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Christoph Basten,[1] Benjamin Guin[2] and Cathérine Koch[3]

Abstract

We exploit a unique dataset that features both un-intermediated mortgage requests and independent responses from multiple banks to each request. We show that households typically are not prudent risk managers, but prioritize minimizing current mortgage payments over insurance against future rate increases. Contrary to assumptions in the previous literature, we find that banks do also influence contracted rate fixation periods. They trade off their own exposure to interest rate risk against household requests and against credit risk.

Key words: Interest rate risk, credit risk, maturity mismatch, duration, fixation period, repricing frequency, fixed-rate mortgage, adjustable rate mortgage.

JEL classification: D14, E43, G21.

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1 Introduction

In the wake of the Global Financial Crisis, central banks worldwide have exhibited a preference for setting historically low interest rates. In this paper, we ask how households and banks take the risk of potentially rising interest rates into account when choosing mortgage rate fixation periods (*FPs*).[1] These choices are important. On the one hand, mortgages constitute by far the largest liability of households that do not rent *(Campbell, 2006; Badarinza et al, 2016).* For borrowers with short fixation periods (*FPs*), a positive interest rate shock can imply a significant decrease in households' income disposable for consumption (*Flodén et al, 2017*). This can ultimately impair their ability to meet their mortgage obligations. On the other hand, for the typical retail bank, mortgage lending constitutes the largest asset class (*Jordà et al, 2016*).[2] Given a short average *FP* of most bank funding, longer *FP* of mortgages tend to increase banks' maturity mismatch. Rising interest rates would then squeeze banks' net profits and decrease the value of their equity. By contrast, shorter *FPs* can leave households unable to service their mortgage after rate increases, and hence increase banks' credit risk.

To examine how both households and banks deal with the resulting trade-offs, we examine a unique dataset of mortgage applications and offers that reveals the *FP* preferences of both households and banks. We contribute both to the household finance literature on mortgage choice, and to the literature on banks' interest rate risk management. The former literature has so far analyzed determinants of households' *FP* choices typically framed as a binary choice between Adjustable Rate Mortgages (*ARM*) and Fixed Rate Mortgages (*FRM*) *(Campbell & Cocco, 2003).* Yet, it typically analyzes aggregated data *(Badarinza et al, 2017)* or at best loan level contract data *after* interaction between households and banks (*Koijen et al, 2009; Calza et al, 2013; Ehrmann & Ziegelmeyer, 2017)*. This has required the implicit assumption that banks simply provide the *FPs* requested by households, so that the resulting contracts reflect the pure preferences of households. More recently, however, this implicit assumption has been questioned. *Fuster & Vickery (2015)* and *Foà et al (2015)* show that contracted *FPs* are correlated with bank characteristics and wholesale market conditions. However, these

[1] The mortgage rate fixation period or repricing period designates the period until the rate may change again.

[2] As in most countries, in the Swiss setup studied here the largest category of mortgage borrowers are households and the largest category of lenders are banks, so we use the terms households and banks interchangeably with the more generic terms borrowers and lenders.

papers cannot control for possible time-variant selection of different households to different banks.

By contrast, we analyze pure, *un-intermediated* household requests for different *FPs*. While we confirm that households care primarily about the relative price of longer vs. shorter fixation periods, we also show that they typically do not behave as prudent risk managers. Precisely those households that would most need insurance against rate increases by taking longer *FPs* are *less* likely to request these in a low interest rate environment. Instead, they prefer to minimize the present costs associated with their mortgage. This may be due to the fact that in Switzerland the last time average variable rates exceeded five percent was in the early 1990s when the interest rate hike triggered Switzerland's last wave of house price declines and mortgage defaults, and many current mortgage borrowers may not sufficiently remember that episode.[3] This interpretation would be consistent with the empirical literature pointing out that individuals overemphasize recent experiences when forming expectations about economic variables, including consumer prices (*Malmendier & Nagel, 2016*), asset returns (*Malmendier & Nagel, 2011*) and house prices (*Kuchler & Zafar, 2015*).

We also contribute to the literature on banks' management of interest rate risk. It argues that collateral constraints can impede banks from hedging this risk via swaps (*Rampini & Viswanathan, 2010; Rampini & Viswanathan, 2013; Rampini et al, 2017*). This provides an explanation of why some banks keep remaining interest rate risk exposure on their balance sheets (*Purnanandam, 2007; Vuillemey, 2017; Hoffmann et al, 2017)*, beyond the opportunities to increase earnings by bearing this risk. When by contrast banks see their target level of interest rate risk reached or exceeded, they have an incentive to offer loans with shorter *FPs* so as to reduce the mismatch in the repricing frequency between assets and liabilities (*Santomero, 1983; Kirti, 2017*). In this paper, we examine this claim and draw a more differentiated picture. To do so, we link our dataset of mortgage requests to supervisory data on banks' pre-existing interest rate risk exposure and further bank characteristics. Using these combined data, we then show that banks can and, on many occasions, do actively steer the contracted *FPs* by (i) not just offering *FPs* that differ from those requested but also by (ii) selectively rejecting requests, and (iii) charging higher mark-ups on mortgage rates for *FPs*

[3] Variable rates for mortgages in Switzerland decreased from 7.8 % in 1991 via 4.1% in 2000 and 3.3% in 2003 to 2.7% in 2013, which is the end of our observation period. See Figure 2. Source: https://data.snb.ch/, accessed on 22 November 2017.

not currently sought.[4] In line with *Kirti (2017)*'s evidence for non-financial firms, we find that banks that are more exposed to pre-existing interest rate risk tend to offer shorter *FP* to mortgage borrowers. However, when considering banks' *rejections* and mortgage *pricing* decisions, we do not find such evidence.[5]

The remainder of the paper is structured as follows. Section 2 presents the institutional setup, our data on mortgage demand and supply, and the supervisory data used. It also discusses the external validity of our dataset. Section 3 first derives our hypotheses on household behavior and discusses a suitable empirical strategy to test these hypotheses. Following that, it presents our results. Section 4 discusses both hypotheses and empirical strategy for our analysis of bank behavior and presents the corresponding results. Section 5 concludes.

2 Institutional Background and Data

This section explains first the difference between *mortgage rate fixation period*, *mortgage maturity* and *contract period* in the Swiss context. Moreover, it discusses how these terms relate to the *mortgage rate* and the *duration* of a mortgage. It then provides descriptive statistics on our micro-level data of individual mortgage requests and offers from the online broker *Comparis*, as well as on the supervisory information we have for the banks studied.

2.1 Mortgage Contract Terms and Mortgage Duration

The focus of this paper is on the *Fixation Period (FP)*, or *Repricing Period*, of the mortgage interest rate. We define this *FP* as the number of years for which the mortgage rate is fixed, while interest rates in the interbank market and hence banks' refinancing and opportunity costs may vary. Some banks' offers specify a single *FP* for the entire mortgage, while others propose to split the mortgage into several *tranches* with distinct *FPs* and distinct mortgage rates.[6,7]

[4] In the setup analyzed by *Foà et al (2015)*, banks can additionally use the "advice" channel. By contrast, in our pure online setting this channel is not available to banks.

[5] This analysis relates to a more general literature on mortgage supply decisions and pre-existing bank characteristics who point out the role of securitization *(Fuster & Vickery, 2015)*, access to long-term funding *(Foà et al, 2015)* and bank capitalization *(Michelangeli & Sette, 2016; Basten & Koch, 2015)*. We show the relevance of banks' pre-existing interest rate risk exposure for their mortgage supply decisions.

[6] In some but by no means all cases, the tranching coincides with the 67% or 80% LTV thresholds.

[7] In principle, tranching is attractive to banks since it makes it more difficult for households to switch to a cheaper bank when one tranche matures but one or more other tranches have not matured yet. We do not explicitly investigate such motives for tranching here, as they would not appear correlated with *FP* choices.

Conceptually, the *FP* is distinct from the *mortgage maturity*, defined as the number of years after which the entire principal must be repaid to the lender. In some countries these two contractual terms coincide, in Switzerland they sometimes do not.[8] Fully amortizing mortgages are rare and not popular in Switzerland for tax reasons. Even for owner-occupied property, borrowers can deduct interest payments from their taxable income. In some cantons (states) they can additionally deduct outstanding mortgage debt from taxable wealth. For this reason, households tend to amortize only at the minimum speed required by the regulator. Since July 2012, regulation requires that the *Loan-to-Value (LTV)* ratio must be reduced to 67% within at most 20 years after the date of the house purchase, and since July 2014 within at most 15 years. Yet, after this period has expired, many households just keep the remaining debt outstanding and invest any surplus savings into other asset classes rather than amortizing their mortgages. The amortization schedules resulting from these regulatory requirements are decoupled from the mortgage rate's fixation period. This allows us to analyze the preferred *FPs* as stated by borrowers and lenders *independently* from the amortization schedules.

A third relevant term in that respect is the *contract period* of a mortgage. This is the number of years for which neither lender nor borrower can leave the existing contract without incurring a penalty. At the end of the contract period, Swiss borrowers typically repay not out of their savings, but by refinancing or rolling over their mortgage (or tranche) either with the same or with another lender. In many countries the option to prepay before the end of the initially agreed contract period is frequently exercised, giving rise to *prepayment risk* for lenders (see *Campbell & Cocco, 2003; Green & Wachter, 2005*). Swiss mortgage contracts, by contrast, typically contain "*yield maintenance clauses*" as described in *Green & Wachter (2005)*: when households prepay, they must (at least) fully compensate the bank for any interest foregone as a consequence of their prepayment. Thus households usually prepay a mortgage only if they are forced to sell their property, e.g. due to a change of jobs or divorce, but not for strategic reasons.

Beyond proposing *contract periods* and *fixation periods* which may or may not coincide with those requested by the household, a bank offers a specific *mortgage rate*. This is the interest rate paid by the borrower. Given the quoted *mortgage rate*, we also compute *mortgage spreads* as the difference between the quoted rate and the refinancing costs under full hedging

[8] The values of the three contract terms, *FP*, *Mortgage Maturity* and *Contract Period*, are equivalent for mortgages with a *FP* of 1-10 years. For Libor mortgages, *Mortgage Maturity* and *Contract Period* are usually longer than the corresponding *FP*.

of interest rate risk. This is given for each tranche by the interest swap rate prevailing for that *FP* on the day of the offer. To make both single- and multiple-tranche offers comparable, we compute the tranche-weighted average fixation period offered by banks (*Weighted Offered FP*), mortgage rate (*Weighted Rate*), and mortgage spread (*Weighted Spread*). The weight of each tranche is given by its amount relative to that of the entire mortgage.

We also compute for each offer the implied *Duration*, which has the advantage of elegantly combining offered *Fixation Period (FP)* and *mortgage rate* into a single outcome variable. More specifically, the tranche-level *Duration* is the weighted average of all years after which the mortgage offer implies a cash-flow to the bank, with weights being the relative sizes of the net present values (*NPV*) of all cash flows (e.g. *Hull, 1993*).

In the case of Swiss mortgages, the single most important *NPV* of a cash flow is usually the repayment of the principal at the end of the *contract period*, complemented by the suggested interest payments and possibly any amortization payments made before the end of the contract period. Since we do not observe actual amortizations later agreed between household and bank, the baseline version of our *Duration* measure assumes zero amortization.[9] To compute the net present values of all interest payments and the principal repayment, we use the interest rates on Swiss government bonds on the tranche-level duration. As before, we calculate a tranche-weighted duration, *Weighted Offered Duration.* Again, the weight of each tranche is given by its amount relative to that of the entire mortgage.

The relationship with respect to other mortgage contract terms is as follows: a longer *Offered Fixation Period (OFP)* attached to individual tranches or the mortgage as whole increases the *Weighted Offered Duration*, while a higher *Mortgage Rate* (applied to individual tranches or the mortgage as a whole) reduces the *Weighted Offered Duration*.

2.2 Securitization in Switzerland

In Switzerland, one way of refinancing mortgages beyond standard deposits are covered bonds ("*Pfandbriefe*") issued on behalf cantonal banks by the "Pfandbriefzentrale" and on behalf of all other banks by the "*Pfandbriefbank*". Compared to many other European countries, the fraction of mortgages refinanced in this way is, however, relatively low at only

[9] In alternative versions, we assume that households must deliver sufficient annual amortization payments to reduce their LTV ratio to at most 67% within 20 years, as suggested by the Swiss Bankers Association's self-regulation from July 2012 onward. The corresponding results are available upon request.

12% (see *Jans et al, 2017*). More importantly, regardless of the refinancing method, mortgages issued by Swiss banks remain on bank balance sheets (*Meuli et al, 2016*). Hence, banks are not able to eliminate the associated risk for either economic or regulatory purposes. Hence, securitization is not of major relevance for our analysis of banks' exposure to interest rate risk as opposed to analyses on banks in the U.S. (*Fuster & Vickery, 2015*).

2.3 Data on Mortgage Demand and Supply

Our key data source is the Swiss website *Comparis*. The dataset provides information on individual mortgage requests submitted to the *Comparis* website between 2010 and 2013.[10] For each request, we observe responses from multiple banks. On the household side, the data contain comprehensive information on the property to be bought (including size, age and location zip code of the property), the household's finances (including income, wealth, pension savings, debt, further real estate holdings) and the requested mortgage amount and *Fixation Period*. To submit a request, a household had to pay CHF 148 (about USD 150).

