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by Christoph Basten and Cathérine Koch

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Higher Bank Capital Requirements and Mortgage Pricing: Evidence from the Countercyclical Capital Buffer (CCB)

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By CHRISTOPH BASTEN (ETH ZURICH & FINMA) AND CATHÉRINE KOCH (BIS)*

How has the CCB affected mortgage pricing after Switzerland became the first country to activate this Basel III macroprudential tool? By analyzing a database with several offers per mortgage request, we construct a picture of mortgage supply and demand. We find, first, that the CCB changes the composition of mortgage supply, as relatively capital-constrained and mortgage-specialized banks raise prices more than their competitors do. Second, risk-weighting schemes linked to borrower risk do not amplify the CCB's effect. To conclude, changes in the supply composition suggest that the CCB has achieved its intended effect in shifting mortgages from less resilient to more resilient banks, but stricter capital requirements do not appear to have discouraged less resilient banks from risky mortgage lending.

Keywords: banks, macroprudential policy, capital requirements, mortgage pricing

JEL codes: E44; E5; G21; G28

* BASTEN: ETH Zurich and Swiss Financial Market Supervisory Authority FINMA; KOCH (corresponding author): BIS Bank for International Settlements, Centralbahnplatz 2, 4002 Basel, Switzerland; catherine.koch@bis.org. We are grateful to *comparis.ch* for providing their data and to Katja Rüegg and Stefan Rüesch for many helpful discussions. The views expressed here are those of the authors and may not be attributed to the BIS, Comparis, ETH Zurich or FINMA. For comments and discussions we would like to thank Urs Birchler, Martin Brown, Claudia Buch, Jill Cetina, Ingo Fender, Leonardo Gambacorta, Benjamin Guin, Mathias Hoffmann, Terhi Jokipii, Georg Junge, Jongsub Lee, Reto Nyffeler, Steven Ongena, George Penacchi, John Schindler, Uwe Steinhauser and Kostas Tsatsaronis, as well as seminar participants at the Bank of England, the Bank for International Settlements, Deutsche Bundesbank, the European Central Bank, the MoFiR 2015 Workshop on Banking, the Basel Committee's Research Task Force Workshop 2015, the Cleveland Fed OFR Financial Stability Conference 2014, the FDIC, FINMA, the GRETA Credit Conference 2014, the Office of Financial Research (OFR) in the US Treasury Department, the Swiss National Bank, and the Universities of Lausanne, St. Gallen and Zurich. Any remaining errors are solely our responsibility.

1 Introduction

Macroprudential policies have recently attracted considerable attention. They aim at both strengthening the *resilience* of the financial system to adverse aggregate shocks and at actively limiting the build-up of financial risks in the sense of "*leaning against the financial cycle*". One reason for the appeal of such policies is that, by explicitly taking a system-wide perspective, they complement macroeconomic and prudential measures in seeking to address systemic risks arising from externalities (such as joint failures and procyclicality) that are not easily internalised by financial market participants themselves (see CGFS, 2010). Against this background, the new Basel III regulatory standards feature the *Countercyclical Capital Buffer (CCB)* as a dedicated macroprudential tool designed to protect the banking sector from the detrimental effects of the financial cycle (see BCBS, 2010a). We provide the first empirical analysis of the CCB based on data from Switzerland – which became the first country to activate such a buffer on February 13, 2013. To reinforce banks' defenses against the build-up of systemic vulnerabilities, the activation of the CCB raised their regulatory capital requirements, thereby contributing to the sector's overall resilience. However, little is known about the CCB's contribution towards the second macroprudential objective: higher requirements might slow bank lending or alter the quality of loans during the boom and thereby enable policy-makers to "lean against the financial cycle". Up to now, policy debates have focused mainly on the quantity of aggregate credit growth. We aim to shift the focus of the debate towards the *quality*, namely the *composition* of lenders and how tighter capital requirements interact with borrower risk characteristics. Does the CCB have the potential to shift lending from less resilient to more resilient banks, and from riskier to less risky borrowers? Based on our findings, our analysis advances the understanding of some mortgage supply side aspects about whether the CCB can contribute towards the second objective of macroprudential policy, the "leaning against the financial cycle".

To answer these questions, we examine how the CCB affects the pricing of mortgages. Our unique dataset obtained from an online mortgage platform allows us to separate mortgage supply from demand: each mortgage request receives several binding offers from several different banks, and, each bank can offer mortgages to many different households with distinct borrower risk characteristics.[1] To identify the CCB effect on mortgage supply, we exploit lagged bank balance sheet characteristics that might render a bank more sensitive to the regulatory design of the CCB. To examine whether risk-weighting schemes that link borrower risk characteristics to capital requirements do, in fact, amplify the CCB effect, we use comprehensive information as specified in the mortgage request. The procedures of the online mortgage platform warrant that banks submit independent offers that draw precisely on the same set of anonymized hard information observed by their competitors (and available to us), undistorted by any private or soft information.

Two sets of results stand out. First, the CCB affects the *composition of mortgage supply*. Once the activated CCB imposes higher capital requirements, *capital-constrained* banks with low *capital cushions* raise their mortgage rates relatively more than their competitors. Further, after the CCB is activated, *specialized* banks that operate a very mortgage-intensive business model also raise their mortgage rates to a greater degree in relative terms. In fact, the CCB applies to new mortgages as well as to the stock of all mortgages held on a bank's balance sheet. Our results for specialized mortgage lenders thus suggest that banks try to pass on the extra capital costs of previously issued mortgages to new customers. Both insights are indicative of changes

[1] This is a unique opportunity, since multiple lenders per borrower are normally only observed for syndicated loans or credit registers with reporting thresholds for corporate lending (e.g. Jiménez et al, 2012a and 2012b or Jiménez et al, 2014).

in the *composition of mortgage supply*. Based on the assumption that, ceteris paribus, households prefer lower mortgage rates over more expensive ones,[2] we conclude that the CCB tends to shift new mortgage lending from relatively less well capitalized banks to relatively better capitalized ones, and from relatively more to relatively less mortgage-exposed banks. For these reasons, both changes in the composition of mortgage supply are broadly supportive of the second macroprudential objective in that they tend to allocate new mortgage lending to banks that are more resilient.

Our second set of core findings incorporates the borrower side and the effectiveness of common *risk-weighting schemes* that translate borrower risk into bank capital requirements. We find that banks generally claim extra compensation for granting riskier mortgages (ie, by charging higher mortgage rates). However, these risk-weighting schemes do not appear to amplify the effect of the CCB on mortgage rates or mortgage creation. Apparently, the link between borrower risk characteristics (here, loan-to-value (LTV) ratios) and capital requirements is too weak to actively discourage banks from offering mortgages to high-LTV borrowers after the CCB is activated.

Our paper contributes to the literature in three different respects. First, our empirical setup allows us to advance the understanding of the effects of the CCB as a macroprudential policy tool, particularly in the context of Basel III.[3] More generally, our insights also contribute to a better understanding of how higher capital requirements impact the pricing of loans to private households. Second, our dataset allows us to disentangle mortgage supply from mortgage demand. By merging bank-level information with the respective offers, we can attribute changes in the *composition of mortgage supply* to distinct bank balance sheet characteristics that shape a

2 Unfortunately we cannot observe which offer is ultimately accepted.

3 A simulation of the effects has been carried out by Drehmann and Gambacorta (2012).

bank's pricing of mortgages. These dimensions of our data set our approach apart from standard analyses based on mortgage contracts, which have a blind spot with respect to the spectrum of all offered (but non-concluded) rates. Third, our analysis informs the debate on the effectiveness of risk-weighting schemes, a standard concept in bank regulation.

Our paper is structured as follows. The remainder of this chapter reviews the relevant literature. Section 2 sketches the institutional background of the Basel III regulation in general and its Swiss implementation in particular. It then illustrates the CCB's regulatory design with the help of a back-of-the-envelope calculation and develops two key hypotheses. Section 3 presents our dataset and the sequence of events. Section 4 translates our hypotheses into distinct regression specifications and presents our results, while Section 5 concludes.

1.1 Literature Review

As Switzerland was the first country to activate the CCB, empirical evaluations of the impact of this particular macroprudential policy tool do not yet exist, to the best of our knowledge. However, several more specific strands of the literature relate to our paper, as highlighted in more detail below.

First, while there has been some work on the need for more countercyclical instruments as well as on possible conditioning variables (see, eg, CGFS, 2010 and Borio et al, 2010), work on the effects of an *activated CCB* as implemented by *Basel III* is very limited. There are, however, some papers investigating other policy measures that share some specific features with the CCB. Aiyar et al (2014) evaluate the effects of bank-specific capital requirements in the UK that used to vary countercyclically under Basel I. They point out that, if there exists a set of lenders to whom such requirements do not apply, "policy leakage" effects might ensue, which may defeat the purpose of countercyclical capital requirements. The authors also find that the effectiveness of countercyclical capital requirements depends on banks' existing levels of capitalization, which motivates our first analysis of bank balance sheet characteristics. In a parallel paper, Aiyar et al (2014) study how shocks to minimum capital requirements are transmitted internationally and they find a significantly negative effect on cross-border lending. By contrast, Jiménez et al (2012b) evaluate the effects of "dynamic provisioning" – a measure introduced by the Spanish regulator in 2000.[4] Using observations at the bank-loan-firm level, the authors analyze the impact of these provisions on bank lending to firms. They find that the countercyclical provisioning rules did indeed help to smooth the Spanish credit cycle, even though they failed to avert the build-up of vulnerabilities in the property sector. More specifically on the CCB, Drehmann and Gambacorta (2012) simulate the effects of the CCB on bank lending and find that the buffer can indeed slow down credit growth during booms, while moderating credit contractions once being released.

Second, our paper relates to a literature on the level of *bank capitalization* and *bank lending*. On the theory side, Boot et al (1993), Sharpe (1990), and Diamond and Rajan (2000) develop models that examine how changes to equity capital should affect bank lending. Gersbach and Rochet (2012), in turn, show that the volatility of lending can be reduced by requiring higher capital ratios in boom times. With respect to the regulatory framework, Repullo and Suarez (2004) investigate how the transition from Basel I to Basel II translates into changes in a theoretical loan pricing equation. On the empirical side, Kishan and Opiela (2000) stress that the degree of capitalization matters in that small and less well capitalized banks respond most strongly to monetary policy. The impact of capital cushions or "excess capitalization" is also

[4] Crowe et al (2011) point out that countercyclical provisioning differs from countercyclical capital requirements in that provisioning requirements can be binding also when banks are already better capitalized than required by regulators.

investigated by Gambacorta and Mistrulli (2004 and 2014). More specifically on the effects of regulatory capital requirements, several papers conduct mostly accounting-based quantitative impact studies (QIS) on the effect of capital requirements on loan pricing. These include King (2010), Cosimano and Hakura (2011) and Hanson et al (2011).

Third, we contribute *loan-level evidence* to the literature on *loan pricing* started with the "dealership model" by Ho and Saunders (1981) and continued more recently by, amongst others, Saunders and Schumacher (2000) and Maudos and Fernandez de Guevara (2004). These papers investigate banks' loan pricing in terms of a spread above the prevailing wholesale funding rate, with the mark-up depending inter alia on credit risk, interest rate risk, and bank capitalization.

