used to derive the LTV ratio of the mortgage. Second, we observe the transaction price of each property, which represents a natural counterpart to gauge the soundness of appraisal values.

We compute housing overappraisals for the Spanish home purchase mortgage market, from January 2015 until September 2018. We collect the transaction price and the appraisal value of the properties underlying all newly granted mortgages, and merge this information with the Spanish credit register. In this way, we observe both the identity and a full set of characteristics of the bank, the appraiser, and the property associated to each mortgage. The bank characteristics include the macroprudential and microprudential capital requirements.

Overappraisals are widespread in both Spain and the U.S., with two thirds of real estate properties appraised above the transaction price (Cho and Megbolugbe, 1996; Calem et al., 2018; Bover et al., 2019; Eriksen et al., 2020). In our sample, the median appraisal bias equals 12 p.p. To isolate the effect of regulation on overappraisals, we design an identification strategy that leverages a discontinuity in the capital requirements of mortgages. The E.U. Capital Requirements Regulation posits that the risk weights of residential mortgages equal 35% if the loan has a LTV ratio up to 80%, and jump to 100% for the portion of the mortgage which exceeds the 80% LTV ratio. We evaluate whether this sharp variation in capital requirements at the 80% LTV cutoff generates a similar discontinuity in overappraisals. Our identification strategy is also supported by the fact that mortgage rates, house prices, and loan sizes vary smoothly at the regulatory threshold.

Since the mispricing of collateral values manipulates the LTV ratio, we consider a regression discontinuity design in which the probability of an overappraisal treatment equals the difference between the loan-to-price (LTP) ratio and the 80% regulatory threshold. This strategy exploits the fact that transaction prices tend to be predetermined to the request of a mortgage. Consistently with the hypothesis that collateral values are inflated so that the LTV ratio is below the regulatory threshold, we find that overappraisals rise by 3.5 p.p. at the 80% LTP ratio. Importantly, there is no variation around alternative LTP notches.

We provide further evidence on the causal effect of regulatory requirements on overappraisals by leveraging a regulatory reform that eliminated a discontinuity in the amount of mortgage provisions around the 80% LTV ratio. Indeed, before October 2016 the regulatory treatment of residential mortgages around the 80% LTV threshold differed not only in terms of capital risk weights, but also in terms of general provisions.[1] These provisions were designed so to rise at the 80% LTV ratio

[1] The general provisions belong to the countercyclical provision system implemented by Banco de España

from 0.6% to 1.5% of the newly granted mortgage. This distinction was eliminated by the Circular 4/2016 of the Banco de España which came into force in October 2016. We exploit this quasi-experimental variation in the discontinuity of mortgage regulatory requirements by estimating a difference-in-discontinuities regression, and find that the reform reduced the jump of overappraisals at the 80% LTP ratio by 0.5 p.p. This evidence corroborates the use of overappraisals to inflate collateral values so that LTV ratios are below 80%.

We then uncover the determinants of overappraisals. First, overappraisals tend to be concentrated among low-capital banks, which benefit relatively more from any relaxation of regulatory requirements. Second, the inflation of collateral values depends on the relationship between banks and appraisers: overappraisals are concentrated in those bank-appraiser pairs in which the bank is a major customer for the appraisal company. Third, overappraisals vary with the characteristics of local housing markets, and are concentrated in zip codes with a larger house price dispersion. Since in these areas the fundamental value of a property is opaque, appraisers can inflate their assessments. This evidence confirms that overappraisals owe to regulatory arbitrage rather than regulatory forbearance (Boot and Thakor, 1993; Brown and Dinc, 2005; Morrison and White, 2013; Liu and Ngo, 2014).

Our results are consistent with the experience of Banco Popular previous to its dramatic crisis in June 2017, that led Banco Santander to purchase it for 1 euro. According to the European Central Bank, Banco Popular had a 27% overappraisal in its residential mortgages, overstating collateral values by around 2 billion euros. Interestingly, the bulk of the overappraisals was concentrated in a set of land properties evaluated by the same appraisal company over a period of time immediately before the last large-scale capital increase in June 2016. This example highlights how an appraiser boosts its evaluations (*i*) for a major customer bank, (*ii*) over properties with opaque values, (*iii*) when the bank can benefit the most from the window

between 2000 and 2016 (Saurina, 2009; Jimenez et al., 2017).

dressing of its fragile capital ratios.

Overappraisals reduce substantially the risk-weighted mortgages, thus allowing banks to increase their supply of credit. In particular, banks raise SME lending by 43 cents on the dollar of overappraisal-based capital reliefs. Banks lend more to SMEs to boost their short-term profitability, as the interest rates for SMEs are 2 p.p. higher than those of mortgages and non-SME corporate loans. However, SMEs are also much riskier, with a 4 p.p. relatively higher default rate, and require relatively larger risk weights. Thus, overappraisals allow banks to reduce the regulatory requirements of their mortgage portfolio, thereby freeing up capital that can be used to back up additional risk-taking in the corporate loan market.

Related Literature: This paper shows that banks benefit from the collateral mispricing in the housing market to reduce their capital requirements. The relevance of studying housing overappraisals is twofold. First, the focus on overappraisals is instrumental to identify the causal link between regulatory requirements and the overstatement of asset collateral values. In this setting we can estimate directly and transparently the amount of collateral mispricing by comparing the evaluations of the appraisal companies with the actual transaction prices. Second, our analysis on overappraisals allows us also to dig deeper into the drivers of a phenomenon that has negative widespread consequences on the housing market and the financial system. For instance, the literature has established that overappraisals lead to higher foreclosure rates (LaCour-Little and Malpezzi, 2003; Ben-David, 2011; Agarwal et al., 2015), higher default rates of residential mortgage-backed securities (Griffin and Maturana, 2016a; Kruger and Maturana, 2020), and larger house price fluctuations (Ben-David, 2011; Griffin and Maturana, 2016b; Griffin et al., 2018). The disruptive effect of collateral mispricing is further corroborated by the fact that the Spanish banks rescued in the last financial crisis had disproportionally higher levels of mortgage overappraisals (Akin et al., 2014). From this perspective, we add to the literature by providing a novel determinant of overappraisals: bank regulatory arbitrage activity.

This paper adds to the debate on regulatory arbitrage, which shows how banks minimize capital requirements via securitization activity (Acharya et al., 2013; Demyanyk and Loutskina, 2016; Kisin and Manela, 2016), the transfer of funds towards countries with fewer regulation (Houston et al., 2012; Barth et al., 2013), the rise of sovereign bond exposures (Acharya and Steffen, 2015), the implementation of lower internal risk estimates (Behn et al., 2016; Benetton et al., 2020). We add to this literature on two dimensions. First, we highlight the overstatement of asset collateral values a novel regulatory arbitrage tool. Second, we show how the capital reliefs in the mortgage market allow banks to boost their risk taking in the corporate loan market. Thus, overappraisals are not just an unintended consequence of capital regulation confined within a specific market segment, but rather they imply a widespread increase in the risk exposure throughout the entire asset side of bank balance sheets.

2 Institutional Background

2.1 Mortgage Capital Requirements

The capital requirements of Spanish banks are defined by the Capital Requirements Regulation (CRR) No 575/2013, which was enacted by the European Commission on June 2013, and came into force on January 2014. Under the CRR, the capital requirement associated to each bank asset position can be computed via either the Standard approach (SA) or the Internal Ratings Based (IRB) approach.

Under the SA, Chapter 2 of the CRR posits that the risk weights of residential mortgages (RWM) are estimated according to the following formula:

$$\begin{aligned} \text{RWM} = 35\% \times \min\{\text{Mortgage Value}, 0.8 \times \text{Collateral Value}\} + \dots \quad (1) \\ \dots + 100\% \times \max\{0, \text{Mortgage Value} - 0.8 \times \text{Collateral Value}\} \end{aligned}$$

where *Mortgage Value* is the mortgage size, and *Collateral Value* is the appraisal value of the property underlying the mortgage.[2] The CRR imposes that the fraction of a

[2] Article 2 of Circular 2/2016 posits that "the LTV is the ratio resulting from dividing the [mortgage value] by the value of the last available appraisal".

mortgage which is below the 80% LTV cutoff is subject to a 35% risk weight, whereas the 100% risk weight applies only to the fraction of the mortgage which exceeds the 80% LTV ratio. Therefore, the EU regulation defines a discontinuity in bank capital requirements associated to residential mortgages which depends on LTV ratios.

The CRR allows banks to compute risk weights with the IRB approach, rather than using the SA. Namely, banks can develop their own modelling techniques to derive risk weights as a function of both the probability of default and the loss given default of each loan. In this case, the bank-specific risk weights display discontinuities that do not need to coincide with those implied by the SA.

This paper focuses on the discontinuities posed by the SA, rather than exploiting variation in IRB requirements as in Benetton et al. (2020). However, SA risk weights are the relevant measures for the capital requirements of Spanish banks for two reasons. First, the use of the IRB approach by the banks in our sample is rare: since the design of own modelling techniques is costly,[3] only very large banks outweigh the costs with the benefits derived from the potential reduction in capital charges. According to the transparency exercise carried out by the EBA in 2016Q4, only six Spanish banks had part of their retail portfolio evaluated under the IRB approach.[4] Second, SA requirements are relevant also for those few banks that have adopted the IRB models. For instance, the largest bank in our sample uses SA risk weights for 25% of its outstanding mortgages, and this share has been increasing over time. Thus, over our sample period the SA risk weights apply to a substantial fraction of mortgage originations for even the largest banks.

2.2 Mortgage Provision Requirements

The origination of a mortgage does not entail only capital requirements, but also general provisions. These provisions are non-cash expenses which banks accumulate

[3]The adoption of IRB risk weights entails high implementation costs, as it is subject to the permission of the supervisory authorities after an in-depth analysis of the models and operating systems.

[4]https://eba.europa.eu/risk-analysis-and-data/eu-wide-transparency-exercise/2016

ex-ante to cover for potential future losses, and differ from the specific provisions, which instead deal ex-post with incurred losses.

From July 2000 to September 2016, the Banco de España established a system of countercyclical provisions, in which banks had to build up provisions during expansions and release them in downturns (Saurina, 2000; Jimenez et al., 2017). After an initial calibration of the countercyclical system, the Circular 4/2004 imposed the computation of the general provisions by splitting overall bank lending into six classes, and computing for each class the due amount of general provisions as a function of two elements: one relating to the time variation in the size of the specific portfolio class, and one relating to the difference between the size of the portfolio for each specific class and the total amount of bank specific provisions, that is

$$\text{General Provisions}_{b,t} = \sum_{c=1}^{6} \alpha_c \Delta \text{Credit}_{b,c,t} + \dots \\ \dots + \sum_{c=1}^{6} \beta_c \left[\text{Credit}_{b,c,t} - \text{Specific Provisions}_{b,t} \right]. \tag{2}$$

Circular 4/2004 considered six different classes, pooling loans with similar ex-ante risk profile. Each class featured a different combination of parameters α_c and β_c, determining the class-specific amount of general provisions. For the case of residential mortgages, the loans with LTV ratios up to 80% belonged to the "low risk" category, which implied provisions according to the parameters $\alpha_{\text{Low Risk}} = 0.60$ and $\beta_{\text{Low Risk}} = 0.11$. Instead, the mortgages with LTV ratios above 80% were considered as "medium-low risk", with provisions defined as a function of a higher set of parameters: $\alpha_{\text{Medium Low Risk}} = 1.50$ and $\beta_{\text{Medium Low Risk}} = 0.44$. Hence, the Circular 4/2004 implied a discontinuity in general provision requirements at the 80% LTV ratio.

The Banco de España reformed the provisions with the Circular 4/2016 enacted in April 2016, which ended the countercyclical system for all mortgages originated from October 2016. Nowadays, the amount of general provisions depends only on the growth of bank lending portfolios (i.e., $\beta = 0$), and mortgages with LTV ratios both below and above 80% have a provision requirement of $\alpha = 0.40$. Thus, the reform has eliminated the discontinuity in provision requirements at the 80% LTV cutoff.

2.3 Appraisal Process

The appraisal process for real estate properties is regulated by law (Ley 2/1981, Orden ECO/805/2003). The entire body of regulation aims at the determination of fair and prudent appraisal assessments, to gauge property fundamental values, net of short-term market swings.

The vast majority of appraisals are implemented with the "comparable method", in which the appraisers compare the dwelling of interest with the values of at least six similar properties in similar locations purchased over the previous two years. The appraisers not only choose which are the comparable similar properties, but also the weights to apply to each of them in the derivation of the appraisal.[5]

The appraisals are performed only by licensed institutions that have received the official approval by the Banco de España. If an appraiser reports systematically biased evaluations, it faces monetary sanctions and even the withdrawal of the license.

In 2013 the Spanish parliament enacted an amendment to the law regulating the mortgage market (Ley 1/2013 and Circular 3/2014), by positing that banks' direct equity stakes in appraisal companies should be capped at 10% of the voting shares. This reform was intended to improve the independence of appraisal companies.

