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Abstract

This paper investigates the speed and completeness of the pass-through from market rates to mortgage rates in Switzerland. The pass-through dynamics are studied under a marginal funding cost perspective. By choosing the appropriate benchmark rates, this study takes into account banks' forecasts of the evolution of their funding costs. It is found that the pass-through of rates of adjustable-rate mortgages is incomplete and sluggish compared to the rates of mortgages with a fixed maturity. For the latter, changes in market rates appear to be transmitted quickly and completely, particularly when benchmark rates are falling. This finding suggests that a low-interest-rate environment stimulates competition among financial institutions. Evidence for a structural change is found for all interest rates. The structural change occurred around the beginning of 2007 for fixed-rate mortgages and in mid-2005 for floating-rate mortgages. For all mortgage rates, asymmetries are detected in the pre-break period. More specifically, the adjustment of fixed-rate-mortgage rates is characterized by downward rigidity, which supports the existence of some form of imperfect competition. By contrast, the rates of adjustable-rate mortgages exhibit upward price stickiness. This result suggests that competition was stronger in this specific mortgage-lending market. In the post-break period, no clear evidence is found in favor of asymmetries with respect to the adjustment coefficient.

JEL-Classification: E43, E52, G21, C23
Keywords: Interest Rate Pass-Through, Monetary Policy, Mortgages, Cointegration analysis, Panel Data

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1 Introduction

This paper investigates how quickly and completely money-market rates pass through to mortgage rates in Switzerland. It focuses on the mortgage lending segment because of its relevance for the Swiss economy. Housing costs, and particularly rental charges, which are primarily driven by mortgage rates, have an overproportional importance in the Swiss consumer price index, with a weighting factor amounting to 20 percent. Mortgage rates thus indirectly affect forecasts of the Swiss price level. On the other hand, mortgage loans constitute the bulk of Swiss lending to households and corporations. Between 2001 and 2010, their proportion relative to total bank domestic customer claims increased from 73 to 82 percent.[1] It is thus essential to the stability of the financial system to shed light on the dynamics of mortgage rates. Moreover, an understanding of the adjustment of bank retail rates is central to the assessment of monetary policy effectiveness. By steering the target rate, central banks exert a significant influence on banks' price-setting behavior. In a first stage, changes in the target rate affect money-market and capital-interest rates with longer maturities. These rates can be considered as banks' marginal costs. A change in marginal costs might in turn induce financial institutions to adjust retail rates both on deposits and on loans.

The literature related to the interest rate pass-through generally analyzes if changes in the marginal costs of funds are passed completely to banks' retail rates and how quickly these rates adjust to their long-run equilibrium. A sluggish adjustment is generically attributed to menu costs and asymmetric information in credit markets (Stiglitz and Weiss (1981)). Many other factors affect the decision to adjust retail rates, such as expected bank exposure to interest-rate risk, competition and regulation in various segments of the economy, costs associated with adverse selection and moral hazard, consumer inertia and switching costs (Payne and Waters (2008)). The analysis of the transmission mechanism is thus multifaceted.

The present study examines the extent of interest rate pass-through from a marginal cost perspective. In this context, rates set by banks equal a markup over marginal costs, proxied by market rates with a matching maturity.[2] This way of analyzing the pass-through is better known as the *cost-of-funds approach*.[3] Recent studies use panel methods to study the pass-through. For instance, De Graeve et al. (2007) employ a panel data set of Belgian bank retail rates and allow for heterogeneity in banks' price-setting behavior by using ap-

[1] See `http:\www.snb.ch`.

[2] In the following, market rates generally refer to both money-market rates and capital-market rates.

[3] See de Bondt (2002), Sander and Kleimeier (2004), de Bondt (2005), de Bondt, Mojon and Valla (2005), Kok Sørensen and Werner (2006) and De Graeve, Jonghe and Vennet (2007) for euro area data.

propriate econometric techniques that prove to be consistent with heterogeneity at the micro level.

This is the first paper to investigate the interest pass-through process in Switzerland.[4] It follows De Graeve et al. (2007) in analyzing the transmission mechanism with panel data and considering heterogeneity in banks' pricing policies. At the core of the analysis are published (end-of-month) mortgage rates of products with different maturities. All rates apply to new transactions. The pass-through is modeled by an error correction model. Asymmetries are studied both with regard to the adjustment of retail rates to their long-term equilibrium and to the sign of changes in benchmark rates. In other words, the analysis tests whether banks adjust their mortgage rates faster: a) when they are above or below their equilibrium, respectively, b) in periods of monetary tightening or easing. Finally, a test for an endogenous structural break is conducted. The sample period covers from April 2001 to December 2010.