2. The CCB and Expected Effects

To avoid moral hazard and discipline bank lending behaviour, regulations require banks to hold a fraction of each granted loan in the form of equity capital. This fraction, expressed in terms of a minium capital requirement relative to risk-weighted assets, depends on the presumed riskiness of the loan and urges banks to have sufficient "skin in the game" in order to prevent excessive risk-taking. Under the regulatory standards of Basel II and III, banks can choose among different approaches when determining these risk weights. The simplest one of these is called *Standardized Approach*, which – in its Swiss implementation – specifies risk weights for residential mortgages exclusively as a function of the customer's LTV ratio. This section introduces the CCB as an additional capital charge on top of this *minimum capital requirement* as well as any other requirements imposed by Basel II or III (such as the new *Capital Conservation Buffer*). We then proceed to a brief back-of-the-envelope calculation to suggest a rough estimate of how much extra costs the CCB imposes on a bank for a new mortgage. Finally, we develop two sets of hypotheses that will guide our empirical approach.

2.1 The CCB and its First Activation

The Countercyclical Capital Buffer (CCB) is the key macroprudential tool within the set of new Basel III regulatory standards established by the *Basel Committee on Banking Supervision* (see BCBS, 2010b). The revised Basel framework sets significantly higher requirements for loss absorption, puts greater emphasis on a higher quality of capital and better captures the full scope of bank risk. It also imposes new requirements to promote stable bank funding profiles and maintain adequate stocks of high-quality liquid assets in the banking system. Complementing these measures, the CCB is aimed specifically at addressing the *procyclical effects* of risk-based bank capital requirements associated with previous versions of the Basel standards and its national implementations[5] (see BCBS, 2010c). As a macroprudential device, it is geared not only at strenghtening individual banks on a standalone basis, but also at augmenting financial stability more generally. In terms of the resilience objective of macroprudential policy, the CCB, if activated, will require banks to increase their risk-weighted capital ratios during boom periods, thus rendering them more resilient to potential loan losses when risks materialize during downturns. By contrast, uncertainty still governs the CCB's potential to support regulators in their pursuit of the *"leaning against the financial cycle"* objective of macroprudential policy, ie by increasing the cost of lending and hence slowing credit growth during boom periods.[6, 7]

[5] See for instance Gordy and Howells (2006) or Aikman et al (2014), as well as the relevant papers cited therein.

[6] Despite this uncertainty, Article 44 of the Swiss Capital Adequacy Ordinance (CAO), which regulates the Swiss implementation of Basel III, attributes equal weight to both objectives.

[7] There has also been a lively discussion on appropriate indicators to suitably time the activation and release of the CCB. We refer the reader to Borio et al (2011) and CGFS (2012) as well as the references therein.

Switzerland was the first country in the world to activate the CCB. On June 1, 2012, the Federal Council adopted the Basel III regulation through a revision of the "Capital Adequacy Ordinance" (CAO), one year after the issuance of the new standard by the BCBS. This legal act included the option for the government to activate a CCB from July 1, 2012 onward, while all other Basel III requirements officially went into force on January 1, 2013. The CCB option was then exercised on February 13, 2013. As Section 4 below points out, we exclusively focus on the effects of the *activation* of the CCB rather than those of it becoming a policy *option*. By design, the CCB becomes a legal option only once, whereas the activation may be exercised and adjusted whenever deemed appropriate.

The implementation of the CCB by the Swiss authorities restricts its scope to assets that are secured by domestic residential property. The initial calibration was set at 1% of these risk-weighted residential mortgages, granting banks a transition phase until September 1, 2013.[8] Most central to our analysis, the CCB as designed in Switzerland applies to the entire domestic residential mortgage book, ie the stock of previously concluded mortgages already on the bank's balance sheet as well as all new mortgages that a bank is going to make. Furthermore, the CCB applies uniformly to all banks contained in our sample, including subsidiaries of foreign banks.[9,10] Section 3.2 describes the precise timing of events, which sets the background of our empirical analysis.[11]

[8] About a year later, in January 2014, that requirement was raised to 2%, to be fulfilled by July 2014. But this increase in the CCB's requirements is not subject to our analysis for lack of data on the subsequent period.

[9] By contrast, foreign branches would not yet be covered, as full reciprocity has not yet been implemented. However, foreign branches do not play a significant role in the Swiss mortgage market and no branch enters our sample.

[10] For further details on the adoption of the Basel III regulation and the first activation of the CCB, see also FINMA (2012a), FINMA (2012b), SNB (2013a) and SNB (2013b).

[11] A complementary Appendix II contains more detailed information on the Swiss mortgage market and other equity capital regulation compulsory for Swiss banks.

2.2 A Back-of-the Envelope Illustration

As all banks in our sample are regulated under the Basel Committee's *Standardized Approach,* we can sketch a simple back-of-the-envelope estimate for the additional credit risk charges that they incur as a result of CCB activation.[12] In the Swiss implementation of the *Standardized Approach*, the risk weights for residential mortgages only vary with a mortgage's loan-to-value (LTV) ratio. Figure 1 illustrates our back-of-the-envelope calculation for a bank that intends to make a mortgage worth CHF 1 million (and with the stock of existing mortages set to zero). According to the Swiss National Bank (SNB), the market-wide average risk weight per mortgage in Switzerland lies at around 40%, which corresponds to a loan-to-value (LTV) ratio of about 77% (see SNB, 2012). This leads to a *risk-weighted* mortgage amount of CHF 400,000 in our example. The CCB's first activation requires all banks to hold additional CET 1 capital worth 1% of *risk-weighted domestic residential mortgages*. For this reason, keeping balance sheet size constant, the CCB prompts the bank in our example to replace debt or deposits worth CHF 4,000 by equity capital. If the Modigliani and Miller (see Modigliani and Miller, 1985) theorem holds, effectively stating that equity capital and debt finance are equally costly, the CCB's imposed liability substitution should not affect the bank's total funding costs.[13] However, if the Modigliani and Miller (1985) theorem fails to hold, the bank has to bear the diffence in funding costs. In our example, we therefore have to multiply the additional capital requirement of CHF 4,000 with this cost differential (which is denoted as X in Figure 1). If that cost differential

[12] Switzerland's two big banks, UBS and Credit Suisse, follow the Internal Ratings-Based (IRB) approach, but they are not included in our sample.

[13] Junge and Kugler (2013) find, for a sample of five publicly listed Swiss banks, that the elasticity between a bank's leverage and its CAPM-β is about 55% of what it would be if the Modigliani-Miller theorem did fully hold. Furthermore, in their analysis of the extra costs of Basel III, they estimate a cost difference of 4.66% using the annual return of the Swiss SPI stock market index and the 12-month CHF LIBOR rate for 1990–2010.

amounts to, for example, 10%, then the CCB will on average imply additional funding costs of CHF 400, or 4 basis points when set in relation to the requested total mortgage amount.[14]

2.3 Developing two Hypotheses

Based on the above, we are deriving two separate sets of empirical hypotheses that will guide the remainder of our analysis.

Do Bank Balance Sheet Characteristics impact the CCB effect? (Hypothesis 1)

An increase in regulatory capital requirements reduces the "*capital cushion*" between a bank's actual and its required capital ratio. Indeed, Berger et al (2008) present evidence that US banks set targets for "capital cushions" to ensure that they do not accidentally violate their requirements.[15] As a consequence, a bank's response to the CCB should depend on its current capitalization level relative to the minimum requirement. Aiyar et al (2014) illustrate a bank's options to respond to a rise in minimum capital requirements. To restore its "capital cushion" after the CCB activation consumes part of it, a bank can either *raise capital* or *constrain* new lending or *both*. In analyzing these options, our focus is exclusively on the *immediate* CCB effect on mortgage *pricing*. We do so for three reasons.[16] First, a bank can strengthen its capital base indirectly by demanding higher mark-ups, which result in higher profits such that higher retained earnings over some period ultimately restore the "capital cushion". Second, more direct ways of raising equity capital (e.g. by asking shareholders) can take longer and are unlikely to be the bank's short-run response. Third, as argued by Allen and Saunders (2012), banks usually stand

[14] While not relevant here, the cost differential X is of course endogenous in that a stronger capitalisation level will tend to reduce the bank's overall risk profile and, hence, reduce the cost of other funding sources.

[15] Similar results are obtained for European banks by Jokipii and Milne (2011). They speak of "capital buffers", while Berger et al speak of "capital cushions" and Gambacorta and Mistrulli (2004) speak of "excess capital". We follow Berger et al and speak of "capital cushions".

[16] Nevertheless, we explicitly address the selection issue in our empirical analysis by testing whether customers receive more rejections after the CCB's activation. Our results suggest that there is no significant difference.

ready to absorb every risk at an appropriate price. In line with this, Edelberg (2006) finds that, since the introduction of risk-based loan pricing, US banks respond to loan requests from high-risk applicants by offering higher rates as opposed to more outright rejections. In our context, "a bank constraining its lending" thus translates into banks raising their mortgage rates instead of submitting more outright rejections.

Also, as the specific Swiss variant of the CCB applies to the existing stocks of domestic residential mortgages as well as newly concluded ones (see above), it has more bite for specialized banks with large mortgage books. As rates on existing mortgages cannot easily be adjusted (unless such a possibility is explicitly included in the mortgage contract),[17] we expect that banks with a very mortgage-intensive business model per unit of equity would respond more strongly to the CCB activation.

Hypothesis 1

A bank whose balance sheet characteristics render it more sensitive to the regulatory design of the CCB raises its mortgage rates relatively more in response to the CCB's tighter capital requirements than its competitors. In particular,

*a) **capital-constrained** banks with lower capital cushions and*

*b) **mortgage-specialized** banks with a mortgage-intensive business model per unit of equity*

raise their mortgage rates more in relative terms.

Do risk-weighting schemes amplify the CCB effect? (Hypothesis 2)

Figure 3 illustrates how risk-weighting schemes translate the individual customer's loan-to-value (LTV) ratio into capital requirements for the offering bank and thereby link the riskiness of the

[17] While some banks in Switzerland stipulate in loan contracts that they are also entitled to adjust fixed rates when regulatory costs change, doing so in practice is reported to be difficult for reputational reasons.

mortgage to bank capitalization in the Swiss context. The tranche of a mortgage equal to or above a customer's LTV ratio of two-thirds (67%) receives a risk weight of 75%, while the mortgage tranche with LTV ratios below two thirds receives only a risk weight of just 35% (see FINMA, 2013a). The top tranche equal to or above the LTV ratio of 80% receives a risk weight of 100%.[18] In this way, risk-weighting schemes put an extra capital levy on mortgages with LTV ratios equal to or above 67% and again on those with LTV ratios equal to or above 80%. As the CCB requirement is specified in terms of risk-weighted assets, we expect banks to claim extra compensation for granting these more capital-consuming mortgages and even more so after the CCB imposes higher capital standards.[19] This leads us to our second hypothesis on the risk characteristics of mortgage applicants.