2.4 The Spanish Mortgage Market

The Spanish mortgage market represents an ideal case study to identify the causal effect of capital requirements on housing overappraisals. First, the characteristics of overappraisals in the Spanish mortgage market are remarkably similar to that of the United States. In both countries, two thirds of real estate properties are appraised above their transaction price (Cho and Megbolugbe, 1996; Calem et al., 2018; Bover et al., 2019; Eriksen et al., 2020), and the bank-appraiser relationship is a major

[5] The law permits two additional methods: (*i*) the "cost method", which sums the value of the land or building to restore, and the estimated costs for constructing or restoring the building; and (*ii*) the "updated value method", which is based on rental prices. These methods apply to 10% and 1% of the appraisals in our sample, respectively.

determinants of the overstatement of collateral values (Agarwal et al., 2017).[6] Second, overappraisals may bunch for reasons not related to regulatory requirements if mortgage rates display sharp discontinuities around LTV notches (Calem et al., 2015; Agarwal et al., 2019; Calem et al., 2018). However, this concern is not valid in our setting, as in Spain mortgage rates vary smoothly at the regulatory threshold.[7] Importantly, the lack of discontinuities in mortgage rates at the regulatory cutoff impairs the external validity of our identification strategy, but does not affect whatsoever the external validity of our findings.[8] Finally, we focus on a period in which there is no borrower-based measure. In this way, any activity of regulatory arbitrage is undertaken to reduce the requirements faced by banks.

3 Data

To compute the appraisal bias associated to each mortgage and link it to the capital position of the bank granting the loan, we merge four datasets. The first one comes from the Recorders of Deeds ("Colegio de Registradores de la Propiedad y Mercantiles") and contains granular information on the universe of real estate transactions and mortgage originations since 2015. For each transaction, we observe the cadastral reference, which is the official, unique, and binding identifier of a real estate property. In addition, we observe the transaction value, a set of mortgage characteristics (e.g., the mortgage loan principal, the interest rate, and the maturity), and a set of

[6] In 2007 New York State Governor Cuomo sued Washington Mutual for forcing the appraisers First American Corporation and eAppraiseIT to inflate their assessments, via the discretional selection of the properties with which to compare the dwelling under appraisal. To tackle with the concerns of tight bank-appraiser relationships, the Federal Housing Finance Agency created the Home Valuation Code of Conduct in 2009, which prohibits mortgage brokers and real estate agents from selecting or paying appraisers. These rules are very similar to those enacted by the Spanish regulator in 2013, with the aim to boost the independence of appraisers.

[7] Appendix D shows that mortgage rates are quite flat across LTV notches. The combination of bank-time, mortgage characteristics-time, and property characteristics-time fixed effects explains 36% of the dispersion in interest rates. Thus, mortgage rates are mainly due to borrower-specific characteristics (Carbo-Valverde et al., 2018).

[8] Banks would have an incentive to appeal to overappraisals to reduce capital requirements even if mortgage rates were to be discontinuous at the 80% LTV ratio. In this case, the challenge would be how to isolate the jump in overappraisals due to the discontinuity in regulatory requirements from that due to the discontinuity in mortgage rates.

property characteristics (e.g., the location, whether the property is existing, new, or in progress, and the size). Importantly, this source of data reports also the appraisal value of each mortgage.

The second database is the Central Credit Register (CCR - "Central de Información de Riesgos") of the Banco de España, which contains the universe of loans granted by the financial institutions operating in Spain. Financial institutions are legally obliged to provide information on each mortgage about the loan principal, the interest rate, and the maturity, without a minimum reporting threshold. This source of data not only contains the cadastral reference of the property underlying each mortgage, but also identifies the bank granting the mortgage, the appraisal company, and even the appraisal method used to derive the collateral value.[9] This information is available from December 2016.[10]

The third database is Moody's Analytics Bank Focus, which gives us the balance-sheets at the consolidated level for all Spanish banks. We further complement the bank characteristics with a fourth dataset, that reports detailed information on both the macroprudential and microprudential buffers associated to each bank. This source of data is collected by the Banco de España in its role of banking supervisor. In this way, we can determine the actual regulatory solvency of each bank, by comparing the total capital position with the mandatory requirements.

We merge all these datasets by the cadastral reference, the identity of the bank granting the mortgage, and the mortgage origination date, over a period of time that ranges from January 2015 to September 2018.[11] To avoid any bias in our measurement

[9] The information of the CRR on the appraisal value associated to each mortgage coincides in virtually all cases with the data reported by the Recorders of Deeds, corroborating the quality of our measure of appraisals.

[10] Although the CCR reports information on the universe of mortgages from well before December 2016, this is the earliest date in which we also observe the cadastral reference of the property underlying the loan. This is the key characteristics that allows us to match the information of each mortgage in the CCR with the details on transaction values reported by the Recorders of Deeds.

[11] Since the CCR reports the cadastral reference only from December 2016 on, we extend the time span of our analysis by merging the information available in the CCR by December 2016 with all the transactions of the Recorders of Deeds from January 2015 to November 2016. We manage to perform this match by exploiting the information of the CCR on the origination date of outstanding mortgages. This procedure has the drawback of missing those mortgages that were originated after 2015 and matured before December 2016. Nevertheless,

of mortgage overappraisals, we take a conservative approach in the sample selection to ensure that our information consists of the home purchase mortgages granted by banks to households for properties which are sold at the market price. We then discard all the transactions associated to (*i*) rural properties, (*ii*) properties whose price is regulated by law, (*iii*) properties purchased by companies, (*iv*) properties whose transaction price is below 30,000 euros, and (*v*) properties whose cadastral reference appears more than once in a given year.[12] In this way, we end up with 285,576 mortgages, that roughly account for 60% of the universe of newly granted mortgages over the period January 2015 - September 2018, originated by 41 banks, and evaluated by 36 appraisal companies.

With all these sources of data, we compute three main statistics for each mortgage i granted by bank b at time t and evaluated by the appraisal company a. First, we define the loan-to-value (LTV) ratio, $LTV_{i,b,a,t}$, as the ratio between the size of the mortgage loan and the collateral evaluation of the property underlying the mortgage, as assessed by the appraisal company, that is

$$LTV_{i,b,a,t} = \frac{\text{Mortgage Value}_{i,b,a,t}}{\text{Appraisal Value}_{i,b,a,t}}.$$

Second, we define the loan-to-price (LTP) ratio, $LTP_{i,b,a,t}$, as the ratio between the size of the mortgage loan and the market transaction price of the property underlying the mortgage,

$$LTP_{i,b,a,t} = \frac{\text{Mortgage Value}_{i,b,a,t}}{\text{Transaction Price}_{i,b,a,t}}.$$

Finally, we compute overappraisals, $OA_{i,b,a,t}$, as the ratio between the appraisal value and the transaction price, that is

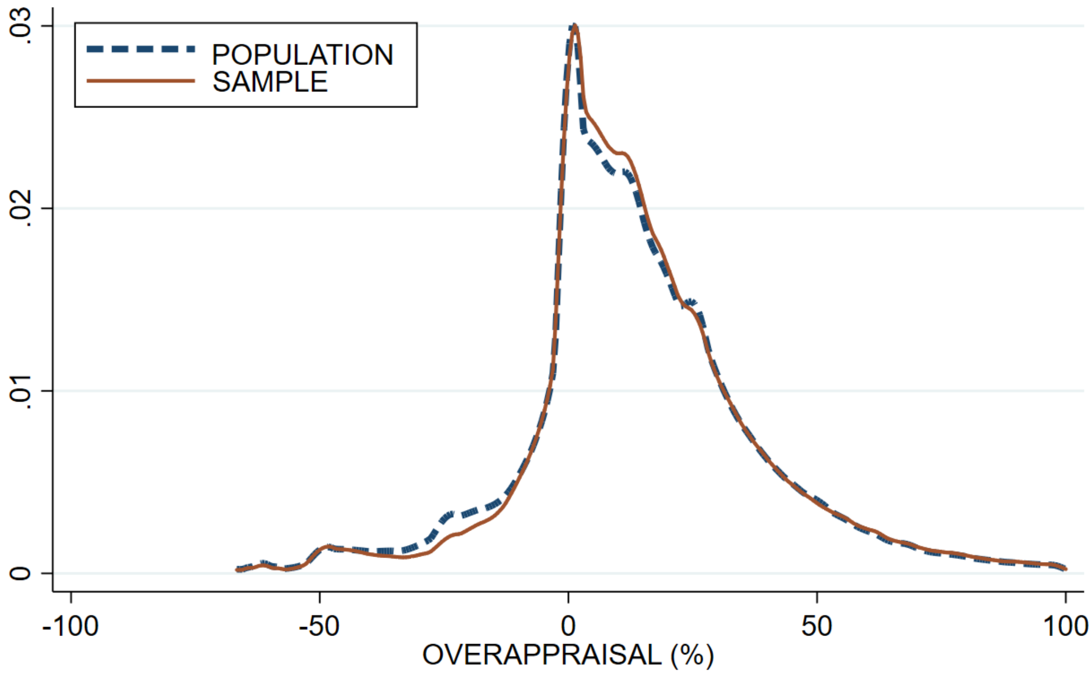
$$OA_{i,b,a,t} = \frac{\text{Appraisal Value}_{i,b,a,t}}{\text{Transaction Price}_{i,b,a,t}} - 1.$$

Hence, a mortgage is characterized by an overappraisal (or a positive appraisal bias) if

short-term mortgages are very rare in the Spanish economy. For instance, just 1% of the mortgages granted between December 2016 and September 2018 have a maturity at origination lower than two years.

[12]A cadastral reference might appear more than once in a year because either there is more than one mortgage associated to the same property, or the same property is bought more than once in a year, or the mortgage refers to a new building development in which all flats share temporarily the same cadastral reference.

Figure 1: The Distribution of Overappraisals in the Final Sample



Note: This figure shows the distribution of overappraisals in our sample and in the actual population of mortgages.

$OA_{i,b,a,t} > 0$, that is, whenever the appraisal company reports a collateral evaluation for a property which is above its transaction price.

Figure 1 compares the distribution of overappraisals in the entire population of mortgages and in our final sample. The figure shows that only 22% of the mortgages have an appraisal value that coincides with the actual transaction prices.[13] The appraisal bias is positive for 66% of the mortgages, and negative for the remaining 12%. The skewness of the appraisal bias distribution towards positive value is due to the fact that appraisals set below transaction prices dramatically increase the probability that the sale is cancelled (Fout and Yao, 2016). In the literature, the discrepancy between appraisal values and registered transaction prices is explained with either a de-facto easing of borrowers' financial constraints, with borrowers applying pressures on appraisers to raise their valuations (Agarwal et al., 2015; Piskorski et al., 2015; Calem et al., 2018) or tax evasion motives (Montalvo et al., 2020). In this paper, we

[13]We define an appraisal value that coincides with the transaction prices if the discrepancy is below 5%.

provide a novel rationale for the inflation of collateral values: an activity of regulatory arbitrage that allows banks to minimize their capital requirements.

As we report in the descriptive statistics of Appendix A, the median mortgage of our final sample amounts to 91,200 euros, which is 80% of the median transaction value of 114,000 euros, has a maturity of 25 years, and an interest rate of 2.5%. The median mortgage is characterized by a positive appraisal bias of 12%. In this way, the median LTV ratio is 70.3% notwithstanding that the median LTP ratio is higher and equals 80%.

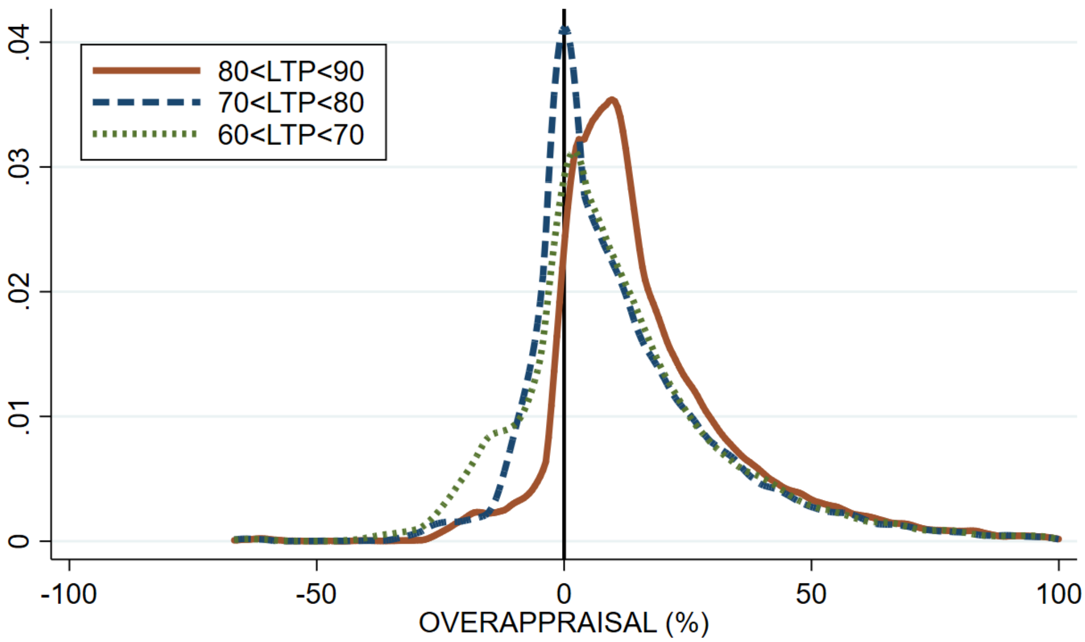
We also observe a large variation in the activity between appraisal companies and banks. Although the median appraisal company evaluates the mortgages granted by 15 different banks, there is a marked pattern of bank-appraisal relationship, as 79% of the turnover of the median appraisal company is concentrated in just one bank. Even the most diversified appraisal company has more than 20% of its total turnover concentrated in just one bank. This tight relationship between appraisal companies and some specific financial institutions is rooted in the fact that banks used to own majority stakes in the appraisal companies, and keeps persisting notwithstanding the fact that these direct equity stakes were banned in 2013.

