The Geography of Mortgage Lending in Times of FinTech

September 2018

by Christoph Basten *

I analyze how banks allocate their mortgage lending to different regions in an online setup in which they can equally respond to individual mortgage applications from all of Switzerland. I confirm that banks charge higher spreads in regions where house prices are deemed more over-heated, even without regulatory incentives. At the same time, banks seize the online channel to achieve better diversification across regions, making more and more competitive offers to regions in which they are currently under-represented. Finally, offer behavior is more aggressive the more intense online competition in the applicant's region.

Keywords: Mortgage Lending, FinTech, Credit Risk, Bank Regulation, Competition

JEL Classification: G2, L1, R2

Work in Progress. Comments very welcome.

* *University of Zurich*, christoph.basten@bf.uzh.ch.

Part of the analyses were completed while I was still working for the Swiss Financial Market Supervisory Authority FINMA and I thank them for the opportunity to analyze these issues as well as for constructive feedback on parts of the analyses. Yet any opinions expressed in this paper are my own and may not be taken to represent those of FINMA.

1 Introduction

Every mortgage is associated with a specific location in which its collateral is based in a way in which other assets on bank balance sheets are not. This location matters for the lender in at least three ways. First, from a risk management perspective location affects the future value of the collateral, as real estate price changes[1] over time are often more correlated within than across regions. But real estate prices may exceed the values deemed sustainable to different extents in different regions, so that lending to more regions deemed more over-heated may imply a greater risk of significant price declines in the next downturn. Second, from a risk management perspective the location of the collateral matters also when put into relation with each bank's existing portfolio. On the one hand, there is a benefit to diversify mortgage lending across more than one region, while on the other hand a bank may have better knowledge of, and may even be better able to influence, prices in regions in which it has a greater presence already. Third, beyond both these risk management considerations, the region of the collateral and the client matters also from an industrial organization perspective in that different regions are served by different sets of competitors so that the same bank may face different levels of competition and hence different profitability in different regions.

All three considerations imply that a bank's choice of how to allocate its mortgage lending to different regions matters. Yet in practice a bank cannot freely choose the geographical distribution even of its new lending, because its access to potential borrowers from different locations may depend on, amongst others, how well known it is in each region and how many branches it has in which it can get into contact with potential clients. Having to disentangle direct costs and benefits of mortgage lending to different regions from costs of gaining access to new clients by opening new branches or advertising in different regions adds a layer of complexity. It also does so when it comes to understanding how banks choose so far: For when a bank allocates say 2/3 of its new lending to the region in which it is headquartered and has a denser branch network and 1/3 to another region, how do we know to what extent that was a conscious choice and to what extent the bank failed to access more clients in the other region?

[1] To simplify, I intermittently write of "house prices" as well as of "real estate prices", even though a significant proportion of the real estate of relevance consists of single apartments rather than entire houses.

Yet new technology can help banks, and researchers, overcome these constraints. Thus this paper exploits data from a Swiss website that from 2008 onwards allowed households from across the country to apply for mortgages and then allowed banks from across the country to bid for those. Households would then receive offers from all banks willing to lend to them, without need for prior knowledge of them or a branch nearby. This increased banks' options, and it provides me as a researcher with data that for the purpose at hand have at least four distinct advantages. First, I can separately observe demand and supply, which is not normally possible at the loan level for mortgage markets. Second, I can shut down any effect of a bank's differential access to clients from different regions. Third, I observe for each application responses from different banks, thus ruling out the usual regularity that different banks end up interacting with different types of clients. And fourth, I observe 100% of the information on each mortgage applicant that is also available to each potential lender, which would not be possible in an offline context with often further soft information based on prior interactions.

This setup allows me to investigate how each lender's decision on whether to make any offer at all, as well as the price offered, vary first with presumed area-specific risk, second with each lender's prior geographical focus, and third with the degree of competition in that area, after controlling for applicant-specific characteristics such as threshold values of loan-to-value (LTV) and loan-to-income (LTI) ratio, as well as for key bank characteristics such as size, capitalization and the focus of existing assets and liabilities. I call this *response level data*, as opposed to (contracted) loan level or even more aggregated data.

These unique data have so far only been used by two prior papers. First, *Basten and Koch (2015)* use them to analyze how temporary increases in the cost of mortgage lending caused by the Swiss activation of the Basel III Counter-Cyclical Capital Buffer (CCyB) have affected banks' willingness to bid for mortgages as well as their mortgage pricing. They find that banks more affected by the CCyB have raised bid prices more and that as a consequence part of new mortgage lending has shifted from more to less CCyB-affected banks, with implications for financial stability in the Swiss banking sector as a whole.

Second, *Basten et al (2017)* analyze how households decide which mortgage rate fixation periods to apply for and how banks then decide their eagerness to provide different fixation periods. They find that precisely those households who would benefit most from insuring

against rate increases given the lowest abilities to pay more also have the tightest budgets now and therefore tend to apply for shorter rate fixation periods to benefit from the lower initial costs. Contrary to the usual assumption in the previous mortgage choice literature, which cannot differentiate between demand and supply of different fixation periods, the paper then shows that banks do not always accommodate these household choices. Rather they tend to offer longer fixation periods than applied for to households with Loan-To-Income (LTI) ratios above 4.5 or Loan-to-Value (LTV) ratios above 67%, although there is no further effect of LTI values above 5.5 or LTV values above 80%.

Beyond these data, there is to the best of my knowledge so far only one paper that manages to investigate the responses of different banks to the same mortgage request: *Michelangeli and Sette (2016)* submit randomized mortgage applications to different banks in Italy and find that better capitalized banks are ceteris paribus more likely to bid for mortgage requests as well as to make more competitive prices. However, none of these three existing papers has yet explicitly exploited the geographical dimension of mortgage applications and offers.

In this paper, I do indeed find evidence that in their online behavior banks are more conservative vis-à-vis regions that are considered to carry a larger risk of house price over-heating. In particular, they charge larger spreads between offered mortgage rates and re-financing costs for the same maturity. At the same time, I find that banks seize the online channel as an opportunity to improve the regional diversification of their portfolio by bidding more eagerly for mortgages in regions in which they are so far under-represented. Both findings suggest that the online channel can allow banks to reduce the riskiness of their mortgage portfolio in ways not as easy offline. Finally, I find that, as one would expect, banks do indeed bid more aggressively in markets with more intense competition, both when I measure this offline and online.

The remainder of the paper is structured as follows. Section 2 starts off with the hypotheses to be tested. Following that, Section 3 introduces the data and institutional background and Section 4 the empirical strategy. Following that, Section 6 presents the results and Section 7 concludes.

2 Hypotheses

In this section I develop hypotheses on how the region of the applicant affects banks' behavior along three dimension: First via inter-regional differences in the risk of house price over-heating, second via the trade-off between inter-regional diversification and regional knowledge, and third via inter-regional differences in the intensity of mortgage market competition.

2.1 Hypothesis on Bubble Risk

While the entire national mortgage market is affected by the same interest rate regime, so that mortgage growth and house price changes are correlated across regions, there can nonetheless be differences in the extent of possible house price over-heating. Reasons include differential economic developments based on different industries, differences in the past supply of mortgages between the banks active in different regions, as well as differences in zoning and constructing regulation. For example, throughout and after the period studied Swiss media frequently report how institutional investors like pension funds invest into income producing real estate (IPRE) in suburban regions because zoning regulation did not allow sufficient construction to invest all their money in the centers, even though many economists warned that the rental demand for residential property in many of these regions was limited.[2] This resulted in inter-regional differences in the risk of house price over-heating. These risks are approximated by different measures as explained in the data section. As more over-heating implies a larger risk of declines in house prices and hence in mortgage collateral in the next downturn, I expect:

> *Hypothesis 1: Banks are more likely to reject, and/or to quote a higher spread above their refinancing costs, for applications from regions characterized by larger risk of house price over-heating.*

This is the prediction we would get if assuming that inter-regional differences in credit risk are fully taken into account. Yet this prediction is not as obvious as it might seem at first look, because while inter-regional differences should influence banks' economic capital requirements, they do not influence their regulatory capital requirements in the sample studied.

[2] See e.g. https://www.srf.ch/sendungen/eco/immobilien-apotheken-chinas-silicon-valley , accessed on 25 May 2018.