Hypothesis 2

Risk-weighting schemes that are linked to the LTV ratio of a mortgage amplify the CCB effect and lead to a relatively ***larger*** *increase in mortgage rates for borrowers with LTV ratios* ***equal to or above 67%*** *and a* ***yet larger*** *increase for LTV ratios* ***equal to or above 80%.***

3. Data and Sample Period

3.1 Unique Empirical Features of the Comparis Dataset

Our data on mortgage requests and offers originate from the Swiss online platform *Comparis.ch*. It allows Swiss consumers to compare prices of various financial services, some for free and some against a fee. Between 2008 and 2013, Comparis operated this mortgage business through a protocol that allowed households to generate individual mortgage

[18] Basel II implied a default risk weight of 35% for residential mortgages given "strict prudential lending standards" and mandated national authorities to impose higher risk weights when such standards were not met. The risk-weighting scheme illustrated in Figure 3 reflects the Swiss implementation of those more general principles applicable during our sample period. For details, see FINMA (2013a)

[19] Higher credit risk is also implied by higher Price-To-Income (PTI) ratios. In our regressions we implicitly control for PTI ratios.

applications, which would ultimately result in different binding quotes from participating lenders.[20]. To access the service and compare mortgage offers, customers paid CHF 148 (about USD 156 as of 2014) and submitted comprehensive information on the real estate property to be bought, their household finances, personal details such as their age, the requested mortgage amount, and the desired maturity model. Comparis then sent the anonymized request to different lenders, including banks from all major banking groups (except for the two big banks).[21] After having screened the customers, mortgage lenders decided whether to make a binding offer and at which mortgage rate and conditions. Indeed, banks had an incentive to submit competitive bids while knowing that customers would most likely have a choice among several independent offers. These offers carried different mortgage interest rates, while banks were not allowed to deviate from the requested mortgage amount.[22]

The Comparis dataset forms the backbone of our paper and it has several remarkable features that suit our empirical approach. First, it allows us to distinguish between mortgage demand and supply. In particular, we observe *several* distinct offers by lenders on the supply curve for each unique mortgage demand request that appears only once in our dataset. Second, we are able to observe both the willingness to make a loan (like Jiménez et al, 2012a) and its pricing. Third, all lenders receive the same anonymized information, but cannot take advantage of additional soft information, or considerations of relationship lending, or cross-selling of products. Fourth, lenders do not know which competitors are participating, nor can they observe the details of their competitors' offers. These features warrant that lenders submit binding, independent offers that

[20] Comparis has changed its mortgage platform and business model significantly in late 2013. Since then, customers pre-select from a list of lenders and discuss their needs with an advisor before receiving offers from different lenders. The period for which we have data ends approximately with the end of the previous business model on October 24, 2013. Unfortunately, the old model of the mortgage platform and its procedure are no longer accessible on the internet for proprietary reasons.

[21] Three insurance companies also offered mortgages via Comparis. We do not include them in this analysis, as we lack information on their balance sheets.

[22] In some cases, banks offered a shorter maturity or a variable rate for only the top tranche of the mortgage. We repeat our estimations while dropping these composite mortgages altogether and find that this does not alter our core results.

truly reflect their eagerness to bid for the mortgage. Fifth, since the request is costly and since offers are binding conditional on verifiable information, customers have an incentive to submit correct information. Sixth, our dataset contains lenders from all Swiss banking groups (except for the two big banks),[23] which are all subject to the CCB.

3.2 Our Sample Period and the Sequence of Events

We focus on a period of 15 months around the CCB activation, which played out against an otherwise stable regulatory environment. Figure 2 illustrates our sample period and the sequence of regulatory events in Switzerland. On 1 June 2012, the revision of the *Swiss Capital Adequacy Ordinance* (CAO) creates the legal basis for a CCB, making it a policy option available from July 1, 2012 onwards. Yet, the CCB was only activated on February 13, 2013.

Also on June 1, 2012 the CAO revision specifies the details of other Basel III elements that became effective on January 1, 2013. We expect these regulatory changes to start exerting any potential effects on mortgage pricing at the latest from the point in time when they had definitely been decided on (1 June 2012). [24]

Two additional changes in the Swiss mortgage market regulation become effective on July 1, 2012. Indeed, also on June 1, 2012, the Swiss Financial Market Supervisory Authority FINMA declares the Swiss Bankers Association's self-regulation as a new minimum standard applicable to all banks. This brings about two major revisions. First, the Loan-to-Value (LTV) ratio must be

[23] For the two Globally Systemically Important Banks (GSIBs) UBS and Credit Suisse, domestic mortgage lending is not a core business activity and furthermore their risk weights and capital requirements are computed using the Internal Ratings-Based (IRB) approach rather than the Basel Standardized Approach (SA) described in this paper and used by all other banks in our sample.

[24] In an attempt to minimize costs, it is most rational for banks to start adjusting as soon as binding information becomes available. Note, however, that this assumption is not crucial for our identification of the CCB effects, as fixed effects absorb any remaining common effects.

reduced to at most two-thirds within at most 20 years. Second, home buyers must provide at least 10% of the house value as "hard equity", i.e. own funds excluding pension assets.[25, 26]

Given these concomitant events, our sample starts on July 1, 2012, against a – from that point in time onwards – stable regulatory environment. Given the availability of the CCB as a policy option, the period from July 1, 2012 to February 12, 2013 serves as our control period (denoted as CCB=0), and the period from February 13, 2013 (the activation of the tool), until the end of our dataset on October 24, 2013 serves as our treatment period (denoted as CCB=1).

3.3 Demand and Supply Participation

Table 1 introduces our dataset in terms of demand and supply participation based on all participating banks.[27] The first column refers to the period CCB=0 starting on July 1, 2012, while the second column ranges from the activation of the CCB on February 13, 2012, until the end of our sample on October 24, 2013 (CCB=1). Our data on mortgage demand show that the number of requests declines slightly over time. We attribute this to the fact that initially Comparis was the only major online mortgage platform in Switzerland, whereas other platforms entered the business later. Turning to mortgage supply, Table 1 shows that customers receive on average 4.2 (=2674/633) answers in the period before the CCB activation and 3.7 (=1818/496) answers after it. More importantly, the shares of offers and rejections relative to the total number of answers are fairly stable if not increasing over time. On average, 89% of received answers are offers before the activation of the CCB and 91% after it. This mitigates potential selection

[25] By contrast, Swiss mortgage market regulation does to this day not take any references to other common mortgage risk indicators like the Price-to-Income (PTI), Debt-Service-to-Income (DSTI), or Payment-to-Income (PTI) ratio.

[26] Further references on this self-regulation are available in the Appendix II.

[27] To avoid any distortions from different lenders bidding for different maturity models, we restrict our view to 10-year fixed rate mortgages which account for more than half of the requested mortgage models (see our companion paper Basten and Koch, forthcoming). While most offers carry only a single rate for the entire mortgage, others carry different rates for different tranches. In that case we compute the tranche-weighted average mortgage rate for each offer.

concerns in that banks might constrain their lending by rejecting more applications after the CCB went into force. We will return to potential selection concerns in Subsection 4.1.

The structure of our dataset is no doubt unique in the analyses it allows us to conduct. But the question arises whether this dataset is actually representative of the entire Swiss mortgage market. Our Appendix II offers a host of comparisons and tests based on publicly available statistics on the entire Swiss mortgage market. These analyses confirm that the data are representative both in terms of the borrower side (geographical distribution, risk characteristics, etc.) and in terms of the supply side.

4. Empirical Analysis

After giving some conceptual background, this section presents our empirical analysis structured by the two hypotheses established in Section 2. Subsection 4.1 decomposes the mortgage interest rate in line with the "dealership model" of banking. In Subsection 4.2, we present some descriptive statistics and address potential selection effects that might bias our results. Subsection 4.3 focuses on mortgage supply to analyze which specific balance-sheet characteristics render a bank more sensitive to the CCB's regulatory design. Subsection 4.4 turns to borrower risk characteristics of mortgage demand to assess the effectiveness of risk-weighting schemes that might amplify the CCB effects.

4.1 Decomposing the Mortgage Interest Rate

The CCB affects the offered mortgage rate via two separate channels, one reflecting a bank's sensitivity that ensues from balance sheet characteristics, the other capturing the risk characteristics of the borrower. We have previously laid out how the CCB's tighter capital requirements can prompt banks to increase mortgage rates if the Modigliani and Miller (1985) theorem does not hold. To implement this idea empirically, we now build on the classic *dealership model* originated by Ho and Saunders (1981), which was extended more recently by, amongst others, Saunders and Schumacher (2000) and Maudos and Fernandez (2004). In this mark-up pricing framework, banks set a loan rate r_L at a spread above the prevailing wholesale market funding rate r. This wholesale rate is also the rate at which any deposits that are not needed to fund bank lending would be invested, which corresponds to the opportunity cost of lending. The mark-up, in turn, can reflect a variety of factors. While Ho and Saunders (1981) focus only on interest rate risk, Maudos and Fernandez (2004) point out theoretically and empirically that the spread above the wholesale rate is increasing not only in interest rate risk, but also in credit risk. Furthermore, the loan rate is increasing in a bank's capitalization level, although Maudos and Fernandez interpret capitalization merely as a proxy for a bank's risk aversion. By contrast, Saunders and Schumacher (2000) point out that banks may choose higher capital ratios not only because of economic risk aversion, but also to comply with regulatory requirements (like the CCB). This leads us to the following equation tailored to our setup:

$$loanrate_{ij} = swaprate_i + credit\_risk_{ij} + bank\_residual_{ij} \tag{1}$$

The loan rate offered by bank j to customer i depends first on the *swap rate* , which captures both the prevailing refinancing cost (six-month Libor) in the wholesale market and the cost of hedging against the interest rate risk implied by making a loan with a 10-year maturity[28]. Further it

[28] As each unique request appears only once in our dataset, it pertains to a specific point in time. The chronological sequence of all requests constitutes a time series that allows us to abstract from a time index in Equation (1). When addressing mortgage supply, our empirical analysis will later use request fixed effects that implicitly capture time fixed effects. When addressing mortgage demand characteristics, we can no longer use request fixed effects and resort to the swap rate plus monthly time fixed effects that nest all requests within each month. February 2013 is split into pre- and post-activation parts and therefore receives two-month fixed effects.

depends on the *credit risk* that bank j associates with the riskiness of the borrower i.[29] As credit risk connects the borrower risk characteristics with the individual capital requirements of a bank, it carries both an i and a j subscript. Here the CCB's additional capital charge comes into play, because extra equity capital worth 1% of the risk-weighted mortgage amount translates into higher *cost of equity capital* in Equation (1). As the average risk weight in turn increases with the LTV ratio, risk-weighting schemes might amplify the CCB effect (Hypothesis 2 above). The *bank residual* in Equation (1) captures bank j's operating costs as well as a targeted mark-up over marginal cost and all remaining cross-sectional differences among banks with respect to request i. Indeed, the CCB requires banks to hold extra equity capital worth 1% of all issued risk-weighted mortgages. According to Hypothesis 1a, banks with a low capital cushion will exhibit a stronger response to the CCB. Each bank has to cope with a burden of extra cost that ensues from mortgages listed on its balance sheet that have been contracted in the past. In this sense, the CCB, ceteris paribus, squeezes mark-ups, especially for banks with a mortgage-concentrated asset portfolio. In an attempt to restore its mark-up, a bank can raise its mortgage interest rate as put forward by Hypothesis 1b.