4 Results

4.1 The Discontinuity of Capital Requirements

The E.U. Capital Requirements Regulation posits that the SA risk weight of residential mortgages equals 35% if the loan has a LTV ratio up to 80%, and jumps to 100% for the portion of the loans which exceeds the 80% LTV threshold. According to this rule, the mortgages with a LTP ratio immediately above the 80% cutoff are those with the highest probability of being treated with an overappraisal. In this case, the overstatement of the collateral value drives the LTV ratio below the 80% threshold, and implies a lower capital requirement for the bank originating the mortgage. For instance, a €810,000 mortgage associated to a €1,000,000 property – so that the LTP ratio is 81% – requires a 1.25 p.p. overappraisal to ensure that the collateral value equals €1,012,500, and the LTV ratio drops to the 80% regulatory threshold.

Figure 2: The Distribution of Overappraisals Around Key LTP Ratios



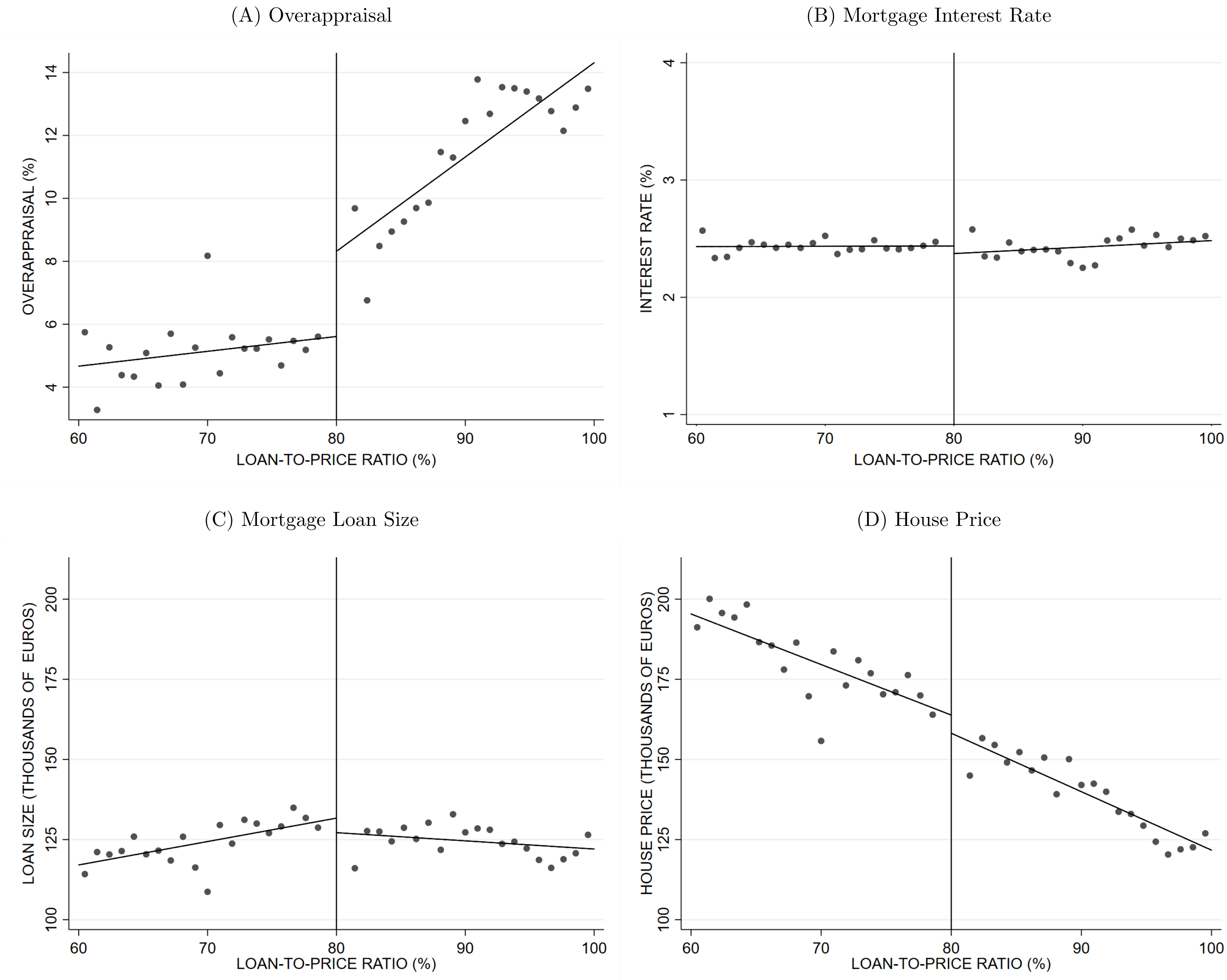
Note: This figure shows the probability density function of the overappraisal associated to mortgages with different LTP ratios. The solid red line represents the probability density function of those mortgages with a LTP ratio between 80% and 90% whereas the long dashed blue and the short dashed green line correspond to mortgages with LTP ratios between 70% and 80% and between 60% and 70%, respectively.

In the data, the inflation of collateral values depends crucially on mortgage LTP ratios. Although the evidence of Figure 1 points out to a distribution of overappraisals very skewed towards positive values, the bulk of this positive appraisal bias is concentrated among mortgages with a LTP ratio between 80% and 90%. Figure 2 shows that the overappraisals of the mortgages with a LTP ratio below 80% are almost centered around zero: only 52% of them have a positive appraisal bias. Instead, this share is as high as 78% for the mortgages with a LTP ratio just above 80%.[14]

We can dig deeper in the relationship between regulatory requirements and overappraisals by exploiting the discontinuity of capital risk weights. Namely, we look at mortgages with LTP ratios around the 80% cutoff, and we plot the average level

[14]Appendix B shows that the bias in the distribution of appraisals around the 80% LTP ratio holds also for the mortgages granted by banks which use IRB risk weights.

Figure 3: Overappraisals, Interest Rates, Loan Size, and House Prices around the 80% Loan-to-Price Ratio.



Note: Panel (A) reports the relationship between overappraisals and LTP ratios, by computing the average overappraisal for each LTP bucket, between the 60% and 100% ratio. Panels (B), (C), and (D) replicate the analysis by substituting overappraisals with the mortgage interest rate, the mortgage loan size, and the house price, respectively.

of overappraisals, interest rates, loan sizes, and house prices for all mortgages within each unit LTP bucket, from 60% to 100%. Figure 3 reports all these graphics, and highlights the presence of a sharp discontinuity in the level of overappraisals exactly at the 80% LTP threshold. While the appraisal bias for mortgages below the 80% cutoff is rather flat around a value of 5 p.p. across all LTP buckets, the inflation of collateral values jumps above 8 p.p. immediately at the 80% ratio, and increases with the LTP of the mortgage. Intuitively, a mortgage with a LTP ratio of 90% requires a larger overappraisal than a mortgage with a LTP of 85% to ensure that the LTV ratio is below the 80% threshold and the mortgage requires a lower capital requirement. Importantly, there is no sizable variation in the level of interest rates, loan sizes, and house price at the 80% LTP ratio.[15]

4.2 Regression Discontinuity Design

We use the discontinuity in the capital risk weights to estimate the average treatment effect of regulatory requirements on overappraisals. Although capital requirements depend on the LTV ratio of a mortgage, we cannot use the distance of the LTV ratio from the 80% cutoff as a measure of the probability of an appraisal treatment within a regression discontinuity design (RDD). Since overappraisals are a device to overestimate the collateral value of a mortgage with the explicit objective to minimize both its LTV ratio and the associated capital risk weight, then the LTV ratios are manipulated, especially around the 80% threshold. This feature of the data invalidates the use of an RDD.

We solve this problem by using the LTP ratio – rather than the LTV ratio – as the assignment variable. In this way, the distance of the LTP ratio of a mortgage from the 80% regulatory threshold captures the probability of an appraisal treatment. Our approach is corroborated by the fact that the LTP ratio is less likely to be manipulated. On the one hand, the transaction price tends to be defined before

[15] Appendix D studies in further detail the behavior of mortgage interest rates.

the buyer asks for a mortgage. Fout and Yao (2016) show that collateral assessments which require the formulation of a new transaction price (e.g., whenever the appraisal bias is negative) raises substantially the probability that the sale gets cancelled, thus discouraging substantially any post-appraisal variation in prices. On the other hand, there is no much room for adjustment in the loan size as Spanish home buyers have low levels of liquid assets.

With the distance of the LTP of a mortgage from the 80% threshold as the assignment variable, we estimate the following RDD

$$\begin{aligned} OA_{i,b,a,t} &= \beta_1 \mathbb{I}\{LTP_{i,b,a,t} > 80\%\} + \beta_2 (LTP_{i,b,a,t} - 80\%) + \dots \\ &\dots + \beta_3 \mathbb{I}\{LTP_{i,b,a,t} > 80\%\} \times (LTP_{i,b,a,t} - 80\%) + \dots \\ &\dots + \delta_{b,t} + \delta_{a,t} + \delta_{\text{province},t} + \mathbf{X'_{i,t}}\theta + \epsilon_{i,b,a,t}, \end{aligned} \quad (3)$$

in which the dependent variable is the overappraisal of mortgage i granted by bank b at time t and evaluated by the appraisal company a, $OA_{i,b,a,t}$, and the main independent variable is the treatment indicator variable $\mathbb{I}\{LTP_{i,b,a,t} > 80\%\}$, which equals one if the LTP ratio of the mortgage i is higher than 80%. The regression controls for the distance of the LTP ratio of mortgage i from the 80% cutoff, $(LTP_{i,b,a,t} - 80\%)$, and its interaction with the treatment indicator, $\mathbb{I}\{LTP_{i,b,a,t} > 80\%\} \times (LTP_{i,b,a,t} - 80\%)$.

We saturate the regression with bank-time fixed effects $\delta_{b,t}$, appraisal company-time fixed effects $\delta_{a,t}$, and province-time fixed effects $\delta_{\text{province},t}$, which allow us to evaluate the overappraisals across mortgages which are granted over the same year by the same bank, evaluated by the same appraisal company, and located in the same province. The bank-time and appraiser-time fixed effects allow us to absorb any unobserved time variation in both the "demand" and the "supply" of overappraisals. The regression also includes a set of covariates $\mathbf{X_{i,t}}$ which controls for mortgage and property characteristics (e.g., the logarithm of mortgage maturity at origination; the mortgage interest rate in percentage values; eleven dummy variables associated to the different reference interest rates: one for fixed mortgage rates, five for the different Euribor maturities, and other five associated with reference rates other than the Euribor; three dummy variables associated to whether the property is new, existing, or in progress; the logarithm of the size of the property in squared meters).

The estimate of the average treatment effect of the jump in capital requirements around the 80% LTP ratio on overappraisals could be biased by the fact that the mortgages granted before October 2016 faced a further discontinuity in provision requirements around the same 80% cutoff. As we explain in Section 2.2, this differential treatment in terms of provisions was eliminated by a regulatory reform that was enacted in April 2016 and came into force in October of the same year. To address this concern, we estimate regression (3) on a sample of mortgages over the post-reform period, from October 2016 on.

Column (1) of Table 1 reports the results of the estimation of the RDD around the 80% LTP ratio for the mortgages with a LTP ratio ranging between 70% and 90%. The estimate of the average treatment effect indicates that at the 80% LTP cutoff overappraisals jump by 3.5 p.p., which accounts for 12% of the standard deviation of overappraisals across mortgages. Importantly, if we test for a presence of a similar sharp change in the appraisal bias around alternative key cutoffs, such as the 70% and 90% LTP ratios, we do not find any statistically significant discontinuity, as it is shown in Columns (2) and (3), respectively.