This study contributes to the literature by including the financial crisis of 2007–2009 and demonstrating that the transmission of mortgage interest rates became faster during this period, which was characterized by a negative shock to both the monetary policy rate and market rates. Furthermore, this paper accounts for banks' forecasts of the evolution of their funding costs by using swap rates, which are based on current and expected future values of Libor rates, as explanatory variables. Recent studies emphasize the importance of incorporating the "forward-looking" behavior of banks into the analysis of the pass-through (Banerjee, Bystrov and Mizen (2010)).

In the literature, there is a widespread consensus that bank interest rates are sticky in the short term. In contrast, evidence for completeness of the long-term pass-through is not uniform. It seems that the degree of the pass-through varies across countries, financial institutions, market segments and products.[5] In addition, the transmission of monetary impulses is also influenced by the length and timing of the sample period.[6] Some studies provide evidence for an asymmetric and heterogeneous price adjustment of retail rates. It has been

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[4]Two studies that use Swiss data and deserve mention are Kalt (2001) and Bichsel and Perrez (2005). Both investigate the credit channel of monetary transmission. The former analyzes the balance sheet channel using balance sheet and profit and loss account data from corporate customers of one of the big banks in Switzerland. Kalt (2001) finds weak evidence for an impact of monetary policy shocks on the investment behavior of Swiss firms. The paper of Bichsel and Perrez (2005) uses individual banks' balance sheet data to empirically study the bank lending channel. The authors find that the lending activities of better capitalized banks are relatively immune to changes in monetary policy stance. However, the results are not robust when the authors use a different specification.

[5]See, for example, Hannan and Berger (1991) for banks' deposit rates, Cottarelli and Kourelis (1994) and Borio and Fritz (1995) for corporate lending rates and Mojon (2000) for both lending and deposit rates with different maturities.

[6]See, among others, Sander and Kleimeier (2004), Kleimeier and Sander (2006), Gambacorta and Iannotti (2007) or Payne and Waters (2008).

argued that the prevailing monetary policy conditions are crucial for understanding the asymmetric behavior of the pass-through process. In line with the *collusive-pricing* hypothesis, Mojon (2000) and Gambacorta and Iannotti (2007) find that the pass-through to loan (deposit) rates is higher when these retail rates are below (above) their equilibrium. In contrast, in accordance with the *customer-reaction* hypothesis, Lim (2001) and Liu, Margaritis and Tourani-Rad (2008)) provide evidence supporting the opposite view.

A strand of literature investigates how the pass-through in euro area countries differs across sub-periods after a structural break (Sander and Kleimeier (2004), Marotta (2009)). For instance, de Bondt et al. (2005) document that the pass-through process in the euro zone has become faster since the introduction of the euro, which stimulated competitive forces. Sander and Kleimeier (2004) cover the time span between January 1993 and October 2002 and determine an endogenous structural break. They conclude that the pass-through of retail rates in the euro area has generally become faster in the post-break period. By contrast, Marotta (2009), covering a similar time span as Sander and Kleimeier (2004) and allowing for multiple endogenous structural changes, concludes that the pass-through was generally less complete after the launch of the single monetary policy, which he ascribes to an erosion of competition in lending markets.

The main finding of this study is that the dynamics of the interest rate pass-through differ strongly between the rates for adjustable- and fixed-rate mortgages. This is clearly shown in a simple model with neither a structural break nor an asymmetric adjustment. It emerges that the pass-through is very fast and complete for fixed-rate-mortgage rates, whereas it is sluggish and incomplete for interest rates of floating-rate mortgages. The analysis is complemented by endogenously determining a structural break. For fixed-rate-mortgage rates, the structural change occurred from the end of 2006 to the start of 2007, which corresponds to the period just before the beginning of the recent financial crisis of 2007–2009. In contrast, for floating-rate-mortgage rates, the estimated breakpoint is April 2005. Finally, asymmetries with regard to either the adjustment coefficient or the immediate pass-through coefficient are allowed for. With respect to the former type of asymmetry, all mortgage interest rates seem to adjust asymmetrically toward equilibrium in the pre-break period. Whereas interest rates for fixed-rate mortgages exhibit downward rigidity, suggesting that banks were able to exert market power up to 2007, floating-rate-mortgage rates seem to exhibit upward price stickiness in the period before the structural break occurred. When asymmetries with regard to the immediate adjustment coefficient are considered instead, it is found that banks react more quickly when market rates fall. This result holds particularly for fixed-rate-mortgage rates in the post-break period, which includes the recent financial turmoil. Here, the pass-through is found to be complete, and the long-term relation is immediately restored. These findings demonstrate that a low-interest-rate environment stimulates competition and that market power has decreased since 2007 for fixed-rate mortgages.

The remainder of this paper is organized as follows. Section 2 describes the data used for the analysis of the interest rate pass-through in Switzerland. Section 3 outlines the econometric methodology, and section 4 presents the empirical results. Section 5 concludes.