To sum up, the CCB effect on a bank's offered mortgage rate runs through two separate channels: first via the *residual* addressing a bank's balance sheet characteristics, and, second via the *credit risk term* addressing the borrower risk characteristics of the currently requested mortgage.

[29] *Credit risk* features two cost components: first, the *cost of the expected loss (EL)* linked to the new loan and second the *cost of holding equity capital* that captures any *unexpected* losses linked to the new loan.

4.2 Possible Selection Bias and Descriptive Statistics

Apart from the pricing of mortgages, one might raise the concern that the CCB impacts mortgage demand and supply in terms of the submitted mortgage requests or accepted risk profiles. Table 2 presents simple t-tests to address this issue. With respect to mortgage demand, customers might expect banks to reject more requests with high LTV ratios and therefore shy away from requesting riskier mortgages in the first place. If that was the case, our analyses of mortgage rates might suffer from a selection bias as fewer risky mortgages would enter the sample after the CCB activation. The first panel of Table 2 shows that neither requested LTV nor PTI[30] ratios representing the full sample change significantly over time. We then split our sample into customers asking for a new mortgage and customers requesting to roll over their mortgage at a new bank. Our results suggest that there is no significant difference in the borrower risk characteristics for new customers. In contrast to that, the requested LTV and PTI ratios for rollover requests slightly decline after the activation of the CCB, which, however, does not seem to be very significant economically. Our regression analysis on the sensitivity measures (Hypothesis 1) will distinguish between new mortgages and rollover requests to explicitly re-address this issue. As to the analysis of risk-weighting schemes (Hypothesis 2), our main results remain qualitatively unchanged and, if anything, are strengthened when we exclude rollover requests.

With respect to mortgage supply, banks might constrain lending either by rejecting more requests or raising their offered mortgage rate. If banks rejected more applications, our analysis of mortgage rates might again suffer from a selection bias. The second panel of Table 2

[30] Comparis computes the annual Payment-to-Income (PTI) ratio as 5% of the mortgage amount for interest payments in a "normal" interest rate environment, plus 1% of the mortgage amount for repayment if the initial loan-to-value (LTV) ratio exceeds 67%, plus 1% of the house value for annual maintenance costs.

demonstrates that the share of offers, however, tends to slightly increase (by 2%), albeit at a low level of significance. We conclude that banks do not constrain lending by rejecting more applications, so that any CCB effect should operate through the pricing of mortgages. The remainder of Table 2 shows that there exist significant differences in the pricing of all mortgages across various sample splits. As simple t-tests control neither for aggregate trends over time nor for bank or borrower risk characteristics, we refer to our more sophisticated regression analyses in Sections 4.3 and 4.4 to gain more insights.

Table 3 displays the descriptive statistics for the estimation sample. The upper panel indicates a mean offered mortgage rate of 208 bp, while 41% of our observations fall into the CCB=1 period. The center panel presents borrower characteristics of those requests to which banks respond with an offer.[31] The average offer draws on a submitted LTV ratio of 65%. About 56% of all offers are submitted to LTV ratios equal to and above 67%, and 20% with LTV ratios equal to and above 80%. The average offer is sent to a borrower aged about 45 years who reports an average annual household income of CHF 177,000 (about USD 186,000) and average household wealth including retirement savings worth about CHF 521,000 (about USD 549,000).[32] The bottom panel of Table 3 presents our bank sensitivity measures. It states that about 61% of all offers are issued by banks which are capital-constrained, while 47% of these offers are submitted by banks specialized in the mortgage business.

[31] Note that descriptive statistics of these borrower characteristics are "inflated" relative to Tables 1 and 2 insofar as the underlying estimation sample of Table 3 draws on multiple offers per individual request.

[32] While these values may seem relatively high from an international perspective, our Appendix II shows that they are indeed representative for Switzerland.

4.3 Sensitivity Measures of Bank Balance Sheets

Equation (2) describes our regression specification with the tranche-weighted[33] mortgage rate $rate_{ij}$ offered by bank *j* to requesting borrower *i* as the dependent variable.

$$rate_{ij} = \alpha_1 + \beta_{11} sens_{j,201x} + \beta_{12} ccb_i * sens_{j,201x} + FE\_req_i + FE\_bank_j + \varepsilon_{ij} \quad (2)$$

In fact, Equation (2) unfolds the $bank\_residual_{ij}$ of Equation (1). More specifically, to study whether bank characteristics render a bank more sensitive to the CCB shock, we let the bank-level sensitivity indicator $sens_{j,201x}$ and its interaction with the CCB shock dummy ccb_i enter our estimation. To mitigate endogeneity concerns, we use lagged time-varying sensitivity measures taken from the respective bank's annual public report of the previous year, i.e. bank-level data of 2011 for all offers to requests submitted in 2012. Further, individual bank (j=1, …, J) fixed effects should absorb *time-invariant* heterogeneity among banks. To absorb borrower risk characteristics, we add request (i=1, …, I) fixed effects (FE_req_i) to our specification (see Khwaja and Mian, 2008). As each request *i* appears exactly once in our dataset, it pertains to a unique point in time and thereby absorbs any time-specific demand shock (see Aiyar et al, 2014). We compute heteroskedasticity robust standard errors, but do not cluster them by bank as the number of clusters would be too low, the cluster size differs considerably across banks and we use bank fixed effects.[34,35] To address the bank-specific residual, we study capitalization and specialization as bank balance sheet characteristics that potentially render a bank more sensitive

33 While banks cannot deviate from the requested mortgage amount, they have the possibility to slice the offer into (up to three) tranches which might carry different mortgage rates. To render offers comparable, we use the share of each tranche in the composite mortgage offer to weight tranche-specific mortgage rates and compute their weighted average.

34 See Wooldridge (2003) or Petersen (2009) for a general discussion on the computation of standard errors in finance panel datasets.

35 As a robustness check, however, we cluster standard errors by request. Our results remain virtually unaffected.

to the effects of the CCB. As a placebo, we also study the role of bank asset liquidity, which we would expect to impact the rate itself, but not to interact with the CCB.

Capital-Constrained Banks with low Capital Cushions (Hypothesis 1a)

First, we look at the role of *capital cushions*, defined as the percentage deviation of a bank's actual capital ratio (total capital as a percentage of risk-weighted assets) from the capital ratio below which the supervisor would intervene.[36, 37] To make estimates more robust to outliers, our regressions do not include the continuous measure of the capital cushion, but a *"constrained"* indicator of whether a bank's cushion is below or above the median value for all banks in a given year. Banks with comfortable capital cushions have more degrees of freedom. We therefore anticipate that banks with a small capital cushion deemed *constrained* in our framework on average charge higher rates $(\beta_{11} > 0)$. When the CCB introduces an additional capital charge, these banks become even more constrained and may be expected to start charging even higher rates as a compensation for granting a mortgage $(\beta_{12} > 0)$.

Specialized Banks with Mortgage-Intensive Business Models (Hypothesis 1b)

Mortgage-specialized banks, defined as banks whose ratio of mortgages to equity capital lies above the median of all banks, might be more sensitive to the CCB's particular design in Switzerland. These banks can pass their gains from economies of scale on to their customers by charging cross-sectionally lower mortgage rates $(\beta_{11} < 0)$. As the CCB applies to all residential mortgages listed on balance sheets, it bites even more into the capital of banks reporting a higher

[36] The intervention threshold in Switzerland differs across five risk categories, into which the supervisor has allocated banks depending on amongst others a bank's total assets. For details, see our Appendix II and the references therein.

[37] Given data availability in public annual reports, we use the total capital ratio, but acknowledge that, for some banks, total capital cushions and Tier 1 capital cushions may be of different size.

share of mortgages relative to equity capital. Therefore, we expect that mortgage-specialized banks respond more strongly to the CCB activation $(\beta_{12} > 0)$.

Liquid Banks

Acting as a placebo measure, the liquidity of banks' asset structure should not matter for the CCB effect. We define liquid banks as those reporting a ratio of liquid assets to total assets above the median of all banks. In general, less liquid banks might only be willing to make a mortgage, if they are highly compensated as they risk running into liquidity problems (see Khwaja and Mian, 2008). Making a mortgage would mean that a distinct share of the liquid assets become illiquid and the bank might find it difficult to meet, for instance, sudden withdrawals of deposits in the near future. For this reason, we expect a negative coefficient on the liquidity indicator $(\beta_{11} < 0)$, but an insignificant interaction term $(\beta_{12} = 0)$ with the CCB indicator.

Bank Sensitivity Measures: Results

Table 4 displays our estimation results on testing *Hypotheses 1a and 1b* related to mortgage supply characteristics. We regress the offered mortgage rate on the different balance sheet sensitivity measures and their interactions with the *CCB* dummy indicating the activation of tighter capital requirements. Based on the full sample, Columns (1) to (3) focus on each sensitivity measure in isolation, whereas Column (4) exhibits the joint estimation. We drop bank fixed effects in Column (5) and apply the full specification to distinct subsamples in Columns (6) to (8).

Results in Columns (1) and (4) point out that *capital-constrained* banks *raise* their rates relatively more after the CCB's regulatory shock than do their unconstrained peers. In line with the joint estimation, these constrained banks now charge on average 2.72 bp more which reflects their tradeoff between approaching the now even closer intervention threshold and additional profits. The *constrained* indicator is not statistically significant in either estimation.

Results in Columns (2) and (4) reveal that banks that *specialize* in the mortgage business increase their mortgage rates after the CCB activation by on average 5.57 bp relative to non-specialized competitors. Higher capital requirements force banks to hold more equity capital for each mortgage already on their balance sheets. Some of that additional cost on their existing portfolio is passed on to new customers.[38] Again, the *specialized* indicator is insignificant in both regressions.

The third bank balance sheet measure acts as a placebo. Our results in Columns (4) reveal that the interaction effect turns insignificant in the joint estimation, while only the simple *liquid* indicator carries a negative and significant coefficient. The regulatory design of the CCB, however, does not touch on any aspect of liquidity. Consequently, more liquid banks offer mortgage rates which are on average 4.21 bp cheaper than those of their competitors, but the interaction effect with the CCB is insignificant.

As a robustness check, we drop the bank fixed effects in Column (5). Both interaction coefficients of the CCB with the constrained indicator and that with the specialized indicator remain intact. The CCB interaction with the constrained indicator even increases in the level of significance while confirming our baseline specification as the more conservative one.