We then perform a battery of robustness checks, which are reported in Appendix C. First, we show that the evidence on the jump at the 80% LTP ratio also holds in an RDD based on a second-order polynomial. Second, we provide evidence against the hypothesis that the discontinuity in overappraisals at the 80% LTP ratio may be due to the possible bunching of mortgages at the very same threshold. To do so, we estimate a "donut" specification (Almond and Doyle, 2011; Barreca et al., 2011) of Equation (3), in which we exclude all those mortgages with a LTP ratio between 79% and 81%. In this way, we show that the variation of overappraisals keeps holding even

Table 1: The Regression Discontinuity Design

	Dependent Variable: Overappraisal (%)		
	(1)	(2)	(3)
Bucket LTP	[70-90]	[60-80]	[80-100]
RDD Estimate	3.502***	-0.626	0.067
	(0.787)	(0.537)	(1.148)
Bank-Time FE	YES	YES	YES
Appraiser-Time FE	YES	YES	YES
Province-Time FE	YES	YES	YES
Mortgage Controls	YES	YES	YES
Property Controls	YES	YES	YES
R^2	0.192	0.160	0.206
N. Observations	51,414	19,234	51,440

Note: This table contains the regression discontinuity estimates of capital regulation on housing overappraisal, following the design of Equation (3). The dependent variable is the overappraisal of a given mortgage i granted by a given bank b at time t and appraised by the appraisal company a, $OA_{i,b,a,t}$. The treatment indicator $\mathbb{I}\{LTP_{i,b,a,t} > 80\%\}$ equals one if the LTP ratio of mortgage i is higher than 80%. The regression includes also the distance of the LTP ratio of mortgage i from the 80% cutoff, and its interaction with the treatment indicator. The regression features province-time, bank-time and appraiser-time fixed effects, as well as mortgage and property controls (i.e., the logarithm of mortgage maturity; the mortgage interest rate in percentage values; eleven dummy variables associated to the different reference interest rates: one for fixed mortgage rates, five for the different Euribor maturities, and other five associated with reference rates other than the Euribor; three dummy variables associated to whether the property is new, existing, or in progress; the logarithm of the size of the property in squared meters). The sample consists of mortgages granted over the period October 2016 - September 2018. Column (1) considers the mortgages with LTP ratio between 70% and 90%, such that the cutoff point is at the LTP ratio of 80%. Columns (2) and (3) use two alternative intervals centered around the 70% and 90% LTP ratio, respectively. We use a bandwidth of 10% in all specifications. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

when excluding from the sample any potential mortgage bunching dynamics. Third, we address the potential confounding role of covered bonds, as a LTV ratio below the 80% cutoff also determines whether a mortgage can be part of covered bonds. This fact is unlikely to bias our analysis, as the securitization of mortgages is just 4% in our sample. However, we tackle this concern explicitly, by estimating Equation (3) on a sample that excludes any mortgage associated to any covered bond. Finally, we formally reject the hypothesis that any other covariate jumps at the 80% LTP ratio, by re-estimating Equation (3) with mortgage rates, mortgage sizes, mortgage maturity, house prices, and property sizes as the relevant dependent variables.

All these results indicate that the discontinuity of overappraisals at the 80% LTP ratio causes a sharp increase in the mispricing of mortgage collateral values.

4.3 Difference-in-Discontinuity Regression

After having shown that overappraisals jump at the 80% LTP ratio due to the discontinuity in capital requirements, we provide further evidence on the causal effect of regulation on the mispricing of collateral values by exploiting the quasi-experimental variation in requirements associated with the October 2016 provisions reform. Indeed, the mortgages in our sample originated between January 2015 and September 2016 were subject to the countercyclical provision system, with larger general provision requirements for loans with a LTV ratio above 80%. This distinction in the treatment of mortgage provisions around the 80% ratio was eliminated in October 2016.

To exploit the reform and identify the causal effect of regulation on overappraisals, we extend the regression discontinuity design of Table 1 to a difference-in-discontinuity (diff-in-disc) analysis, as in Lalive (2008), Casas-Arce and Saiz (2015), and Grembi et al. (2016). This approach combines the regression discontinuity design with a difference-in-difference method, and evaluates whether the discontinuity displays a variation over time, by comparing pre-reform and post-reform mortgages.

To do so, we extend the sample period of our analysis by including all the mortgages originated between January 2015 and September 2016.[16] Then, we estimate the following regression

$$
\begin{aligned}
OA_{i,b,a,t} = {} & \beta_1 \, \mathbb{I}\{LTP_{i,b,a,t} > 80\%\} + \beta_2 \, (LTP_{i,b,a,t} - 80\%) + \ldots \\
& \cdots + \beta_3 \, \mathbb{I}\{LTP_{i,b,a,t} > 80\%\} \times (LTP_{i,b,a,t} - 80\%) + \ldots \\
& \cdots + \gamma_1 \, \mathbb{I}\{LTP_{i,b,a,t} > 80\%; t \geq \tau\} + \gamma_2 \, (LTP_{i,b,a,t} - 80\%; t \geq \tau) + \ldots \\
& \cdots + \gamma_3 \, \mathbb{I}\{LTP_{i,b,a,t} > 80\%; t \geq \tau\} \times (LTP_{i,b,a,t} - 80\%; t \geq \tau) + \ldots \\
& \cdots + \delta_{b,t} + \delta_{a,t} + \delta_{\text{province},t} + \mathbf{X}'_{\mathbf{i,t}}\theta + \epsilon_{i,b,a,t},
\end{aligned}
\tag{4}
$$

in which $\tau \equiv$ October 2016 denotes the month in which the reform came into force. The parameter β_1 is the RDD estimate, which informs on the average discontinuity of overappraisals around the 80% LTP cutoff throughout the entire sample period. Instead, the coefficient γ_1 is the diff-in-disc estimate, capturing how the variation in provision requirements due to the reform affects the discontinuity in overappraisals around the 80% LTP threshold for all the mortgages granted after October 2016 vis-à-vis the appraisal bias of the loans originated until September 2016.

We estimate regression (4) for all mortgages with LTP ratios between 70% and 90% over two different samples: one consisting of all mortgages granted after January 2015, and a second sample which abstracts from the mortgages granted between the time in which the reform was enacted (i.e., April 2016) and the time in which it came into force (i.e., October 2016). This excludes the possibility that the diff-in-disc estimate could be biased by banks' anticipation of the future change in provision requirements.

Table 2 reports the results of this exercise and shows that overappraisals jump by 4 p.p. around the 80% LTP ratio for all the mortgages originated before the reform, whereas afterwards the discontinuity in the appraisal bias shrinks to 3.5 p.p., in line with the RDD estimate of Table 1. This result holds independently on

[16] From now on, the paper focuses on the sample of mortgages originated from January 2015 on.

Table 2: The Difference-in-Discontinuity Regression

	Dependent Variable: Overappraisal (%)	
	(1)	(2)
Bucket LTP	[70-90]	[70-90] Without Announcement Period
RDD Estimate	3.945***	4.025***
	(0.722)	(0.731)
Diff-in-Disc Estimate	-0.519*	-0.532*
	(0.289)	(0.306)
Bank-Time FE	YES	YES
Appraiser-Time FE	YES	YES
Province-Time FE	YES	YES
Mortgage Controls	YES	YES
Property Controls	YES	YES
R^2	0.178	0.189
N. Observations	80,409	68,582

Note: This table contains the estimates obtained from a difference-in-discontinuities analysis that extends the setting of Table 1 by adding three further controls: the treatment indicator $\mathbb{I}\{LTP_{i,b,a,t} > 80\%; t \geq \tau\}$, which equals one if the LTP ratio of mortgage i granted at time $t \geq \tau \equiv$ October 2016 is higher than 80%, the distance of the LTP ratio of the same mortgage from the 80% cutoff, and its interaction with the treatment indicator. Column (1) considers all mortgages from January 2015 to September 2018 (with the period January 2015 - September 2016 being the pre-reform sample, and the period October 2016 - September 2018 being the post-reform one), whereas Column (2) excludes from the pre-reform sample all the mortgages granted after the reform was enacted and before it came into force, that is, between April and October 2016. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

whether we exclude the mortgages originated throughout the announcement period. Since provisions are tax-deductible expenses, the implied opportunity cost of an extra dollar of provisions is much lower than the cost of an extra dollar of capital, which explains why the October 2016 reform reduced the jump of overappraisals at the 80% LTP cutoff by 0.5 p.p.

This analysis provides further compelling evidence supporting the notion that collateral values are inflated to decrease banks' regulatory requirements. Indeed, the combination of the results of the regression discontinuity design and the diff-in-disc implies that any potential confounding factor that could threat our identification strategy should not only explain why overappraisals jump discontinuously at the 80% LTP ratio, but also why this discontinuity suddenly decreased in October 2016.

4.4 Channels

This section uncovers three main channels that leads to the overstatement of collateral values. First, overappraisals tend to be concentrated among low-capital banks, which can benefit relatively more from any relaxation of regulatory requirements. Second, the inflation of collateral values depends on the relationship between banks and appraisers: overappraisals are concentrated in those bank-appraiser pairs in which the bank is a major customer for the appraisal company. Third, overappraisals vary with the characteristics of local housing markets, and are concentrated in zip codes with a larger house price dispersion. Since in these areas the fundamental value of a property is relatively more opaque, appraisers can inflate their assessments. This evidence confirms that overappraisals owe to regulatory arbitrage rather than regulatory forbearance, as the mispricing of mortgage collateral are concentrated in those zip codes in which it is arguably more complicated to verify the soundness of appraisals (Boot and Thakor, 1993; Brown and Dinc, 2005; Morrison and White, 2013; Liu and Ngo, 2014).

To highlight the role of bank capital, Appendix E regresses the overappraisals on the distance of each bank from its regulatory requirements, controlling for appraiser-time and province-time fixed effects, as well as bank, mortgage, and property covariates. The results indicate that a one standard deviation reduction in the distance of bank capital from the regulatory requirements raises the inflation of collateral values of the mortgages with a LTP between 80% and 90% by 3.8 p.p., corresponding to 32% of the standard deviation of overappraisals across banks. Instead, the tightness of bank capital requirements does not correlate with overappraisals for mortgages with LTP ratios below 80%. We also complement these results with a matching analysis in the spirit of Abadie and Imbens (2006, 2011).

Then, Appendix F digs deeper on the results of Appendix E, by estimating the same regression over two different samples: one consisting of the mortgages granted by the bank which is the main customer of the appraiser evaluating the underlying real estate property, and a second sample with the mortgages granted by all the other non-main customer banks. We find that the association between overappraisals and the distance of bank capital from the minimum requirements is entirely concentrated among those mortgages which are originated by appraisers' major customer banks.

Finally, we look at the role of the local housing market in Appendix G. In this case, we add to the regression used in Appendix E a measure of the opaqueness of property fundamental values: the dispersion in house prices at the month-zip code level, and its interaction with the distance of bank capital from the regulatory constraint. We find that the larger overappraisals for low-capital banks are concentrated in areas with higher house price dispersion.

This entire set of results is consistent with the experience of Banco Popular previous to its dramatic crisis in June 2017, that led Banco Santander to purchase it for 1 euro. According to the European Central Bank, Banco Popular had a 27% overappraisal in its residential mortgages, overstating collateral values by around 2 billion euros.[17] Interestingly, the bulk of the overappraisals was concentrated in a set

[17]See Jorge Zuloaga, "El BCE Detectó Tasaciones Infladas en un 27% en Popular Durante la Ampliación de

of land properties evaluated by the same appraisal company over a period of time immediately before the last large-scale capital increase in June 2016. This example highlights how an appraiser boosts its evaluations (*i*) for a major customer bank, (*ii*) over properties with opaque values, (*iii*) when the bank can benefit the most from the window dressing of its fragile capital ratios.

5 Overappraisals, Capital Reliefs, and the Supply of Corporate Loans

After having shown that appraisers inflate their evaluations for major customer banks with low capital ratios so to reduce regulatory requirements, we look at the implications of this novel form of regulatory arbitrage. We start by deriving the amount of the reduction in risk-weighted mortgages that each bank enjoys because of the inflation of mortgage collateral values. Namely, we denote by $\mathrm{R\hat{W}M}_{i,a,b,t}$ the implied capital saving associated with each mortgage in our sample, defined as

$$\mathrm{R\hat{W}M}_{i,a,b,t} = \max\left[\mathrm{RWM}\left(LTP\right)_{i,a,b,t} - \mathrm{RWM}\left(LTV\right)_{i,a,b,t}, 0\right], \tag{5}$$

where $RWM(LTP)_{i,a,b,t}$ denotes the amount of the risk-weighted mortgage computed using its LTP ratio following the prescriptions of the standardized approach, and $RWM(LTV)_{i,a,b,t}$ is the counterfactual amount of risk-weighted mortgage which is instead based on the LTV ratio. As described in Section 2.1, the standardized approach of the CRR assigns a risk weight of 35% to the part of the loan that does not exceed the 80% of LTV and 100% to the part that is above this threshold. As long as collaterals are inflated, then the LTV ratio is larger than the LTP ratio, which implies a lower amount of risk-weighted mortgages.