More specifically, all banks in our sample follow the Swiss version of the Basel Standardized Approach (SA) rather than the Internal Ratings Based (IRB) approach for computing their asset risk weights that determine their capital requirements. In this Swiss version, as specified in the Swiss law "Eigenmittelverordnung" (ERV)[3], risk weights for owner-occupied residential real estate during the period considered were set to 35% for any portion of a mortgage with a loan-to-value (LTV) ratio below two-thirds, to 75% for any portion with an LTV ratio between two-thirds and 80%, and to 100% for any portion with an LTV ratio above 80%[4], as discussed in *Basten and Koch (2015)*. As a result, if a house valued at CHF 1 million is financed with a mortgage of CHF 666'667, the entire mortgage receives a risk-weight of 35% and thus results in risk-weighted assets (RWA) of only 233'333. By contrast, for a mortgage of CHF 800'000, the 133'333 above CHF 666'667 receive a risk-weight of 75% and therefore result in RWA of 100'000, so that RWA for the entire mortgage increase to CHF 333'333. Depending on the regulator's classification of the bank into one of five risk classes, the bank must then refinance between 10 and 15% of the RWA with equity rather than with borrowed money like deposits or covered bonds, which is typically considered more expensive due to amongst other things taxation. The relevance of the LTV ratio for the credit risk associated with a mortgage is formulated more formally in, amongst others, *Campbell and Cocco (2015)*. In the same vein, credit risk is ceteris paribus greater if the borrower starts with a higher loan-to-income (LTI) or payment-to-income (PTI) ratio, or if – as studied in this paper —house prices in the area where the applicant would like to buy are more likely to be unsustainable. Yet neither of these two factors is taken into account when computing risk weights in the Swiss standardized approach, in particular in the case of inter-regional differences because it is harder to agree on how to best measure these. To summarize, economic capital considerations would suggest that banks should be more conservative about mortgage lending in regions with larger risk of house price bubbles, whereas regulatory capital considerations would suggest that they focus only on the risk driver LTV. Only the data will tell which of these predictions the banks studied follow more.

[3] www.admin.ch/opc/de/classified-compilation/20121146/index.html

[4] Often mortgages are split into separate tranches that correspond to these LTV brackets and that may differ in terms of rate fixation period, contract period or mortgage rate, but they do not have to be split along these lines by regulation.

2.2 Hypothesis on Regional Diversification

Beyond the region-specific risk of house price over-heating, which would be the same for every potential lender, there is also the bank-specific consideration to trade off a greater diversification of its mortgage portfolio across regions against focusing on regions it knows better or where it can better influence prices nor or in a downturn. Looking at the existing literature, *Quigly and Van Order (1991)* have analyzed how actual mortgage defaults are correlated intra- and inter-regionally and infer that mortgage portfolios are indeed riskier if they are less regionally diversified. As a consequence they suggest that capital requirements associated with mortgage lending should be higher not only when the LTV ratio is higher but also when the bank's portfolio is less diversified. However, absent such sophisticated regulation their paper does not yet tell us whether or how banks do actually adjust their lending policies in the first place to improve their geographical diversification.

On the other hand, *Favara and Giannetti (2017)* show both theoretically and empirically that a bank with many mortgages in the same area can better internalize the negative externalities of collateral liquidations on the prices of other nearby collateral in an episode of increased defaults. This by itself would speak in favor of seeking to sufficiently dominate one area in order to internalize and therefore ideally remove that externality. Furthermore, *Agarwal and Hauswald (2010)* show that banks find it easier to screen firm lenders located closer to them, which is typically the place where a bank has already done most lending in the past. This finding, which arguably applies also to evaluating borrowers and collateral in the mortgage market, would seem to also speak in favor of concentrating more on regions already known as opposed to seeking to diversify more. However, other than in the past when a bank had to send someone physically visit real estate to value it, nowadays most valuation is done with hedonic models run by banks themselves or supplied by real estate consultancies. These also provide reliable data on the current strengths and weaknesses of the municipality where the real estate is located. Hence we would expect prior physical presence to matter less for borrower screening than it did in the past and arguably still does for less standardized lending, such as most of corporate lending. Furthermore, the ability to influence liquidation prices in a downturn is arguably limited to the 1 or 2 largest players in a region. Therefore I argue that the motive to increase inter-regional diversification will dominate:

> *<u>Hypothesis 2:</u> Banks have a higher offer propensity and quote lower spreads for applications from regions where they are currently under-represented.*

2.3 Hypothesis on Regional Competition

Beyond the risk management concern of analyzing and affecting the riskiness of mortgage lending, location matters also through the degree of competition. Firstly it may matter through the distance between borrower and lender: Thus *Degryse and Ongena (2005)* show that Belgian banks manage to charge higher loan prices to firms located closer to them, essentially cashing in on the benefit to firms of not having to travel as far for each physical interaction with their bank. For a mortgage contract per se it is not clear that households get sufficient benefit from being closer to their bank as the number of times they have to physically visit their bank to settle the mortgage contract will be fairly limited nowadays. Yet they may prefer a bank located closer to them because that would also facilitate any other interactions and they may want to bundle their different bank businesses in order to reduce fees and/or time needed for banking. More importantly, different regions will be characterized by different intensities of competition in the mortgage market. Again for corporate lending *Degryse and Ongena (2007)* show that Belgian banks' competitive aggressiveness depends amongst others on how much they interact with their competitors also in other regions. This again is something that may be relevant also in the mortgage context.

More specifically, I expect that banks will offer lower spreads in regions in which competition is more intense. To measure the intensity of competition, I resort firstly to the standard Herfindahl-Hirschmann Index (HHI) based on banks' pre-existing mortgage portfolios, both offline and online. Secondly, following *Degryse and Ongena (2007)*, I employ a measure of banks' Multi-Market Contact (MMC), which I also compute on the basis of pre-existing portfolios of mortgages granted both offline and online. Thirdly, I look at the number of competitors that also bid for customers in the same canton on the Comparis platform, a measure varying between 4 and 11- On these grounds I posit:

> *<u>Hypothesis 3:</u> Banks will offer lower prices in cantons in which competition on either of the three measures is deemed more intense.*

Given these hypotheses, I next explain how I put them to the data.

3 Data

The key data used in this project are data from the Swiss website *Comparis.ch.* Between 2008 and 2013 they operated a portal on which households could apply for mortgages and were then provided responses from several different banks. The resulting data are unique and offer at least four advantages for my analysis. First, I separately observe demand and supply. Second, banks in their operation and me in analyzing them can close down the effects of banks' differential access to clients from different regions based on amongst others pre-existing branch networks. Third, I can rule out that different banks tend to interact with different types of clients. And fourth, I observe 100% of the information each bank also has on each client.

In particular the feature of observing how different banks respond to the same client has to the best of my knowledge been a feature achieved only by researchers working on lending to larger corporates, such as *Jimenez et al (2012)* and *Jimenez et al (2014).* By contrast, households engaged in mortgage borrowing have not been observed to interact with several different banks. Yet *Jordà et al (2016)* and many other papers by these and other authors have shown forcefully the importance of the key role of mortgage markets in causing banking, financial and general economic crises, given that mortgages tend to be the largest financial liabilities of most households, as well as the largest class of assets for many banks.

For the present purpose, the data include two outcomes of interest. First, an indicator of whether a specific bank makes an offer to a specific client. Second, given that it does, the rate offered. Offers can consist of between 1 and 3 tranches of different amounts, which may differ in the rate fixation period as well as in the offered mortgage interest rate. For each tranche, I subtract from the offered mortgage rate the swap rate for the same fixation period applicable on the day of the offer, as available through Bloomberg. This is to reflect the bank's refinancing costs absent any maturity transformation and is the measure of refinancing costs commonly used in the market under study, cf. in *Basten and Koch (2015)* and *Basten and Mariathasan (2017)*. Finally, I compute the weighted average across the up to three tranches, with weights given by the fractions of the total mortgage amount attributable to the respective tranche.

While the Comparis data on mortgage applications and offers are available for 2008-13, most other data of interest unfortunately start only in 2010. Therefore I focus on the years from 2010 onwards. In particular, I first resort to banks' annual reports to obtain data on their total assets, mortgages over total assets, CET1 capital over total assets and deposits over total assets, as well

as their cushion of CET1 over risk-weighted assets minus the regulatory requirement for that. In addition and important for the present analyses, I was able to obtain supervisory data on the volumes of mortgages already on banks' balance sheet by bank, year and canton (state).