To further assess the robustness of these findings, we re-run our regression on several subsamples. Columns (6) to (8) replicate the full specification of Column (4). New mortgages in Column (6) clearly drive our previous findings as they constitute more than 60 percent of the observations and their numerical estimates increase in absolute size. Rollovers in Column (7),

[38] This behavior is in line with the observation made by SNB (2015) that the asset margin on new mortgages was also banks' adjustment margin of choice in response to the falling liability margins brought about by ultra-low interest rates in 2014 and 2015.

however, differ in that constrained banks charge much higher prices on rollovers per se, but there is no reinforcement after the CCB. Remarkably, both subsamples confirm that specialized banks raise their rates relatively more once the CCB imposes tighter capital requirements. In fact, our baseline sample exclusively relies on requests for 10-year fixed rate mortgages. Nevertheless, in some cases banks offer a shorter maturity or a variable rate for a small part of the mortgage. However, these slight differences apply only to the tranche with an LTV ratio equal to or above 67%. A priori we would not expect such a mechanism to interact with the CCB activation indicator. We drop these composite mortgages (about 359 observations) altogether in Column (8). Excluding those offers with a shorter maturity on part of the mortgage amount does not significantly alter our results.

In brief, we cannot reject Hypotheses 1a and 1b that capital-constrained as well as mortgage-specialized banks raise their mortgage rates relatively more. We infer that the *composition* of mortgage supply changes in that banks with a higher exposure to the CCB's regulatory design substantially adjust their mortgage pricing. We highlight these two results as core findings of our paper.

One question concerns the role that signaling plays in bringing these effects about. Banks might interpret the activation of the CCB's tighter capital requirement as the supervisor flying his red flag to signal more elevated credit risk in the mortgage market than previously priced into mortgage rates. Mortgage rates across all banks might then experience a jump to account for this previously underestimated risk premium. Constrained and specialized banks might change their risk perception relatively more as they are particularly exposed because of lower capital cushions or a business focus on an asset class whose risk premiums have been underestimated. For econometric reasons and lack of clear identification, we cannot explicitly test this *signaling* *mechanism*. Instead, we assume that it might reinforce the behavioural patterns described in our hypotheses.

4.4 Do Risk-Weighting Schemes linked to LTV ratios amplify the CCB?

To examine the impact of risk-weighting schemes before and after the CCB activation, we now focus on the *credit risk* term of Equation (1). The swap rate now enters our estimation equation explicitly and lender fixed effects absorb time-invariant bank characteristics.

$$\begin{aligned} &rate_{ij} \\ &= \alpha_2 + \beta_{21} ltv_i + \beta_{22} ltv67_i + \beta_{23} ltv80_i + \beta_{24} ccb_i * ltv67_i + \beta_{25} ccb_i ltv80_i \\ &+ \gamma_{20} refin_i + \gamma_{21}' CUSTOM_i + FE + \varepsilon_{ij} \end{aligned} \quad (3)$$

Equation (3) describes our new estimation approach. We regress the tranche-weighted mortgage rate $(rate_{ij})$ offered by bank *j* to requesting customer *i* on the customer-specific LTV ratio, two dummies *ltv67* and *ltv80* indicating whether this LTV ratio equals or exceeds respectively 67% or 80%, as well as the interactions of these dummies with the *CCB* activation indicator. To control for aggregate supply effects such as refinancing conditions, we include the Swiss 10-year swap rate ($refin_i$) that prevails when customer *i* submits her request. To control for the individual borrower risk characteristics of non-repeated requests, the vector $CUSTOM_i$ adds further individual customer data such as income, wealth, an indicator of other debt and age. We again include bank fixed effects and, to control for aggregate demand effects across individual requests, we add month[39], property-type and domiciled canton fixed effects. Standard errors are robust for the previously specified reasons.

[39] We use monthly time fixed effects while splitting the event month February 2013 into two parts.

Due to the higher risks as well as higher risk weights, we anticipate that banks put an extra levy on LTV ratios which equal or exceed 67% and 80% $(\beta_{22} > 0, \beta_{23} > 0)$, respectively. After the activation of the CCB, very high LTV mortgages consume even more of the equity capital. For this reason, we assume that banks charge even higher mortgage rates after the CCB shock, as they require extra compensation for the additional capital that they have to hold $(\beta_{24} > 0, \beta_{25} > 0)$.

Risk-Weighting Schemes: Results

Table 5 presents our results while sequentially adding different request-level control variables. Columns (1) to (6) feature the full estimation sample, while Columns (7) to (9) present different sample splits. Column (6) drops lender fixed effects while using significant request control variables as presented in Column (3). Our results on the full estimation sample show that LTV per se is insignificant. However, but banks charge on average between 2.1 to 2.6 bp extra on the entire mortgage for LTV ratios equal to or above 67%: On top of that they add another 1.5 to 1.9 bp on LTV ratios equal to or above 80%. Both interactions of the CCB with the high LTV dummies mostly turn out to be insignificant. Columns (5) and (6) show two minor exceptions. Here, the interaction coefficients of the CCB with the LTV67 indicator carry a negative estimate, but turn out to be only borderline significant.

Therefore, we conclude that risk-weighting schemes as applied to Swiss banks under the *Standardized Approach* (see above) do not amplify the CCB effect. We stress this as the second core finding of our paper, while rejecting Hypothesis 2. One likely reason for this result is the fact that escalating risk weights apply only to the mortgage tranche equal to or above 67% or 80% LTV threshold instead of the entire mortgage. Our alternative hypothesis suggests that LTV threshold indictors just set apart riskier mortgages, inducing lenders to charge a risk premium. In that case, risk-weighting schemes might indeed prove to be ineffective when capital requirements on behalf of the bank become stricter, while lending standards with respect to the customer risk characteristics in general remain unaffected.

We now briefly discuss our results on control variables in Columns (1) to (5) in order to assess whether our regression specification yields reasonable results also for these other variables. The estimated coefficient on the swap rate states that a 100 bp increase in the swap rate translates into an increase of the average mortgage rate of about 74 bp. A hint at the fact that many of our participating banks substantially draw on retail instead of wholesale funding can rationalize this number. We further find that a 100 bp increase in the specified income or wealth (entering our regression in logs) of the customers reduces the offered mortgage rate by on average 3 or 0.8 bp, respectively. Coefficients on the indicator of other private debt or the customer's age do not yield significant estimates. This leads us to use the regression specified in Column (3) as our preferred set of control variables, which incorporates income and wealth but ignores insignificant customer characteristics.

To challenge the robustness of our findings, we split our sample in Columns (7) to (9). Instead of using all offers, we focus on the best offer received by each request in Column (7). This offer is arguably the offer most likely to be accepted.[40] The direct effect of the LTV67 indicator remains positive and significant, while that of the LTV80 indicator loses its statistical significance. Our main result, whereby there is no significant interaction between the CCB activation and the LTV indicators, however, remains unaffected. This confirms that our main results are not driven by offers that are unlikely to be accepted anyway. Column (8) repeats our

[40] We do not isolate the best offer to test our first set of hypotheses on sensitivity measures. The reason is that our regression specification as displayed in Equation (2) includes request fixed effects. These request fixed effects, however, run counter to a regression specification with just one observation per request.

preferred specification for *new* mortgages. These results are very similar to those for the mixed sample, both with respect to the direct effects of respectively LTV67 and LTV80 and with respect to their interactions with the CCB activation indicator. We abstain from running a separate regression on rollover requests. The reason is that simple T-tests of Table 2 have demonstrated that rollover requests have an average LTV ratio which lies below the threshold LTV ratios, anyway. Column (9) now isolates those mortgage offers that only feature a maturity of 10 years for each individual tranche. This subsample again confirms our basic findings that risk-weighting schemes do not amplify the CCB effect.

We conclude from these results that LTV thresholds do not amplify the CCB effects for banks, which hints at the weak nexus between risk-weighting schemes and capital requirements. However, it is still possible that a *signaling mechanism* is at work. If the aggregate risk perception for all mortgages has surged, but not for riskier ones in particular, our time fixed effects would absorb the effect.

5. Conclusions

Our paper examines Swiss banks' mortgage pricing directly before and after the CCB was activated, imposing higher capital requirements on banks. Since Switzerland was the first country to activate a CCB, this is, to the best of our knowledge, the first empirical evaluation of this macroprudential tool.

Our dataset, covering offers from several lenders per individual mortgage request, allows us to separate mortgage demand and supply. For this reason, we can go beyond average market effects and instead examine how the CCB activation affects the *composition* of mortgage supply and demand. Our analysis can hence advance the understanding of whether the CCB can contribute towards the objectives of macroprudential policy, especially towards some supply-side aspects of the second one of *"leaning against the financial cycle"*. To shed light on mortgage supply, we examine how individual bank balance sheet characteristics shape mortgage pricing. To understand how borrower risk characteristics interact with tighter capital requirements, we analyze critical loan-to-value (LTV) ratios, as risk-weighting schemes translate the riskiness of individual borrowers into regulatory bank capital requirements.

Our findings relate to both mortgage supply and demand. First, the CCB activation can change the *composition of mortgage supply*. *Capital-constrained* banks with small *capital cushions* raise their rates more in relative terms after the CCB is activated. Further, banks that are very *specialized* in mortgage lending are similarly found to increase their offered mortgage rates by more than their competitors do. Consequently, as higher capital requirements apply to both new mortgages and the existing mortgage stocks on their balance sheets, banks apparently seek to pass on the extra costs of previously issued mortgages to their new customers. Given that households choose the cheapest offer, we conclude that the CCB tends to shift new mortgage lending from relatively worse to relatively better capitalized banks, and from relatively more to relatively less mortgage-exposed banks. We interpret this tendency as being broadly supportive of some supply-side aspects of the macroprudential objectives of "*leaning against the financial cycle*".

Our second set of core findings relates to the pricing of riskier mortgage requests. *Risk-weighting schemes* under the Basel II *Standardized Approach* applied to the Swiss banks in our sample put an extra capital levy on riskier mortgages with LTV ratios equal to or above 67% and 80%, respectively. We find that, while banks generally charge more for riskier mortgages, risk-weighting does not amplify the CCB's effects. This suggests that the nexus between the customer's leverage and regulatory risk weights is relatively weak. A probable reason is that in the Swiss case higher risk weights apply only to the tranche of lending above the respective LTV thresholds rather than to the entire mortgage amount. This diminishes the average risk weight's effect on the whole mortgage.

At the same time, a *signaling mechanism* might be at work:[41] banks might interpret the CCB activation as the supervisor flying a red flag to signal that there is considerably more credit risk in the mortgage market than was previously priced into mortgage rates. In this sense, mortgage rates might rise sharply across all banks to account for the previously underestimated risk premium.

To sum up, our study suggests that the CCB's activation in Switzerland has contributed to the overall resilience of banks, pushed up mortgage rates, especially for more exposed banks, and shifted mortgage lending to more resilient banks. These developments in the mortgage market are supportive of the two broad objectives of macroprudential policy, especially the second one. However, with current risk-weighting schemes under the Swiss implementation of the *Standardized Approach*, it has not apparently induced banks to raise prices even more for riskier (high-LTV) mortgages and to substitute low- for high-LTV customers. Stronger incentives in this context would require a tighter link between risk weights and borrower characteristics than is achieved by the current exclusive reliance on a limited set of LTV thresholds in the determination of risk weights.