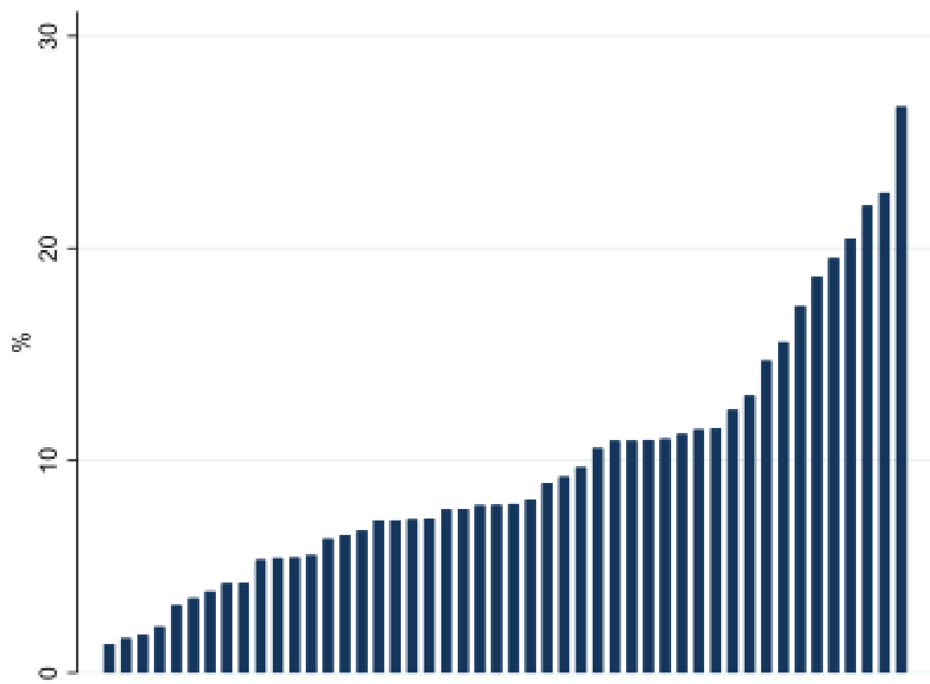
We compute a measure of capital savings by normalizing the reduction in risk-weighted mortgages due to overappraisals with the overall level of capital require-

2016", *El Confidencial*, October 1, 2019.

ments implied by banks' total mortgage portfolios. To do so, we derive a bank-level measure of capital reliefs at the annual frequency by pooling the reduction in capital requirements for all mortgages within each bank, and divide it by the total amount of risk-weighted mortgages, that is

$$\text{Reliefs}_{b,t} = \frac{\sum_i \hat{\text{RWM}}_{i,a,b,t}}{\sum_i \text{RWM}\left(LTV\right)_{i,a,b,t}}. \tag{6}$$

Figure 4: Bank Capital Reliefs due to Overappraisals



Note: This figure shows the savings in terms of risk weights of each bank (in percentages), represented by each bar, from the mortgages used in our sample. We first obtain the savings at mortgage level as the maximum of the difference between the risk-weighted assets calculated for a given mortgage based on the transaction price under the standardized approach minus those calculated based on the appraisal; and zero. Then, we define the total normalized savings for each bank aggregating the total savings across all the mortgages granted by a given bank over total risk-weighted assets associated to all mortgages granted by that bank.

Figure 4 reports the average level of the variable $\text{Reliefs}_{b,t}$ for all the banks in our sample. The plot shows that the median capital relief equals 9%, and there is substantial variation in the amount of capital reliefs across financial institutions. We exploit this variation in the next analysis, in which we look at the implications of overappraisal-based capital reliefs on banks' supply of corporate credit. Why corporate credit? In this case, the granularity of the information in the Spanish credit register on the flow of credit at the bank-firm-time level together with the presence of multi-bank firms gives us a unique opportunity for identifying the variation in credit supply.

The credit register reports detailed information on the credit position of each Spanish firm with each bank operating in Spain, for any loan above 6,000 euros. Using this source of data, we compute the variation in credit at the bank-firm pair at the annual frequency, from the year 2016 up to 2019. Basically, we define the change in credit between December 2015 and December 2016, and so on and so forth, up to December 2019. With this panel structure, we can evaluate how the variation in lending at the bank-firm pair between, say, December 2015 and December 2016 is related to the bank amount of overappraisal-based capital reliefs between January 2015 and December 2015. We end up with a panel of credit changes at the bank-firm-year level defined over 41 banks and 336,136 multi-bank firms, for a total of 2,386,516 firm-bank-year observations.

We then estimate the causal effect of capital reliefs on corporate credit supply with the following regression

$$\Delta C_{f,b,t} = \beta_1 \, \text{Reliefs}_{b,t-1} + \beta_2 \, \text{Reliefs}_{b,t-1} \times \mathbb{I}_{\text{f} \in \text{SMEs}} + \mathbf{X}'_{\mathbf{b,t-1}} \gamma + \delta_{f,t} + \delta_b + \epsilon_{f,b,t}, \quad (7)$$

where $\Delta C_{f,b,t}$ denotes the change in credit between firm f and bank b in year t, $\text{Reliefs}_{b,t-1}$ is a lagged value of bank capital reliefs due to overappraisals, the variable $\mathbb{I}_{\text{f} \in \text{SMEs}}$ is an indicator function that equals one if firm f is a SME, $\mathbf{X_{b,t-1}}$ is a set of lagged bank controls (e.g., the return on assets, the logarithm of total assets, the loan to deposit ratio, the fraction of non-performing loans, the cost to income ratio, the liquidity ratio, the capital ratio, and the interbank ratio), $\delta_{f,t}$ is a set of firm-time fixed effects, whereas δ_b denotes the bank fixed effects. In this setting, β_1 captures the effect of overappraisal-based capital reliefs on the overall supply of corporate credit, whereas β_1 informs on the additional effect on SMEs.

The identification of credit supply is achieved by leveraging the variation of credit within multi-bank firms, as in Khwaja and Mian (2008). Namely, the introduction of firm-time fixed effects allows us to evaluate the change in credit within any firm-year. Since the firm-time fixed effects absorb the unobserved time variation in credit due to demand motives, what remains is due to bank credit supply. Importantly, the combination of the bank fixed effects and the set of bank controls guarantees that we can isolate the variation in credit supply solely caused by the changes in the amount of overappraisal-based capital reliefs.

Table 3 reports the results of the estimation of regression (7). Column (1) reports the results for the case in which we abstract from the interaction of capital reliefs with the SME indicator variable, and shows that the capital reliefs do lead to a boost in overall corporate credit, as the estimated coefficient β_1 is highly statistically significant. However, when we introduce the interaction term in Column (2), then β_1 is not anymore statistically different from zero, whereas now the highly statistically significant estimated coefficient is β_2. The interaction term is not only statistically significant, but also economically relevant. Indeed, the estimated value of the coefficient β_2 implies that banks raise SME lending by 43 cents on the dollar of overappraisal-based capital reliefs. Thus, almost half of the capital reliefs are invested in a larger flow of corporate credit. Finally, Column (3) addresses the concern that our measure of capital reliefs could capture any unobserved time-varying characteristic of bank credit supply policies that acts as a confounding factor. To do so, we introduce bank-time fixed effects, which absorb both the bank fixed effects and the bank controls. In this setting, the regression can estimate only the role of the product between capital reliefs and SMEs. We find that also in this case the estimate of the coefficient β_2 associated with the interaction term is statistically significant.

Why do banks lend more to SMEs? Banks do it to improve their profitability in the short term. Indeed, SME lending is a highly remunerative activity, as the interest rate for these loans is 2 p.p. higher than the rate associated either to mortgages or to non-SME corporate loans. However, this higher interest rate is motivated by the

Table 3: Capital Reliefs and the Supply of Corporate Credit

	Dependent Variable: $\Delta C_{f,b,t}$		
	(1)	(2)	(3)
$\text{Reliefs}_{b,t-1}$	$1.981^{\star\star\star}$ (0.737)	1.172 (0.906)	
$\text{Reliefs}_{b,t-1} \times \mathbb{I}_{\text{f} \in \text{SMEs}}$		$2.129^{\star\star}$ (0.980)	$1.962^{\star}$ (1.098)
Firm-Time Fixed Effects	YES	YES	YES
Bank-Time Fixed Effects	NO	NO	YES
Bank Fixed Effects	YES	YES	NO
Bank Controls	YES	YES	NO
R^2	0.42	0.42	0.63
N. Observations	2,386,516	2,386,516	2,386,516

Note: This table reports the results of the estimation of regression (7), in which the dependent variable is the change in credit at the bank-firm-year level, from December 2015 to December 2019. Column (1) considers as the main explanatory variable a measure of bank-year capital reliefs due to housing overappraisals, $\text{Reliefs}_{b,t-1}$. Column (2) interacts bank-year capital reliefs with an indicator which equals one if the firm is a SME, $\mathbb{I}_{\text{f} \in \text{SMEs}}$. Both cases include firm-time fixed effects, ban fixed effects, and a set of bank controls (e.g., the return on assets, the logarithm of total assets, the loan to deposit ratio, the fraction of non-performing loans, the cost to income ratio, the liquidity ratio, the capital ratio, and the interbank ratio). Column (3) introduces also bank-time fixed effects. Standard errors clustered at the bank-province-size-industry level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

fact that SME lending is also much riskier, as its default rate is 4 p.p. higher than that of mortgages and non-SME corporate loans. The higher default rate of SMEs explains why this type of lending requires a relatively higher average risk weight: the risk weight associated to SME loans is 75%, which is much higher than the 35%-100% scheme for mortgages, and the 20%-100% scheme for non-SME lending. The differential regulatory treatment across these types of lending provides a rationale of the bank rebalancing towards SME lending due to the overappraisal-based capital reliefs. Indeed, the mispricing of mortgage collateral values allows banks to reduce their overall risk weights, and consequently gives them an opportunity to partially use the relaxation of regulatory requirements to shift their loans towards the highly profitable – but also highly risk-weight intensive – SME loans.

Overall, this evidence highlights that the use of overappraisals to save on capital requirements leads banks not only to reduce the actual collateral value of their mortgage portfolio, but also to boost their risk-taking in the corporate loan market. This novel unintended consequence of regulation concedes banks to increase substantially the overall risk exposure of their balance sheets.

6 Conclusion

This paper identifies a novel form of regulatory arbitrage in which appraiser companies inflate mortgage collateral values on behalf of their major customer banks, so to reduce their capital requirements. The identification of the causal effect hinges on the discontinuity of capital requirements, and also a reform that eliminated a discontinuity in mortgage provision requirements. We find that housing overappraisals reduce bank risk-weighted mortgages by 9% on average. We then uncover that banks use the overappraisal-based capital reliefs to boost their supply of SME lending, which yields relatively higher interest rates, but is also much riskier.

Overall, our results shed some light on an unintended consequence of regulation that may hinder the solvency of financial institutions. Indeed, the use of overappraisals to save on capital requirements leads banks not only to reduce the actual collateral value of their mortgage portfolio, but also to boost their risk-taking in the corporate loan market. From this perspective, our analysis provides a rationale to the observation that Spanish banks rescued in the last financial crisis had disproportionally higher levels of mortgage overappraisals (Akin et al., 2014).

A potential solution for the mispricing of collateral values would be the computation of LTV ratios which uses the minimum between the appraisal value and the transaction price, as recently suggested by the European Banking Authority and the European Systemic Risk Board.[18] Alternatively, a solution could be a reform in line with the 2009 U.S. Home Valuation Code of Conduct, that introduced independent appraisal management companies, which intermediate between lenders and appraisers, keeping anonymous the identity of both parties. These policies could be implemented jointly with an increase in in-situ inspection activities, as those implemented by the Banco de España starting from October 2018. In line with the findings of Bonfim et al. (2020) on zombie lending, we have some suggestive evidence pointing out that the appraisal bias shrank immediately after October 2018. However, the lack of information on which appraisers were actually visited by the supervisor does not allow us to gauge causal implications. For this reason, we leave a detailed analysis of these regulatory activities for future research.

[18]See the "Opinion of the European Banking Authority on Mortgage Lending Value (MLV)" on October 5, 2015, and "Recommendation of the European Systemic Risk Board on Closing Real Estate Data Gaps" on October 31, 2016.

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A Data Definitions and Summary Statistics

Mortgage and Property Characteristics

Interest Rate (%): Nominal interest rate at the inception of the loan.

Maturity (log months): Logarithm of the time to maturity (measured in months) at mortgage origination.

Transaction Price (,000): Registered transaction price of the housing.

Size (log m2): Logarithm of the built-up area (measured in squared meters).

Loan-to-Value Ratio (%): Mortgage principal at origination over the appraisal value of the housing.

Loan-to-Price Ratio (%): Mortgage principal at origination over the registered transaction price of the housing.

Overappraisal (%): Appraisal value over the registered transaction price of the housing.

Bank Characteristics

Total Capital Ratio (%): This ratio is the total capital adequacy ratio under the Basel rules. The ratio is obtained as the sum of Tier 1 and Tier 2 capital which includes subordinated debt, hybrid capital, loan loss reserves and the valuation reserves as a percentage of risk weighted assets and off balance sheet risks.

ROA (%): Return on average total assets.

Granted Mortgages (Log ,000): Logarithm of the loans secured by residential property used to measure the size of the bank in the segment of interest in our analysis.