2 Data

The mortgage rates used in this study are weekly published interest rates for new mortgage loans.[7] The interest rate series were collected by VermoegensZentrum VZ in a survey covering both banks and other financial institutions, such as insurance companies, that are active in the Swiss mortgage business.[8] For each mortgage rate (floating-rate- and fixed-rate-mortgage rates with maturities of 2, 5, 7 or 10 years), a panel data set consisting of 23 banks between January 1998 and December 2007 is available. Because the VZ data were obtained only up to December 2007, these mortgage rate series were "chain-linked" with the series of published end-of-month Interest Rate Statistics for new transactions collected by the SNB. The construction of a longer panel might raise concerns about the data break in the series, which may affect the results. However, the SNB survey, which was introduced in January 2008, and the VermoegensZentrum VZ survey use the same definition of mortgage interest rates for the purpose of data collection. By taking the end-of-month figures of both data sets, balanced panels for different product categories are constructed in the period between April 2001 and December 2010. The numbers of institutions included differ across mortgage products and range between 9 and 20 banks. All market rates used as benchmark rates are obtained from the SNB.[9] End-of-month figures were selected for the set of possible benchmark rates.

Figure 1 plots the average mortgage rates by maturity, the average deposit rate, the beginning-of-month values of the 3M-Libor and the middle corridor for the 3M-Libor target range. Mortgage rates for products with a fixed maturity appear to evolve roughly in accordance with the 3M-Libor, whereas this is not the case for products with a floating interest rate. Moreover, the volatility of both floating-rate-mortgage rates and deposit rates appears to be

[7] Note that mortgage loans for which interest rates are published in banks' booklets or on their websites are usually described in one of the following ways: "The interest rates are indicative values only ... and apply to owner-occupied residential properties and primary mortgages", "and apply to top-quality residential property and borrowers with impeccable creditworthiness" or "The interest rates shown apply to the first mortgage with a loan up to 66 percent of the market value of the property".

[8] See also `http://www.vermoegenszentrum.ch` for more details.

[9] The SNB obtains the money- and capital-market rates daily, either from data service providers or from own calculations.

lower than that of the target rate and of the fixed-maturity-mortgage rates. The strong price rigidity of floating-rate mortgages suggested by the figures may be explained by the peculiarity of the Swiss rental market. Until August 2008, rental payments were linked to the rate of adjustable-rate mortgages of the cantonal banks. Starting in September 2008, an average mortgage-rate index based on the costs of all banks' mortgage loans was introduced as the reference rate for rental-payment adjustments. In Switzerland, an increase in interest rates on mortgage loans can be partially rolled over to tenants, who represent a large share of the Swiss population. The social impacts of rising mortgage rates are obvious and cause pressure on the banking sector that may distort financial institutions' pricing policies, although the state has taken no formal measures to address this issue. Obviously, this problem is characteristic of floating-rate-mortgage rates. The similar rigidity observed for saving deposit rates might result from the fact that banks keep deposit rates artificially low when market rates start to rise (Kroll (1995)). The Figure also demonstrates that the periods before and just after monetary policy easing are characterized by a low volatility of fixed-rate-mortgage rates (Q1/2001 to Q2/2001 and Q4/2006 to mid-Q3/2008). During these periods, the volatility of the Swiss term structure (measured by the difference between the 10-year spot rate for bonds issued by Swiss commercial banks and the 3M-Libor) was also very low. This finding suggests that mortgage rates follow changes in market rates with a comparable maturity.

The benchmark rates chosen in the analysis for the study of the pass-through for fixed-rate mortgages are swap rates of a comparable maturity.[10] Swap rates are implied derivative prices constructed from Libor futures. In a swap transaction (interest-rate swap, or IRS), two parties agree to exchange variable interest payments (e.g., the 6-month Libor rate) for fixed interest payments (e.g., a government-bond yield with a long maturity) on a notional principal amount at regular intervals over a specified period. In 2009, the SNB conducted a survey in which reference rates served as the bases for the prices of various credit products. The results showed that the IRS curve is an important reference rate for the pricing of loans and motivates the choice of their rates. Particularly, it emerged that fixed-rate mortgages are predominantly priced from the IRS curve.[11] The rate of adjustable-rate mortgages is reset

[10]In spite of the strong co-movement between the saving-deposit rate and interest rates of adjustable-rate mortgages illustrated by Figure 1 (the correlation coefficient is 0.9), the pass-through is viewed as the transmission of (exogenous) monetary policy impulses to retail bank rates. Because financial institutions set both saving-deposit and mortgage rates, the causal relationship between the two rates is not clear.

[11]Interest-rate swaps are used to reduce interest-rate risk. For instance, a bank may fund its fixed-rate- (long-term) mortgage loans through savings accounts. Obviously, the financial institution incurs a maturity mismatch between the two types of business. To reduce this type of risk by better matching the income streams on its assets to the payment streams on its liabilities, the financial institution can swap the fixed-rate-interest-rate income generated through its mortgage lending for floating-rate-interest-rate income (Whittaker (1987)). Consequently, the funding costs for fixed-mortgage rates are more closely related to these swap

periodically according to various indices, which often include the operational target of the central bank.[12] The 3M-Libor is hence chosen as the benchmark rate in the pass-through analysis of floating-rate-mortgage rates.