Comparis then sent the anonymized requests to participating lenders. These included both banks and insurance companies. After screening the requests, banks decided whether to make a binding offer and specified the terms of the offer. While they had to take the requested mortgage *amount* as given, banks could deviate from the requested *FP*. Furthermore, besides choosing the *FP*, they could also decide to split the mortgage into up to three tranches with different tranche-level fixation periods and tranche-specific mortgage rates. For example, one way to obtain an average fixation period of five years was to offer the entire mortgage with a five-year fixation period, while another was to offer half of the amount with a fixation period of 8 years and the other half with a fixation period of 2 years. For fixed-rate tranches, i.e. tranches with fixation periods of one or more years, the fixation period typically coincided with the *contract period* of that tranche. For our baseline analyses, we focus on the tranche-weighted offered FP, *Weighted Offered FP*, as well as the duration of the entire mortgage, *Weighted Offered Duration.*

This dataset has several characteristics that are advantageous for our empirical analysis. First, we observe separately requests and offers and can thus distinguish between the preferences of households and those of banks. Second, we observe for each request the response from not just one but several banks. Thus, we can fully rule out possible self-selection, even of a time-

[10] At the end of 2013, *Comparis* changed its business model.

variant type, of different types of households to different types of banks. Third, all banks have access to exactly the same set of anonymized information that we observe and control for, so we can rule out that bank responses depend also on the additional soft information generated in other contexts through relationship banking.

In Table 1, Panel A presents summary statistics on the 5,914 requests submitted between 2010 and 2013, while Panel B shows market benchmark yields to characterize the macroeconomic environment. Panel C shows data on the share of rejections among the 20,117 bank responses submitted by the 27 banks, while Panel D presents details on the 16,349 responses that were offers. Finally, Panel E shows characteristics of the participating banks, also at the response level so as to give each bank the same weight as in our response level regressions. In principle, households can choose between ARM, with *FPs* of 0, 0.25 or 1 year, and FRM with *FPs* of 2-10 years. For our baseline estimates, we focus on *FPs* of 0-1, 5 and 10 years, which together account for 83% of all requests. This allows us to use the same requests also for multinomial analyses, for which the intermediate *FP* brackets of 2, 3, 4 and 6, 7, 8, 9 years are not sufficiently well populated.[11]

Panel A of Table 1 shows that the average requested fixation period (*RFP*) of the requests we consider is 7.3 years. Moreover it shows that 15% of mortgage requests are for fixation periods of 0-1 years, 25% are 5 years, and 60% are for 10 years. The *Payment-to-Income (PTI)* ratio[12] amounts to 26% on average, with 17% of all submitted requests exhibiting *Payment-to-Income (PTI)* ratios which exceed 33%. The *Loan-to-Value (LTV)* ratio amounts to 65% on average, with 55% of all submitted requests exhibiting *Loan-to-Value (LTV)* ratios in excess of 67%, while 8% of all submitted requests specify *LTV* ratios in excess of 80%. In Appendix 5, we provide a correlation table of these variables. We show that they are positively but imperfectly correlated. This mitigates concerns of multi-collinearity when including the variables simultaneously in the same regression.

In addition, our empirical analysis draws on detailed household characteristics. On average, household wealth (used in logs in our regression given its skewed distribution) reaches CHF 293,608. Almost a quarter of the captured households already own some type of real estate,

[11] *ARM* capture three sub-categories, “Libor mortgages” for which rates reset automatically every 3 months, “Variable rate” mortgages for which banks have the option to adjust rates at their discretion, while households may terminate the contract type at any time without incurring a prepayment penalty, and 1-year mortgages.

[12] The numerator of this ratio, the payment, consists of 5% of the mortgage amount for "calculatory" interest payments, 1% for house maintenance, and 1% for amortization when the LTV ratio exceeds 67%.

while 22% report outstanding debt. Our average request is submitted by a customer aged 46 with the intention to purchase a property built on average 28.5 years ago.

Panel B shows two benchmark yields prevailing during the month when banks respond. Rows 1 and 3 show the spread of 10-year over 3-month mortgages, and of 10-year over 1-year Swiss federal government bonds respectively. Rows 2 and 4 show the average yields on 10-year mortgages and Swiss federal government bonds respectively.

The term premiums amounted to 1.15% and 0.96% respectively, thus reflecting a usual, i.e. upward sloping, yield curve. It implies that mortgages with longer fixation periods were more expensive for borrowers, while they allowed banks that borrow at shorter and lend at longer fixation periods to earn a term premium - if they are willing to take on, or hedge at a cost, the resulting interest rate risk, as we discuss in Section 4 below.

Panel C presents summary statistics on banks' responses. We observe a total of 20,117 or about 4 answers per request. This is because not all 27 banks are active in all regions of Switzerland. Among all bank responses the rejection rate amounts to 19%, reducing our sample to 16,349 offers, or about 3 bank bids per request.

Panel D exhibits details on these bank offers. It shows that, on average, the offered fixation period weighted across tranches, *Weighted Offered FP,* was roughly 7.5 years. In line with this number, the tranche-weighted duration offered by the banks, *Weighted Offered Duration*, came to 7.0 years. Banks offered mortgage rates of about 2.2% on average, with the weighted spread above the market swap rates reaching 0.97%. In about 19% of offers banks proposed a fixation period that deviated from that requested by households: hence banks do often, but by no means always accommodate households' preferences. Below we investigate when and why banks deviate from requested fixation periods.

2.4 Supervisory Data on Bank Characteristics

We complement the *Comparis* data on mortgage demand and supply with key characteristics of the banks submitting responses, obtained from the Swiss Financial Market Supervisory Authority (*FINMA*). Panel E of Table 1 provides the summary statistics on these characteristics. We present them at the response level. Hence, banks that submit more responses more weight. This ensures that the summary statistics are representative of the sample which we analyze.

First, we discuss measures of banks' pre-existing interest rate risk exposure. These measures are constructed from *Interest Rate Risk Reports* that individual banks submit quarterly to *FINMA*. The original reporting form is displayed in Figure 1. It shows that banks report the cash flows resulting from their assets and liabilities by asset and liability categories and by 18 different repricing brackets. All cash flows are reported *after* hedging. Cash flows *before* hedging are not reported separately. Yet, we do observe *whether* a bank did use any interest rate swaps in a given quarter: as Row 4 of Panel E shows, 96% of responses in our sample were submitted by banks that did use interest rate hedges. However, they did not use them to fully hedge their entire interest rate risk exposure.

Our measure of banks' interest rate risk (*IRR*) exposure indicates the percentage change in the present discounted value of net cash flows which results from a parallel shift of the yield curve by 100 basis points (bp). This can be interpreted as the change in the bank's equity following such a change.[13]

Formally, assets and liabilities are distinguished by repricing brackets $b = 1,...,18$. For each of these brackets, $CF(b)$ gives the net cash flow as the difference between incoming and outgoing cash flows. A 100 basis points shift in the yield curve will change the valuation of the cash flows for each of the 18 brackets. This results in the following present discounted value of net cash flows:

$$Discounted\ CF_{b,t} = \sum_{b=1}^{18} CF(b)[DF(b)^{+/-100bp} - DF(b)] \qquad (1)$$

where $DF(b)$ is the discount factor based on the risk-free rate for maturity b. $DF(b)^{+100bp}$ is the hypothetical discount factor in a scenario with an *upward* shift of the yield curve by 100 basis points. $DF(b)^{-100bp}$ is the hypothetical discount factor in a scenario with a *downward* shift of the yield curve by 100 basis points.

Our data report the impact of the *more adverse* of the two possible scenarios in terms of banks' equity values. To construct our measure of banks' interest rate risk exposures, *IRR*, we do the following: we multiply the discounted cash flows, $Discounted\ CF$, with a negative sign if and only if the more severe loss arises in the case of an *upward* shift of the yield curve.

[13] Similar proxies of banks' exposures to interest rate risks have been employed in the existing literature. *Beutler et al (2017)* use a closely related proxy in the Swiss context. *Esposito et al (2015)* outline the Italian implementation, which is quite similar except that only 14 instead of 18 brackets are used. Moreover, similar measures have been used by *Hoffmann et al (2017)* who examine European banks' exposure to interest rate risk and *Chaudron (2016)* who analyses size and development of Dutch banks' interest rate risk positions in the banking book.

Otherwise, our *IRR* measure is identical to present discounted cash flows, $Discounted\ CF$. A detailed and intuitive example of the construction of this *IRR* measure is provided in the Appendix 6.

Loosely speaking, this calculation means that *positive* values of *IRR* imply that the net present value of cash flows, and hence banks' equity values, would *decrease* following *interest rate increases*. By contrast, *negative* values of *IRR* imply that banks' equity values would decrease in the case of interest rate *decreases*. Vice versa, equity values of these banks would *increase* following a rate *increase*.

The summary statistics presented in Panel E of Table 1 suggest that our *IRR* measure is positive on average. This suggests that it is the more common case amongst the banks studied. Dropping banks with negative *IRR* from the sample does not materially influence our results given the small number of cases.

In Panel E, we display three variations of this measure that differ in their treatment of the assets and liabilities with unspecified fixation periods, such as sight deposits, reported in Columns 5-17 of the form. Our first and baseline measure uses banks' own assumptions on the effective fixation period of these positions. Our second measure uses the average assumption computed across the reports from all banks in a given quarter. Our third measure uses an assumption that is invariant both across banks and across periods and is set to two years. The table shows that the average response in our sample is submitted by a bank that would lose 7% of its equity through a 100 basis point upward shift of the yield curve based on the bank's own assumptions, 5% based on average assumptions, and 8% based on fixed assumptions.

Contrary to what *Vuillemey (2017)* reports for US banks, not all but the large majority of banks in our sample do use interest rate derivatives.[14] Nonetheless, in line with the arguments put forward in both *Vuillemey (2017)* and *Rampini et al (2017)*, banks do by no means hedge all interest rate risk but rather retain a sizable amount on their balance sheets in face of the costs of hedging. Furthermore, as suggested by *Rampini et al (2017)* and *Hoffmann et al*

[14] *Purnanandam (2007)* finds that interest rate derivatives are predominantly used by larger banks, likely reflecting economies of scale and scope of operations, and that dealing with them allows banks to hedge against possible interest rate shocks.

(2017), we find that in our sample the amount of interest rate risk retained after hedging is negatively correlated with bank capitalization.[15]

The subsequent lines of Panel E show that the average bank in our sample has total assets of close to CHF 10,000 million, of which we use again the log due to its skewed distribution. Furthermore, about 6% of the average bank's total assets were financed with Core Equity Tier 1 (CET1) capital, 70% with deposits, and 20% with wholesale funding.

2.5 External Validity

As pointed out before, our multi-borrower-multi-lender setup grants the internal validity of our estimates by avoiding self-selection concerns of households to bank. Online mortgage intermediation, however, accounts only for a small share in the overall mortgage market. Hence, the question arises whether our analyses are externally valid. Put differently, while our estimates allow us to analyze the demand and supply of mortgage fixation periods in an online context, we need to show that our results carry over to the rest of the Swiss mortgage market. A priori, the answer is not clear. On the one hand, households that fail to get a mortgage offer from their existing bank end up using the *Comparis* platform. On the other hand, only low risk customers with confidence and expertise in financial issues might use the platform. Indeed, we observe a wide range of both house and household characteristics, but some bias on *unobservables* could remain. For this reason, we compare our data with, to the best of our knowledge, all publicly-available datasets on the Swiss mortgage market: first, with "Banks in Switzerland" a publication by the Swiss National Bank (*SNB*, *2014*), and second, with a survey of mortgage borrowers conducted by *Seiler (2013).* The drawback of the former is that it captures only the stock of mortgages already on banks' balance sheets rather than specifically the set of mortgages granted or refinanced in a given year. The drawback of the latter is that, due to a different research question (the use of pension money for house purchases) the survey itself does not warrant a representative picture of the entire market itself. Yet, these are the best sources known to us. *Appendix 4* reveals that the geographical composition of our sample aligns well with both studies and suggests that our sample matches the distribution of the Swiss population as a whole. Our dataset appears to have slightly higher weights on the German-speaking cantons when compared to data published by the Swiss National Bank (Panel A). Yet, it appears to have slightly lower weights when compared

[15] The corresponding results are not displayed in the table to save space. They are available upon request.

to the data reported by *Seiler (2013)* which shows the distribution for all major regions in our sample (Panel B). More importantly, there is no clear evidence of a bias in favor or against the more urban areas, neither when we look at the distribution of the number of requests, nor when we look at the implied mortgage volumes.

3 Household Behavior

The first two parts of this section present our hypotheses and empirical strategy on pure, un-intermediated household preferences. In particular, we discuss the widespread, but so far unproven assumption of the existing literature that observed mortgage *FP* reflect purely the choices of households. In the third part of the section, we present the empirical results.

3.1 Household Behavior: Hypotheses

What drives households to select a specific mortgage rate fixation period (*FP*)? A household has to trade off the costs of a mortgage contract against its implied risks. Existing papers have typically analyzed aggregate data or, at best, individual contracted mortgages *after* a household and a bank have interacted. The only exceptions known to us are *Fuster & Vickery (2015)* and *Foà et al (2015)*, both of which show that contracted mortgage types do vary with bank balance-sheet characteristics. Our unique dataset features *un-intermediated* mortgage requests that receive multiple bank responses in a second step and hence allows us to isolate borrowers' choices on the demand side.

Following *Koijen et al (2009)*, *Badarinza et al (2017)* and *Ehrmann & Ziegelmeyer (2017)*, we posit that households pay attention to the term premium as the relative price between shorter and longer *FPs.*

> <u>Hypothesis 1.</u> *Households tend to request* ***longer*** *fixation periods (FPs) when the* ***term premium*** *between long and short fixation periods (FP) is* ***lower***.