Net Loans/ (Deposits + Borrowings) (%): It is defined as the loans to deposits and borrowings with the exception of capital instruments and is used as a measure of bank liquidity.

Fraction of NPLs (%): Amount of total loans which are doubtful over total loans.

Cost/Income (%): Total operating expenses by total operating income. It measures the efficiency of company's operations.

Interbank Ratio (%): Money lent to other banks divided by money borrowed from other banks.

Total Exposure Retail SA/Total Exposure Retail (%): Credit risk original exposure to the retail portfolio under the standardized approach over the total credit risk original exposure to the retail portfolio (i.e., IRB and standardized approaches). This variable is used to define banks using the IRB approach as those for which this variable is higher than zero.

Appraisal Company Characteristics

Number Banks: Number of banks that interact with an appraisal company.

Share of Turnover by Main Bank (%): We define the share of turnover of the main bank as the maximum share across banks in a given appraisal company.

Table A.1: Descriptive Statistics.

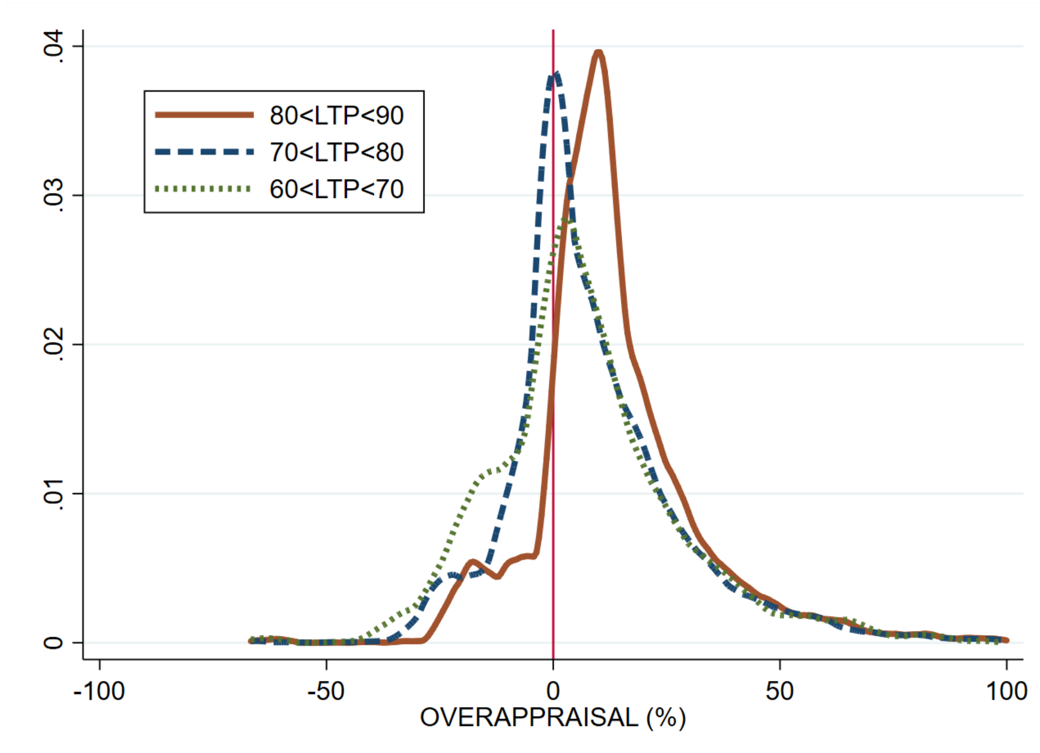
	(1) Unit	(2) Mean	(3) Median	(4) SD	(5) P5	(6) P95
Panel A. Mortgage and Property Characteristics.						
Interest Rate	%	2.49	2.50	1.17	0.93	4.10
Maturity	Months	286.15	300.00	82.90	120.00	360.00
Transaction Price	Thousands €	150	114	136	42	375
Size	m^2	86.74	82.19	72.26	49.40	228.74
Loan-to-Value Ratio ($LTV_{i,b,a,t}$)	%	68.25	70.27	17.82	36.06	95.41
Loan-to-Price Ratio ($LTP_{i,b,a,t}$)	%	78.16	80.00	20.50	40.00	103.75
Overappraisal ($OA_{i,b,a,t}$)	%	17.71	12.58	30.25	-18.01	66.49
Panel B. Appraisal Company Characteristics.						
Number of Banks	-	16.14	15.00	10.53	2.00	38.00
Share of Turnover by Main Bank	%	74.73	78.92	22.92	40.00	100.00
Panel C. Bank Characteristics.						
Total Capital Ratio	%	15.22	14.51	4.56	11.69	20.16
ROA	Months	0.44	0.38	0.38	0.01	1.02
Granted Mortgages	Millions €	432	56	1,029	3	2,528
Net Loans/(Deposits + Borrowings)	%	61.02	62.46	12.2	40.4	74.58
Fraction of NPLs	%	8.16	7.97	3.94	3.04	14.73
Cost/Income	%	65.86	65.62	11.38	49.68	91.5
Newly Securitized Loans/Total Assets	%	0.42	0.00	0.97	0.00	2.83
Interbank Ratio	%	82.85	38.61	134.7	4.81	256.85

B Overappraisals and the IRB Risk Weights

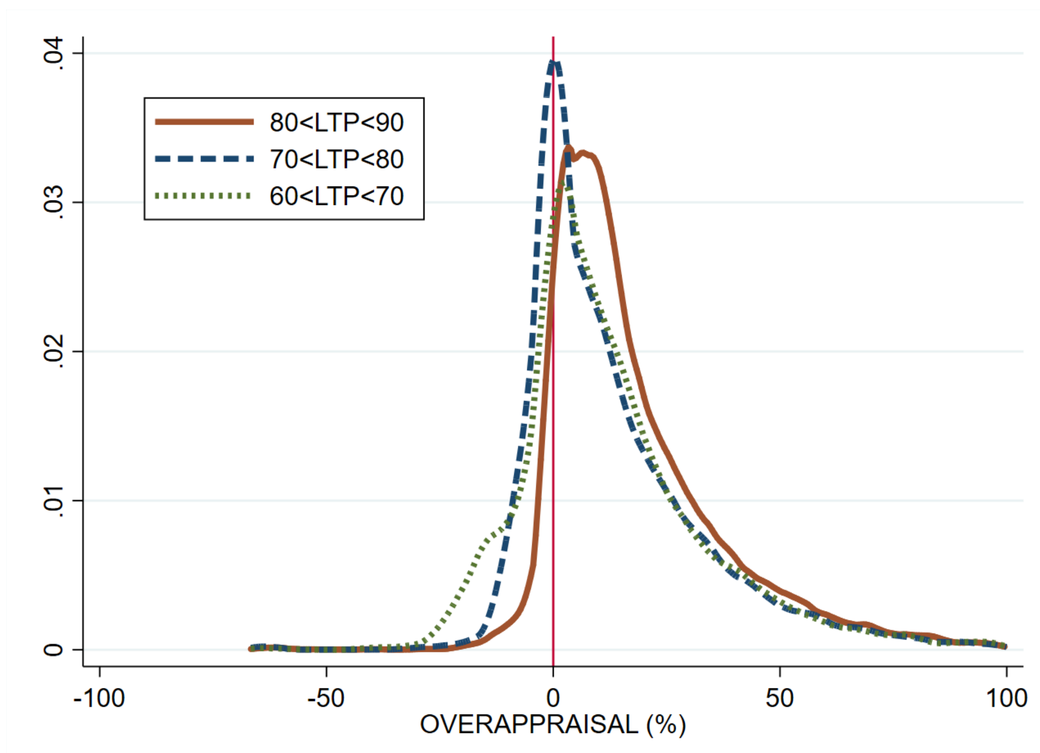
Our empirical setting exploits a discontinuity in the mortgage capital requirements defined by the SA risk weights. However, importantly for our analysis, the bias in the distribution of appraisals around the 80% LTP ratio holds not only for the mortgages granted by banks which use SA risk weights. Figure B.1 reports the distribution of overappraisals across key LTP ratios, but this time splits the data in two samples: one with the mortgages originated by the banks with SA risk weights (Panel A), and one with the mortgages granted by the financial institutions that also use IRB risk weights (Panel B). Although the skewness in the appraisals of mortgages with LTP ratios immediately above the 80% threshold is more pronounced among SA banks, also the mortgages of IRB banks tend to have positive overappraisals when the LTP ratio is just above 80%. This evidence confirms that the discontinuities implied by the SA risk weights are highly relevant also for those banks using IRB risk weights for portions of their mortgage portfolios. Indeed, as we discuss in Section 2.1, the IRB risk weights tend to be used by relatively larger financial institutions. However, even the largest bank of our sample still uses SA risk weights for 25% of its outstanding mortgages as of 2018, and this share has been increasing over time.

Figure B.1: The Distribution of Overappraisals Around Key LTP Ratios for SA and IRB Banks.

(A) Mortgages Granted by SA Banks



(B) Mortgages Granted by IRB Banks



Note: This graph replicates the analysis of Figure 2, with the difference that Panel (A) refers to the distribution of overappraisals for mortgages around key LTP ratios which are granted by banks using only SA risk weights, whereas Panel (B) refers to the mortgages granted by banks which use also IRB risk weights.

C RDD Robustness Checks

This section provides a battery of robustness checks of the results based on the regression discontinuity design of Equation (3), which are reported in Table 1.

The first column of Table C.2 shows the result of the baseline regression also reported in Column (1) of Table 1. Then, Column (2) shows that the significance of our results does not rely on imposing a linear structure to the regression discontinuity design. We do so by estimating a quadratic specification, and find that this case improves both the economic significance of the RDD estimate – by implying a jump of 3.8 p.p. in overappraisals at the 80% LTP ratio – and its statistical significance. Column (3) instead addresses the concern that the discontinuity in overappraisals at the 80% LTP ratio may be due to the possible bunching of mortgages at the very same threshold. To reject this hypothesis, we estimate a "donut" specification of Equation (3) in the spirit of Almond and Doyle (2011) and Barreca et al. (2011), in which we exclude all those mortgages with a LTP ratio between 79% and 81%. In this case, the number of observations drop substantially, but we keep finding evidence of a statistical significance discontinuity in overappraisals. Finally, Column (4) addresses the potential confounding role of covered bonds. Indeed, the capital regulation imposes that the 80% LTV ratio also determines whether a mortgage can be funded by covered bonds. Thus, we could observe overappraisals which are not related directly to an attempt at reducing capital requirements, as banks try to maximize the number of mortgages that could be securitized. Covered bonds, however, are unlikely a relevant confounding factor, since the securitization of newly-issued mortgages is just 4% in our sample. Notwistanding, we tackle this concern explicitly, by estimating Equation (3) on a sample that excludes any mortgage associated to any covered bond. As expected, we find that the exclusion of securitized mortgages barely alters the point RDD estimate.

The validity of the regression discontinuity design hinges on the assumption that all the relevant covariates at the mortgage level vary smoothly at the 80% LTP ratio,

Table C.2: The Regression Discontinuity Design - Robustness

	Dependent Variable: Overappraisal (%)			
	(1)	(2)	(3)	(4)
	Baseline	Quadratic	Donut	Covered Bonds
Bucket LTP	[70-90]	[70-90]	[70-90]	[70-90]
RDD Estimate	3.502***	3.849***	1.609**	3.427***
	(0.787)	(0.360)	(0.794)	(0.771)
Bank-Time FE	YES	YES	YES	YES
Appraiser-Time FE	YES	YES	YES	YES
Province-Time FE	YES	YES	YES	YES
Mortgage Controls	YES	YES	YES	YES
Property Controls	YES	YES	YES	YES
R^2	0.192	0.199	0.210	0.200
N. Observations	51,414	51,414	34,469	49,438

Note: This table contains a set of robustness checks to the regressions estimated in Table 1. Column (1) reports the baseline regression estimated in Column (1) of Table 1. Column (2) considers a quadratic polynomial regression discontinuity design. Column (3) implements a donut design, which excludes from the sample all the mortgages whose LTP ratio is between 79% and 81%. Column (4) excludes from the sample all those mortgages that were associated to any covered bond throughout the sample period. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

so that the jump in overappraisals can be credibly traced back to the discontinuity in capital requirements. Figure 3 reports some prima-facie evidence supporting our approach by showing that mortgage rates, mortgage sizes, and house prices do not change sharply at the regulatory threshold. In this section, we provide further evidence on the validity of our design, by formally testing that any other covariate jumps at the 80% LTP ratio. Table C.3 reports the results of a series of regressions similar to Equation (3) with the only difference that we use a new set of dependent variables: the mortgage rates, the mortgage sizes, the house prices, the mortgage maturities, and finally the property sizes. The results indicate that in no case we reject the null hypothesis of no discontinuity at the 80% LTP ratio.