3 Methodology

3.1 The Pass-Through Model

The interest rate pass-through is conventionally modeled by an error correction term (ECT) representation:

$$r_{k,t} = c_{0k} + \lambda_k m_t + u_{k,t} \tag{1}$$

where r is the mortgage interest rate, m is the benchmark rate, and k is the financial institution in the panel, and:

$$\Delta r_{k,t} = c_{1k} + \Sigma_{j=0}^{J} \alpha_{jk} \Delta m_{t-j} + \Sigma_{i=1}^{I} \beta_{ik} \Delta r_{k,t-i} + \gamma_k u_{k,t-1} + \epsilon_{k,t} \tag{2}$$

where the error correction term corresponds to the lagged estimated residuals of the cointegration equation (1), γ stands for the speed of adjustment to the long-run cointegrating equilibrium and α_0 is the impact multiplier. The optimal lag lengths are denoted by I and J, respectively.

Equation (1) represents the long-run relationship between mortgage interest rates and market rates, and the short-run dynamics are described by equation (2). The pass-through model is empirically studied by adopting the approach of De Graeve et al. (2007). To study the short-run dynamics, all aggregate coefficients are computed as a weighted average of the bank-specific estimators of equation (2). More specifically, the methodology proposed by Swamy (1970) is used. Moreover, to analyze the long-run dynamics, the average long-run pass-through is estimated using the panel fully modified regression estimator of Phillips and Moon (1999). As indicated by De Graeve et al. (2007), their specification allows each bank to exhibit a different immediate

rates.

[12] The survey's results were not conclusive with regard to floating-rate mortgages. The most common indices used for determining the interest rate of this type of loan are the 3M-Libor, the bank's internal interest-rate curve and other replicating approaches based on the Libor and IRS curves.

reaction to changes in the benchmark rate. For instance, the adjustment coefficient, γ, equals $\sum_{i=1}^{K} w_i^{\gamma}\gamma_k$, and the immediate pass-through coefficient, α_0, is $\sum_{i=1}^{K} w_i^{\alpha_0}\alpha_{0k}$.

In this paper, the hypotheses of completeness of the long-run pass-through coefficient ($\lambda = 1$) and of the impact coefficient ($\alpha_0 = 1$) are tested. In addition, the analysis tests whether the adjustment coefficient γ differs according to whether mortgage rates are above ($u_t > 0$) or below ($u_t \leq 0$) their equilibrium level. Finally, this paper examines if the impact coefficient (α_0) is the same in periods of monetary tightening ($\Delta m_t > 0$) and in periods of monetary easing ($\Delta m_t \leq 0$).

Before proceeding to the ECT model implementation, it is necessary to test for cointegration between the dependent and the independent variables.

3.2 Unit Root and Cointegration Tests

Previous studies on pass-through have found that interest rates are non-stationary. The present analysis hence needs to take into account whether all interest rate series contain a unit root, and, if they are I(1), whether mortgage rates and benchmark rates are cointegrated. Only if cointegration is found can the ECT model presented above be estimated.

3.2.1 Unit Root Test

Two unit root tests are performed: the Levin, Lin and Chu (2002) (LLC) and the Im, Pesaran and Shin (2003) (IPS) unit root tests. Both tests allow for individual fixed effects and linear trends, but they differ in their assumptions about the autoregressive coefficient. They consider the following model:

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \Sigma_{j=i}^{p_i}\beta_{ij}\Delta y_{it-j} + \epsilon_{it} \tag{3}$$

where i denotes the individual in the panel, and the lag order p_i is determined based on the AIC. LLC assumes a common unit root process, $\rho_i = \rho$, and uses equation (3) to test the null hypothesis of a unit root, H_0: $\rho = 0$, against the alternative of no unit root, H_1: $\rho < 0$. The IPS test allows for individual unit root processes and is based on the null hypothesis that $\rho_i = 0$ for all i against the alternative that H_1: $\rho_i < 0$ for some i's.

3.2.2 Cointegration Test

The available techniques for panel cointegration tests are an application of the cointegration analysis in the time-series dimension. The general approach is to obtain residuals from the cointegrating equation and then to test whether they are I(1) by running an auxiliary regression. Kao (1999), Pedroni (1999) and Pedroni (2004) provide different statistics for this purpose, all of which assume homogenous slope coefficients across panel units. Kao (1999) tests the residuals $\hat{e}_{it}$ of the OLS panel estimation by applying DF- and ADF-type tests:

$$\hat{e}_{it} = \rho \hat{e}_{it-1} + \Sigma_{j=1}^{p} \varphi_j \Delta \hat{e}_{it-j} + \epsilon_{it} \tag{4}$$

The null hypothesis of no cointegration, H_0: $\rho = 1$, is tested against the alternative of stationary residuals, H_1: $\rho < 1$. The ADF test used here is appropriate for a cointegration approach with endogenous regressors.