Furthermore I add data on possible house price bubbles taken from Fahrländer Partner Real Estate (FPRE). Together with Wüest und Partner (WuP) and IAZI, FPRE is one the three leading Swiss real estate consulting companies who, amongst other services, provide hedonic models that allow banks to gauge whether the market price a potential mortgage borrower wishes to pay is deemed appropriate. On the basis of these and further data, FPRE also predict every year to what extent real estate prices in each of 106 statistical ("MS") regions defined by the Federal Office of Statistics are deemed over-heated. This measure exists for years 2008-13, so I lag it by one year to ensure the current figure is likely known to all banks when making their decisions. In the resulting data, the average across all 106 regions starts at 117% at the start of my sample period increases to 155% by its end, with the standard deviation increasing from 12% to 17%. For more details on this measure, see *FPRE & BAK Basel (2009).*

I have also been provided an ordinal measure by Wüest und Partner (WuP) consultants which estimates house price bubble risk in each of the up to 2'538 Swiss municipalities as "very small", "small", "intermediate", "high" or "very high". However, unfortunately their measure is available only for 2011-13 so that with a one year lag I would have to restrict the sample to bank responses made in 2012 or 2013. Finally, I was able to obtain data on the "UBS Bubble Index", published each quarter by the research department of the country's largest bank, UBS, in their newsletter "Schweizer Immobilien" (Swiss real estate). They provide a binary indicator of whether or not house prices in each of the 106 statistical regions are deemed at bubble risk, but they as well start only in 2010q3, so that with lagging I could use their data at the earliest starting in 2010q4. Hence my analyses of house price bubble risk focus on the FPRE measure.[5]

Overall I start with 6'920 applications submitted in 2010-13, which attract a total of 25'137 responses. 20'593 of these are offers and 4'544 rejections. Table 1 shows the corresponding Summary Statistics. To provide a picture that corresponds as closely as possible to the data used for the subsequent regressions, the summary statistics use the same number of observations as the regressions. Thus the upper panel which focuses on the key characteristics of the mortgage applications assigns more weight to applications that — depending on the time they were

[5] Nonetheless, I very much thank all three for supplying the respective data.

submitted — received more responses. The number of responses varied between 1 (in 1.53% of cases) and 10 (in 0.04% of cases), most applications received between 3 and 6 responses, the average application about 4 responses. The mortgage amount applied for, and which by design could not be adjusted by the responding banks, varied between CHF 100'000 and CHF 2'000'000, with an average value of CHF 566'403. The Loan-to-Value (LTV) ratio varied between 15% and 90%, with an average value of about 65%. Here the maximum is shaped by the fact that for any mortgage violating the self-regulatory requirement of at least 10% of "hard equity" from the household, the bank willing to provide it would face a regulatory risk weight of 100% instead of on average about 40%. The Loan-to-Income (LTI) ratio varied between 0.69 and 9.62, with an average of about 3.59. Average house prices across the 106 statistical regions and across 2010-13 were considered to amount to between 94% and 200% of sustainable prices by FPRE consultants, with a mean of 130% reflecting the wide-spread perception that after increasing since the mid-1990s house prices were due to correct somewhat at some point.

To give some context, the Swiss mortgage market during the years studied is particularly interesting to study with respect to inter-regional differences in credit risk, for during the period studied the market as a whole was widely considered overheated, as emphasized e.g. *SNB (2013)*, *FINMA (2014)* or in leading domestic media. Furthermore, the Swiss mortgage market is characterized by a relatively large number of banks offering mortgages, allowing to analyze the impact on mortgage offers of many more bank characteristics than in markets dominated by only a handful of banks.[6] Given higher risk weights under the Swiss Standardized Approach (applying in 2010-13 to all banks in my sample and more generally to all but the two G-SIBs UBS and CS) and hence higher costs to clients for mortgages with LTV ratios above 80%, most borrowers started with LTV ratios below 80% (see Summary Statistics) then reduced this to 67% within 20 years as required by the self-regulation of the Swiss Bankers' Association. By contrast, they did typically not amortize any further than required, because higher outstanding debt tended to reduce income tax and (in some cantons) wealth tax liabilities. Instead of amortizing more, any disposable income not consumed was typically used for other investments. Instead of fully amortizing their mortgage, borrowers would typically roll it over with the same or another bank whenever it matured. Typical mortgage rate fixation periods ranged between 3 months and 10 years. Furthermore, Swiss mortgage borrowers could typically

[6] In the Swiss market, insurers and pension funds are allowed to and do also offer mortgages. However, during the years studied their combined market share was below 5%. Furthermore, while insurers were known to offer competitive prices on some 10-year mortgages given their more long-term liabilities, they have typically focused on very low-risk cases only. So I focus on banks only, even though the Comparis data cover also several insurers.

apply for either Fixed-Rate Mortgages (FRM) whose mortgage rates are fixed for the entire maturity of between 1 and 10 years, or for Adjustable Rate Mortgages (ARM) where the contract period and maturity is typically either 3 or 5 years but rates reset with the CHF libor every 3 months. For more details on Swiss retail banks, see *Basten and Mariathasan (2018)*.

Looking at bank characteristics, where banks are again weighted by the number of responses they submitted, total assets (TA) range between CHF 434 million and about CHF 37 billion, with an average of about 17 billion. Between about 40 and 90% of these, and on average 70% of them are invested in mortgages, which reflects the general focus of Swiss retail banks on mortgage lending, cf. *Basten and Mariathasan (2018)*. On the liability side, the most important position for most banks are deposits, with a range between about 17 and 66% and an average size of 48%. The leverage ratio of CET1 capital over total assets ranges from 3.7% to 11.29%, with a mean of 6.29%, reflecting a typically higher capitalization than amongst international G-SIBs. When scaling CET1 by capital by RWA instead of TA, this roughly doubles, reflecting an average RW of about 50% that comes about as a weighted average between an average risk weight of about 40% on mortgages in the Swiss Standardized Approach (see *Basten and Koch, 2015*) and higher risk weights for corporate and consumption loans. The cushion banks just have above their regulatory intervention threshold amounts to on average 5.27% of RWA, but ranges between -1.28% and +15.31%. Thus at least one bank in our sample was violated the threshold, in which case the supervisory authority proposes measures to rectify this. About 82% of the responses resulted in offers, the price of which did on average exceed banks' interest rate risk adjusted refinancing costs by 49-152bp. to cover credit risk, operating costs and profits.

One important question when analyzing data from online lending is how representative these are of the Swiss mortgage market as a whole. To analyze this, we start with the key risk characteristics of the households. The best available benchmark for this is SNB (2014). Based on bank survey that covers the 25 largest mortgage lenders and thereby 80% of the market, it reports that 7% of mortgages start with an LTV value above 80%, which corresponds very closely to the value of 8% in our sample. Furthermore, they report 18% of households starting with a Payment to Income (PTI) ratio above 33%, where the annual payment is computed as 5% of the loan for interest plus 1% for amortization plus 1% of the loan for house maintenance. When I multiply my LTI ratios with 0.07, I find that 17% of households start out with a PTI ratio in excess of 1/3. While I cannot formally compare the two percentages with a t-test for lack of data on standard deviations in the SNB data, the differences of 1 percentage point each suggest that from the household side the Comparis data are very much representative of the

market as a whole, featuring neither a flight of particularly risk households from offline to banks to the website nor an above-average eagerness by particularly safe households to obtain better conditions online.

Next and at least as important given the focus of this paper on geography, Table A1 presents the distribution of all 6'920 mortgage applications submitted between 2010 and 2013 across the 26 cantons (states), in Column (1) in terms of absolute numbers and in Column (2) in terms of percent. In Column (3) it then compares that distribution with the percent of new mortgage borrowers in the Swiss Household Panel (SHP) by the Swiss Federal Office of Statistics stemming from each of the 26 cantons. A new mortgage borrower is defined as a household who first transitions from renter to home owner in 2008-13[7] and therefore has mortgage debt in 2014. Finally, Column (4) presents the distribution of cantons of all existing mortgages on bank balance sheets as of 2013. Overall, I find that the distribution of applications is quite representative of the market as a whole and is not for example biased toward more urban areas or toward any Switzerland's four language regions.