Based on these findings, our analysis reveals three key features of the ideal dataset to conduct insightful empirical assessments of macroprudential policy measures. First, a clear-cut *separation* between supply and demand is of utmost importance in isolating potentially driving

[41] The existence of such a channel would also be consistent with our finding of stronger responses from less well capitalized and more mortgage-focused banks. We cannot explicitly test the *signaling mechanism*. Instead, we assume that it might reinforce the behavioural patterns described in our hypotheses.

factors and to assess their impact. Second, *prices* (or mortgage interest rates) capture crucial information on the willingness to lend, and go hand in hand with quantities of lending. Third, a dataset with *multiple* lender and borrower relationships plots both the entire demand and supply schedule. Standard micro-level credit registers or market data on contracted mortgages have a blind spot with respect to the spectrum of all offered and requested (but non-concluded) rates and quantities. With respect to the demand side, the characteristics of denied mortgage applicants disappear entirely and those of successful borrowers vanish in the aggregate. The information on all mortgage applicants, however, allows researchers and policy analysts to track changes, selection and side effects within the pool of potential borrowers. With respect to the supply side, information on the whole supply schedule with a link to balance sheet information on the offering lender allows us to draw inferences on the composition of mortgage supply and whether new lending accrues to the riskiest or the most resilient market participants. To conclude, these three presented features can speak to the objectives of macroprudential policy and provide solid guidance for policy recommendations.

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DEFINITION OF VARIABLES

Dependent Variable	
Offered Mortgage Rate	Tranche-weighted offered mortgage interest rate measured in basis points and winsorized at the 1st and 99th percentile. We use the share of each tranche in the composite mortgage offer to weight tranche-specific mortgage rates and compute their weighted average.
Independent Variable	
CCB (0/1)	Indicator of the activation of the countercyclical capital buffer (CCB) on February 13, 2013
Refinancing Control	
Swap Rate 10y	10-year Swiss interbank swap rate.
Mortgage Characteristics	
LTV	Loan-to-value ratio as specified by the customer.
LTV67	Indicator of whether the LTV equals or exceeds the value of 67%.
LTV80	Indicator of whether the LTV equals or exceeds the value of 80%.
Bank Sensitivity Measures	
Capital Cushion	Capital Cushions are measured as the percentage deviation of the bank's capital to risk-weighted assets ratio from that ratio below which the Swiss banking supervisor FINMA would intervene.
Constrained (0/1)	Indicator equal to one if the Capital Cushion is *below* the sample median.
Liquid (0/1)	Indicator equal to one if the Liquidity Ratio is *above* the sample median.
Liquidity Ratio	Share of liquid assets (banknotes and coins + sight deposits with the Swiss or foreign central banks + credit balances on Swiss postal accounts and with clearing houses+ money market paper) to total assets.
Mortgages/Equity Capital	Ratio of mortgages to Equity Capital. Equity Capital is defined as CET1 capital and can be decomposed into corporate capital and capital reserves.
Specialized (0/1)	Indicator equal to one if Mortgages/Equity Capital is above the median.
Customer Controls	
Income	Annual household income as specified by the customer expressed in logs.
Wealth	Household wealth including retirement savings as specified by the customer expressed in logs.
Debt (0/1)	Indicator of whether the customer reports any kind of debt.
Age	Age of the customer submitting the request.

Appendix I

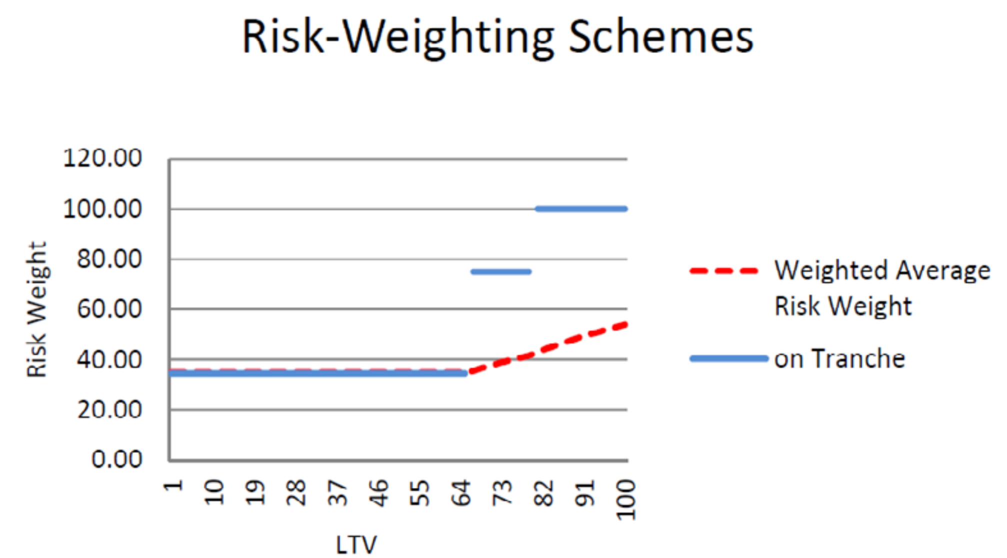
Figure 1: Back-of-the-envelope computation of a bank's expected additional cost

By how much does the CCB raise an average bank's cost per mortgage?

Mortgage Amount		CHF	1'000'000
Risk-Weighted Mortgage (RWM) using average risk weight of 40%		CHF	400'000
Additional Equity Capital Requirement of the CCB set to 1% of RWM		CHF	4'000
Cost Differential Substitute Equity Capital for Debt Cost of Equity – Cost of Debt= X%	X% of	CHF	4'000

Figure 2: Our Sample Period and the Sequence of Events relevant to Mortgage Pricing

Figure 3: Mortgage Tranche and Total Average Risk Weights as Functions of the LTV Ratio



Source: Authors' computations based on the regulation laid out in FINMA (2011)

Table 1: Mortgage Demand and Supply Participation

	CCB=0	CCB=1
Mortgage Demand		
Number of Requests	633	496
Mortgage Supply		
Number of Answers	2,674	1,818
Number of Offers	2,390	1,655
Number of Rejections	284	163

Notes: This table presents our database in terms of mortgage demand and supply participation. It focuses on requested 10-year fixed rate mortgages only.

Table 2: Simple T-tests

		CCB=0			CCB=1			Difference post-pre	T-test statistic
		mean	sd	N	mean	sd	N		
Mortgage Demand									
LTV ratios	all requested	65.11	16.50	633	64.94	16.07	496	-0.17	-0.176
	new mortgages	69.27	15.08	382	70.61	12.62	305	1.33	1.235
	rollover requests	58.78	1.05	251	55.90	1.22	191	-2.89*	1.799
PTI ratios	all requested	25.64	7.90	633	25.04	7.61	496	-0.6	-1.281
	new mortgages	27.13	7.43	382	27.30	6.97	305	0.17	-0.922
	rollover requests	23.36	8.06	251	21.43	7.19	191	-1.93***	-2.611
Mortgage Supply									
Share of offers		0.89	0.19	633	0.92	0.17	496	0.02**	2.150
Offered Mortgage Rate	all submitted	195.65	14.36	2390	226.03	25.40	1655	30.39***	48.377
	best rate	185.63	11.38	631	216.87	26.21	495	31.24***	26.890
	LTV≥67, all	196.90	14.65	1327	224.73	25.11	947	27.82***	33.219
	LTV≥67, best rate	186.66	10.66	354	216.27	26.73	280	29.6***	19.019
	new mortgages	195.62	14.41	1468	225.61	24.85	1043	29.99***	38.097
	rollover requests	195.69	14.30	922	226.76	26.32	612	31.07***	29.829

Notes: This table gives the results of a standard two-sample unpaired T-test assuming equal variances. The offered mortgage rate is measured in basis points and winsorized at the 1st and 99th percentiles. Standard errors in parentheses with ***, ** and * denoting significance at the 1%, 5% and 10% level.

Table 3: Descriptive Statistics of Offered Mortgage Rate Regressions including Bank Sensitivity

	Mean	Median	Standard Deviation	Minimum	Maximum	Observation
22 banks						
offered mortgage rate (in bp)	208.08	201.20	24.68	159	277.5	4,045
Swap Rate 10y (in %)	1.09	1.03	0.21	0.82	1.70	4,045
CCB (0/1)	0.41	0.00	0.49	0	1	4,045
Borrower Traits						
LTV (in%)	65.17	70.00	15.73	7	100	4,045
LTV67 (0/1)	0.56	1.00	0.50	0	1	4,045
LTV80 (0/1)	0.20	0.00	0.40	0	1	4,045
Income (in CHF tsd)	176.71	155.00	92.65	15.00	1400.00	4,045
Wealth (in CHF tsd)	521.40	313.00	967.57	5.00	20000.00	4,045
Income (ln)	11.98	11.95	0.44	9.62	14.15	4,045
Wealth (ln)	12.64	12.65	1.01	8.52	16.81	4,045
Debt (0/1)	0.16	0.00	0.37	0	1	4,045
Age	44.60	44.00	9.36	20	79	4,045
Bank Sensitivity (above/below median)						
Constrained (0/1)	0.61	1	0.49	0	1	4,045
Specialized (0/1)	0.47	0	0.50	0	1	4,045
Liquid (0/1)	0.62	1	0.49	0	1	4,045

Notes: This table exhibits descriptive statistics of our regression sample. We express the dependent variable *offered mortgage interest rate* in basis points and winsorize it at the 1st and 99th percentiles. LTV67 [LTV80] stands for an indicator of whether this LTV exceeds the value of 66 [79]. All Bank Sensitivity measures (above/below median) feature (0/1) indicators of whether the bank is above the median among all participating banks in a given year (except for Constrained which refers to the capital cushion being *below* the median). ***Constrained*** draws on excess capitalization in percent, measured as the distance between the bank's capital coverage ratio and the target ratio relative to the target ratio. ***Specialized*** refers to the ratio of mortgages to equity capital. ***Liquid*** reflects the percentage share of liquid assets in total assets. Please refer to the Definition of Variables for more details.

Table 4: Offered Mortgage Rate Regression with Bank Sensitivity Measures

	Full Sample					New Mortgages	Rollover Requests	All 10y fixed tranches
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sensitivity Measures								
Constrained	9.19			2.74	0.04	-3.33	17.98*	4.68
	(6.01)			(6.29)	(0.70)	(6.87)	(9.77)	(6.42)
CCB*Constrained	4.26***			2.72**	3.47***	3.10*	2.76	2.90***
	(0.90)			(1.20)	(1.32)	(1.62)	(1.71)	(1.12)
Specialized		3.93		4.03	-3.55***	4.82	2.84	2.10
		(2.49)		(2.52)	(0.70)	(3.04)	(4.53)	(2.16)
CCB*Specialized		6.11***		5.57***	5.45***	6.00***	4.72**	5.77***
		(0.92)		(1.26)	(1.39)	(1.66)	(1.92)	(1.17)
Liquid			-2.61	-4.21**	-3.05***	-4.69**	-4.86	-3.60**
			(1.72)	(1.83)	(0.71)	(2.24)	(3.29)	(1.78)
CCB*Liquid			-2.08**	0.49	-1.06	0.48	-0.10	-0.21
			(0.89)	(1.33)	(1.42)	(1.77)	(1.90)	(1.24)
Constant	190.32***	194.81***	201.26***	191.07***	210.62***	194.14***	179.95***	191.38***
	(6.17)	(2.84)	(1.42)	(6.85)	(0.65)	(7.74)	(10.68)	(6.85)
Observations	4,045	4,045	4,045	4,045	4,045	2,511	1,534	3,686
R-squared	0.83	0.83	0.83	0.83	0.80	0.82	0.86	0.87
Request Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes
Bank Fixed Effects	yes	yes	yes	yes	***no***	yes	yes	yes

Notes: This table shows the results of an OLS regression with the offered mortgage rate as dependent variable. The offered mortgage rate is measured in basis points and winsorized at the 1st and 99th percentiles. ***Constrained*** indicates whether a bank reports a capital cushion below or equal to the median of all banks in a given year. **Specialized *(Liquid*)** indicates whether whether a bank reports a ratio of mortgages on balance sheet to equity capital (liquid assets to total assets) that equals or exceeds the median of all banks in a given year. Columns (1) to (5) feature the full sample, whereas Columns (6) and (7) show subsamples of new mortgages and rollover requests, respectively. Column (8) excludes composite offers with individual tranches of shorter maturity than 10 years. Please refer to the Definition of Variables for more details. All regressions include request fixed effects and fixed effects for each offering bank except for column (5). Heteroskedasticity consistent standard errors in parentheses with ***, ** and * denoting significance at the 1%, 5% and 10% level.