When testing for cointegration in a heterogeneous panel by imposing homogeneity across individual units of the panel, a non-stationary component in the residuals is generated, which leads to a rejection of the cointegration hypothesis even if it is true. In Pedroni (1999) and Pedroni (2004), various methods of constructing statistics that deal with this shortcoming are discussed. Two sets of statistics are proposed: the panel and the group mean statistics. Incorporating heterogeneity leads to a slight modification of equation (4):

$$\hat{e}_{it} = \rho_i \hat{e}_{it-1} + \Sigma_{j=1}^{p_i} \varphi_j \Delta \hat{e}_{it-j} + \epsilon_{it} \tag{5}$$

The set of panel statistics (panel-ν, panel-ρ, the non-parametric panel-$t^\star$ and the parametric panel-t) is based on pooling the residuals along the within dimension of the panel. They allow the cointegrating vectors to be homogenous under the alternative. Heterogeneity is considered under the alternative in the set of group mean statistics (group-ρ, the non-parametric group-$t^\star$ and the parametric group-t) which are based on pooling the residuals along the between dimension of the panel. The null and alternative hypotheses are analogous to those of Kao (1999).

4 Results

4.1 Unit Root and Cointegration Tests

To test for unit root and cointegration, the chosen benchmark rates described above are used.

The results for the two panel unit root tests are displayed in columns *i* and *ii* of Table 1. The IPS test cannot reject the null hypothesis that the mortgage rates are I(1). The LLC test rejects the null of a unit root for floating-rate-mortgage rates. In sum, the empirical evidence suggests that all mortgage rates exhibit the I(1) property and that they are stationary in their first-differenced forms (these results are not presented).[13]

The results of the cointegration tests are shown in columns *iii*-*x* of Table 1. The Pedroni residual-based cointegration tests fails to reject the null hypothesis of no cointegration between fixed-rate-mortgage rates and their benchmark rates at a high level of significance. Only according to the panel-ν statistic, adjustable-rate-mortgage rates seem not to be cointegrated with the 3M-Libor. The Kao ADF-t-test is against the null of no cointegration for all products but 7-year and 10-year fixed-rate-mortgage rates. Overall, the results indicate clear evidence in favor of cointegration. This leads to the choice of the ECT specification using the methodology of De Graeve et al. (2007) for the analysis of the pass-through.

4.2 Analysis of the Interest-Rate Pass-Through

Table 2 reports the estimation results. The last column, $\lambda = 1$, shows the Wald test statistics for the null hypothesis that the long-run pass-through coefficient equals one.

The results indicate that the long-term pass-through is incomplete for floating-rate mortgages but complete for the interest rates of fixed-rate mortgages. The result of a complete long-term pass-through of mortgage rates is similar to those found by Cottarelli and Kourelis (1994) for lending rates and Borio and Fritz (1995) for several European countries; de Bondt (2002), de Bondt (2005) and Banerjee et al. (2010) for lending rates in the euro area; Kok Sørensen and Werner (2006) for mortgage rates in the euro area; and Fuertes and Heffernan (2009) document a complete pass-through for mortgage lending in the United Kingdom. Also, Hofmann and Mizen (2004) find evidence for a complete long-term pass-through of mortgage rates. This result is in line with the findings of Banerjee et al. (2010). The authors implement a forward-looking model of interest rate pass-through by allowing bank retail rates to depend on forecasts of wholesale rates in addition to current and lagged changes of retail and wholesale market rates and the long-term cointegrating relationship. In fact, they claim

[13] For all benchmark rates, various unit root tests in a time-series dimension were performed. To save space, the results are not presented in this paper. The ADF tests do not reject the null hypothesis of a unit root. The analysis is complemented by performing the KPSS unit root test of the null of stationarity. The conclusion remains the same because the underlying hypothesis can be rejected for all reference rates at conventional levels of significance (5 and 10 percent). Moreover, the ADF test can be rejected for all market-rate series in their first difference form.

that interest-rate expectations play an important role in the price-setting behavior of banks and that backward-looking models often understate the impact of monetary policy impulses on bank interest rates. Because swap rates embody expectations of movements in future official rates, they can be considered as "forward-looking" market rates, which provides an explanation for the large estimates found for the long-term coefficients of fixed-rate-mortgage rates. The transmission mechanism is hence found to be effective.