Likewise, Table A2 contrasts the geographical distribution of the headquarters of the 27 banks in our sample with that of the universe of Swiss retail banks used in *Basten and Mariathasan (2018)*. In that paper, they start out from the universe of all Swiss banks and then zoom in on the 50 retail banks by following the supervisor's definition of a retail bank as one that earns at least 55% of its income either as net interest income or as loan fees, as opposed to from proprietary trading or from wealth management fees. Of course the distribution of banks is less smooth in my sample than that of households given only 27 banks in total. Yet, importantly for the present purposes, one observes that the sample includes banks from across the country with greater numbers of banks stemming from the most populated cantons Zurich, St. Gallen and Berne as well as Aargau and Basel, but also representatives from French-speaking Geneva, Valais and Vaud as well as from Italian-speaking Ticino. Overall this makes me confident that the findings presented below are representative of bank behavior across all of Switzerland. Given the extreme heterogeneity of Switzerland in terms of language, religion, topography and urbanization, it may furthermore be argued that despite the limited size of the country behavior is also representative of that in larger, but less heterogeneous countries.

[7] I start in 2008 to make the distribution sufficiently representative.

4 Empirical Strategy

The present setup allows to identify banks' pure preferences about borrower locations as they can equally bid for mortgages from the entire country. One important issue to be solved beyond that however is that banks can respond to each application along two dimensions: First, they can decide whether to make an offer or a rejection. Second, if they make an offer, they can choose which spread over current (maturity-congruent) refinancing costs to quote. In line with Edelberg (2006), who argues that conceptually there is always a price at which banks should be willing to make an offer, if necessary at infinity, the data show that indeed banks do make an offer in most cases, suggesting that the pricing dimension is likely more important in this setup. Yet especially with a view to applicants from different regions it is also possible that some banks do at least in some cases specify their policy in a binary way rather than through a pricing function simply because this is easier and indeed we do still observe rejections. Then however the question arises whether our estimates on the effects on pricing are biased, because we observe pricing outcomes only conditional on banks making an offer in the first place.

To test whether this is indeed an issue, we need a Heckman selection model as first proposed by *Heckman (1979)*. In a first step, this model uses a probit specification to estimate the propensity for the bank to make an offer at all and hence to quote a mortgage price. In the second step we can then control for the propensity for observing a price. What is needed for this to work econometrically is that beyond all the regressors we include in the second step we need at least one variable that demonstrably does affect the offer propensity but that does plausibly not directly affect banks' pricing behavior. A sensible variable to employ for this purpose is a dummy for the interaction taking place in the 2nd half of the year, because banks may set targets for the overall volume of new mortgage lending they wish to make in a year in total or even more specifically online, and may end up offering less often towards the end of that year if the target has already been reached or is closer to being reached than towards the start of that year. After conversation with practitioners we envisage this to be a binary decision on whether or not to keep offering, whereas the time of year should not directly affect banks' pricing behavior. On these grounds I have re-estimated all relevant equations using a Heckman selection model. The results, which I currently report at the end of the results section, broadly confirm the results obtained without this strategy. Therefore I have decided to keep reporting the simple estimates first, as these can be understood by a yet broader audience, and show their robustness to a Heckman procedure after that.

In the analyses about regional diversification, I first compute the total volume of all outstanding mortgages across all banks across Switzerland and separately for each canton, then use these figure to compute which fraction of the Swiss mortgage market each canton accounts for. This will differ across cantons not only because cantons differ in their number of inhabitants, but also because of differences in ownership rates and average house prices. Then I likewise compute for each bank how the mortgages already on its balance sheet are distributed across the 26 cantons. Finally, I compute an indicator "Over-Represented" that takes the value 1 whenever a bank responds to an application from a canton that already constitutes a larger share of that bank's portfolio than it does on average across all banks. Typically this will be the case in the canton in which the bank is headquartered as well as in nearby cantons, but typically not in far-away cantons in which banks tend to have fewer branches and are less well known.

When analyzing the effects of competition in each cantonal mortgage market, I use three measures. The first is the well-known Herfindahl-Hirschmann Index (HHI), which is the sum of squared market shares. Hence in the hypothetical case in which one bank provided 100% of all mortgages in a canton, the HHI would assume the value 1. If by contrast the market is shared by many infinitely small banks, it approaches zero. In the present context, it ranges across the 26 cantons from 0.12 in the canton of Berne to 0.49 in Appenzell Innerrhoden.

The second measure is the Multi-Market Contact (MMC) index as previously used by amongst others *Degryse and Ongena (2007).* They refer to work a number of sources that introduced the "linked oligopoly" hypothesis, whereby banks with multi-market contact find it easier to collude, as punishment for non-collusion is larger. Under that hypothesis, more MMC would be expected to weaken competition. On the other hand, they refer to other work that argues the opposite: When firms cannot observe their competitors' true marginal cost, they have an incentive to initially flood a market with goods at prices below marginal cost so as to pretend lower marginal cost and hence persuade competitors to leave. By contrast, when the same firms interact in more markets, this becomes more difficult so that more multi-market contact is argued to increase rather than decrease competition. To tackle the issue empirically, one must compute an indicator D_{ij} that takes value 1 if and only if bank i operates in canton j. Then one can compute $a_{kl} = \sum_{j=1}^{26} D_{kj} D_{kj}$ for each pair of banks k and l and across all 26 cantons j. Furthermore, one defines f_j as the number of different banks operating in canton j. Then the MMC measure is defined as $MMC_j = \frac{2}{26(f_j(f_j-1)} \sum_{k=1}^{104} \sum_{l=k+1}^{104} a_{kl} D_{kj} D_{lj}$. Then MMC represents the sum of all pairs of banks in the applicant's canton, weighted by the

relative frequency of their contacts in other cantons. It can take values between zero (no contact elsewhere) and one (when all banks in the canton also meet each other elsewhere). Indeed in our setup it ranges between 0.046 and 0.405. Furthermore, comparing all cantons in year 2010, we find a correlation of 0.67 between HHI and MMC: Thus in cantons which according to the HHI measure have more concentrated mortgage markets banks interact with more banks with which they also interact in other cantons. This by itself would tend to suggest that higher MMC measures here are associated with less rather than more competition, but let us see what the outcome data say. In their work, *Degryse and Ongena (2007)* find that more multi-market contact increases the incidence of Relationship Banking, through which banks can extract higher rents from clients.

Finally. I use the number of competitors in that market specifically in the Comparis online context, where it ranges from 4 to 11. Here the presumption is that banks will ceteris paribus face more competition the more other banks are also searching for clients in that canton. Interestingly, in 2010 the number of other Comparis online providers exhibited a correlation of -0.34 with HHI (and of -0.52 with MMC), suggesting that markets more concentrated in the market as a whole did also attract fewer bidders online. This by itself would suggest that banks deem these cantons, like the rural Appenzell Inner-Rhoden, harder to conquer for banks from further away online just as much as offline, rather than supposing that online they can make up for any competitive disadvantages they might have offline. But let us see whether their bidding behavior does really suggest the same rationing or the opposite.

As additional household controls I use the same measures also available to banks. In particular, I focus on the two common risk measures loan-to-value (LTV) and loan-to-income (LTI) ratio. Since their effects are likely non-linear I use for each risk measure indicators of whether the LTV exceeds 67% and 80%, respectively, defined non-exclusively. These two thresholds do during the period of study also enter regulation of risk-weights in the Swiss Standardized Approach. Likewise, I use non-exclusive indicators for LTI ratios in excess of 4.5 and 5.5 respectively.[8] Whether the bank sends an offer is a binary outcome, so I use logit estimation.[9] The second outcome is continuous, so I use simple ordinary least squares estimation.

[8] The 4.5 threshold corresponds closely to a "Payment-to-Income" (PTI) ratio of 33% when computed with 5% interest, 1% amortization and 1% maintenance cost. This is also commonly used in the market, but the exact interest rate to use here is controversial. Hence I use LTI as it does not depend on interest rate assumptions and is thus more transparent.

[9] Robustness checks with probit or linear probability models yield qualitatively similar results.