The existing literature focuses mainly on binary choices between Fixed Rate Mortgages (*FRMs*) and Adjustable Rate Mortgages (*ARMs*). Such a standard approach captures just one term premium, namely the relative price of *FRMs* relative to *ARMs*. Our dataset provides us with up to 12 different requested *FPs*, although for some analyses we focus on the three most frequently requested ones that can be categorized as short term (0-1 year), medium term (5 years) and long term (10 years). In order to analyze what drives the household's initially stated, un-intermediated *FP* preferences, we use the prevailing term premium on Swiss government bonds[16] as a publicly-known proxy that helps households to form their expectations. Alternatively, we resort to average mortgage rates quoted by banks in Switzerland as reported on the *Swiss National Bank* website at monthly frequency.

To investigate the role of household and property characteristics, we follow *Campbell & Cocco (2003)*. More specifically, we draw on *Payment-to-Income* (*PTI*)[17] and *Loan-to-Value (LTV)* ratios to capture key risk metrics for the household to meet its obligations. Households with the highest *PTI* or *LTV* ratios are also those which are most likely to become budget or liquidity constrained. Those households might just attempt to minimize current mortgage costs. Or, following *Rampini & Viswanathan (2016),* poor households might prioritize consumption smoothing over time relative to that across states of the world. In the following, we link our first hypothesis to the stated household risk metrics.

With respect to the *PTI* ratio, we expect that households that spend a larger share of their income on mortgage payments are more likely to become liquidity-constrained when mortgage rates rise, as shown empirically by *Flodén et al (2017)*. This makes it more advisable for them to insure against such rate increases by requesting longer fixation periods (*FPs*). Put differently, high-*PTI* customers might pay an insurance premium corresponding to the term spread to hedge their exposure to possible future interest rate increases. On these grounds we posit:

> <u>*Hypothesis 2a.*</u> *Households tend to request mortgages with a* ***longer*** *fixation period (FPs) if they report a* ***higher*** *Payment-to-Income (PTI) ratio.*

In a similar vein, more leveraged households report higher loan-to-value (*LTV)* ratios. If adverse house price shocks boosted their *LTV* ratios at maturity, they might find themselves unable to re-finance, ultimately urging them to default on their mortgage. For this reason, they might prefer longer *FP*s to protect against falling house prices before they have amortized sufficiently and hence reduced the value of their outstanding mortgage debt.

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[16] Data on Swiss government bonds are available from *Bloomberg* at daily frequency.

[17] We follow the standard procedure applied by most Swiss banks and use a hypothetical "stress test" mortgage rate of 5% to compute the *PTI* ratio.

<u>Hypothesis 2b.</u> Households tend to request ***longer*** *fixation period (FPs) if they exhibit* ***higher*** *Loan-to-Value (LTV) ratios.*

We acknowledge that this hypothesis can be challenged. High-*LTV* households face higher debt service costs on account of the *credit risk premium* that banks impose on them. While remaining exposed to falling house prices, they might prefer shorter *FPs* to save the *term premium* and their borrower-specific *add-on* if they expect house prices to rise over the lifetime of their mortgage. Instead, they might invest the saved premiums and use the proceeds to pay down a higher share of the outstanding mortgage at maturity. Hence, households might trade off the sum of the expected *term* and *credit risk premiums* against the opportunity costs of saving the money and earning interest on it, or consuming it earlier.

3.2 Household Behavior: Empirical Strategy

To test these hypotheses on household behavior empirically, we start by treating the *Requested Fixation Period (RFP)* as a continuous variable with values 0 for variable rate mortgages, 0.25 years for 3-month *LIBOR* mortgages, and 1-10 years for Fixed Rate Mortgages. We relate this dependent variable to a set of exogenous variables which indicate the term premium between long and short fixation periods, to the *Payment-to-Income (PTI)* ratio, the *Loan-to-Value (LTV)* ratio, and to a set of household control variables.

The existing literature, which usually focuses on a binary choice between Fixed Rate Mortgages (*FRMs*) and Adjustable Rate Mortgages (*ARMs*), uses proxies for the relative cost of *FRM*s relative to *ARMs*. In our dataset, however, we observe 12 different mortgage fixation periods (*FP*). In our refined multinomial analysis, we focus on the three most frequently requested *FP*, namely 0-1 years, 5 years, and 10 years, as the other FP have only few observations. As a benchmark rate that is generally observable by households and informs their expectations of the term spread, we resort to Swiss government bond yields available from *Bloomberg* at daily frequency. Alternatively, we use average mortgage rates as reported on the *Swiss National Bank* website at monthly frequency.[18]

In particular, we start by estimating the following linear relationship using *Ordinary Least Squares* while calculating heteroscedasticity robust standard errors:

[18] Two other macroeconomic factors households should take into account when choosing their *FP* are interest rate and inflation expectations (*Malmendier & Nagel, 2016)*. We do not explicitly investigate these here for lack of suitable measures with sufficient variation in our sample.

$$RFP_{i,t}=\alpha+\beta_1 Term\ Premium_t+\boldsymbol{PTI_i}'\boldsymbol{\beta_2}+\boldsymbol{LTV_i}'\boldsymbol{\beta_3}+\boldsymbol{Z_i}'\boldsymbol{\beta_4}+\varepsilon_{i,t} \qquad (2)$$

where $Term\ Premium_t$ is the difference between the average ten-year and the average one-year government bond yields in month *t*. Moreover, we include several household and property characteristics of request *i*. As it is not clear a priori whether the effect of *PTI* will be linear, we include as exogenous variables both the *Payment-to-Income* (*PTI*) ratio as a continuous variable and a dummy variable for the *PTI* ratio exceeding 33% (*PTI>33% (0/1)*). Moreover, we include the *Loan-to-Value (LTV)* ratio, which indicates the loan amount relative to the value of the house, as a continuous variable, and additionally add separate threshold dummy variables for those *Loan-to-Value (LTV)* ratios exceeding respectively 67% and 80%. We control for further household characteristics subsumed by vector $\boldsymbol{Z}$: a dummy for holdings of other real estate (*Other real estate (0/1)*), a dummy for the presence of other debt (*Debt (0/1)*) and the age of the mortgage borrower (*Age*). We also control for the key characteristics of the property to be financed, its *Property age*, and type (single-family home, apartment, etc.).

We consider this estimation an intuitive and therefore sensible first approach, but it is restrictive in that it assumes a linear relationship between the explanatory variables of interest and the *Requested Fixation Periods (RFPs)*. Furthermore, it does not take into account that *RFPs* are non-negative, and households cannot request *RFPs* above 10 years in the setup studied. Therefore, and in line with the *Probit* analyses conducted in amongst others *Ehrmann & Ziegelmeyer (2017)*, we re-examine the relationships studied in Equation (2) by means of multinomial *Logit* and *Probit* analyses.

Households typically request mortgages with *RFPs* of 0-1 years, 5 years and 10 years which make up roughly 83% of all requests. We classify these three *RFPs* as short-term, medium-term and long-term horizons.[19] In the case of our multinomial analyses, we thus assume that there are three *unordered*, *exhaustive* and mutually *exclusive* buckets of mortgage *Fixation Period (FP)* outcomes *j=ST, MT, LT*. In particular, *FP* assumes the value *j=ST* if the *FP* is up to one year, *j=MT* if the *FP* is five years, and *j=LT* if the *FP* is ten years. In line with a

[19] Vice versa, *RFPs* of 2, 3, 4, 6, 7, 8 and 9 years together contain only about 17% of all requests. Including each of these brackets separately would produce unreliable and difficult to interpret estimates, whereas lumping 2-4 and 6-9 years would seem to be too coarse. As a robustness test, we use this set of FPs also in our OLS analyses. Further robustness checks drawing on all requests (including FPs of 2-4 and 6-9 years) produce qualitatively similar results.

standard multinomial logit model, we denote the probability that request *i* chooses alternative *j*, given the household characteristics $x_{i,t}$ as:

$$P(FP_i^* = j | \boldsymbol{x_{i,t}}) = \pi_{i,j} \ , \ j=ST, MT, LT \qquad (3)$$

We assume that the following relationship exists between the probability shown in (3) and the vector of exogenous characteristics $x_{i,t}$, as a linear index structure $x_{i,t}'\beta_j$ with an outcome-specific parameter vector β_j to be estimated:

$$\pi_{i,j} = \frac{\exp(\boldsymbol{x_{i,t}'\beta_j})}{\sum_{j=1}^{J}\exp(\boldsymbol{x_{i,t}'\beta_j})} \quad , \ j= ST, MT, LT \qquad (4)$$

Where the vector $x_{i,t}$ indicates the same set of exogenous variables included in Equation (1). The estimated parameters β_j may differ across alternatives *j*. The model is estimated using maximum likelihood with the likelihood function for a sample of *i=1,…,n* requests given by:

$$\log L = \sum_i^n \sum_{j=1}^3 I_{i,j} log\, \pi_{i,j} \ , \ j= ST, MT, LT \qquad (5)$$

where $I_{i,j}$ is a binary indicator taking on the value of unity if request *i* chooses alternative *j* and zero otherwise. We present our results in two different ways. First, we show log-odds ratios where the baseline category is *j=ST* (i.e. the requested fixation period is 0-1 years). In addition, we provide marginal effects for each outcome variable (evaluated at the mean of an independent variable if it is a continuous variable or at zero in case of a binary variable).

3.3 Household Behavior: Results

We start by testing *Hypothesis 1* using *OLS* regressions and present the results in Table 2. The outcome variable in all columns is the Requested Fixation Period (*RFP*) in years, ranging between 0 and 10 years. The key explanatory variable of interest in all columns is the term premium between 1-year and 10-year government bond rates, *Spread (government bonds)*, on the day on which the request was submitted. Column (1) furthermore adds the *PTI* ratio, Column (2) additionally adds the *PTI >33% (0/1)* dummy variable, Column (3) further includes the interaction term between *PTI >33% (0/1)* and *Wealth (ln)*. Moreover, we also include the *LTV* ratio in the specification shown in Column (4) and *LTV >67% (0/1)* and *LTV >80% (0/1)* dummy variables in regressions displayed in Column (5) and Column (6) respectively. All regression results shown in all columns control for the log of household wealth, households' additional real estate holdings, existing household debt, the age of the applying household head, the property type (9 dummies for 10 categories), and property age.

The most robust finding that stands out across all columns is that households clearly request shorter *Fixation Periods* (*FPs*) the higher the term premium and hence the higher is the price of longer FP relative to that of shorter ones. More precisely, a one percentage point increase in the spread between 1-year and 10-year government bond rates decreases the Requested Fixation Period (*RFP*) by about 1.5 years. This confirms our *Hypothesis 1*. Similar empirical evidence has been reported in the existing literature, for example by *Koijen et al (2009)* or *Ehrmann & Ziegelmeyer (2013).* In contrast to these papers, we are able to cleanly show that this relationship is indeed driven by household demand and does not reflect banks' choices. We believe that this is less obvious than it may sound: prima facie banks may have an incentive to push longer FP when term premiums are higher, allowing them to earn more. However, higher term premiums also reflect the market opinion that spot rates are more likely to rise, and are also associated with higher costs of hedging interest rate risk with interest rate swaps. Therefore a priori the relationship reported in the existing literature might also have been driven by banks, but our results confirm unambiguously that they are indeed driven by household behavior, thus corroborating what up until now had to be assumed.

More novel are our results relating to *Hypothesis 2*. Here our regressions include both the *PTI* and *LTV* ratios as continuous variables and dummies for values above the thresholds of 33% for the *PTI* ratio and 67% and 80% for the *LTV* ratio. These thresholds are often considered critical in the Swiss market for obtaining and granting mortgage loans. In particular, *LTV* ratios above these two thresholds (67% and 80%) also incur higher capital charges for banks, as explained in detail in *Basten & Koch (2015)*. We decide to use flexible specifications in which we include the continuous and discrete *PTI* and *LTV* variables subsequently in our regressions.

Regarding *Hypothesis 2a*, we first test whether our continuous measure *PTI* is a relevant factor for households' requested Fixation Periods (*RFP*) (Column (1)). The estimated coefficient of *PTI*, however, is not statistically significant at conventional levels. Nor are the dummy variable, *PTI >33% (0/1),* or its interaction with household wealth, *Wealth (ln),* (as displayed in Columns (2) and (3)). So interestingly we find that households who arguably would rationally benefit more from insurance against rate increases are not significantly more likely to request longer *FPs*. Instead, households appear to focus mostly on the current cost of a mortgage.

To test *Hypothesis 2b*, we first estimate the coefficient on our continuous *LTV* variable. The results displayed in Column (4) show that it is not statistically significantly different from zero at all conventional significance levels. Prima facie, this may seem to suggest again that there is no evidence in favor of this hypothesis. However, results displayed in Columns (5) do show that households with *LTV* ratios in excess of two-thirds request *FPs* that are on average about 0.32 years *shorter*. The result displayed in Column (6) suggests that households with LTV ratios in excess of 80% request *FPs* that are *another* 0.52 years shorter. These findings speak against the picture of "households as risk managers" given in a normative way in *Campbell & Cocco (2003*), and are instead consistent with the results in *Rampini & Viswanathan (2016)* whereby poor households are likely to take out less insurance as they prioritize consumption smoothing across periods over consumption smoothing across states of the world. Also in line with this are our findings that both lower additional wealth and the existence of further household debt are associated with requests for shorter *FPs.*

Table 3 shows the results of investigating the effects of the same explanatory variables estimating a *Multinomial Logit Model*. We present our results on the choice of requested FP in two ways: columns (1)-(2) show the raw coefficients which can be interpreted as log-odds ratios where all point estimates are compared to the baseline category, *FP requested (0-1)*. In addition, we provide marginal effects of the estimated coefficients of each variable at the mean for continuous variables and at zero for binary variables in Columns (3)-(5).