Table C.3: The Regression Discontinuity Design - Alternative Dependent Variables

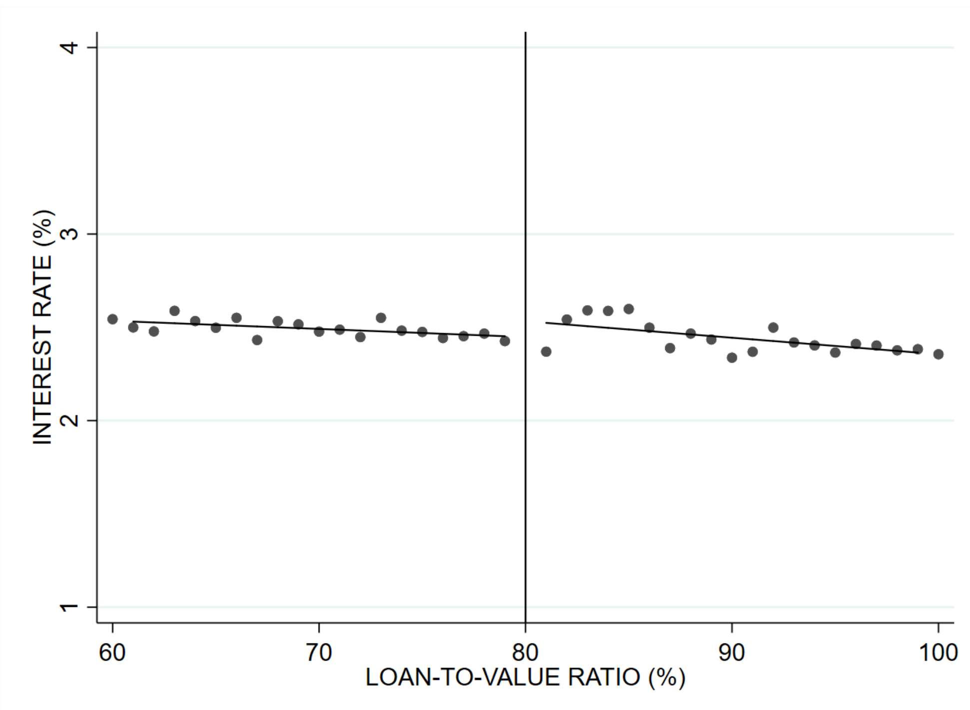
	(1) Dependent Variable: Mortgage Rate	(2) Dependent Variable: Mortgage Size	(3) Dependent Variable: Mortgage Maturity	(4) Dependent Variable: House Price	(5) Dependent Variable: Property Size
Bucket LTP	[70-90]	[70-90]	[70-90]	[70-90]	[70-90]
RDD Estimate	0.000	-0.001	-0.001	0.001	-0.018
	(0.001)	(0.001)	(0.003)	(0.001)	(0.019)
Bank-Time FE	YES	YES	YES	YES	YES
Appraiser-Time FE	YES	YES	YES	YES	YES
Province-Time FE	YES	YES	YES	YES	YES
Mortgage Controls	YES	YES	YES	YES	YES
Property Controls	YES	YES	YES	YES	YES
R^2	0.312	0.177	0.279	0.210	0.154
N. Observations	51,414	51,414	51,414	51,414	51,414

Note: This table contains a set of robustness checks to the regressions estimated in Table 1, by changing the definition of the dependent variable. Column (1) considers the mortgage interest rate, Column (2) focuses on the house price, Column (3) looks at the mortgage size, Column (4) evaluates the mortgage maturity, and Column (5) considers the property size. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

D Mortgage Interest Rates

Figure 3 shows that mortgage interest rates are rather flat across LTP notches. A very similar pattern can be observed when looking at the variation of interest rates across LTV notches, as depicted in Figure D.1. Instead, in the other countries – such as the United Kingdom – the interest rates are highly discontinuous and the number of mortgages bunches at LTV notches (Best et al., 2018).

Figure D.1: Mortgage Interest Rates around the 80% Loan-to-Value Ratio



Note: Analogously to Figure 3, this figure plots the relationship between the mortgage interest rate and the LTV ratio of the mortgage.

In this section, we dig deeper on the determinants of the mortgage rates in the Spanish economy. To do so, we regress the interest rates of all mortgages in our sample over different sets of fixed effects, and evaluate to what extent the combination of these fixed effects explains the variation of mortgage rates, by looking at the R^2 of the regression.

Table D.1 shows that bank-time fixed effects explain 18% of the overall variation in mortgage rates, whereas mortgage characteristics-time fixed effects accounts for just an additional 15%. Strikingly, the overall combination of bank-time, mortgage characteristics-time, and property characteristics-time fixed effects explains just around a third of the overall variation in mortgage interest rates. This evidence highlights that although mortgage rates vary, in the Spanish economy there is no strong correlation between these rates and key mortgage characteristics as the LTV ratio. Hence, mortgage rates may be well determined by factors which are not absorbed by our set of fixed effects, such as the specific relationship between banks and borrowers and borrower-specific characteristics. To further corroborate this argument, we show in Column (4) of Table D.1 that the introduction of zip code-time fixed effects explains in isolation 24% of the variation in mortgage interest rates. Since zip code-time fixed effects can partially capture borrower specific characteristics – such as income and wealth – this finding provides further evidence on their relevance in the determination of interest rates in the Spanish mortgage market.

Table D.1: The Determinants of Mortgage Interest Rate Variation

	(1)	(2)	(3)	(4)
R^2	0.182	0.337	0.357	0.602
Bank-Time FE	YES	YES	YES	YES
Mortgage Characteristics-Time FE	NO	YES	YES	YES
Property Characteristics-Time FE	NO	NO	YES	YES
ZIP Code-Time FE	NO	NO	NO	YES
Observations	196,421	190,616	190,586	152,917

Note: This table summarizes the explanatory power of bank, mortgage and housing characteristics for the variation in mortgage interest rates based on the R-squared obtained from a series of regression analyses in which we regress the mortgage interest rate (in percentages) on several sets of fixed effects. In column (1) we regress the dependent variable on bank-year-month fixed effects. In column (2) we extend the analysis including fixed effects for loan characteristics which are interacted with year-month fixed effects. Thus, we use fixed effects for the interest rate of reference (eleven dummy variables associated to the different reference interest rates: one for fixed mortgage rates, five for the different Euribor maturities, and other five associated with reference rates other than the Euribor), for the mortgage maturity (based on ten maturity buckets, one for each decile of the distribution of maturities), and for the LTV ratio (based on ten buckets comprising LTV ratios between 0 and 10%, 10% and 20%, and so successively up to the last bucket that includes loans with LTV ratios above 90%). Column (3) reports the R-squared obtained when we extend column (2) by adding fixed effects for housing characteristics that are interacted with year-month fixed effects. Thus, we use fixed effects for the housing conditions (three dummy variables associated to whether the property is new, existing, or in progress), for the housing size and price per square meter (based on ten buckets, one for each decile of the distribution of housing sizes and price per square meter). The R-squared contained in columns (4) is obtained by extending the specification in column (3) with ZIP code-year-month fixed effects.

E The Role of Bank Capital

This section shows that the use of overappraisals to reduce regulatory requirements is highly concentrated among banks with low capital ratios. Indeed, if overappraisals aim at reducing bank required capital, then we should observe larger overstatements of collateral values by low-capital financial institutions, which are those that can benefit the most from the relaxation of capital requirements. To establish this fact, we estimate the following regression

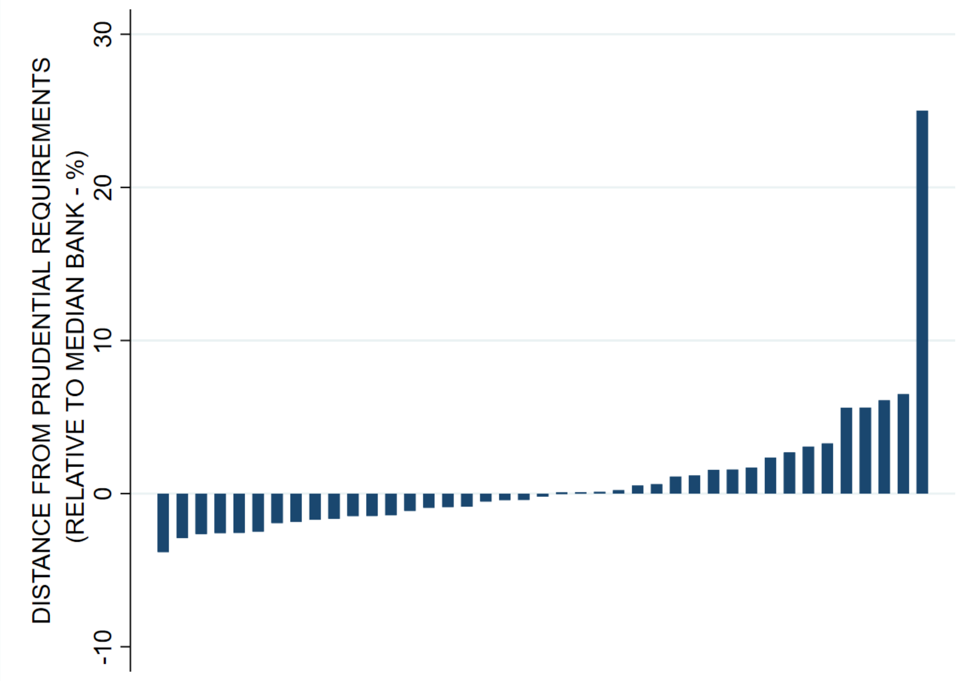
$$OA_{i,b,a,t} = \beta \, \text{Capital}_{b,t} + \delta_{a,t} + \delta_{\text{province},t} + \mathbf{X'_{b,t}}\gamma + \mathbf{X'_{i,t}}\theta + \epsilon_{i,b,a,t}, \qquad \text{(E.1)}$$

in which the main explanatory variable $Capital_{b,t}$ defines the distance of the capital of bank b from its regulatory requirements, which includes the sum of macroprudential and microprudential buffers on the top of the 8% regulatory threshold. The observation of these buffers in the data allows us to uncover the actual tightness of the regulatory constraint of each bank. Figure E.1 shows that distance from the regulatory constraint is highly heterogeneous across banks, and we exploit this variation to estimate how overappraisals are larger among low-capital banks.

In this case, we cannot saturate the regression with bank-time fixed effects since we are assessing the relationship between bank capital ratios and overappraisals. Hence, we isolate the role of bank capital by explicitly controlling for a set of bank characteristics $\mathbf{X_{b,t}}$, such as bank relevance in the mortgage market (i.e., the logarithm of mortgages granted over the last year), profitability (i.e., the level of ROA), efficiency (i.e., the cost to income ratio), risk (i.e., the ratio of non-performing loans over total loans), business model (i.e., the ratio of net loans over total deposits and borrowing), risk weight methodology (i.e., a dummy variable that is equal to one if the bank has already implemented a IRB approach), interbank liquidity (i.e., the interbank ratio) and a control for securitized mortgages (i.e., the amount of outstanding securitized bonds over total assets).

Table E.1 estimates regression (E.1) over five different samples consisting of mort-

Figure E.1: The Distance of Bank Capital from Prudential Requirements



Note: This figure shows the difference between the capital position of each bank (in percentage points) and its capital (micro and macroprudential) requirements. Each bank in our sample is represented by a single bar. To preserve the anonymity, we report the capital position of each bank in excess of the median capital position of the distribution across banks such that a bank exactly at the median would exhibit a value of zero.

gages with LTP ratios defined over five different specific buckets. We find that whenever the bank granting a mortgage with a LTP ratio between 80% and 90% has a capital ratio closer to the minimum requirements, then the appraisal evaluation is inflated. The same applies for mortgages with a LTP ratio between 90% and 100%.[19] and in a setting which saturates even more the regression by introducing zip-code fixed effects. Instead, the tightness of bank capital requirements does not correlate with overappraisals for mortgages with LTP ratio below 80%.

The relationship between bank capital and overappraisals is economically significant, as a one standard deviation reduction in the distance of bank capital from the regulatory requirements raises the inflation of collateral values of the mortgages with

[19]Overappraisals are also relevant for mortgages with LTP ratios above 90% because in this case the inflation of collateral values reduces the exposure of banks to the 100% risk weight applied to the fraction of the mortgage which exceeds the 80% LTV ratio.

a LTP between 80% and 90% by 3.8 p.p. (when using the coefficient of the regression with zip code fixed effects), corresponding to 32% of the standard deviation of overappraisals across banks.

To provide further evidence on the link between bank capital and the inflation of collateral values, we conduct a new analysis based on the specific matching estimation technique developed in Abadie and Imbens (2006, 2011). This technique implements a nearest neighbour matching estimation to obtain the average treatment effect associated to the overappraisals of low-capital banks.

In particular, we compare overappraisals between treated observations (i.e., those banks whose capital ratio is below the median of the distribution of banks capital ratios) and control observations (i.e., those banks whose capital position is above the median) using the nearest neighbour matching approach across housing characteristics, as well as those mortgage characteristics which are unrelated to bank creditworthiness. These covariates include the latitude and longitude of the housing location, the housing size, and the interest rate. In addition, we implement exact matching in terms of the year in which the mortgage is granted, and in terms of several mortgage and housing characteristics, such as the interest rate of reference, the maturity, the housing condition (new in progress, new, and existing) and the province in which it is located. In this way, we compare mortgages that are similar across all these dimensions and only differ in the level of capital of the bank that granted the mortgage.