5 Results

In the following I present results on how banks' offer behavior and pricing depend on (i) inter-regional differences in the risk of house price over-heating, (ii) the pre-existing inter-regional diversification of the responding bank's mortgage portfolio, and (iii) inter-regional differences in mortgage market competition. All regressions control also for the key household characteristics also available to banks, namely indicators for LTV ratios above 67% and above 80%, as well as for LTI ratios above 4.5 and above 5.5. Specifically for the regressions on banks' prior diversification, which varies across client locations depending on the responding bank's prior portfolio, I can also household fixed effects instead of controls and hence add two columns doing so, whereas for bubble risk and competition do not vary within clients.

Overall I find consistently across Tables 2-7b that applications with LTV ratios above 67% and even more so with LTV ratios above 80% are less likely to receive an offer. The same is true of applications with LTI ratios above 4.5 and even more so for LTI ratios above 5.5. Similarly robust across all tables, we find that conditional on receiving an offer these more risky applications are offered higher prices, suggesting that the offer and the price margin are not used as substitutes but as complements of implementing the same risk management strategy. When we look at Heckman robustness checks in Table 7a, these results are largely confirmed with risk premiums charged again for any mortgage with LTV above 67% or with LTI above 4.5. A slight twist in which Heckman results differ from the simpler ones reported above is that conditional on making an offer at all, banks tend on average to somewhat moderate the surcharge again for LTV ratios above 80% or LTI ratios above 5.5: Presumably when they do make an offer in these cases despite the added risk, they have good reasons for doing so, such as large additional assets of the household, so that they do not need to set the price quite as high.

While across Tables 2 through 6 Columns (1) and (2) control only for key household characteristics, Columns (3) and (4) control additionally for the responding bank's total assets (logged to account for its skewed distribution), mortgages over total assets, deposits over total assets and risk-weighted capitalization cushion, all measured in the December preceding the date of the mortgage application and response. Again across Tables 2-6 and confirmed in the Heckman regressions in Tables 7a-7b, I find that larger banks are more likely to respond with an offer, as well as to quote a more competitive price conditional on offering. I attribute both findings to these banks' higher efficiency on average. The same is true for banks whose balance

sheet is already focused more on mortgage lending as opposed to for example corporate lending, consumption loans or financial assets.

Looking at the liability side, I find that banks whose balance sheets are to a larger degree financed through deposits as opposed to e.g. covered bonds or especially interbank loans tend to reject applications more often, and when they do make an offer tend to be more expensive. Like for all bank level variables this is to be interpreted as a correlation rather than necessarily as a causal effect. Thus one possible explanation is that banks with particularly ambitious mortgage growth plans are more likely to borrow extra money from sources like other banks, whereas banks with less ambitious growth plans may to a larger extent make do with the deposits their clients bring in anyway, given that even with changes in deposit rates deposit volumes are harder to fine-tune for the bank than e.g. interbank lending. Relatedly, banks whose Core Equity Tier 1 Capital as a percentage of risk-weighted assets gives them a larger cushion vis-à-vis the minimum value below which the supervisor would intervene[10] are found across all tables to make if anything fewer offers (not statistically significant at the conventional levels) and conditional on making an offer tend to quote less competitive prices (statistically significant at 1%). This suggests that these are generally banks with a more cautious strategy, rather than that they happen to exceed their requirements by more and are hence willing to run more risk on the asset side of their balance sheet. After these general findings, let us now proceed specifically to the effects of regional house price bubble risk, banks' pre-existing regional diversification, and cantonal market competition.

[10] Intervention thresholds differ depending on which of five risk categories a bank has been assigned to by the supervisory authority FINMA. For details, see FINMA Circular 2011/2.

5.1 Results on Over-Heating Risk

Table 2 analyzes how banks respond to inter-regional differences in the risk of house price over-heating as explained above. Regardless of whether I do or do not control for further bank characteristics, I consistently find that for each 10% by which the average actual real estate price in the statistical area exceeds the price FPRE consultants would consider sustainable, the bank charges 0.037 percentage points or 3.7 basis points extra as a risk premium. The results also suggest that for each 10 percentage points higher estimated over-heating the average bank is between 0.4 and 1.3 percentage points less likely to make any offer at all, although the latter effect is not statistically significant at the conventional levels. Results on prices are very similar, if anything even slightly larger looking at the Heckman results in Column (1) of Table 7a. These results confirm *Hypothesis 1* above. The size of these results is certainly economically significant: If one bank did not charge this risk premium add-on, its offer would be more attractive to the household receiving it and it might hence prefer that offer. But the value of the underlying collateral is might well drop by a larger percentage in the next real estate crisis which often happens after significant interest rate increases in which not all borrowers are able to keep servicing their mortgage and banks might therefore have to liquidate some of the collateral at prevailing market prices. Not all banks in our sample did necessarily for all areas follow and incorporate specifically the bubble risk estimations by FPRE consultants, but they may have followed other estimates correlated with those. While a high measure by FPRE consultants does not say for sure that these areas will see larger house price declines in the coming downturn, they may at least have a relatively higher risk thereof and hence it is reassuring to see that banks are on average taking that into account in the online context. In fact it may be easier to take it into account in an online context with equal access to clients from across the country than in an offline context where, depending on the bank's existing network of branches, only clients from some regions and not from other may come and ask for the bank's offer in the first place.

5.2 Results on Regional Diversification

Table 2 has analyzed how banks' responses vary with each of the 106 statistical regions' estimated risk of house price over-heating. Beyond this is some consensus that the higher house prices are relative to rents or income, the higher the likelihood of a larger price collapse in the next downturn. Yet beyond these agreed measures, regional house prices may vary also with changes in preferences for living in the center or country-side or with sector-specific shocks that affect some regions more than others, and of course not all such changes are predictable ex ante. That speaks in favor for banks to diversify their portfolio across regions, i.e. seek to acquire more new business in areas that are currently under-weighted in the bank's existing portfolio and vice-versa. Table 3 thus analyzes how banks' decisions depend on whether the bank is so far "over-represented" in the applicant's canton, i.e. whether the share of that canton in its country-wide mortgage portfolio exceeds that of the entire market. The results in Column (1) do indeed suggest that whenever this is the case, the bank is on average 7 percentage points less likely to make an offer, although this effects shrinks to 3.4% and loses its statistical significance at conventional levels once we control for the full set of bank characteristics in Column (3). By contrast, regardless of the set of controls we significantly find that conditional on making an offer banks quote a 1.5-4.5bp. higher price in regions already over-weighted in their portfolio than in those so far under-weighted. The latter result is qualitatively confirmed in Column (6), which replaces household characteristics with household fixed effects, as well as by Table 7a that controls first for the bank's likelihood of sending an offer in the first place.

These results suggest that banks do indeed use the online channel to improve their regional diversification, an objective arguably harder to achieve offline. They seem not bothered by concerns that they have insufficient local knowledge of regions so far under-represented in their portfolio, which seems sensible given the availability of the same hedonic models for all of Switzerland as well as reliable public statistics for all of the country.

Hence this opportunity to improve their inter-regional diversification appears to be a benefit of the online channel both for the risk management of individual banks and for overall financial stability, which complements the greater potential of online lenders to quickly respond to changes in demand without necessarily incurring additional risk, as found for US FinTech mortgage lenders by *Fuster et al (2018).*

5.3 Results on Regional Competition

Table 4 looks at the effect on banks' rejection and pricing strategies of the intensity of competition in the local mortgage market. To analyze this, I treat each of the 26 states as a separate mortgage market. This is justified by the fact that cantonal banks as well as many regional banks are active in only one or a few cantons and according to practitioners the top management chooses which states to be active in, rather than going by e.g. the more granular districts or postcode areas, or the less granular linguistic areas of respectively German-, French- and Italian-speaking Switzerland. For the same reason, the supervisory authority does annually collect data on each bank's mortgage portfolio separately for each of the 26 cantons, which I was able to use for the analyses presented here. Interestingly, the results in Table 4 suggest that in cantonal markets that are so far more concentrated banks are now more likely to offer and conditionally on making an offer tend to quote more attractive rates. This result, which is confirmed by the Heckman analyses in Tables 7a-b, is at first sight surprising. At second sight we may rationalize it with the idea that online banks are particularly eager to enter markets that so far are more concentrated, hoping to reap larger profits there if not in the current online mortgage lending then in offline lending to other clients or in other business with the same clients may ensue once they have a foot in the door of these cantons.