This table by and large confirms the results discussed above. An increase in the spread between 1-year and 10-year government bond rates, *Spread (government bonds)*, decreases the propensity of requesting a mortgage with a ten year *FP* relative to a short *FP* of not more than 1 year. The estimated coefficient is statistically significant at all conventional significance levels. To get a better understanding of its economic magnitude, we also calculate marginal effects. The results displayed in Column (5) show the marginal effect of all explanatory variables on the choice of a Fixation Period of 10 years. They suggest that a one percentage point increase in the spread between 1-year and 10-year government bond rates decreases the propensity to choose *FP requested (10)* by 26 percentage points.

We run several robustness checks which confirm these results. First, we can show that estimates based on *Multinomial Probit* instead of *Multinomial Logit Models* are qualitatively similar. Second, we use the term premium between *Libor* and 10-year average mortgage rates reported on the SNB website, instead of that between 1- and 10-year government bond rates. We again obtain qualitatively similar results. Last, we rerun our baseline estimation using only those about 50% of requests that are for roll-overs rather than for new mortgages, which again yields qualitatively similar results. All of these robustness checks are left out for lack of space, but are available upon request.

4 Bank Behavior

In this section, we turn to banks' responses. We first discuss how these may vary both with key borrower risk characteristics and with banks' pre-existing interest rate risk exposures. Our first measure is the Payment-to-Income (*PTI*) ratio, which indicates the risk that the household cannot meet ongoing mortgage payments consisting of interest and agreed-on amortization. Our second measure is the Loan-to-Value (*LTV*) ratio, which indicates the risk that, when ongoing income does not suffice to make due payments, the value of the collateral does not suffice either. Both increased *LTV* and increased *PTI* ratios increase the overall "credit risk", i.e. the risk that any liabilities of the borrower vis-à-vis the lender are not met as agreed upon. After forming our hypotheses on how banks share their exposure to interest rate risk, we describe our empirical strategy and present the results.

4.1 Bank Behavior: Hypotheses

Retail banks are typically characterized by a positive maturity mismatch as the repricing frequency of its assets is on average lower than that of most of its liabilities, such as short-term sight deposits or wholesale funding. While they can hedge the resulting interest rate risk exposure via interest rate swaps (*Vuillemey, 2017*), the majority of banks keep some exposure on their balance sheets (*Purnanandam, 2007; Hoffmann et al, 2017; Vuillemey, 2017*). One reason may be collateral constraints which impede banks from hedging via swaps (*Rampini & Viswanathan, 2010; Rampini & Viswanathan, 2013; Rampini et al, 2017*). Moreover, hedging all risks would render the bank business less profitable even if swaps are fairly priced.[20]

[20] In case of an upward sloping yield curve, offering shorter loan FP means that a bank forgoes to earn the term premium.

Retail banks can manage their remaining interest rate risk exposure on balance sheets by adjusting the repricing frequencies of their assets or liabilities. In line with the existing literature (*Santomero, 1983; Kirti, 2017*), we take the liability side as quasi exogenous (related to deposit supply) and fixed (related to bond issuance) in the short run.[21] We argue that banks adjust the repricing frequencies, or Fixation Periods (*FPs*), of their assets such that they meet their optimal remaining interest rate risk exposure. When banks see their target levels exceeded, we expect them to display a preference for loans with shorter *FPs* so as to reduce the mismatch in the repricing frequency between assets and liabilities.[22]

> *Hypothesis 3.* *Banks display preferences for* ***shorter*** *Fixation Periods (FPs) if they are already more* ***exposed to pre-existing interest rate risk (IRR).***

Banks have several options to micro-manage their remaining *IRR* when offering loans.[23] First, they can *reject* any request with stated fixation periods or customer characteristics that do not suit their portfolio. Second, they can make an offer in response to inconvenient characteristics but offer a *FP* that differs from the one requested. We coin this behavior *non-compliance*. Third, they can perfectly accommodate the customers' request with the requested *FPs* but charge a higher markup. This can be compensation for accepting additional risks, or for entering an interest rate swap contract to sell the risk in market.

Banks already more exposed to pre-existing interest rate risk, i.e. banks for which the average repricing period of the assets exceeds that of the liabilities on average more, may ceteris paribus be expected to prefer shorter mortgage rate fixation periods, and so (i) reject more often the longer the Requested FPs, (ii) offer shorter *FPs*, and (iii) charge higher mark-ups over fully hedged refinancing costs for longer requested *FPs (RFPs).*

Note that for banks with high *IRR* the decision to push borrowers to short-term fixation periods is not trivial. They can reduce their *IRR* by granting loans with higher repricing frequencies. However, if the returns underlying the loans are not highly correlated with

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[21] Short-term liabilities can consist of any kind of customer deposits (sight or term deposits). Wholesale funds, by contrast, are raised in the interbank market. We assume that it is relatively costly to raise these funding types in the short run.

[22] Note that this hypothesis is not obvious. Banks might have heterogeneous expectations about future interest rates. Those banks which are already more exposed to interest rate risk (IRR) might simply attribute a lower probability to the possibility of future interest rate hikes. For this reason, they will prefer offering longer fixation periods. Alternatively, one might argue that banks with higher pre-existing exposure to interest rate increases are simply less risk averse and willing to take on more interest rate risk.

[23] The existing literature has looked at the average repricing frequency of assets, typically corporate loans (*Kirti, 2017*). Our unique data set allows us to examine *pure offered FPs* for the dominant asset class of retail banks, mortgages.

nominal interest rate movements, then the interest rate risk is converted into credit risk (*Santomero, 1983*). In other words, banks' bidding for shorter *FPs* might backfire as it could predominantly entail a risk transformation instead of net risk reduction.

We can identify these mortgages based on stated risk metrics like the customer's *Payment to Income (PTI)* ratio and *Loan to Value (LTV)* ratios. In general, we expect that banks that are already heavily exposed to *IRR* will charge relatively more for these risks.

To illustrate the argument, first assume that a bank offers a mortgage with a shorter *FP* to a borrower with an elevated *PTI* level.[24] An interest rate hike increases her debt service costs when this borrower needs to re-finance the mortgage at unchanged income levels. In case of a strong parallel shift of the yield curve[25] as triggered by an interest rate rise, the borrower's regular installments to service her debt might reach unbearable levels. As a consequence, she might have to default on the mortgage (*Elul et al, 2010*). If the bank had sold a mortgage with a longer *FP* to this customer with elevated affordability risk, the default event could have been avoided as the longer *FP* implictly had provided protection against mortgage rate hikes. So an interest rate rise might not only trigger an independent realization of *IRR* for the bank in terms of maturity mismatches, but also create additional credit risk for mortgages with short *FPs*.

Our second illustration deals with a borrower's *LTV* ratio. We expect that as house prices are more likely to fall when interest rates rise, high-*LTV* households become more likely to go "under water". Upon maturity, when the borrower needs to re-finance the mortgage, other banks might refuse to accept the customer. The current bank is hence urged to either make concessions and offer unfavorable adjustments to the mortgage's terms and conditions, or it might let the customer default. Interest rate hikes might thus entail higher mortgage default rates[26] (*Cocco & Campbell, 2015; Elul et al, 2010)* and substantially raise the volume of losses given default.

In both cases, we expect banks to prefer longer FPs resulting in higher mortgage rates, both because of a charge of the risk premium for the elevated credit or affordability risk and an

[24] The PTI ratio threshold above which Swiss banks conventionally charge a premium is 33%.

[25] To rule out any other incentives for either the bank or the customer to opt for a different FP, we assume that the shape of the yield curve remains unchanged.

[26] According to standard procedures in many countries, banks usually urge their customer to add other types of collateral in order to restore the value, or reduce the outstanding mortgage level when they seek refinancing after a house price decline.

additional term premium for longer *OFPs* in the presence of an upward sloping yield curve. In particular, we expect that banks with higher levels of *IRR* on balance sheets will be more sensitive to additional borrower credit risks. For this reason we posit the following.

> <u>Hypothesis 4.</u> *The preference of high-IRR banks for shorter fixation periods, as described in Hypothesis 3, is more muted for borrowers with* ***high PTI*** *or* ***LTV*** *ratios.*

To test this, we examine if banks that are more exposed to pre-existing *IRR* prefer, along their various response channels, relatively longer *FP* for borrowers with high *PTI* or *LTV* ratios.

The extent to which a more exposed bank can impose higher risk premiums on customers depends on market conditions and its competitors' exposure to *IRR*. As banks cannot observe other banks' exposure to *IRR*, their quotes truly reflect their willingness to grant a mortgage and thereby reveal insights into their *IRR* management. Yet, in case of a very competitive market environment, a bank might prefer to offer shorter *FPs* to more risky customers in order to avoid carrying the mortgage on balance sheets for longer (e.g. *Claessens et al, 2017)*.

4.2 Bank Behavior: Empirical Strategy

To analyze bank behavior, we relate a bank's choice variables to its *IRR* exposure as well as further bank and household characteristics. In principle, we estimate the following relationship:

$$Y_{b,i,t} = \alpha + \beta\ IRRE_{b,t-1} + \boldsymbol{\gamma}'\ \boldsymbol{Borr_i} * IRR_{b,t-1} + \boldsymbol{\delta}'\ \boldsymbol{Bank_{b,t-1}} + FE_{Borr} + \varepsilon_{b,i,t} \quad (8)$$

where $Y_{b,i,t}$ reflects details of bank *b*'s offer at time *t*, $IRR_{b,t-1}$ is the exposure to *IRR* at the end of the previous reporting period, $\boldsymbol{Borr_i}$ represents the vector of borrower credit risk metrics (*LTV* and *PTI*) and $\boldsymbol{Bank_{b,t-1}}$ is a vector of lagged balance-sheet characteristics of bank *b* as filed in the last regulatory report. We use standard bank control variables like size (log of total assets), capitalization (*CET1 ratio)*, deposits and wholesale funding ratios. Further, we test whether access to the swap market *Swap Use (0/1)* impacts the offered conditions.

While exploiting our dataset structure featuring multiple bank offers per individual request, we use request fixed effects FE_{Borr} to absorb and control for borrower characteristics. As a side effect, this procedure does not allow us to estimate standalone borrower characteristics such as the requested fixation period (*FP Requested*), *PTI* and *LTV* ratios. Our primary interest, however, lies in $\boldsymbol{\gamma},$ the interaction coefficients with banks' *IRR*, and in β which reflects the effects of banks' *IRR*.

We let the *Weighted Offered FP*, *Weighted Spread, Weighted Offered Duration* enter equation (6) as left-hand side variables, the effects on which we estimate using *OLS*. If the banks' choice variable is *binary* to denote an *Explicit rejection*, we estimate a logit model using *Maximum Likelihood (ML)* techniques.

$$Rejection_{b,i} = \frac{exp(\alpha + \beta\ IRRE_{b,t-1} + \boldsymbol{\gamma}'\ \boldsymbol{Borr_i} * IRR_{b,t-1} + \boldsymbol{\delta}'\ \boldsymbol{Bank_{b,t-1}} + FE_{Borr})}{1 + exp(\alpha + \beta\ IRRE_{b,t-1} + \boldsymbol{\gamma}'\ \boldsymbol{Borr_i} * IRR_{b,t-1} + \boldsymbol{\delta}'\ \boldsymbol{Bank_{b,t-1}} + FE_{Borr})} + \varepsilon_{b,i,t} \qquad (9)$$

For our baseline specifications, we restrict the sample to the most frequently requested FPs, 0-1 years, 5 years, and 10 years, to align supply analyses with our demand side analysis.[27] As our bank data start only with the first quarter of 2010, we omit a couple of requests from that first quarter to avoid using contemporaneous rather than lagged bank characteristics

4.3 Bank Behavior: Results

We start discussing our results on bank behavior with descriptive statistics in Table 4. Panel A of this table shows the shares of rejections by category, split into short-term (*FP requested 0-1),* medium-term *(FP requested 5),* and long-term *(FP requested 10)* categories for a total of 5,867 requests and the respective responses by banks.[28] It suggests that the rate of rejection is highest for requests that specify very short-term *FPs,* with one in three requests being rejected (33%). For the other two categories, the share of rejections comes to 15% and 17%, respectively. Simple mean comparisons in Columns (5) and (6) indicate that the differences of 19 percentage points and 17 percentage points are statistically different from zero. Overall, we interpret this as first descriptive evidence that banks do not necessarily offer the fixation periods (*FPs*) that are requested by households. Instead, banks might use the opportunity to reject certain requests to select their most preferred fixation period choices.

Panel B of Table 4 displays bank responses at the offer level without rejected responses. Conditional on submitting an offer, the first row shows the shares of bank offers that deviate

[27] In robustness checks, we have also used the entire sample and obtained very similar results.

[28] The number of requests is smaller compared to the previous section as we do not observe bank characteristics in the first quarter of 2010.

in terms of the tranche-weighted fixation periods (*FPs*). Column (1) indicates that banks, on average, do not comply in about 19% of all requests. A formal t-test suggests that the degree of FP non-compliance is statistically different from zero at all conventional significance levels. This is first descriptive evidence that banks also use this second channel of non-compliance with the requested fixation periods (*RFP*) in case of an offer. The share of FP non-compliance is substantially higher in the case of short-term requested FPs (*0-1y*) (73%, Column 2) than in the case of medium-term requested FPs (*5y*) (9%, Column 3) and 12% in the case of longer term *FPs* (*10y*) (Column 4). In Columns (5)-(7), we test the corresponding differences in means and find that they are statistically different from zero at all conventional significance levels.