The results provide evidence for short-term stickiness. The immediate pass-through coefficient, α_0, ranges between 16 percent for rates of floating-rate mortgages to 70 percent for rates of mortgages with a maturity of 10 years. For fixed-rate mortgages, more than 60 percent of the final response is immediately realized. Interest rates of floating-rate mortgages appear to adjust slowly, as only a small fraction of the long-term pass-through is realized on impact. The values for the mean lag θ indicate that banks restore the equilibrium relationship after 3 months for floating-rate mortgages and after 4 to 5 months for fixed-rate mortgages.

4.3 Analysis of Non-Linear Adjustments

In this paragraph, the assumption that the adjustment speed of mortgage rates is symmetric is relaxed. If, for example, the benchmark rate decreases without an immediate adjustment of the retail interest rate, the error term $\epsilon_{k,t}$ will be positive. In the case that financial institutions face menu costs and have some degree of market power, their incentive to lower lending rates will be weak. Nominal downward price rigidity and upward price flexibility would thus be characteristic of banks operating in an imperfectly competitive mortgage-lending market (Sander and Kleimeier (2004)). By contrast, the higher the elasticity of the loan demand, the greater banks' incentive to adjust prices downward. If banks have less market power, maintaining retail lending rates above their equilibrium value for a long period of time would lead to a loss of customers and a corrosion of profits outweighing the incurred adjustment costs. In this situation, one would expect a faster downward price adjustment. Scholnick (1996), Lim (2001), Gambacorta and Iannotti (2007) and Marotta (2009) argue that there are two different views according to which asymmetries in the short-run interest-rate adjustment can be interpreted: the *customer-reaction* hypothesis states that lending rates have greater upward rigidity in a very competitive market because customers react negatively when interest rates rise. In contrast, the *collusive-pricing* hypothesis states that banks react more reluctantly to downward adjustment of lending rates if they operate in a less competitive market where customers are not able to switch to another service provider offering better conditions.

In line with the previous literature, asymmetries are modeled with the threshold autoregressive model (TAR^0) developed by Tong (1983).[14] In equation (2), the adjustment coefficient becomes:

$$\gamma = \begin{cases} I_t \times \gamma & \text{if } u_{k,t-1} > 0 \\ (1 - I_t) \times \gamma & \text{if } u_{k,t-1} \leq 0 \end{cases} \tag{6}$$

where I_t is a dummy variable that equals one if $u_{k,t-1} > 0$. γ^+ is the coefficient estimate obtained for times when $u_{k,t-1} > 0$, and γ^- is obtained for $u_{k,t-1} \leq 0$. In addition, one can distinguish between two mean lags, one when the disequilibrium is positive and one when it is negative. The adjustment speed measure θ is: $\theta^+ = \frac{|\lambda - \alpha_0|}{|\gamma^+|}$ and $\theta^- = \frac{|\lambda - \alpha_0|}{|\gamma^-|}$.

Alternatively, the response of bank rates to changes in market rates seems to depend in some cases on the size and sign of market-rate changes.[15] Similar to Marotta (2009) and Horvráth, Krekó and Naszódi (2004), the test of an asymmetric specification for the short-term dynamics in equation (2) is implemented by adding two regressors that capture contemporaneous positive and negative changes in the benchmark rate. More specifically, α_0 is allowed to take on different values according to whether market rates are rising or falling:

$$\alpha_0 = \begin{cases} M_t \times \alpha_0 & \text{if } \Delta m_{k,t} > 0 \\ (1 - M_t) \times \alpha_0 & \text{if } \Delta m_{k,t} \leq 0 \end{cases} \tag{7}$$

where M_t is a dummy that equals unity if $\Delta m_{k,t} > 0$. α_0^+ and γ^+ denote the short-run pass-through and the adjustment coefficient, respectively, when the benchmark rate rises, and α_0^- and γ^- apply for a falling market rate.

The results of the TAR model that considers asymmetries with respect to the adjustment coefficient are shown in Table 3, and those for the TAR model that studies asymmetries with regard to the sign of changes in the benchmark rate are presented in Table 4.

Only for floating-rate-mortgage rates and for interest rates of mortgages with a maturity of 10 years is evidence in favor of an asymmetric threshold model with respect to the cointegrating relationship detected. The results suggest that floating-rate-mortgage rates are adjusted more rapidly when deviations from the long-term equilibrium are negative. The equilibrium relationship is restored

[14] See also Sander and Kleimeier (2004), Kleimeier and Sander (2006) and De Graeve et al. (2007) for applications of this technique. These studies allow the threshold to deviate from zero. Here, it is set equal to zero to make the interpretation of the results more comparable across mortgage products.

[15] See Borio and Fritz (1995), Mojon (2000), Sander and Kleimeier (2004) or Kleimeier and Sander (2006).

after one month when these mortgage rates are below their equilibrium level, whereas the adjustment coefficient is not significant when they are below it. By contrast, the adjustment speed of interest rates for mortgages with a maturity of 10 years is higher when rates are above their long-term relationship (two months to attain equilibrium) than in the opposite case, where the adjustment coefficient is not significant.