Columns (1) - (5) of Table E.2 report the results obtained for alternative intervals of the LTP ratio: (1) below 60%, (2) between 60% and 70%, (3) between 70% and 80%, (4) between 80% and 90%, and (5) between 90% and 100%. A positive coefficient in any of these columns indicates that banks with lower capital positions are associated with a higher overappraisal. We observe that the only significant effects are obtained in Columns (4) and (5), that is, for those intervals of LTP ratios for which the overappraisal would contribute to reduce the regulatory requirements of

Table E.1: The Role of Bank Capital

	Dependent Variable: Overappraisal (%)									
Bucket LTP	(50-60]		(60-70]		(70-80]		(80-90]		(90-100]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distance Minimum Capital Requirement	-0.353 (0.218)	-0.395 (0.293)	-0.247 (0.174)	-0.176 (0.187)	-0.250 (0.175)	-0.279 (0.166)	-0.592*** (0.212)	-0.409** (0.207)	-0.486* (0.258)	-0.376* (0.223)
Bank Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Appraiser-Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province-Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Mortgage Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Property Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ZIP Code FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
R^2	0.111	0.374	0.100	0.324	0.097	0.241	0.108	0.249	0.111	0.286
N. Observations	12,644	6,372	19,292	9,857	52,219	25,679	32,115	15,736	30,834	13,207

Note: This table reports the results of a regression analysis in which the dependent variable is the overappraisal of a given mortgage i granted by a given bank b at time t and appraised by the appraisal company a, $OA_{i,b,a,t}$, and the main explanatory variable is the difference between bank b capital ratio and its capital (macroprudential and microprudential) requirements. The regression includes bank controls, such as the logarithm of mortgages granted over the last year, ROA, the cost to income ratio, the ratio of non-performing loans over total loans, the ratio of net loans over total deposits and borrowing and ratio of loans and advances to banks relative to deposits from banks, a dummy variable that is equal to one if the bank has already implemented a IRB approach, and the amount of outstanding covered bonds over total assets. The regression borrows the set of fixed effects and controls from Table 1, with the only differences of the lack of bank-time fixed effects. Even-numbered columns introduce also zip code fixed effects. Columns (1) and (2) focus on mortgages with LTP ratios between 50% and 60%, Columns (3) and (4) focus on mortgages with LTP ratios between 60% and 70%, Columns (5) and (6) focus on mortgages with LTP ratios between 70% and 80%, Columns (7) and (8) focus on mortgages with LTP ratios between 80% and 90%, and Columns (9) and (10) focus on mortgages with LTP ratios between 90% and 100%. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table E.2: Matching Analysis

	Dependent Variable: Overappraisal (%)				
	(1)	(2)	(3)	(4)	(5)
Bucket LTP	(50-60]	(60-70]	(70-80]	(80-90]	(90-100]
Low Capital Banks	0.622	0.636	0.566	3.072***	2.368***
	(0.752)	(0.585)	(0.356)	(0.544)	(0.517)
N. Observations	8,123	13,171	40,614	17,470	17,776

Note: This table shows an analysis based on the matching estimation technique developed in Abadie and Imbens (2006, 2011). It reports the average treatment effect on the level of overappraisal of the mortgages granted by low-capital banks by comparing outcomes between the treated and control observations, using the nearest neighbour matching across the housing and mortgage characteristics. Treatment observations correspond to those mortgages granted by banks whose capital ratio is below the median of the distribution of bank capital ratios, whereas control observations correspond to those mortgages granted by banks whose capital ratio is above the median. We require exact matching in terms of the year in which the mortgage is granted, in terms of several mortgage and housing characteristics such as the interest rate of reference, the maturity, the housing condition (new in progress, new, and existing), and in terms of the province in which the housing is located. Additionally, mortgages are matched using the nearest neighbour in terms of the latitude and longitude of the housing location, the housing size, and the interest rate. Columns (1) - (5) report the results obtained for alternative intervals of the LTP ratio: (1) below 60%, (2) between 60% and 70%, (3) between 70% and 80%, (4) between 80% and 90%, and (5) between 90% and 100%. For each analysis we report the average treatment effect together with the standard errors clustered at bank and time level. $\star$, $\star\star$, and $\star\star\star$ denotes statistical significance at 10%, 5%, and 1% level, respectively.

low-capital banks. In fact, the most significant effect both in statistical and economic terms is obtained for the interval immediately above the 80% LTP ratio, which includes the mortgages that would lead to the strongest reduction in the level of risk weights. Importantly, we do not find significant effects for LTP ratios below 80%.

F The Role of the Bank-Appraiser Relationship

This section shows that the appraisal bias depends crucially on the bank-appraiser relationship, as appraisers inflate the collateral values only if the bank granting the mortgage is their major business partner. To do so, we focus on the mortgages with the highest probability of an appraisal treatment for regulatory arbitrage, that is, the mortgages with LTP ratios between 80% and 90%, and compute the regression (E.1) for two different samples: one consisting of the mortgages granted by the bank which is the main customer of the appraiser evaluating the underlying real estate property, and a second sample with the mortgages granted by all the other non-main customer banks. The main customer bank is defined by looking at the number of appraisals for each appraiser-bank pair.

Table F.1 reports the outcomes of this exercise. The results indicate that the association between overappraisals and the distance of bank capital from the minimum requirements is entirely concentrated among those mortgages which are originated by appraisers' major customer banks. Indeed, the coefficient relating bank capital to the mispricing of collateral for the mortgages granted by the non-major customer banks is not statistically significant, and the point estimate is 38% lower than the one estimated on the mortgages granted by the major customer banks. In this latter case, a one standard deviation reduction in the distance of bank capital from its regulatory requirements raises the inflation of the collateral value by 6.3 p.p., accounting for 53% of the standard deviation of overappraisals across banks.

Why do appraisal companies boost the evaluations of mortgages granted by relevant customer banks? A possible explanation is that appraisers internalize the incentives of their relevant customers (Calem et al., 2018), and therefore understand the benefits that capital-constrained banks may have in inflating the collateral values so that to reduce their capital requirements. Our evidence is also consistent with the attempt of appraisers to build long-term relationships with the lenders (Agarwal et al., 2017). For instance, Agarwal et al. (2017) show that when lenders are not aware of the identity of the appraisal company evaluating the collateral value of a mortgage, overappraisals are less likely to happen.

Overall, this evidence highlights the crucial role of the bank-appraiser relationship in the determination of overappraisals, such that appraisers inflate the mortgage collateral values on behalf of their major customer bank to reduce capital requirements. Banks' cherry-picking of the appraisal companies with which to work in the evaluation of the mortgage collateral values resembles closely to the channels highlighted by the literature on credit rating shopping (Sangiorgi et al., 2009; Bolton et al., 2012).

The tight relationship between appraisers and lending institutions – and its implications on the soundness of collateral valuations – is not just specific to the Spanish economy. For instance, in 2007 New York State Governor Cuomo sued Washington Mutual for forcing the appraisers First American Corporation and eAppraiseIT to inflate their assessments, via the discretional selection of the properties with which to compare the dwelling under appraisal. This is the reason why the regulator promoted reforms (e.g., the 2009 Home Valuation Code of Conduct in the U.S. and the 2013 Ley 1/2013 in Spain) aimed at boosting the independence of appraisers vis-à-vis mortgage lending institutions. Our results highlight that reducing the direct equity stakes among these two parties may not be enough to de-bias appraisals as long as appraisers and banks are linked informally by established and prolonged business relationships.

Table F.1: The Role of the Bank-Appraiser Relationship

	Dependent Variable: Overappraisal (%)		
	(1)	(2)	(3)
	All Banks	Main Customer Banks	All Other Banks
Bucket LTP	(80-90]	(80-90]	(80-90]
Distance Minimum Capital Requirement	-0.409** (0.207)	-0.678*** (0.214)	-0.417 (0.289)
Bank Controls	YES	YES	YES
Appraiser-Time FE	YES	YES	YES
Province-Time FE	YES	YES	YES
Mortgage Controls	YES	YES	YES
Property Controls	YES	YES	YES
ZIP Code FE	YES	YES	YES
R^2	0.249	0.229	0.293
N. Observations	15,736	6,825	8,618

Note: This table reports the results of a regression similar to the one of Table E.1 which relates overappraisals $OA_{i,b,a,t}$ to the distance of the capital of bank b from its regulatory requirements, focusing only on mortgages with a LTP ratio between 80% and 90%. Column (1) estimates the regression using all mortgages, Column (2) considers only those mortgages granted by the bank b which is the main customer bank of the appraisal company a, and Column (3) considers only those mortgages evaluated by the appraisal company a and granted by all other non-major customer banks. Standard errors clustered at the bank-time level are reported in brackets. $\star$, $\star\star$, and $\star\star\star$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

G The Role of the Local Housing Market

This section shows that overappraisals vary with the characteristics of the local housing market. In particular, overappraisals tend to be concentrated in those local markets in which property values are relatively more opaque. Indeed, opaque markets allow appraisal companies to have more discretion in their assessments.

To uncover this pattern, we define areas with more opaque property values as those zip codes with a large dispersion of transaction prices associated to properties with similar characteristics. This definition is based on the evidence of Eriksen et al. (2019, 2020), highlighting how appraisers inflate their evaluations by cherry-picking the properties with which to compare the dwelling of interest.[20] Hence, areas with relatively larger house price dispersion provide more discretion to appraisers in the justification of their evaluations.

We estimate the role of the local housing market by focusing again on the mortgages with the highest probability of an appraisal treatment for regulatory arbitrage, that is, the mortgages with LTP ratios between 80% and 90%, and we regress the overappraisal of a mortgage on a measure of house price dispersion at the year-month-zip code-level. We compute house price dispersion with the coefficient of variation of transaction prices in a given year-month-zip code, and define that a zip code features a high level of dispersion if the coefficient of variation is in the top quartile of the cross-zip code distribution. Then, we interact the measure of house price dispersion with the distance of bank capital from the regulatory constraint. This interaction term informs on whether overappraisals are associated with the mortgages granted by low-capital banks as long as the dwelling underlying the mortgage is located in an area with opaque property values.

Also in this case we consider three different samples: one consisting of all mort-

[20] The evidence on cherry-picking of Eriksen et al. (2019, 2020) is consistent with the findings of Agarwal et al. (2007), which document that overappraisals are concentrated in those evaluations carried out with the comparable method, the dwelling of interest with the values of few similar properties in similar locations.

gages within the 80%-90% LTP bucket, a sample with the mortgages granted by the bank which is the major customer of the appraiser evaluating the property underlying the loan, and finally a sample with the mortgages granted by all the non-major customer banks. In this way, we can evaluate whether the bank-appraiser relationship is still crucial to understand how the local housing market characteristics shape the determination of overappraisals. Importantly, all the regressions feature bank-time, appraiser-time, and province-time fixed effects, zip code fixed effects, as well as both mortgage and property controls.

Column (1) of Table G.1 shows that overappraisals tend to be larger in areas with high house price dispersion. Interestingly, the link between local housing market characteristics and the mispricing of mortgage collateral depends on the bank-appraiser relationship. Indeed, Column (2) shows that the variation of overappraisals across zip codes with low activity is fully concentrated in those mortgages granted by the banks which are the major customers to the appraiser. In this case, the appraisal bias is larger for property located in zip codes with larger house price dispersion, and even more so for the mortgages originated by low-capital banks. Instead, Column (3) indicates that there is no effect on the mortgages of the banks which are not major business partners for the appraiser.

Table G.1: The Role of the Local Housing Markets

	Dependent Variable: Overappraisal (%)		
	(1)	(2)	(3)
	All Banks	Main Customer Banks	All Other Banks
Bucket LTP	(80-90]	(80-90]	(80-90]
High House Price Dispersion	1.409*	3.438***	-0.454
	(0.713)	(0.574)	(1.013)
High House Price Dispersion × Distance Minimum Capital Req.	-0.164	-0.332***	0.091
	(0.132)	(0.089)	(0.211)
Bank-Time FE	YES	YES	YES
Appraiser-Time FE	YES	YES	YES
Province-Time FE	YES	YES	YES
Mortgage Controls	YES	YES	YES
Property Controls	YES	YES	YES
ZIP Code FE	YES	YES	YES
N. Observations	15,736	4,897	10,122
R^2	0.282	0.326	0.332

Note: This table reports the results of a regression analysis similar to that of Table F.1 in which we look at the role of local housing markets on the overappraisals of mortgages with LTP ratio between 80% and 90%. Columns (1), (2), and (3) consider the mortgages of all banks, appraisers' major customer banks, and all the other non-major customer banks, respectively, and consider the role of the house price dispersion.The regression also includes the interaction of this measure of house price dispersion with the measure of the distance of bank capital to the minimum requirements. Standard errors clustered at the bank-time level are reported in brackets. ⋆, ⋆⋆, and ⋆⋆⋆ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.