Table 5: Mortgage Rate Regression with Threshold LTVs

	Full Sample						Best Offers	New Mortgages	All 10y fixed tranches
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mortgage Characteristics									
LTV	0.03	0.03	0.03	0.03	0.03	0.02	-0.03	0.04	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
LTV67 (0/1)	2.13***	2.58***	2.39***	2.38***	2.35***	2.64***	2.17**	2.10*	0.20
	(0.70)	(0.69)	(0.70)	(0.70)	(0.70)	(0.74)	(1.06)	(1.09)	(0.66)
LTV80 (0/1)	1.81**	1.85**	1.57**	1.56**	1.54**	1.24	1.01	1.83**	1.11*
	(0.75)	(0.74)	(0.75)	(0.75)	(0.75)	(0.76)	(0.97)	(0.86)	(0.64)
CCB*LTV67 (0/1)	-1.50	-1.49	-1.49	-1.49	-1.52*	-1.70*	0.33	-0.30	-0.49
	(0.92)	(0.91)	(0.91)	(0.91)	(0.91)	(0.99)	(1.35)	(1.31)	(0.83)
CCB*LTV80 (0/1)	0.87	1.34	1.45	1.46	1.48	1.48	1.77	0.16	0.44
	(1.17)	(1.15)	(1.15)	(1.15)	(1.15)	(1.22)	(1.54)	(1.27)	(1.00)
Refinancing Control									
Swap Rate 10y	73.69***	75.11***	74.41***	74.37***	74.27***	75.50***	81.27***	67.16***	73.15***
	(4.69)	(4.66)	(4.66)	(4.67)	(4.67)	(5.15)	(7.16)	(6.07)	(4.16)
Request Controls									
Income		-3.91***	-3.14***	-3.15***	-3.20***	-3.04***	-3.23***	-3.34***	-2.72***
		(0.47)	(0.51)	(0.51)	(0.52)	(0.55)	(0.86)	(0.72)	(0.47)
Wealth			-0.84***	-0.84***	-0.81***	-0.74***	-0.31	-0.93**	-0.48**
			(0.22)	(0.22)	(0.23)	(0.24)	(0.37)	(0.41)	(0.21)
Debt (0/1)				0.14	0.18				
				(0.54)	(0.54)				
Age					-0.02				
					(0.02)				
Constant	118.37***	165.37***	167.87***	168.05***	169.20***	166.45***	148.45***	188.25***	144.15***
	(4.66)	(7.29)	(7.30)	(7.35)	(7.58)	(7.66)	(11.49)	(32.72)	(21.74)
Observations	4,045	4,045	4,045	4,045	4,045	4,045	1,126	2,511	3,686
R-squared	0.76	0.76	0.76	0.76	0.76	0.73	0.87	0.75	0.82
Demand Fixed Effects	time	time	time	time	time	time	time	time	time
	property type	property type	property type	property type	property type	property type	property type	property type	property type
	canton	canton	canton	canton	canton	canton	canton	canton	canton
Bank Fixed Effects	yes	yes	yes	yes	yes	***no***	yes	yes	yes

Notes: This table shows the results of an OLS regression with the offered mortgage rate as left-hand side variable. The offered mortgage rate is measured in basis points and winsorized at the 1st and 99th percentile. LTV67 [LTV80] stands for an indicator of whether this LTV exceeds the value of 66 [79]. CCB*LTV67 [CCB*LTV80] refers to the interaction of the CCB with the LTV67 [LTV80] variable. To control for the general level of refinancing costs, we add the 10-year interest swap rate. Columns (1) to (6) feature the full sample, whereas Column (7) shows asubsamples of the best offered rate per request, Column (8) draws only new mortgages and Column (9) excludes composite offers with individual tranches of shorter maturity than 10 years. Please refer to the Definition of Variables for more details. All regressions include fixed effects for the offering bank (except for Column (6)), the month of submission (while February 2013 is split into a pre and post February 2013 dummy), the request's property type and domiciled canton. Heteroskedasticity consistent standard errors in parentheses with ***, ** and * denoting significance at the 1%, 5% and 10% level.

Appendix II

The purpose of this detailed Appendix II is to provide more detailed background information. Specifically, Section 1 describes the structure and setup of the Swiss residential mortgage market, including the current regulatory standards for banks and borrowers. Section 2 informs about the current set and recent changes of the capital requirements for banks. It also gives references to the legal texts that exceed the scope of our main paper. Section 3 shows how representative our sample is of the entire Swiss residential mortgage market.

The Swiss Mortgage Market

Low Rate of Owner-Occupied Residential Property

The CCB as designed and implemented in Switzerland applies only to Swiss residential mortgages. For this reason, we briefly introduce the Swiss real estate and residential mortgage markets. Relative to other developed countries, Switzerland has always had a comparatively *low rate of owner-occupied residential property*. At the national average, that rate was below one-third until the early 1990s. Since then, it has risen to slightly above 40% given the possibility that home buyers can use pension funds for their purchase of residential property and benefit from tax incentives against the background of a low interest rate environment, especially during the more recent years[42].

Tax Treatment Incentivizing Slow Debt Repayment

The *tax treatment* is meant to be *ownership neutral*: Imputed rents are fully taxed also for owner-occupants, while mortgage interest payments can be deducted from taxable income.[43] This system is in principle neutral to ownership, however it does create incentives for a very *slow mortgage amortization* of residential mortgages. Hence Swiss households tend to amortize

[42] Source: Bundesamt für Wohnungswesen, Wohneigentumsquoten 1990, 2000 und 2012 nach Kantonen, http://www.bwo.admin.ch/dokumentation/

[43] See IMF (2011). IMF (2011) also writes that Switzerland is the only country apart from the Netherlands to have this fully ownership neutral tax regime.

on a far longer schedule than the contractual maturity of an individual single mortgage. They typically make the balloon payment for outstanding principal at the end by refinancing, i.e. taking out a new loan. As a consequence, Swiss *mortgage debt has increased significantly* during the recent boom. It is now one of the highest in the world as a percentage of GDP (see FINMA, 2014), although most home owners accumulate savings while keeping their mortgage debt outstanding.

Typical Maturities and Repayment Behavior

Swiss mortgage suppliers rarely offer contractual maturities above 10 years, although amongst maturities below 10 years those with longer fixing of interest rates have become significantly more popular in the low interest rate environment of the past few years.[44] More than half of all submitted mortgage applications in our data set request mortgages with interest rates fixed for 10 years. In contrast to the US, for example, early repayments in Switzerland usually occur only when households have to move, e.g. because of divorce or job changes. By contrast, borrowers do not repay earlier for strategic reasons, as Swiss banks usually charge a substantial compensating fine for the lost investment opportunity and all incurred costs.

Actors in the Swiss Mortgage Market

In Switzerland, both banks and *insurance companies* offer mortgages, although the insurers hold only about 4% market share (see FINMA, 2014). Some pension funds do also offer mortgages, but their market share is below that of insurers and their mortgage volume has in recent years been declining even in absolute terms. In this paper we focus only on banks, as insurers did not need to comply with the regulatory requirements of the CCB, nor would they constitute an adequate control group, since they do operate in the same market.

[44] According to SNB (2014) the share of *outstanding* mortgage debt with a remaining maturity above 5 years increased from about 15% in 2009 to above 25% in 2014. And this 10 percentage point increase does still greatly underestimate that in the characteristics of recently granted mortgages, as the stock of mortgages on balance sheets adjusts only partly each year.

The Swiss Real Estate Cycle

Finally, looking at the Swiss residential property price cycle, Swiss house prices peaked at around 1992, then they declined until about 1999, and have ever since been continuously growing for the recent 15 years. As Basten and Koch (forthcoming) show in more detail, part of this boom has likely been due to the low interest environment and the appealing business model of mortgage lending for both banks and households. Increased immigration and the fact that demand for residential property faces a relatively inelastic housing supply seem to have also contributed to this growth.[45,46]

Relevant Regulation

The *Capital Adequacy Ordinance* (CAO) provides the regulatory framework of the mortgage market during our sample period (see FINMA, 2013a). More detailed provisions are given by the *Swiss Bankers' Association*'s self-imposed regulatory standards (see SBA, 2011 and 2012). This set of self-imposed guidelines became a declared a minimum standard by the Swiss Financial Market Supervisory Authority *FINMA*, (see FINMA, 2012a).

Capital Requirements and Further Institutional Information on the CCB

The Countercyclical Capital Buffer (CCB) is imposed on top of other capital requirements implied by the Basel Committee on Banking Supervision (BCBS)'s Capital Accords. We list these other capital requirements below that do not change during our sample period. *First*, there is the *Minimum Capital Requirement* (MCR) already in place under Basel II. It amounts to 8% of risk-weighted assets (RWA) and its violation will automatically trigger regulatory action. *Second,* also since Basel II, there are the *bank-specific Pillar II* requirements which depend on national supervisors' assessment of a bank's riskiness. In Switzerland, the majority of these Pillar II requirements depend on which out of five risk categories a bank has been assigned to.

[45] For other up-to-date portraits of the Swiss mortgage market, see Brown and Guin (2013).
[46] For additional information on the Swiss mortgage market, see BCBS (2013) and IMF (2014)

As explained in Jans and Passardi (2013), the supervisor FINMA has assigned Swiss banks to five target and intervention threshold groups depending inter alia on their balance sheet size. The capital requirements specified by the respective risk category range from 2.5% to 6.4% of RWA. Hence, depending on their actual idiosyncratic level of capitalization, two banks may have different capital cushions in excess of the common category's requirement that FINMA has assigned to them. These category-based requirements are gradually phased in until 2019, yet we would expect their effect on loan pricing to take effect at the latest by the time by which the new requirements have been definitely decided on. *Third,* Basel III envisages also a *Capital Conservation Buffer* amounting to 2.5% of RWA, which may be temporarily violated in times of crisis. In Switzerland, ultimately the first 2.5 percentage points of the category based requirements (the 2.5%-6.4% of RWA) will count as Capital Conservation Buffer and hence Pillar I requirement, while the rest will continue to count as Pillar II requirement. FINMA (2011), FINMA (2012b), FINMA (2013c) and Jans and Passardi (2013) provide more details on the implementation of those different capital requirements in Switzerland.