Panel B of Table 4 also suggests that banks exploit offered mortgage rates to incentivize customers to choose distinct *FPs*. As the offers that banks submit capture a whole set of terms and conditions with each tranche carrying a specific *FP* and mortgage rate, we compute tranche-weighted aggregate measures per mortgage offer. More specifically, we examine the tranche-weighted offered mortgage rate and their tranche-weighted offered mortgage spread, i.e. the difference between the offered mortgage rates and the corresponding swap rate at that time. Despite the fact that banks can deviate from the requested *FP* when submitting an offer, we observe that even based on evidence by requested *FP* (as captured by columns), the typical shape of an upward-sloping yield curve persists in that longer requested fixation periods are associated with higher average rates.[29]

To examine whether banks use mortgage pricing to incentivize borrowers to deviate from their stated preferences, we focus on average tranche-weighted mortgage spread offered by the banks (*Weighted Spread*), defined as the difference between offered rates and swap rates for the same fixation period, which constitute the refinancing costs after full hedging of interest rate risk. As opposed to the rates, weighted spreads abstract from the term premium and allow us to look at the pure mortgage margin banks charge. In case of tailor-made offers, the mortgage margin implicitly captures both the (risk-free) term premium and the additional compensation that a bank requires in return for the credit risk associated with a borrower. Results in the third row hence mingle the effects from borrower and bank characteristics. Preliminary evidence suggests that the average spread is higher for short-term requests *(0-1y*)

[29] We acknowledge that the mortgage rates are shown relative to the requested *FPs* but not offered *FPs.* There might be some differences as banks deviate with respect to their offered *FPs* from what is requested.

(1.36%) than for the medium-term requests (*5y*) (0.85%) and long-term term requests and (*10y*) (0.94%). Mean differences displayed in Columns (5) and (6) indicate that the differences are statistically different from zero at all conventional significance levels. The fourth row isolates the average tranche-weighted spread offered by those banks that respond with a fully compliant offer. Interestingly, compliant offers carry higher mortgage margins for short-term FPs (*0-1y*) (2.3%) relative to all offers (third row, Column 1) and other requested FPs (fourth row, Columns 3 & 4). We infer from Table 4 that banks deliberately use mortgage pricing to manage their *IRR* exposure and stress the necessity to compare all offers with compliant offers to identify the strategic pricing decisions of banks. We abstain from any further interpretation at this stage as a proper econometric regression analysis is warranted to disentangle the bank-specific pricing of borrower risks from common factors.

Regression Analysis

We proceed to our regression analysis to examine how bank balance-sheet characteristics, borrower risk metrics and their interactions shape the terms and conditions reflected in banks' responses. Our multivariate analysis allows us to control for relevant bank characteristics. All regressions feature request fixed effects absorbing individual demand-side characteristics in the spirit of *Khwaja and Mian (2008).* We present the main results in Table 5.

Regarding *Hypothesis 3,* we present the results of banks' decisions on the *Weighted Offered FP* in Column (2). The estimated coefficient of *IRR* is statistically significant and negative. This suggests that banks that are, ceteris paribus, highly exposed to pre-existing *IRR* grant, on average, shorter fixation periods. In particular, a one basis point increase in the *IRR* decreases the *Weighted Offered FP* by 0.3 years. This result is consistent with *Hypothesis 3.* Moreover, it is in line with *Kirti (2017)'s* finding for lending to non-financial firms.

We obtain a more differentiated picture when considering banks' rejection decisions and mortgage pricing decisions. To do so, we examine the interaction terms between banks' pre-existing *IRR* and the requested fixation period dummy variables for the medium and long term, *FP Requested (5) (0/1)* and *FP Requested (10) (0/1).* Column (1) shows the results for banks' rejection decision as the dependent variable. The estimated coefficients of both interaction terms are negative. A one basis point increase in the *IRR* measure decreases the propensity to reject, or increases the propensity to accept a mortgage, by 0.15 (0.16) percentages points more if the request is for a 5 year (10 year) fixation period relative to a short fixation period of 0-1 years, which is the baseline.

In terms of pricing of these mortgages, we examine the effects on the *Weighted Spread* displayed in Column (3). As before, we focus on the *Weighted Spread* as opposed to the *Weighted Rate* to avoid misinterpretation due to an increasing yield curve.[30] Our results suggest that banks that are highly exposed to pre-existing *IRR* offer, on average, cheaper mortgages when longer fixation periods are requested. In particular, a one basis point increase in the *IRR* decreases the *Weighted Spread* by an additional 0.04 percentage points (0.03 percentage points) for a 5 year (10 year) requested fixation period relative to a requested fixation period of 0-1 years, which is the baseline.

While evidence for offered Fixation Periods (*OFPs*) is consistent with *Hypothesis 3* and existing empirical evidence, the results for banks' rejection and pricing decisions are not. We conclude that, at least in the Swiss context studied, banks drive their *FP* preferences primarily through offered *FP*. By contrast, rejection behavior and pricing might be driven more by other concerns such as the targeted overall volume of new mortgage lending.

To understand which of the effects dominates, we provide the *Weighted Offered Duration* as a further outcome variable. We thereby avoid the simultaneity bias that emerges from the fact that banks submit offers that specify interlinked terms (*Weighted Offered FP, Weighted Rate*). Based on the duration measure taking both outcome variables into account, we recall that longer FPs are associated with longer durations, while higher mortgage rates entail shorter durations.

Regarding *Hypothesis 3*, our results show that highly IRR-exposed banks offer shorter durations (Column 4). This result seems to be driven by the offered FP (Column 2) as the negative and significant estimate in the mortgage rate analysis (Column 5) points into the opposite direction and would imply longer durations.

Are banks with high *IRR* more reluctant to push high risk borrowers to short-term fixation periods so as to avoid additional credit risk? To test this *Hypothesis 4,* we examine how banks' offered *FPs* relate to their pre-existing *IRR* as well as to key household risk

[30] For completeness, we display the results for the outcome variable *Weighted rate* in column (5). Moreover, we show the results for the outcome variable *Weighted Offered Duration* in column (4).

characteristics, *PTI* and *LTV*. As we employ request fixed effects, we do not explicitly estimate the main effects of these variables. However, we can estimate the effects of the interaction terms of these risk borrower characteristics with the banks' pre-existing exposure to interest rate risk (*IRR*). These help us understanding whether banks more exposed to interest rate risk are particularly reluctant to lend at shorter *FP* to risky borrowers.

In results displayed in Column (2), we show the interaction terms between *IRR* and household risk characteristics, *LTV >67% (0/1)* and *LTV >80% (0/1)*. The corresponding point estimates suggest that banks more exposed to *IRR* do offer relatively *shorter*, rather than longer, *FP* to high risk borrowers as opposed to low risk borrowers. In fact, a hundred basis point increase in the *IRR* measure decreases the *Weighted Offered FP* to a borrower with *LTV >67% (0/1) (LTV >80% (0/1))* by 1.9 years (3.1 years) relative to a low risk borrower. Again these loans are priced at higher rates (Column (5)) and higher spreads (Column (3)). As expected, this implies that these loans display shorter *Weighted Offered Durations* (column (4)).

This evidence seems to suggest that banks do not try to reduce the credit risk of high-LTV borrowers by insuring them against interest rate increases. Instead, they intend to move these borrowers off their balance sheets before house price declines may have put them under water. Our finding is in line with *Claessens et al (2017)* who observe shorter maturities and higher pricing of corporate loans following exogenous downward ratings of these borrowers.

In analyses presented in Appendix 3 and 4, we provide robustness checks. Now the *IRR* measure with bank-specific assumptions on the effective repricing period of assets and liabilities with unspecified repricing periods are replaced with respectively average assumptions across all banks within each quarter, and with a fixed assumption of two years. Results show that banks' responsiveness to the *IRR* measures increases as we close down first inter-bank and then also inter-period variation in banks' assumptions. We interpret this as saying that banks are more responsive to pure variations in their own maturity mismatch than in the versions with varying assumptions reported to the supervisory authority.

We also use the *RFP* as a continuous rather than as a categorical variable. Moreover, we include all *RFP* categories rather than just the main ones. In both cases, the results are qualitatively the same as in the baseline version reported above. The same is true when we restrict the sample to requests for rollover mortgages, thus dropping the about 50% of requests that are for new mortgages. All of these robustness tests are available upon request.

In the above analyses, we ask the question whether banks heavily exposed to *IRR* are less inclined to decrease their *IRR* exposure if this implies an increase in credit risk. In unreported robustness checks, we also examine the main effects of *PTI>33% (0/1)* and *LTV >67% (0/1) (LTV >80% (0/1))* but now controlling for time-variant bank characteristics via *Bank*Year* Fixed Effects. Looking at *Weighted Offered FP* as the outcome variable, we examine the main effects of *PTI>33% (0/1)*, *LTV >67% (0/1)* and *LTV >80% (0/1)*. Moreover, we estimate their interaction with *FP Requested (5) (0/1)* and *FP Requested (10) (0/1)* for the dependent variables *Explicit rejection* and *Weighted spread*. Our results confirm our analyses reported in Table 5.[31]

5 Conclusion

In this paper we have investigated the choice of mortgage rate fixation periods (*FP*) by both households and banks. We contribute to both the literature on (household) mortgage choice[32] and to that on banks' management of interest rate risk.[33] The former has so far only analyzed aggregated data or, at best, data on individual mortgage contracts and has had to assume that these contracts were shaped exclusively by household preferences. By contrast, we analyze *un-intermediated* mortgage demand for different *FPs*. Our results confirm that households care primarily about the term premium, i.e. the current relative price of longer vs. shorter fixation periods. This corroborates a key conjecture of the literature, which has so far required a non-trivial assumption.

More importantly, we find no empirical support for the hypothesis of households acting as prudent risk managers. Instead, our results indicate that those households most in need of insuring against rate increases tend to request shorter fixation periods so as to limit current cost. This may be due to the fact that the last time average variable rates exceeded five percent was in the early 1990s when an interest rate hike triggered Switzerland’s last wave of house price declines and mortgage defaults, and many current mortgage borrowers may not sufficiently remember that episode. This is consistent with the recent empirical literature pointing out that individuals overemphasize recent experiences when forming expectations

[31] The corresponding table is available upon request.

[32] See, for example, *Campbell & Cocco (2003), Koijen et al (2009), Rubio (2011), Calza et al (2013), Malmendier & Nagel, (2016), Rampini & Viswanathan (2016), Ehrmann & Ziegelmeyer (2017),* and *Badarinza et al (2017).*

[33] See, e.g., *Purnanandam (2007), Foà et al (2015), Fuster & Vickery (2015), Gomez et al (2016),* and *Rampini et al (2017).*

about economic variables, including consumer prices (*Malmendier & Nagel, 2016*), asset returns (*Malmendier & Nagel, 2011*) and house prices (*Kuchler & Zafar, 2015*).

We also contribute to the literature on banks' management of interest rate risk. It argues that banks have an incentive to offer loans with shorter fixation periods so as to reduce the mismatch in the repricing frequency between liabilities and assets (*Santomero, 1983; Kirti, 2017*). Using our unique dataset, we show that banks can and, on many occasions, do actively steer the contracted *FP* by (i) selectively rejecting requests, (ii) offering *FP* that differ from those requested, or (iii) charging higher mark-ups on *FP* not currently sought. In line with *Kirti (2017),* we find that banks more exposed to *IRR* are more likely to offer shorter *FP* than have been requested. However, when considering banks' rejection decisions and mortgage pricing decisions, we do not find such evidence.

Moreover, we show that banks' preferences for *Fixation Periods (FPs*) vary with household risk characteristics. Our hypothesis expected banks to, ceteris paribus, push both high-PTI and high-LTV households toward longer *FPs.* However, our evidence suggests that their offered *FPs* do not vary significantly with PTI ratios. Moreover, they tend to offer *shorter FPs* to high-LTV households. Apparently banks prefer to commit to the implied credit risk for a shorter period of time, rather than seeking to insure these households against interest rate increases.

Beyond the contribution to the literature on household mortgage choice and to that on bank interest rate risk management, our results can be relevant for practitioners and policy-makers. Interest rate increases will reduce disposable income for households, particularly those with ARM. In particular amongst households with high PTI ratios, this may increase the propensity to default on mortgage payments. This can, hence, imply increased credit risk for banks lending to them.