Table 5 then takes the effect of cantonal competition further by analyzing banks' responses to meeting more competitors to which they are also exposed in other cantons, as assessed by the MMC measure previously used by amongst others *Degryse and Ongena (2003)*. Here I find no statistically significant effect on banks' offer propensity, but do find that banks tend to offer more aggressive prices in cantons where they meet more competitors also met elsewhere. Of the two opposite hypotheses *Degryse and Ongena* offer on MMC, this supports the one that MMC makes it easier for banks to infer each other's costs, thus reinforcing competition.

Finally, Table 6 focuses only on the number of competitors who also bid for applications from that canton on the Comparis website. This would appear the more relevant measure of competition intensity specifically if I assume that once a client has moved online she will likely also pick one of the offers received there rather than going back to some offline offer. Indeed I find that in cantons with more online competitors banks are more likely to make an offer and conditional on doing so tend to offer lower prices, both results being confirmed by the Heckman analyses in Tables 7a-b. I deem the online-focused measure of competition the most relevant and hence overall see *Hypothesis 3* as confirmed.

6 Conclusion

In this paper I have analyzed how banks' decision which household they would like to offer a mortgage and at what price depends on where the collateral of the applicant is located. Normally we observe at best which clients a bank ends up serving after a loan-level contract has been concluded, but we cannot separate to what extent the resulting regional distribution of the bank's mortgage portfolio expresses the bank's pure eagerness to serve a particular region and to what extent it is simply the consequence of where the bank has historically established a network of branches, reputation, and so on. This paper by contrast exploits data from an online portal in which each bank can equally offer a mortgage to clients from across the country, thus removing the shadow of history. Of course this is not only a convenient analytical tool to keep fixed banks' differential costs of venturing into different regions, but does also truly enlarge banks' own opportunities.

The present analyses suggest that in the period studied Swiss retail banks have seized these opportunities wisely. In line with a generally cautious behavior vis-à-vis clients with higher credit risk as evidenced by higher LTV and LTI ratios, banks have likewise behaved more cautiously whenever an applicant hailed from a region where house prices were deemed more likely to be over-heated and hence to have larger depreciation risk in the next downturn. In the same vein, we find that banks exploit the online channel particularly to improve the inter-regional diversification of their mortgage portfolio: Thus they are more likely to make an offer, and conditional on making one tend to quote more attractive prices, to clients hailing from cantons so far under-weighted in the bank's mortgage portfolio than to clients from regions where it possesses a strong presence already. Arguably such objectives can be achieved at lower cost online than offline, with risk management benefits that may benefit participating banks and, through system risk, may thus also benefit the economy as a whole. Finally, at least when focusing on the intensity of competition online, I find evidence that the presence of more competing providers encourages banks to make more offers and price them more competitively. Since LTV, LTI and Overheating risks do still seem to be priced in, this increase in competition is arguably to the benefit of potential borrowers.

Overall then, I infer that the technological possibility of mortgage applications and responses online can along several dimensions improve economic welfare, consistent with the findings in *Fuster et al (2018)*. Of course this presupposes that information submitted online can be verified just as it could offline, but in the context studied this condition appears to be met.

References

Agarwal, Sumit, & Robert Hauswald, "Distance and Private Information in Lending" *Review of Financial Studies,* Vol. 23, Issue 7 (2010).

Basten, Christoph, & Catherine Koch. "Higher Bank Capital Requirements and Mortgage Pricing: Evidence from the Counter-Cyclical Capital Buffer." *BIS Working Paper No. 511*, (2015).

Basten, Christoph, Benjamin Guin & Catherine Koch. "How Do Banks and Households Manage Interest Rate Risk? Evidence from the Swiss Mortgage Market." *CESifo Working Paper No. 6649* (2017).

Basten, Christoph, & Mike Mariathasan. "How Banks Respond to Negative Interest Eares: Evidence from the Swiss Exemption Threshold." *CESifo Working Paper No 6901* (2018).

Campbell, John, & Joao Cocco. "A Model of Mortgage Default." *Journal of Finance* 70, No. 4 (2015).

Degryse, Hans, & Steven Ongena. "Distance, Lending Relationships, and Competition" *Journal of Finance,* Vol. LX, No. (2005).

Degryse, Hans, & Steven Ongena. "The impact of competition on bank orientation" *Journal of Financial Intermediation* 16 (2007).

Edelberg, W. (2006). Risk-based pricing of interest rates for consumer loans. *Journal of Monetary Economics*, 53(8), 2283-2298.

FPRE & BAK Basel, "Immoprog 2009. Prognosen der regionalen Immobilienmärkte für Geschäfts- und Wohnflächen." *Fahrländer Partner Real Estate*, Zurich (2009).

Favara, Giovanni, & Mariassunta Giannetti. "Forced Asset Sales and the Concentration of Outstanding Debt: Evidence from the Mortgage Market." *Journal of Finance*, Vol. LXXII, No. 3 (2017)

FINMA, "Annual Report 2013." *Swiss Financial Market Supervisory Authority FINMA*, Berne (2014)

Fuster, Andreas, Matthew Plosser, Philipp Schnabel, & James Vickery, "The Role of Technology in Mortgage Lending", *FRBNY Staff Report No. 836* (2018)

Michelangeli, Valentina, & Enrico Sette. "How Does Bank Capital Affect the Supply of Mortgages? Evidence from a Randomized Experiment." *BIS Working Paper* 557, (2016).

Heckman, James, "Sample selection bias as a specification error". *Econometrica* (1979).

Jiménez Gabriel, Steven Ongena, José Luis Peydró, & Jesús Saurina. "Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications." *American Economic Review* 102, (2012).

Jiménez Gabriel, Steven Ongena, José Luis Peydró, & Jesús Saurina. "Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk?" *Econometrica* 82, No. 2 (2014).

Jordà, Òscar, Moritz Schularick, & Alan M. Taylor. "The great mortgaging: housing finance, crises and business cycles Economic Policy." *Economic Policy* 31, No. 85 (2016).

Quigley, John, & Robert Van Order. "Defaults on mortgage obligations and capital requirements for U.S. savings institutions." *Journal of Public Economics*, 44 (1991).

SNB, "Financial Stability Report 2014", *Swiss National Bank,* Berne (2014)

Tables

Table 1: Descriptive Statistics

	Obs	Mean	SD	Min	Max
Year	25'137	2011	1	2010	2013
Month	25'137	6	3	1	12
Amount	25'137	566'403	332'756	100'000	2'000'000
LTV	25'137	64.50	17.30	15.00	90.00
LTV > 67 (0/1)	25'137	0.53	0.50	0.00	1.00
LTV > 80 (0/1)	25'137	0.08	0.26	0.00	1.00
LTI	25'137	3.59	1.52	0.69	9.62
LTI > 4.5 (0/1)	25'137	0.23	0.42	0.00	1.00
LTI > 5.5 (0/1)	25'137	0.08	0.27	0.00	1.00
FPRE Overheating	25'137	1.30	0.13	0.94	2.00
HHI Concentration	25'137	0.19	0.05	0.12	0.49
Multi-Market Contact (MMC)	25'137	0.07	0.03	0.05	0.40
No. of Online Providers (NOP)	25'137	10.92	2.53	4.00	14.00
Total Assets (CHF mio.)	25'137	16'933	12'841	434	37'804
Mortgages/TA	25'137	69.82	10.43	39.79	90.62
Deposits/TA	25'137	47.80	17.90	16.72	65.63
CET1/TA	25'137	6.29	1.64	3.70	11.29
CET1/RWA	25'137	12.87	4.18	6.52	22.71
CET1 Cushion (% of RWA)	25'137	5.27	4.19	-1.28	15.31
Offer (0/1)	25'137	0.82	0.38	0.00	1.00
Offered Fixation Period	20'593	7.36	2.93	0.25	10.00
Weighted Interest Rate	20'593	2.16	0.56	0.93	3.25
Weighted Spread	20'593	0.90	0.21	0.49	1.52

The top panel shows the characteristics of the mortgage applications for all mortgage responses sent between 2010 and 2013, so the weight of each application corresponds to the number of responses it receives. The middle panel shows bank-relevant characteristics of the region where the collateral of the applicant is located. The "Overheating" measure by Fahrländer Partner Real Estate (FPRE) expresses for each of 106 statistical regions and each year the average actual house price in percent of the average "sustainable" house price. The HHI, MMC and NOP measures of competition vary across the 26 Swiss cantons. The bottom panel shows key characteristics of the corresponding responses. Weighted Spread refers to the price of an offer, averaged across the 1-3 tranches, where the weight of each tranche corresponds to its amount. Spread refers to the difference between the offered mortgage rate and the refinancing cost for the same maturity prevailing on that day, as measured by interest swaps data.