The results provide no clear-cut evidence for an asymmetric adjustment of mortgage rates over the sample period between April 2001 and April 2010. Also, the existing literature is generally inconclusive with regard to asymmetries of the pass-through of lending rates. Hofmann and Mizen (2004), Sander and Kleimeier (2004), De Graeve et al. (2007) and Kwapil and Scharler (2009) conclude that mortgage lending rates exhibit a symmetric adjustment process. In contrast, Mojon (2000), Sander and Kleimeier (2004) and Fuertes and Heffernan (2009) find that lending rates are more rigid downward than upward, whereas Lim (2001) claims the opposite.

It is worth noting that asymmetries relative to the sign of changes in the benchmark rate cannot be rejected. For all mortgage rates, the findings suggest that negative changes in the benchmark rate are passed on to mortgage rates more quickly than positive ones. This finding indicates that banks are more reluctant to transfer increases in market rates than they are to lower mortgage rates in the contrary case. For instance, 77 percent of a negative change in the benchmark rate is immediately passed on to the rates of mortgages with a maturity of 2 years, but only 34 percent of an increase in the 2-year swap rate is immediately passed on. The results are robust across products. It takes roughly 2 to 3 months to restore equilibrium when the product-specific benchmark rates are falling, whereas the mean lag is 6 to 12 months when market rates are rising.

4.4 Interest Rate Pass-Through and Structural Change Analysis

Figure 2 traces the residuals resulting from the bank-specific long-run equation (1) against time and shows a similar evolution for the rates of all mortgage products. The residuals are positive up to some point in time, particularly those resulting from the cointegrating relationship between floating-rate-mortgage rates and the 3M-Libor. Thereafter, the regressions' residuals are negative, showing a trend toward zero. The residuals' path points to a structural break in the long-term pass-through.

Table 5 presents the results for the pass-through analysis for different sub-periods. Similar to Sander and Kleimeier (2004), Kleimeier and Sander (2006) or Marotta (2009), the unknown structural break date in the cointegrating relationship is detected using a supremum F (supF) testing procedure over the middle 80 percent of the sample period.[16]

The Table reveals that the break occurred in April 2005 for floating-rate-mortgage rates, and breakpoints for fixed-rate-mortgage rates are detected at the end of 2006 and at the beginning of 2007.[17] The results indicate that the pass-through coefficient was somewhat larger in the post-break period than in the pre-break period. However, for mortgages with a very long maturity (7 or 10 years), the null hypothesis that λ equals one cannot be rejected in either the pre- or the post-break sample period. Only for floating-rate-mortgage rates, the long-term pass-through is higher in the sample period between April 2001 and April 2005 (40 percent) than in the sub-sample starting from April 2005 (24 percent) or in the full sample. The impact coefficient is considerably higher in the post-break period than in the pre-break period or over the entire sample. For fixed-rate-mortgage rates, α_0 is closer to unity in the shorter samples starting from February 2007 and November 2006, respectively. Nonetheless, a Wald test of the hypothesis that the impact coefficient equals unity can be rejected for all mortgage products and sub-periods. In conclusion, it seems that for mortgage rates of products with a fixed maturity, a structural break occurred in the run-up to the recent financial crisis of 2007–2009. Following the structural change, these interest rates were immediately and almost fully adjusted as a result of changes in the respective benchmark rates. This evidence is supported by the findings of the mean lag lying very close to zero for all mortgage rates. Instead, in the pre-break period, mortgage rates were adjusted more sluggishly, with values for α_0 ranging between 20 and 43 percent, which are remarkably lower than those found in the analysis over the full available sample. The pass-through of adjustable mortgage rates was more complete in the pre-break period, but more sluggish than after April 2005.

Table 6 displays the results for the asymmetric TAR model with respect to the adjustment coefficient. The hypothesis of a symmetric adjustment cannot generally be rejected in the pre-break period for any product, with the exception of the 10-year mortgage rate. In contrast to the analysis over the full sample, it is found that floating-rate-mortgage rates were more rigid upward than downward in the time span between April 2001 and April 2005 and that the rates of fixed-rate mortgages were adjusted more quickly during the pre-break period when

[16]See also Andrews (1993) and Hansen (1992) for more details on the methodology and for the critical values.

[17]Unit root and cointegration tests were performed for all sub-periods. Pedroni's panel test fails to reject the null hypothesis of no cointegration in most cases for floating-rate mortgages during the sample period April 2001 to April 2005 when both a constant and a drift are included in the equation. The null hypothesis is always rejected when only a constant is included. Both the LLC and IPS unit root tests reject the null hypothesis that the 10-year mortgage-rate series are I(1) in the period November 2006 to December 2010 when both an intercept and a trend are included in the equation. When including only an intercept, the test cannot reject the null hypothesis that the mortgage rates contain a unit root. Overall, the tests provide evidence in favor of both unit root and cointegration despite the shorter sample periods. All results are available upon request.

they were below their long-term equilibrium.