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Figures and Tables

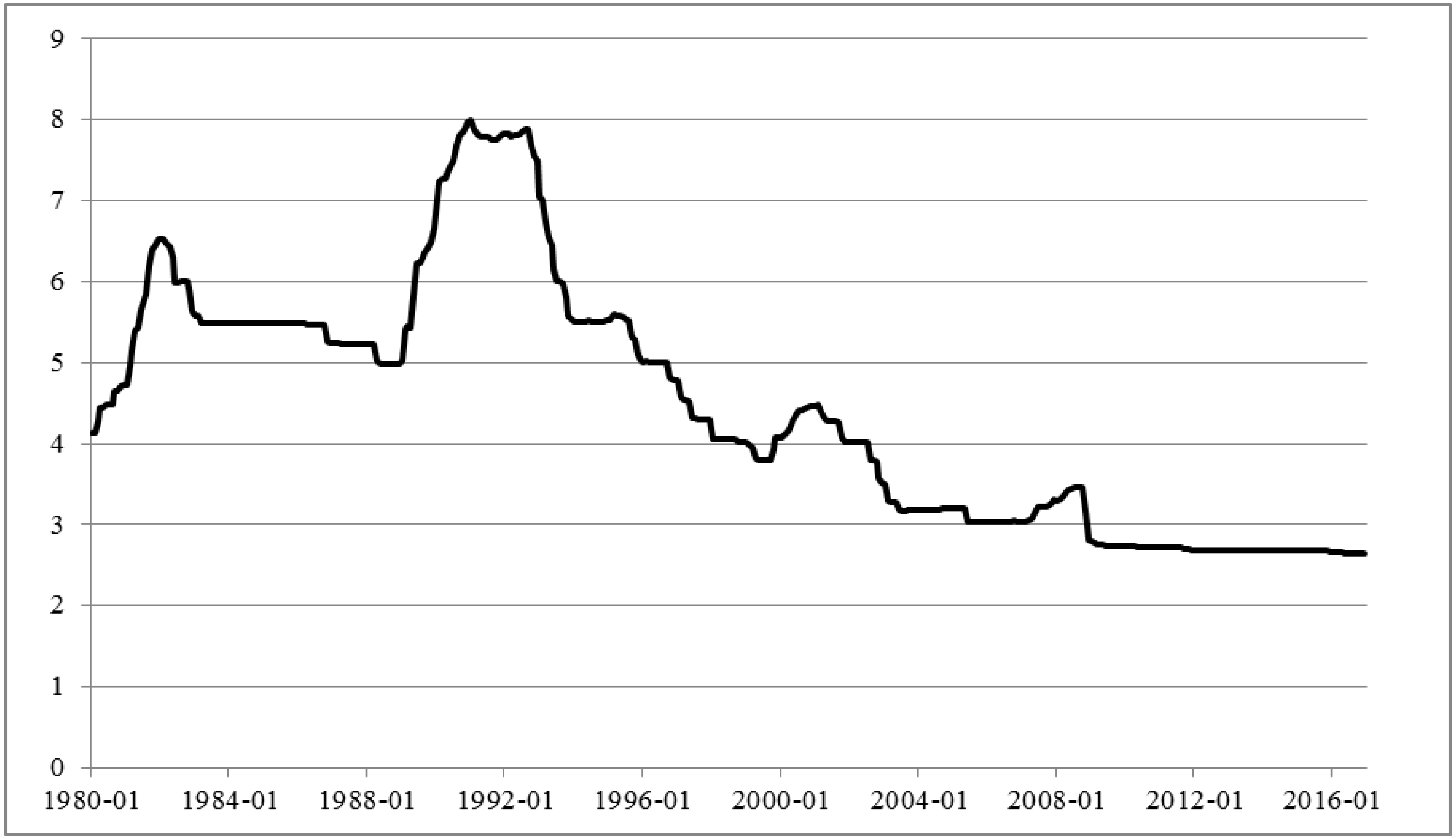
Figure 1: Supervisory Reporting Form on Banks' Interest Rate Risk Exposures

		Category I		Category II									
		Claims	Liabilities (2)	Sight claims		Sight liabilities		Claims against customers (portion with undefined repricing maturity)		Mortgage claims (portion with undefined repricing maturity)		Amounts due in respect of customer deposits, callable, but not transferable	
		col. 101	col. 102		col. 03		col. 06		col. 09		col. 12		col. 15
Nominal amount less any value adjustments	01												
Method for imputing repricing maturities (3)	02												
Time period		Cash-Flows col. 01	Cash-Flows col. 02	Weight in % (4) col. 04	Cash-Flows col. 05	Weight in % (4) col. 07	Cash-Flows col. 08	Weight in % (4) col. 10	Cash-Flows col. 11	Weight in % (4) col. 13	Cash-Flows col. 14	Weight in % (4) col. 16	Cash-Flows col. 17
Up to 1 day	01												
> 1 day to 1 month	02												
> 1 month to 2 months	03												
> 2 months to 3 months	04												
> 3 months to 6 months	05												
> 6 months to 9 months	06												
> 9 months to 1 year	07												
> 1 year to 2 years	08												
> 2 years to 3 years	09												
> 3 years to 4 years	10												
> 4 years to 5 years	11												
> 5 years to 6 years	12												
> 6 years to 7 years	13												
> 7 years to 8 years	14												
> 8 years to 9 years	15												
> 9 years to 10 years	16												
> 10 years to 15 years	17												
> 15 years	18												

		Category III											
		Trading portfolio assets less trading portfolio liabilities		Financial investments (with-out repricing maturity or with arbitrary repricing maturity)		Participations		Tangible fixed assets, intangible assets		Other assets, accrued income and prepaid expenses		Other liabilities, accrued expenses and deferred income and provisions not included in eligible capital (where not already entered under Category I)	
			col. 18		col. 21		col. 24		col. 27		col. 30		col. 33
Nominal amount less any value adjustments	01												
Method for imputing repricing maturities (3)	02												
Time period		Weight in % (4) col. 19	Cash-Flows col. 20	Weight in % (4) col. 22	Cash-Flows col. 23	Weight in % (4) col. 25	Cash-Flows col. 26	Weight in % (4) col. 28	Cash-Flows col. 29	Weight in % (4) col. 31	Cash-Flows col. 32	Weight in % (4) col. 34	Cash-Flows col. 35
Up to 1 day	01												
> 1 day to 1 month	02												
> 1 month to 2 months	03												
> 2 months to 3 months	04												
> 3 months to 6 months	05												
> 6 months to 9 months	06												
> 9 months to 1 year	07												
> 1 year to 2 years	08												
> 2 years to 3 years	09												
> 3 years to 4 years	10												
> 4 years to 5 years	11												
> 5 years to 6 years	12												
> 6 years to 7 years	13												
> 7 years to 8 years	14												
> 8 years to 9 years	15												
> 9 years to 10 years	16												
> 10 years to 15 years	17												
> 15 years	18												

		Category IV						Category V
		Eligible capital required ERROR		of which: dotation capital		of which: subordinated bonds included in eligible capital		Contract volume of non-linear derivatives on interest rate instruments in the banking book
			col. 36		col. 39		col. 42	col. 45
Nominal amount less any value adjustments	01							
Method for imputing repricing maturities (3)	02							
Time period		Weight in % (4) col. 37	Cash-Flows col. 38	Weight in % (4) col. 40	Cash-Flows col. 41	Weight in % (4) col. 43	Cash-Flows col. 44	
Up to 1 day	01							
> 1 day to 1 month	02							
> 1 month to 2 months	03							
> 2 months to 3 months	04							
> 3 months to 6 months	05							
> 6 months to 9 months	06							
> 9 months to 1 year	07							
> 1 year to 2 years	08							
> 2 years to 3 years	09							
> 3 years to 4 years	10							
> 4 years to 5 years	11							
> 5 years to 6 years	12							
> 6 years to 7 years	13							
> 7 years to 8 years	14							
> 8 years to 9 years	15							
> 9 years to 10 years	16							
> 10 years to 15 years	17							
> 15 years	18							

Figure 2: Average variable rates for new mortgages in Switzerland (in percent, monthly average)



Source: Swiss National Bank, www.data.snb.ch, accessed on 22 November 2017.

Table 1: Summary Statistics on Requests and Responses

Panel A of this table shows the characteristics of the 5,914 initial requests submitted by households between 2010 and 2013. Panel B shows benchmark yields in percent at the monthly level. Panel C shows responses by banks at the response level. Panel D shows the responses at the offer level and Panel E shows bank characteristics. Definitions of variables are provided in the Appendix 1.

Panel A. Request characteristics (request level)

	Mean	St.Dev.	Min	Max	Observations
RFP	7.28	3.65	0	10	5,914
FP Requested (0-1) (0/1)	0.15	0.36	0	1	5,914
FP Requested (5) (0/1)	0.25	0.43	0	1	5,914
FP Requested (10) (0/1)	0.60	0.49	0	1	5,914
PTI	26.17	10.81	2	98	5,914
PTI >33% (0/1)	0.17	0.38	0	1	5,914
LTV	65.38	17.26	2	99	5,914
LTV >67% (0/1)	0.55	0.50	0	1	5,914
LTV >80% (0/1)	0.08	0.28	0	1	5,914
Wealth (ln)	12.59	1.07	8.52	16.81	5,914
Other real estate (0/1)	0.24	0.43	0	1	5,914
Debt (0/1)	0.22	0.41	0	1	5,914
Age	45.89	10.42	18	92	5,914
Property age	28.50	35.59	0	255	5,914

Panel B. Benchmark yields (monthly level)

	Mean	St.Dev.	Min	Max	Observations
Market Spread (mortgage rate)	1.15	0.33	0.63	1.65	46
Market 10-year mortgage rate	2.67	0.43	2.07	3.39	46
Spread (government bonds)	0.96	0.41	0.41	1.76	46
10-year government bond rate	1.18	0.50	0.53	2.08	46

Panel C. Bank responses (response level)

	Mean	St.Dev.	Min	Max	Observations
Explicit Rejection	0.19	0.39	0	1	20,117

Panel D. Bank responses (offer level)

	Mean	St.Dev.	Min	Max	Observations
Weighted Offered FP	7.53	3.28	0	10	16,349
Weighted Offered Duration	7.02	2.72	1	10	16,349
Weighted Rate	2.16	0.55	0.10	6.91	16,349
Weighted Spread	0.97	0.34	-1.73	6.87	16,349
FP not comply	0.19	0.39	0	1	16,349

Panel E. Bank characteristics (response level)

	Mean	St.Dev.	Min	Max	Observations
IRR (Bank Assumptions)	0.07	0.04	-0.05	0.18	20,117
IRR (Quarter-Average Assumptions)	0.05	0.03	-0.01	0.15	20,117
IRR (Bank- and Time-Invariant Ass.)	0.08	0.03	0.01	0.18	20,117
Swap Use (0/1)	0.96	0.19	0	1	20,117
Ln (Total Assets)	9.19	1.26	5.83	10.55	20,117
CET1 in % of TA	6.27	1.65	3.33	11.29	20,117
Deposits in % of TA	69.53	7.42	53.43	81.78	20,117
WS Funding in % of TA	19.62	8.32	6.08	34.07	20,117

Table 2: OLS Analysis of Requested Fixation Periods

This table shows the results of linear model estimated using *OLS* with the fixation period requested by a household (*RFP*) as the left-hand side variable. Explanatory variables are household & house characteristics, as well as to the difference between 10-year and 1-year government bond yields prevailing on the day of the request. The sample includes requests for mortgages filed between 2010 and 2013. Observations are at the request level. House variables are indicator variables for the property type, *Property age.* The estimations do not include fixed effects. Heteroskedasticity robust standard errors are reported in brackets. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of the variables are provided in the Appendix 1.

Model	Linear					
Dependent variable	Requested Fixation Period (*RFP*)					
	(1)	(2)	(3)	(4)	(5)	(6)
Spread (government bonds)	-1.482***	-1.482***	-1.481***	-1.481***	-1.482***	-1.467***
	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
PTI	-0.008	-0.006	-0.006	-0.004	-0.004	-0.004
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
PTI >33% (0/1)		-0.096	-1.532	-1.525	-1.628	-1.359
		(0.167)	(1.500)	(1.500)	(1.499)	(1.504)
PTI >33% (0/1)*Wealth (ln)			0.115	0.113	0.122	0.104
			(0.120)	(0.120)	(0.119)	(0.120)
LTV				-0.004	0.003	0.006
				(0.003)	(0.005)	(0.005)
LTV >67% (0/1)					-0.316**	-0.325**
					(0.152)	(0.152)
LTV >80% (0/1)						-0.518***
						(0.191)
Wealth (ln)	0.103**	0.104**	0.085*	0.081*	0.077	0.073
	(0.045)	(0.045)	(0.049)	(0.049)	(0.049)	(0.049)
Other real estate (0/1)	-0.187	-0.185	-0.188	-0.185	-0.186	-0.188
	(0.119)	(0.119)	(0.119)	(0.119)	(0.119)	(0.119)
Debt (0/1)	-0.327***	-0.327***	-0.326***	-0.319***	-0.317***	-0.297**
	(0.120)	(0.120)	(0.120)	(0.120)	(0.120)	(0.120)
Age	-0.048***	-0.048***	-0.048***	-0.050***	-0.051***	-0.051***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Constant	9.781***	9.749***	9.984***	10.336***	10.110***	9.943***
	(0.717)	(0.720)	(0.761)	(0.819)	(0.829)	(0.830)
Observations	5,914	5,914	5,914	5,914	5,914	5,914
Unit of observation	Request	Request	Request	Request	Request	Request
Property variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	No	No	No	No	No	No
R2	0.055	0.055	0.055	0.056	0.056	0.058
Method	OLS	OLS	OLS	OLS	OLS	OLS

Table 3: Multinomial Logit Analysis of Requested Fixation Periods

This table shows the results of *Multinomial Logit Models* using *Maximum Likelihood* (*ML*) with the fixation period requested by a household as the left-hand side variable. Explanatory variables are household & house characteristics, as well as to the difference between 10-year and 1-year government bond yields prevailing on the day of the request. Columns (1)-(2) show the raw coefficients (baseline category is *FP requested (0-1) (0/1)*) and columns (3)-(5) show marginal effects of *Multinomial Logit Models* at the mean for continuous variables and at zero for binary variables. The sample includes requests for mortgages filed between 2010 and 2013. Observations are at the request level. House variables are indicator variables for the property type, *Property age*. The estimations do not include fixed effects. Heteroskedasticity robust standard errors are reported in brackets. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of the variables are provided in the Appendix 1.