Table 2: Risk of House Price Over-Heating

	(1) Offer	(2) Price	(3) Offer	(4) Price
FPRE Overheating	0.044	0.368***	0.129	0.374***
	(0.134)	(0.012)	(0.133)	(0.012)
LTV > 67% (0/1)	-0.063*	0.066***	-0.045	0.067***
	(0.037)	(0.003)	(0.037)	(0.003)
LTV > 80% (0/1)	-1.417***	0.011	-1.426***	0.010
	(0.053)	(0.008)	(0.054)	(0.008)
LTI > 4.5 (0/1)	-0.316***	0.017***	-0.310***	0.011***
	(0.046)	(0.004)	(0.046)	(0.004)
LTI > 5.5 (0/1)	-1.343***	0.033***	-1.416***	0.027***
	(0.062)	(0.008)	(0.062)	(0.008)
Ln(Total Assets)			0.053**	-0.032***
			(0.027)	(0.002)
Mortgages/TA			0.022***	-0.001***
			(0.003)	(0.000)
Deposits/TA			-0.023***	0.000***
			(0.002)	(0.000)
CET1 Cushion			-0.007	0.010***
			(0.005)	(0.000)
Constant	1.875***	0.384***	0.943***	0.679***
	(0.178)	(0.016)	(0.363)	(0.027)
Observations	25,137	20,593	25,137	20,593
R-squared		0.065		0.136
Estimation	Logit	OLS	Logit	OLS

"FPRE Over-Heating" is an estimate by FPRE consultants of the ratio of actual over sustainable apartment prices per year and statistical region. I use the value from the previous year. Columns (1)-(2) control only for key household characteristics, (3)-(4) also for key bank characteristics. Using request or bank fixed effects does not fundamentally change the coefficients of interest, hence I include instead specific characteristics so as to be able to interpret their coefficients as well. Robust standard errors in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 3: Regional Diversification

	(1) Offer	(2) Price	(3) Offer	(4) Price	(5) Offer	(6) Price
Over-Represented (0/1)	-0.070**	0.015***	-0.034	0.045***	-0.014	0.029***
	(0.034)	(0.003)	(0.039)	(0.004)	(0.048)	(0.003)
LTV > 67% (0/1)	-0.063*	0.064***	-0.046	0.065***		
	(0.037)	(0.003)	(0.037)	(0.003)		
	-		-			
LTV > 80% (0/1)	1.420***	0.003	1.428***	0.004		
	(0.053)	(0.008)	(0.054)	(0.008)		
	-		-			
LTI > 4.5 (0/1)	0.318***	0.022***	0.309***	0.017***		
	(0.046)	(0.004)	(0.046)	(0.004)		
	-		-			
LTI > 5.5 (0/1)	1.345***	0.026***	1.417***	0.020**		
	(0.062)	(0.008)	(0.062)	(0.008)		
				-		-
Ln(Total Assets)			0.053**	0.019***	0.109***	0.026***
			(0.027)	(0.002)	(0.031)	(0.002)
				-		-
Mortgages/TA			0.023***	0.001***	0.034***	0.002***
			(0.003)	(0.000)	(0.003)	(0.000)
			-	-	-	
Deposits/TA			0.023***	0.000***	0.032***	0.000
			(0.002)	(0.000)	(0.002)	(0.000)
CET1 Cushion			-0.007	0.013***	-0.002	0.010***
			(0.005)	(0.000)	(0.006)	(0.000)
Constant	1.967***	0.856***	1.067***	1.028***	0.374	1.192***
	(0.033)	(0.003)	(0.343)	(0.025)	(0.396)	(0.021)
Observations	25'137	20'593	25'137	20'593	25'137	20'593
Borrower FE	No	No	No	No	Yes	Yes
Estimation	Logit	OLS	Logit	OLS	Logit	OLS

"Over-Represented" is an indicator for cases in which the share of that state in the bank's existing mortgage portfolio exceeds the share of that canton in all banks' mortgage loans. The Loan-to-Value (LTV) and Payment-to-Income (PTI) ratio are the main mortgage risk indicators. The log of total assets, the fraction of assets in mortgages, the fraction of liabilities raised through deposits and Core Equity Tier 1 (CET1) capital over risk-weighted assets are the key bank characteristics. Columns (1)-(2) control for other applicant characteristics, Columns (3)-(4) also for bank characteristics, whereas Columns (5) and (6) replace the household characteristics with household fixed effects. Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 4: Herfindahl-Hirschmann Index (HHI) of Competition

	(1) Offer	(2) Price	(3) Offer	(4) Price
HHI	1.157***	-0.575***	0.681*	-0.482***
	(0.361)	(0.033)	(0.369)	(0.032)
LTV > 67% (0/1)	-0.059	0.062***	-0.044	0.064***
	(0.037)	(0.003)	(0.037)	(0.003)
LTV > 80% (0/1)	-1.420***	0.003	-1.429***	0.005
	(0.053)	(0.008)	(0.054)	(0.008)
LTI > 4.5 (0/1)	-0.321***	0.024***	-0.312***	0.019***
	(0.046)	(0.004)	(0.046)	(0.004)
LTI > 5.5 (0/1)	-1.344***	0.026***	-1.417***	0.021***
	(0.062)	(0.008)	(0.062)	(0.008)
Ln(Total Assets)			0.049*	-0.017***
			(0.027)	(0.002)
Mortgages/TA			0.022***	-0.000
			(0.003)	(0.000)
Deposits/TA			-0.023***	-0.000***
			(0.002)	(0.000)
CET1 Cushion			-0.006	0.012***
			(0.005)	(0.000)
Constant	1.717***	0.971***	0.998***	1.080***
	(0.073)	(0.006)	(0.345)	(0.025)
Observations	25,137	20,593	25,137	20,593
R-squared		0.038		0.104
Estimation	Logit	OLS	Logit	OLS

HHI is the Herfindahl-Hirschmann Index of the intensity of mortgage market competition in the state the application is from. Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 5: Multi-Market Contact (MMC) Index of Competition

	(1) Offer	(2) Price	(3) Offer	(4) Price
MMC	0.340	-0.528***	-0.050	-0.453***
	(0.573)	(0.053)	(0.580)	(0.052)
LTV > 67% (0/1)	-0.063*	0.065***	-0.046	0.066***
	(0.037)	(0.003)	(0.037)	(0.003)
LTV > 80% (0/1)	-1.418***	0.002	-1.428***	0.004
	(0.053)	(0.008)	(0.054)	(0.008)
LTI > 4.5 (0/1)	-0.316***	0.022***	-0.308***	0.017***
	(0.046)	(0.004)	(0.046)	(0.004)
LTI > 5.5 (0/1)	-1.345***	0.029***	-1.417***	0.023***
	(0.062)	(0.008)	(0.062)	(0.008)
Ln(Total Assets)			0.057**	-0.021***
			(0.027)	(0.002)
Mortgages/TA			0.022***	-0.000
			(0.003)	(0.000)
Deposits/TA			-0.024***	-0.000
			(0.002)	(0.000)
CET1 Cushion			-0.006	0.012***
			(0.005)	(0.000)
Constant	1.907***	0.902***	1.057***	1.058***
	(0.051)	(0.004)	(0.343)	(0.025)
Observations	25,137	20,593	25,137	20,593
R-squared		0.028		0.097
Estimation	Logit	OLS	Logit	OLS

MMC is a measure of Multi-Market Contact: It measures for each pair of banks how many other cantons they also encounter each other. Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 6: Number of Online Providers in the Canton