For more detailed institutional information on the CCB, beyond those discussed in our paper, we refer to BCBS (2010b), BCBS (2010c), SNB (2013a) and SNB (2013b). For a discussion on appropriate metrics for timing the activation of the CCB, see Borio et al. (2010), Borio et al. (2011), Repullo and Saurina (2011), Edge and Meisenzahl (2011) and Hahm and Shin (2013).

How Representative is the Comparis sample of the entire Swiss Mortgage Market?

To investigate how representative our dataset is of the overall Swiss mortgage market, we compare our sample data to other micro-level and aggregate data from three available sources: First, we draw on aggregate data capturing the entire Swiss market from the Swiss National Bank's (SNB) publication "Banks in Switzerland", SNB (2012). Second, we compare our estimation sample to other micro data from the Household Budget Survey (HBS, or HABE), and third to another survey dataset from a study by Seiler (2013) on households' use of pension money for real estate acquisitions. The SNB aggregate data cover a few characteristics of the *stock* of all mortgages listed on Swiss banks' balance sheets. The drawback of this dataset however is, that it does not allow us to compare these characteristics specifically of those of mortgages that have only recently been granted as new or rollover mortgages during our relevant period of time (July 2012 to October 2013). As opposed to that, the HBS and Seiler (2013) datasets allow us to focus more closely on recently made mortgages, but the HBS covers only few characteristics, and the survey data from Seiler (2013) may themselves not be fully representative of the entire market in all respects. To the best of our knowledge, these are the only suitable public data sources and taken together they can give the best possible idea of how our sample compares to the Swiss mortgage market as a whole. We structure the following discussion around the three dimensions along which the data allow for useful comparisons: *Location* of the underlying real estate object, the loan-to-value (LTV) ratio implied by the requested mortgage amount, and key figures on the requesting households' finances.

Location

Our first question is how well our sample covers Switzerland's different regions. To account for time-invariant heterogeneity across the property's location in our regression analysis, we use either canton fixed effects or request fixed effects that are in turn nested by cantons. Despite these fixed effects, the number of observations along the offer dimension (recall that there are multiple offers per individual requests) might not be representative and thus our regression estimates might suit some distinct areas but not Switzerland as a whole. We hence compare the geographical distribution of the observations in our sample to those implied by SNB (2012) and Seiler (2013).

Panel (A) of Table A1 shows the comparison of our sample with the SNB data which are available at the level of the 26 Swiss cantons (federal states). Following the SNB statistics, we compute the share in terms of the volume of extended mortgages by canton of the residential property relative to the volume of all extended mortgages in Switzerland. In this way, Column (1a) relies on aggregate data and features these shares while sorting the cantons by rank order based on the entire Swiss market. By contrast, Column (2a) and (2b) draw on our estimation sample. Column (2a) gives the share of requested mortgage volumes by locational canton and Column (2b) gives the share's rank according. The last two columns replicate the share and its rank in our sample but draw on the un-weighted average of the number of requests instead of implicitly weighting by requested mortgage amounts as in previous columns. These figures show that our sample is quite representative, covering not only the most densely populated cantons like

Zurich, but also the more rural areas. More formally, we can compute the $\chi 2$ statistic to test the null hypothesis that both figures represent the same underlying distribution. Doing so yields test statistics between 5 and 6, depending on whether we look at the volume or number of requests. These values are far below the relevant critical values to reject the null (starting from about 34 for 25 degrees of freedom), so we can conclude that our sample has no geographical bias relative to the entire Swiss mortgage market.

In Panel (B) of Table A1 we reduce our sample to the 7 distinct market regions to align it with the Seiler (2013) survey data. This survey dataset might itself not be representative of the entire Swiss market, yet we found a more focused comparison also quite informative. The comparison shows that we have a slightly higher coverage of French- and Italian- (as opposed to German-) speaking Switzerland, thus alleviating further possible concerns that our sample might give too much weight to German-speaking Switzerland.

Loan-to-Value (LTV) Ratios

Table A2 compares the Loan-to-Value (LTV) ratios in our sample to those in the two other available data sources. Panel (A) starts with the SNB data, noting the drawback that these cover the stock of all mortgages on banks' balance sheets, including those granted in past years. Since SNB data give the fractions of mortgage volumes in 3 different LTV buckets, we compute the same distribution for our data. With regard to the entire Swiss mortgage market, we find that about 92.4% of all issued mortgages fall into the lowest LTV bucket below 67%. This compares well with our sample, in which 91% of all requested mortgages fall into this bucket. As to more risky mortgages in the medium category of LTV ratios above 67% but below 80%, data on the entire Swiss market point out that 5.7% populate this bucket. In our sample, 8.2% of all mortgages populate that medium bucket. The top bucket ranges from LTVs above 80% to 100%. It is filled by 1.9% of the entire Swiss market, whereas only 0.8% of our sample fills this bucket. We attribute these small differences in the most risky buckets to the fact that data on the entire Swiss market unfortunately are only available for the entire stock of all mortgages granted by banks over time and not for our relevant period in specific. In fact, our sample focuses on mortgage requests submitted after July 2012 when stricter rules on LTV ratios above 80% and tighter rules on household equity had become effective. Panel (B) compares mean and median

LTV in our sample to those in Seiler (2013). Here, we do not find a significant difference: In our sample the mean (median) LTV of new mortgage requests amounts to 69 (74), whereas in Seiler (2013) it amounts to 71 (74).

Household Finances

Looking at household finances, our summary statistics in the top panel of our main paper's Table 3 show a median gross annual household income of CHF 155'000 and median household wealth of CHF 313'000. At first sight, these numbers may seem very high, but to put them into perspective, one needs to take the Swiss price and income levels into account. For our purpose, a comparison with figures from other Swiss data sources lends support to our sample dataset. Unfortunately the SNB (2012) data aggregates are based on banks' balance sheets and hence contain no information on property buyers' income or wealth, and Seiler (2013) contains data on personal wealth only from the year of the survey as opposed to the year of the purchase. However, the Household Budget Survey has data on household incomes (albeit not on wealth). This micro-level survey data tells us that while the gross annual income of all households surveyed amounts to only CHF 133'000 on average, that of the average home-owner starts at CHF 150'000 and may be as high as CHF 177'000 with 3 or more children. Since households are typically aged below 65 when purchasing their residential property, we consider the latter set of values more relevant. We conclude that income levels of the households in our sample are within the normal range for Swiss home-owning households.

Overall we infer from these figures and comparisons, that our sample in terms of geographical distribution and borrower characteristics seems to be quite representative of the entire Swiss mortgage and residential property market.

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Tables and Figures

Table A 1: The geographical distribution of our requests

(A) Our Sample vs. SNB Statistics of the distribution across cantons (states)

Locational Canton of the real estate property	Switzerland 2012: Share of Issued Mortgages		Estimation Sample: Share of Requested Mortgage Volumes		Estimation Sample: Share of Requests	
	in % (1a)	Rank (1b)	in % (2a)	Rank (2b)	in % (3a)	Rank (3b)
Zurich	19.19	1	25.59	1	22.51	1
Berne	10.77	2	11.69	3	13.25	2
Aargau	8.73	3	10.26	4	11.47	3
Vaud	8.07	4	11.73	2	10.96	4
St.Gallen	5.73	5	4.61	5	5.52	5
Geneva	5.06	6	2.70	12	1.78	15
Ticino	4.73	7	2.52	13	2.21	13
Lucerne	4.64	8	4.42	6	4.33	6
Basel Land	3.86	9	2.94	9	2.80	10
Valais	3.59	10	1.77	15	2.29	12
Thurgau	3.48	11	3.81	7	3.91	7
Solothurn	3.37	12	2.93	10	3.31	9
Graubünden	3.33	13	1.56	17	1.87	14
Fribourg	3.23	14	3.13	8	3.82	8
Schwyz	2.37	15	2.74	11	2.46	11
Zug	2.04	16	1.82	14	1.27	17
Basel Stadt	1.92	17	1.64	16	1.53	16
Neuchatel	1.53	18	1.03	18	1.19	18
Schaffhausen	0.94	19	0.41	23	0.68	19
Jura	0.75	20	0.41	22	0.59	20
Appenzell AR	0.62	21	0.36	24	0.59	21
Nidwalden	0.54	22	0.61	20	0.42	23
Obwalden	0.47	23	0.75	19	0.59	22
Glarus	0.44	24	0.43	21	0.42	24
Uri	0.40	25	0.16	25	0.17	25
Appenzell IR	0.18	26	0.00	26	0.00	26

Notes: This table compares the entire Swiss mortgage market in Columns (1a) and (1b) with our sample in Columns (2a) to (3b). We compute the share of all mortgages by locational canton of the associated real estate property for the stock of all issued mortgages in Switzerland in Column (1a). By analogy, Column (2a) gives the share of requested mortgage volumes by locational canton and Column (3a) indicates the share of requests per locational canton while giving equal weight to each request instead of weighting by mortgage volume. Source: SNB (2012) and Comparis.

(B) Comparison Sample vs. Seiler survey of the distribution across regions

	Seiler (2013)			Estimation Sample	
	Overall	Pension-financed	Not pension-financed	% of Volumes	% of No
	(1)	(2)	(3)	(4)	(5)
Zurich	28.28	27	31	25.59	22.51
Eastern Switzerland	16	16	16	12.16	12.5
Mittelland	17.72	19	15	20.03	21.82
Northwestern Switzerland	13.36	14	12	15.12	15.91
Lake Geneva Region	10.36	11	9	16.2	15.03
Ticino	4.28	3	7	2.52	2.21
Central Switzerland	8	8	8	10.39	9.58

Notes: Panel (B) shows the distribution of real estate purchases across 7 market regions. Columns (1) and (2) for our sample with (1) covering the distribution of mortgage volumes and (2) covering the distribution of the number of requests. Columns (3) - (5) show the distribution in Seiler (2013), where (4) shows that of purchases partly financed with pension money, (5) shows that financed without any pension money, and (3) shows the weighted average.

Table A 2: Loan-to-Value (LTV) ratios

(A) Distribution across Loan-to-Value (LTV) brackets

	SNB Statistics	Sample
	(1)	(2)
LTV < 67	92.47	91.00
67 <= LTV < 80	5.66	8.20
LTV >= 80	1.87	0.79

(B) Mean and Median Loan-to-Value (LTV) ratios

	Seiler survey	Sample
	(1)	(2)
Mean	70.90	69.41
Median	73.50	74.00

SNB statistics are based on SNB (2012), the Seiler survey data on Seiler (2013), see bibliography. SNB statistics are only available for the stock of all mortgages on banks' balance sheets, we compare these with mortgages newly granted or rolled over during our sample period. The comparison with Seiler (2013) in Panel (B) focuses on new mortgages only.

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