Model	Multinomial Logit (raw coefficients / log-odds ratios)		Multinomial Logit (marginal effects)		
Dependent variable	FP Requested (5) (0/1)	FP Requested (10) (0/1)	FP Requested (0-1) (0/1)	FP Requested (5) (0/1)	FP Requested (10) (0/1)
	(1)	(2)	(3)	(4)	(5)
Spread (government bonds)	0.804***	-0.685***	0.035***	0.220***	-0.256***
	(0.105)	(0.095)	(0.012)	(0.028)	(0.025)
PTI	-0.013**	-0.006	0.001	-0.001*	0.000
	(0.006)	(0.005)	(0.000)	(0.001)	(0.001)
PTI >33% (0/1)	0.752	-0.828	0.048	0.232	-0.279
	(1.319)	(1.103)	(0.100)	(0.143)	(0.174)
PTI >33% (0/1)*Wealth (ln)	-0.076	0.059	-0.003	-0.020*	0.023*
	(0.105)	(0.087)	(0.008)	(0.011)	(0.014)
LTV	0.008*	0.007*	-0.001*	0.000	0.000
	(0.004)	(0.004)	(0.000)	(0.001)	(0.001)
LTV >67% (0/1)	-0.348**	-0.334**	0.034***	-0.010	-0.024
	(0.145)	(0.130)	(0.012)	(0.017)	(0.020)
LTV >80% (0/1)	-0.233	-0.393***	0.036**	0.017	-0.052**
	(0.160)	(0.139)	(0.015)	(0.020)	(0.023)
Wealth (ln)	-0.122***	0.011	0.002	-0.021***	0.019***
	(0.045)	(0.041)	(0.004)	(0.006)	(0.007)
Other real estate (0/1)	-0.183*	-0.174*	0.018**	-0.005	-0.012
	(0.106)	(0.092)	(0.009)	(0.013)	(0.015)
Debt (0/1)	-0.138	-0.228**	0.021**	0.009	-0.030**
	(0.104)	(0.092)	(0.009)	(0.012)	(0.015)
Age	0.008*	-0.030***	0.002***	0.005***	-0.008***
	(0.005)	(0.004)	(0.001)	(0.001)	(0.001)
Constant	0.987	3.507***			
	(0.732)	(0.677)			
Observations	5,914	5,914	5,914	5,914	5,914
Unit of observation	Request	Request	Request	Request	Request
Property variables	Yes	Yes	Yes	Yes	Yes
Fixed Effects	No	No	No	No	No
Pseudo R2	0.058	0.058	0.058	0.058	0.058
Method	ML	ML	ML	ML	ML

Table 4: Descriptive Statistics on Bank Responses by Requested Fixation Periods

Panel A of this table shows banks' relative rejection frequencies at the bank response level in total (column (1)) and depending on the Fixation Periods Requested *(RFP)* by households (columns (2)-(4)). Panel B of this table shows banks' responses at the bank offer level. Row 1 shows the shares of offers that deviate in terms of the tranche-weighted Fixation Periods *(FP)* offered by the banks from the requested Fixation Periods *(RFP)* (which is indicated by the variable *FP not comply*). Row 2 shows the average tranche-weighted mortgage rate offered by the banks (*Weighted Rate*). Row 3 shows the average tranche-weighted mortgage spread offered by the banks (*Weighted Spread*). Row 4 shows the average tranche-weighted mortgage spread (*Weighted Spread*) offered by the banks if the tranche-weighted offered fixation periods equal the requested fixation periods (*Weighted Offered FP=FP Requested*). The means of all variables are shown in total (column (1)) and by the requested Fixation Periods (FP) by households (columns (2)-(4)). In both panels, columns (5)-(7) test the corresponding differences in means. The sample includes only requests filed between 2010 and 2013. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of the variables are provided in the Appendix 1.

Panel A. Requested fixation periods and banks' responses (bank response level)

Variable	Total	FP Requested (0-1y)	FP Requested (5y)	FP Requested (10y)	Difference (2)-(3)	Difference (2)-(4)	Difference (3)-(4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Explicit Rejection	0.187	0.334	0.146	0.167	0.188***	0.167***	-0.021***
	(N=20,117)	(N=3,021)	(N=4,704)	(N=12,392)	(N=7,725)	(N=15,413)	(N=17,096)

Panel B. Requested fixation periods and banks' offers (bank offer level)

Variable	Total	FP Requested (0-1y)	FP Requested (5y)	FP Requested (10y)	Difference (2)-(3)	Difference (2)-(4)	Difference (3)-(4)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
FP not comply	0.187	0.728	0.093	0.119	0.635***	0.610***	-0.026***
	(N=16,349)	(N=2,013)	(N=4,019)	(N=10,317)	(N=6,032)	(N=12,330)	(N=14,336)
Weighted Rate	2.157	1.560	1.860	2.390	-0.300***	-0.830***	-0.530***
	(N=16,349)	(N=2,013)	(N=4,019)	(N=10,317)	(N=6,032)	(N=12,330)	(N=14,336)
Weighted Spread	0.968	1.358	0.847	0.939	0.511***	0.419***	-0.093***
	(N=16,349)	(N=2,013)	(N=4,019)	(N=10,317)	(N=6,032)	(N=12,330)	(N=14,336)
Weighted Spread if FP comply	0.942	2.308	0.819	0.908	1.489***	1.400***	-0.089***
	(N=13,284)	(N=547)	(N=3,644)	(N=9,093)	(N=4,191)	(N=9,640)	(N=12,737)

Table 5: Regression Analysis of Bank Responses, Baseline IRR

This table shows the results of a *Logit Model* (column 1) estimated using *Maximum Likelihood (ML)* and linear models (columns 2-5) estimated using *OLS* with the following left-hand side variables: *Explicit Rejection, Weighted Offered FP, Weighted Spread, Weighted Offered Duration, Weighted Rate.* Explanatory variables are bank characteristics: *IRR (Bank Assumptions), Swap Use (0/1), Ln (Total Assets), CET1 in % of TA, Deposits in % of TA, WS Funding in % of TA.* The sample includes requests for mortgages filed between 2010 and 2013. Observations are at the bank response level. The estimations include request fixed effects but no bank fixed effects. Heteroskedasticity robust standard errors are reported in brackets. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of variables are provided in the App. 1.

Model	Logit (marginal effects)	Linear	Linear	Linear	Linear
Dependent variable	Explicit Rejection	Weighted Offered FP	Weighted Spread	Weighted Offered Duration	Weighted Rate
	(1)	(2)	(3)	(4)	(5)
IRR (Bank Assumptions)	0.474	-28.237***	0.870**	-22.509***	-2.374***
	(4.110)	(2.861)	(0.367)	(2.256)	(0.418)
IRR (Bank Assumptions) * PTI >33% (0/1)	19.202***	-0.104	0.005	-0.173	0.197
	(0.989)	(0.742)	(0.120)	(0.610)	(0.164)
IRR (Bank Assumptions) * LTV >67% (0/1)	-0.104	-1.883***	0.594***	-1.462***	0.352***
	(0.818)	(0.461)	(0.077)	(0.378)	(0.098)
IRR (Bank Assumptions) * LTV >80% (0/1)	19.958***	-3.075***	0.126	-2.655***	0.295
	(1.302)	(0.987)	(0.176)	(0.805)	(0.210)
IRR (Bank Assumptions) * FP Requested (5) (0/1)	-15.352***	15.547***	-3.292***	12.406***	0.161
	(1.175)	(1.393)	(0.224)	(1.123)	(0.246)
IRR (Bank Assumptions) * FP Requested (10) (0/1)	-16.188***	42.070***	-2.644***	33.916***	2.215***
	(1.013)	(1.392)	(0.219)	(1.122)	(0.241)
IRR (Bank Assumptions) * Swap Use (0/1)	3.923	2.163	1.211***	1.342	1.028***
	(4.057)	(2.290)	(0.290)	(1.791)	(0.290)
Swap Use (0/1)	1.267***	-0.080	0.016	-0.077	-0.011
	(0.171)	(0.089)	(0.011)	(0.069)	(0.013)
Ln (Total Assets)	-0.146***	0.058***	-0.018***	0.048***	-0.001
	(0.036)	(0.016)	(0.002)	(0.012)	(0.003)
CET1 in % of TA	-0.116***	0.016*	0.029***	0.003	0.031***
	(0.022)	(0.008)	(0.002)	(0.007)	(0.002)
Deposits in % of TA	-0.089***	0.013**	0.003**	0.012***	-0.004***
	(0.012)	(0.005)	(0.001)	(0.004)	(0.001)
WS Funding in % of TA	-0.143***	0.031***	0.001	0.025***	0.000
	(0.012)	(0.005)	(0.001)	(0.004)	(0.001)
Constant	8.098***	5.214***	0.726***	5.122***	2.192***
	(1.233)	(0.493)	(0.123)	(0.387)	(0.100)
Observations	20,117	16,349	16,349	16,349	16,349
Number of requests	5,432	5,076	5,076	5,076	5,076
Unit of observation	Response	Response	Response	Response	Response
Request FE	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	No	No	No
Method	ML	OLS	OLS	OLS	OLS

Appendix 1: Variable Definitions

Variable name	Definition	Source
Request characteristics		
RFP	Mortgage fixation period requested by the customer in years.	Comparis
FP Requested (0-1) (0/1)	Indicator of whether the mortgage fixation period requested by the customer is 0-1 years.	Comparis
FP Requested (5) (0/1)	Indicator of whether the mortgage fixation period requested by the customer is 5 years.	Comparis
FP Requested (10) (0/1)	Indicator of whether the mortgage fixation period requested by the customer is 10 years.	Comparis
PTI	Payment to income-ratio as specified in the application (in percent).	Comparis
PTI >33% (0/1)	Indicator of whether the payment to income ratio exceeds the value of 33%.	Comparis
LTV	Loan to value ratio (in percent).	Comparis
LTV >67% (0/1)	Indicator of whether the loan to value ratio exceeds the value of 67%.	Comparis
LTV >80% (0/1)	Indicator of whether the loan to value ratio exceeds the value of 80%.	Comparis
Wealth (ln)	Wealth including retirement savings as specified by the customer expressed in natural logarithm.	Comparis
Other real estate (0/1)	Indicator of whether the customer possesses further real estate.	Comparis
Debt (0/1)	Indicator of whether the customer reports any kind of debt.	Comparis
Age	Age of the customer in years.	Comparis
Property age	Difference between the year of the request and the year of property construction.	Comparis
Benchmark yields		
Market Spread (mortgage rate)	Difference between the average interest charged on 10-year fixed and 1-year mortgage rates in Switzerland (per month) (in percent).	SNB
Market 10-year mortgage rate	Average interest charged on 10-year fixed mortgage rate month in Switzerland (in percent).	SNB
Spread (government bonds)	Difference between the average interest charged on 10-year fixed and 1-year Swiss government bond yield (per month) (in percent).	SNB
10-year government bond rate	Average 10-year fixed Swiss government bond yield (per month) (in percent).	SNB
Bank response and bank offer characteristics		
Explicit Rejection	Indicator of whether the bank does not make a binding mortgage offer given that the request was sent.	Comparis
Weighted Offered FP	Tranche-weighted mortgage fixation period offered by the bank.	
Weighted Offered Duration	Tranche-weighted duration of the mortgage offered by the bank.	Comparis
Weighted Rate	Tranche-weighted mortgage rate offered by the bank (in percent).	Comparis
Weighted Spread	Tranche-weighted difference between mortgage rate offered by the bank and interest swap rate (in percentage points).	Comparis
FP not comply	Indicator of whether the tranche-weighted fixation period offered by the bank equals the one requested by the household.	Comparis

Appendix 1 continued

Variable name	Definition	Source
Bank characteristics		
IRR (Bank Assumptions)	Loss from 100bps increase in CHF LIBOR rates in % of CET1 capital, bank assumption on effective resetting period of assets and liabilities with unspecified resetting period.	FINMA
IRR (Quarter-Average Assumptions)	Loss from 100bps increase in CHF LIBOR rates in % of CET1 capital, with average assumption across all banks.	FINMA
IRR (Bank- and Time-Invariant Ass.)	Loss from 100bps increase in CHF LIBOR rates in % of CET1 capital, with bank- and time-invariant assumption of 2 years.	FINMA
Swap Use (0/1)	Indicator of whether the bank uses interest rate swaps.	FINMA
Ln (Total Assets)	Log of total assets.	FINMA
CET1 in % of TA	Core Equity Tier 1 capital in percent of total assets.	FINMA
Deposits in % of TA	Percentage of total assets funded with deposits.	FINMA
WS Funding in % of TA	Percentage of total assets funded through wholesale funding.	FINMA

Appendix 2: Regression Analysis of Bank Responses, Bank-Invariant IRR

This table shows the results of a *Logit Model* (column 1) estimated using *Maximum Likelihood (ML)* (marginal effects presented) and linear models (columns 2-5) estimated using *OLS* with the following left-hand side variables: *Explicit Rejection, Weighted Offered FP, Weighted Spread, Weighted Offered Duration, Weighted Rate.* Explanatory variables are bank characteristics: *IRR (Quarter-Average Ass.), Swap Use (0/1), Ln (Total Assets), CET1 in % of TA, Deposits in % of TA, WS Funding in % of TA.* The sample includes requests for mortgages filed between 2010 and 2013. Observations are on the bank response level. The estimations include request fixed effects but no bank fixed effects. Heteroskedasticity robust standard errors are reported in brackets. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of variables are provided in the Appendix 1.