	(1) Offer	(2) Price	(3) Offer	(4) Price
No. of Online Providers	0.034***	-0.001	0.032***	-0.004***
	(0.007)	(0.001)	(0.007)	(0.001)
LTV > 67% (0/1)	-0.061*	0.064***	-0.044	0.065***
	(0.037)	(0.003)	(0.037)	(0.003)
LTV > 80% (0/1)	-1.426***	0.003	-1.434***	0.004
	(0.053)	(0.008)	(0.054)	(0.008)
LTI > 4.5 (0/1)	-0.323***	0.022***	-0.313***	0.017***
	(0.046)	(0.004)	(0.046)	(0.004)
LTI > 5.5 (0/1)	-1.337***	0.026***	-1.410***	0.020***
	(0.062)	(0.008)	(0.062)	(0.008)
Ln(Total Assets)			0.077***	-0.025***
			(0.027)	(0.002)
Mortgages/TA			0.022***	-0.000*
			(0.003)	(0.000)
Deposits/TA			-0.025***	0.000
			(0.002)	(0.000)
CET1 Cushion			-0.006	0.012***
			(0.005)	(0.000)
Constant	1.563***	0.873***	0.561	1.099***
	(0.076)	(0.007)	(0.364)	(0.028)
Observations	25,137	20,593	25,137	20,593
R-squared		0.023		0.095
Estimation	Logit	OLS	Logit	OLS

The number of competitors also bidding for applications in the canton ranges from 4 to 11. Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 7a: Heckman Robustness Check for all 3 Hypotheses

	(1) Price	(2) Price	(3) Price	(4) Price	(5) Price
Over-Represented (0/1)	0.044***				
	(0.004)				
FPRE Over-Heating		0.379***			
		(0.012)			
HHI			-0.459***		
			(0.034)		
MMC				-0.452***	
				(0.055)	
No. of Online Providers					-0.003***
					(0.001)
LTV > 67% (0/1)	0.064***	0.066***	0.062***	0.064***	0.064***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LTV > 80% (0/1)	-0.057***	-0.052***	-0.057***	-0.059***	-0.057***
	(0.015)	(0.014)	(0.015)	(0.015)	(0.015)
LTI > 4.5 (0/1)	0.007	0.001	0.009*	0.007	0.007
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
LTI > 5.5 (0/1)	-0.043***	-0.038***	-0.043***	-0.041***	-0.043***
	(0.015)	(0.014)	(0.015)	(0.015)	(0.015)
Ln(Total Assets)	-0.018***	-0.031***	-0.017***	-0.020***	-0.024***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Mortgages/TA	-0.000	-0.001**	0.001**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Deposits/TA	-0.001***	-0.000	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CET1 Cushion	0.012***	0.010***	0.011***	0.011***	0.011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.973***	0.619***	1.024***	1.003***	1.030***
	(0.028)	(0.030)	(0.028)	(0.028)	(0.032)
Observations	25'137	25'137	25'137	25'137	25'137
Estimation	Heckman	Heckman	Heckman	Heckman	Heckman

Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table 7b: First Stages for the Heckman Regressions above

	(1) Offer	(2) Offer	(3) Offer	(4) Offer	(5) Offer
Over-Represented (0/1)	-0.010				
	(0.022)				
FPRE Over-Heating		0.038			
		(0.072)			
HHI			0.425**		
			(0.209)		
MMC				-0.120	
				(0.326)	
No. of Online Providers					0.015***
					(0.004)
LTV > 67% (0/1)	0.006	0.012	0.007	0.007	0.008
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
LTV > 80% (0/1)	-0.821***	-0.814***	-0.820***	-0.819***	-0.824***
	(0.035)	(0.036)	(0.036)	(0.036)	(0.035)
LTI > 4.5 (0/1)	-0.155***	-0.153***	-0.157***	-0.154***	-0.157***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
LTI > 5.5 (0/1)	-0.828***	-0.824***	-0.827***	-0.827***	-0.825***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Ln(Total Assets)	0.024*	0.020	0.022	0.026*	0.036**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Mortgages/TA	0.010***	0.009***	0.010***	0.010***	0.010***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Deposits/TA	-0.011***	-0.011***	-0.011***	-0.011***	-0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CET1 Cushion	-0.000	0.001	0.001	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Semester 2 (0/1)	-0.091***	-0.109***	-0.096***	-0.093***	-0.088***
	(0.021)	(0.022)	(0.022)	(0.022)	(0.022)
Constant	0.755***	0.763***	0.684***	0.747***	0.497***
	(0.168)	(0.187)	(0.170)	(0.167)	(0.181)
Observations	25'137	25'137	25'137	25'137	25'137
Estimation	Probit	Probit	Probit	Probit	Probit

Robust SE in parentheses. * p<0.1, ** p < 0.05, *** p<0.01.

Table A1: Geographical Representativeness of Households

Canton	Number of Applications	Percentage of Applications	% of Mortgages Swiss Household Panel	% of Volume All Swiss Banks
Aargau	850	12.28	11.70	8.73
Appenzell AR	4	0.06	1.12	0.62
Appenzell IR	33	0.48	0.56	0.18
Basel Land	287	4.15	3.64	3.86
Basel Stadt	106	1.53	0.28	1.92
Berne	982	14.19	17.65	10.77
Fribourg	220	3.18	5.88	3.23
Geneva	162	2.34	2.24	5.06
Glarus	30	0.43	0.84	0.44
Graubünden	163	2.36	1.96	3.33
Jura	26	0.38	0.56	0.75
Lucerne	256	3.70	5.32	4.64
Neuchatel	73	1.05	5.04	1.53
Nidwalden	20	0.29	0.84	0.54
Obwalden	35	0.51	0.84	0.47
Schaffhausen	71	1.03	0.28	0.94
Schwyz	142	2.05	1.96	2.37
Solothurn	238	3.44	2.80	3.37
St.Gallen	339	4.90	6.16	5.73
Thurgau	233	3.37	3.08	3.48
Ticino	182	2.63	3.64	4.73
Uri	17	0.25	0.00	0.40
Valais	223	3.22	3.92	3.59
Vaud	607	8.77	7.28	8.07
Zug	118	1.71	0.56	2.04
Zurich	1'503	21.72	14.29	19.19
Total	6'920	100.00	100.00	100.00

The distribution in our sample counts each of the 6’920 mortgage applications submitted via Comparis.ch once. We can compare it first with the percentages of households in the nationally representative Swiss Household Panel (SHP), provided by the Federal Office of Statistics, who transition to home ownership in 2008-13 and therefore have outstanding mortgage debt in 2014. Finally, we also compare the distribution with that of outstanding mortgage debt already on banks’ balance sheets as reported to the supervisory authority in 2013. Note that the latter is available only based on all mortgages currently on banks’ balance sheets, rather than on new lending only. Based on either comparison, we conclude that the geographical coverage of our mortgage applications is largely representative and is not, for instance, biased towards more urban areas.

Table A2: Geographical Representativeness of Banks

	Comparis		B&M (2018)	
Canton	**# banks**	**% of banks**	**# banks**	**% of banks**
Aargau	2	7.41	3	6.00
Appenzell AR	0	0.00	0	0.00
Appenzell IR	0	0.00	1	2.00
Basel Land	0	0.00	1	2.00
Basel Stadt	2	7.41	4	8.00
Berne	4	14.81	9	18.00
Fribourg	0	0.00	1	2.00
Geneva	1	3.70	1	2.00
Glarus	1	3.70	1	2.00
Graubünden	0	0.00	1	2.00
Jura	0	0.00	1	2.00
Lucerne	1	3.70	1	2.00
Neuchatel	0	0.00	1	2.00
Nidwalden	0	0.00	1	2.00
Obwalden	1	3.70	1	2.00
Schaffhausen	0	0.00	1	2.00
Schwyz	1	3.70	1	2.00
Solothurn	2	7.41	4	8.00
St.Gallen	4	14.81	3	6.00
Thurgau	0	0.00	1	2.00
Ticino	1	3.70	1	2.00
Uri	1	3.70	1	2.00
Valais	1	3.70	1	2.00
Vaud	1	3.70	4	8.00
Zug	0	0.00	1	2.00
Zurich	4	14.81	5	10.00
Total	27	100.00	50	100.00

This table compares the distribution of banks' headquarters across the 26 cantons (states) of Switzerland with that in Basten and Mariathasan (2018), who select the universe of Swiss retail banks based on the FINMA definition that at least 55% of bank income must be net interest income or loan fees, as opposed to stem from own trading or wealth management advisory services.