Method	Logit (marginal effects)	Linear	Linear	Linear	Linear
Dependent variable	Explicit Rejection	Weighted Offered FP	Weighted Spread	Weighted Offered Duration	Weighted Rate
	(1)	(2)	(3)	(4)	(5)
IRR (Quarter-Average Ass.)	-6.201	-36.790***	2.042***	-26.118***	-3.717***
	(4.532)	(2.287)	(0.405)	(1.739)	(0.500)
IRR (Quarter-Average Ass.)	23.191***	-0.329	0.070	-0.310	0.123
* PTI >33% (0/1)	(1.216)	(0.743)	(0.143)	(0.605)	(0.183)
IRR (Quarter-Average Ass.)	-1.063	-0.493	0.211**	-0.310	-0.008
* LTV >67% (0/1)	(1.040)	(0.441)	(0.089)	(0.355)	(0.107)
IRR (Quarter-Average Ass.)	22.296***	-2.121*	0.280	-1.880**	0.567**
* LTV >80% (0/1)	(1.576)	(1.107)	(0.200)	(0.892)	(0.245)
IRR (Quarter-Average Ass.)	-16.505***	28.416***	-4.384***	19.826***	2.048***
* FP Requested (5) (0/1)	(1.449)	(1.392)	(0.277)	(1.109)	(0.303)
IRR (Quarter-Average Ass.)	-16.544***	50.599***	-3.426***	36.564***	4.689***
* FP Requested (10) (0/1)	(1.238)	(1.391)	(0.273)	(1.108)	(0.301)
IRR (Quarter-Average Ass.)	15.325***	-3.281*	0.860***	-2.677**	0.208
* Swap Use (0/1)	(4.475)	(1.788)	(0.301)	(1.332)	(0.368)
Swap Use (0/1)	0.722***	0.198**	-0.018	0.136**	-0.007
	(0.198)	(0.094)	(0.014)	(0.069)	(0.019)
Ln (Total Assets)	-0.145***	0.059***	-0.019***	0.050***	0.000
	(0.036)	(0.012)	(0.002)	(0.009)	(0.003)
CET1 in % of TA	-0.110***	0.032***	0.028***	0.016***	0.032***
	(0.021)	(0.007)	(0.002)	(0.005)	(0.002)
Deposits in % of TA	-0.100***	0.026***	0.004***	0.021***	-0.003***
	(0.012)	(0.004)	(0.001)	(0.003)	(0.001)
WS Funding in % of TA	-0.142***	0.036***	0.002	0.029***	0.000
	(0.012)	(0.004)	(0.001)	(0.003)	(0.001)
Constant	9.058***	4.088***	0.718***	4.351***	2.142***
	(1.236)	(0.419)	(0.125)	(0.330)	(0.099)
Observations	20,117	16,349	16,349	16,349	16,349
Number of requests	5,432	5,076	5,076	5,076	5,076
Unit of observation	Response	Response	Response	Response	Response
Request FE	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	No	No	No
Method	ML	OLS	OLS	OLS	OLS

Appendix 3: Regression Analysis of Bank Responses, Bank- and Time-Invariant IRR

This table shows the results of a *Logit Model* (column 1) estimated using *Maximum Likelihood (ML)* (marginal effects presented) and linear models (columns 2-5) estimated using OLS with the following left-hand side variables: *Explicit Rejection, Weighted Offered FP, Weighted Spread, Weighted Offered Duration, Weighted Rate.* Explanatory variables are bank characteristics: *IRR (Bank- and Time-Invariant Ass.), Swap Use (0/1), Ln (Total Assets), CET1 in % of TA, Deposits in % of TA, WS Funding in % of TA.* The sample includes requests for mortgages filed between 2010 and 2013. Observations are at the bank response level. The estimations include request fixed effects but no bank fixed effects. Heteroskedasticity robust standard errors are reported in brackets. ***, **, * denote statistical significance at the 0.01, 0.05 and 0.10-level respectively. Definitions of variables are provided in the Appendix 1.

Method	Logit (marginal effects)	Linear	Linear	Linear	Linear
Dependent variable	Explicit Rejection	Weighted Offered FP	Weighted Spread	Weighted Offered Duration	Weighted Rate
	(1)	(2)	(3)	(4)	(5)
IRR (Bank- and Time-Invariant Ass.)	-7.186	-54.618***	1.899***	-42.668***	-4.329***
	(4.818)	(2.697)	(0.387)	(2.119)	(0.483)
IRR (Bank- and Time-Invariant Ass.) * PTI >33% (0/1)	19.050***	-0.126	0.051	-0.205	0.222
	(0.915)	(0.446)	(0.116)	(0.383)	(0.162)
IRR (Bank- and Time-Invariant Ass.) * LTV >67% (0/1)	-0.892	-1.105***	0.297***	-0.829***	0.106
	(0.749)	(0.278)	(0.073)	(0.242)	(0.099)
IRR (Bank- and Time-Invariant Ass.) * LTV >80% (0/1)	18.975***	-1.366**	0.126	-1.365**	0.582***
	(1.203)	(0.671)	(0.165)	(0.582)	(0.222)
IRR (Bank- and Time-Invariant Ass.) * FP Requested (5) (0/1)	-14.045***	37.088***	-4.197***	28.224***	2.102***
	(1.058)	(0.770)	(0.226)	(0.655)	(0.262)
IRR (Bank- and Time-Invariant Ass.) * FP Requested (10) (0/1)	-13.672***	74.971***	-3.390***	58.990***	5.040***
	(0.889)	(0.757)	(0.223)	(0.644)	(0.257)
IRR (Bank- and Time-Invariant Ass.) * Swap Use (0/1)	14.415***	-2.616	0.939***	-2.034	0.257
	(4.866)	(2.554)	(0.315)	(1.987)	(0.383)
Swap Use (0/1)	0.468*	0.224	-0.038**	0.151	-0.006
	(0.270)	(0.176)	(0.019)	(0.136)	(0.027)
Ln (Total Assets)	-0.144***	0.076***	-0.018***	0.064***	0.001
	(0.036)	(0.013)	(0.002)	(0.011)	(0.003)
CET1 in % of TA	-0.110***	0.033***	0.028***	0.017***	0.031***
	(0.022)	(0.008)	(0.002)	(0.006)	(0.002)
Deposits in % of TA	-0.094***	0.030***	0.004***	0.025***	-0.002*
	(0.012)	(0.005)	(0.001)	(0.004)	(0.001)
WS Funding in % of TA	-0.138***	0.040***	0.002	0.033***	0.001
	(0.012)	(0.004)	(0.001)	(0.003)	(0.001)
Constant	8.784***	3.638***	0.738***	3.840***	2.081***
	(1.263)	(0.474)	(0.124)	(0.381)	(0.099)
Observations	20,117	16,349	16,349	16,349	16,349
Number of requests	5,432	5,076	5,076	5,076	5,076
Unit of observation	Response	Response	Response	Response	Response
Request FE	Yes	Yes	Yes	Yes	Yes
Bank FE	No	No	No	No	No
Method	ML	OLS	OLS	OLS	OLS

Appendix 4: Our Sample and the Swiss Mortgage Market

Panel A of this table compares the cantonal shares of mortgages. The first column shows the percentage of mortgage volumes as reported by Swiss National Bank (SNB). Column (2) shows the percentage of mortgage volumes in the sample. Column (3) shows the share of mortgage applications in the sample. Panel B of this table compares the geographical composition in our sample to a survey conducted by Seiler (2013) by regions in Switzerland. Columns (1)-(3) show the distribution in Seiler (2013), where (2) shows that of purchases partly financed with pension money, (3) shows that financed without any pension money, and (1) shows the weighted average. Columns (4) and (5) show the distribution in our sample with (4) covering the distribution of mortgage volumes and (5) covering the distribution of the number of requests.

Panel A. Our sample vs. SNB statistics: the distribution across cantons

	SNB	Our sample	
	% of Volumes	% of Volumes	% of Number
	(1)	(2)	(3)
Zurich	19.19	24.88	21.91
Berne	10.77	11.74	13.70
Aargau	8.73	11.36	11.77
Vaud	8.07	9.90	8.84
St.Gallen	5.73	4.15	4.90
Geneva	5.06	3.90	2.52
Ticino	4.73	2.57	2.76
Lucerne	4.64	3.87	3.89
Basel Land	3.86	3.92	3.97
Valais	3.59	2.31	3.36
Thurgau	3.48	3.01	3.40
Solothurn	3.37	3.12	3.36
Graubünden	3.33	1.99	2.65
Fribourg	3.23	2.71	3.15
Schwyz	2.37	2.63	2.03
Zug	2.04	2.15	1.78
Basel Stadt	1.92	1.76	1.47
Neuchatel	1.53	0.91	1.03
Schaffhausen	0.94	0.80	0.95
Jura	0.75	0.32	0.46
Appenzell AR	0.62	0.37	0.51
Nidwalden	0.54	0.46	0.34
Obwalden	0.47	0.51	0.49
Glarus	0.44	0.34	0.42
Uri	0.40	0.30	0.29
Appenzell IR	0.18	0.05	0.05

Panel B. Our sample vs. survey by Seiler (2013): the distribution across regions

	Seiler (2013)			Our sample	
	Overall	Pension-financed	Not pension-financed	% of Volumes	% of Number
	(1)	(2)	(3)	(4)	(5)
Zurich	28	27	31	25	22
Eastern Switzerland	16	16	16	11	13
Mittelland	18	19	15	19	22
Northwestern Switzerland	13	14	12	17	17
Lake Geneva Region	10	11	9	16	15
Ticino	4	3	7	3	3
Central Switzerland	8	8	8	10	9

Appendix 5: Correlation between key borrower risk characteristics

This table shows the correlation coefficients between key borrower risk characteristics *PTI, PTI >33% (0/1), LTV, LTV >67% (0/1), LTV >80% (0/1).* Definitions of the variables are provided in the Appendix 1.

	PTI	PTI >33% (0/1)	LTV	LTV >67% (0/1)	LTV >80% (0/1)
	(1)	(2)	(3)	(4)	(5)
PTI	1.000				
PTI >33% (0/1)	0.617	1.000			
LTV	0.319	0.135	1.000		
LTV >67% (0/1)	0.258	0.119	0.793	1.000	
LTV >80% (0/1)	0.135	0.129	0.340	0.252	1.000

Appendix 6: Illustration of the construction of banks' IRR measure

Example 1: Bank A

Consider cash flows of Bank A which can be interpreted as a typical savings bank. For simplicity assume that there are only three repricing brackets (instead of 18): Short-term (ST), Medium-term (MT) and Long-term (LT) remaining maturities. The repricing of net cash flows is as follows: CHF -1,000 are repriced in the short-term (ST) (e.g. one year). CHF 500 are repriced in the medium term (MT) (e.g. five years). CHF 500 are repriced in the long-term (LT) (e.g. ten years).

Table 6: Cash-flows by Bank A

Repricing bracket b	Incoming cash flows	Outgoing cash flows	Net cash flows
Short-term (ST)	0	1,000	-1,000
Medium-term (MT)	500	0	500
Long-term (LT)	500	0	500

For illustrative purposes, assume the following discount factors $DF(ST)=(1/1.05)^{1}$, $DF(MT)=(1/1.05)^{5}$ and $DF(LT)=(1/1.05)^{10}$.

Effects of a parallel *increase* of yield curve by 100 basis points

If the yield curve shifts *upwards* by 100 basis points, the effect on discounted net cash flows is:

$$= -1{,}000*((1/1.06) -(1/1.05)) +500*((1/1.06)^{5}-(1/1.05)^{5})+500*((1/1.06)^{10}-(1/1.05)^{10}) = -36.9 \ (< 0)$$

Effects of a parallel *decrease* of yield curve by 100 basis points

If the yield curve shifts *downwards* by 100 basis points, the effect on discounted net cash-flows is:

$$= -1{,}000*((1/1.04)^{1}-(1/1.05)^{1}) +500*((1/1.04)^{5}-(1/1.05)^{5})+500*((1/1.04)^{10}-(1/1.05)^{10}) = 22.0 \ (> 0)$$

The resulting IRR

As pointed out in the text, we consider the more *adverse* scenario of the two (in terms of equity of the bank). This is the scenario of an upward shift in the yield curve by 100 basis points. We multiply the discounted cash-flow measure by -1 so that higher values imply greater exposure to interest rate increases.

$$IRR^{A} = -1 * (-37) = 37 \ (>0)$$

<u>Example 2: Bank B</u>

Consider cash flows of Bank B. For simplicity assume that there are only three repricing brackets (instead of 18): Short-term (ST), Medium-term (MT) and Long-term (LT). The repricing of net cash-flows is as follows: CHF 500 are repriced in the long-term (ST) (e.g. one year). CHF 500 are repriced in the medium term (MT) (e.g. five years). CHF -1,000 are repriced in the long-term (LT) (e.g. ten years).

Table 7: Cash-flows by Bank B

Repricing bracket b	Incoming cash flows	Outgoing cash flows	Net cash flows
Short-term (ST)	500	0	500
Medium-term (MT)	500	0	500
Long-term (LT)	0	1,000	-1,000

Again we assume the following discount factors $DF(ST)=(1/1.05)^1$, $DF(MT)=(1/1.05)^5$ and $DF(LT)=(1/1.05)^{10}$.

Effects of a parallel *increase* of yield curve by 100 basis points

If the yield curve shifts *upwards* by 100 basis points, the effect on discounted net cash-flows is:

$$= 500*((1/1.06) -(1/1.05)) +500*((1/1.06)^5-(1/1.05)^5)-1,000*((1/1.06)^{10}-(1/1.05)^{10}) = 32.9 \ (> 0)$$

Effects of a parallel *decrease* of yield curve by 100 basis points

If the yield curve shifts *downwards* by 100 basis points, the effect on discounted net cash-flows is:

$$= 500*((1/1.04)^1-(1/1.05)^1) +500*((1/1.04)^5-(1/1.05)^5) -1,000*((1/1.04)^{10}-(1/1.05)^{10}) = -0.1 \ (< 0)$$

The resulting IRR

As pointed out in the text, we consider the more *adverse* scenario of the two (in terms of equity of the bank). This is the scenario of a *downward* shift in the yield curve by 100 basis points. As it is the downward shift scenario, we do *not* multiply the discounted cash-flow measure by -1.

$IRR^B = -0.1$