The findings of this paper suggest that before the subprime crisis of 2007–2009, financial institutions were more prone to passing on market-rate changes when rates of fixed-rate mortgages were below their equilibrium, indicating that banks were exerting some degree of market power (*collusive-pricing* hypothesis). Starting in 2007, this asymmetric behavior vanished for mortgage rates with a maturity of 5 years or less. By contrast, upward price rigidity is detected during the pre-break period with respect to the interest rates for adjustable-rate mortgages, supporting the *customer-reaction* hypothesis. Analogous to what was found for fixed-rate-mortgage rates, the interest rates for adjustable-rate mortgages have been adjusted symmetrically in the post-break period. A possible interpretation of these findings is that banks faced relatively strong competition in the market segment for floating-rate mortgages during the pre-break period. Alternatively, upward price rigidities between April 2001 and April 2005 could have been induced, on one hand, by the peculiarity of the Swiss rental market and the consequent reluctance to raise the retail rates. On the other hand, a quicker upward adjustment might not have been a convenient pricing policy for financial institutions. In the light of the strong co-movement between interest rates for adjustable-rate mortgages and deposit rates, one expects that an increase in the mortgage rate would be followed by an adjustment of the deposit rate in the same direction. If the outstanding volume of deposits were larger than that of floating-rate mortgages, the additional burden because of interest payments would exceed the additional interest receipts. The volume of floating-rate mortgages has been inferior to that of deposits since 2001/2002, supporting the above argument.[18] The asymmetric adjustment behavior disappeared in the post-break period. This could be a consequence of the decreasing importance of this mortgage product. In fact, its volume contracted compared to that of fixed-rate mortgages. An increase in competition may also explain the disappearance of asymmetries in the adjustment process of interest rates for fixed-rate mortgages after January 2007.

The analysis is extended to study the effects of the sign of changes in benchmark rates on the immediate pass-through coefficient. Consistent with the analysis over the full sample, Table 7 shows that, in the post-break period, banks adjusted mortgage rates more quickly on impact in periods of monetary easing than in times of monetary tightening. It is worth noting that the coefficient α_0^- is equal to one in all regressions of fixed-rate-mortgage rates in the post-break period. In other words, changes in the benchmark rate are immediately transmitted to the respective mortgage rates. Given that the pass-through for products with a long maturity is complete in the long run, the efficiency of the transmission mechanism improved dramatically in the post-break period, which includes the recent financial meltdown. Also, for adjustable mortgage rates during the time span between May 2005 and December 2010, the impact coefficient

[18] See also Swiss National Bank (2010).

that applies to negative changes in the 3M-Libor is considerably higher than that for positive ones. Specifically, 24 percent of a change in the benchmark rate is immediately passed on to floating-rate-mortgage rates, so that the long-run relationship is immediately restored. In sum, this study reveals that banks react more effectively to drops in market rates than to increases. This could be a direct consequence of the fact that central banks change the operational target rate by relatively larger steps when they lower it than when they raise it. This was clearly the case during the financial crisis of 2007–2009. In turn, a low-interest-rate environment stimulates competition in the mortgage lending market. Similarly, other studies have documented that asymmetries in the adjustment of retail bank rates are related to the magnitude of changes in the monetary policy rate.[19]

5 Concluding Remarks

The present paper is the first to analyze the interest rate pass-through from money- and capital-market rates to mortgage rates in Switzerland. Moreover, it is the first to provide a preliminary analysis of the impact of the recent financial crisis of 2007–2009 on the efficiency of the pass-through. Finally, by the appropriate choice of the product-specific benchmark rates, it explicitly takes into account the forecasts of future rates, giving a more accurate description of the transmission mechanism.

Published rates for new transactions are used. Monthly rates of floating-rate mortgages and fixed-rate mortgages with a maturity of 2, 5, 7 or 10 years are at the core of the analysis. The paper uses mortgage lending rates from a panel of 20 financial institutions over the time period from April 2001 to December 2010. The pass-through is modeled with a standard error correction representation. To fully account for heterogeneities in the price-setting behavior of financial institutions, the panel version of the fully modified estimator proposed by Phillips and Moon (1999) is used. The short-run equations are estimated using Swamy's random coefficient estimator. The appropriate marginal pricing costs that financial institutions incur when selling their products are captured by employing market rates of a comparable maturity. This strategy is known as the *cost-of-funds approach.* Swap rates represent the chosen benchmark rates for the interest rates of fixed-rate mortgages and are ideal because

[19]Horvráth et al. (2004) argue that if the central bank's target rate changes by relatively large steps, two opposite effects influence the pricing behavior of banks. Higher market rate volatility, often accompanied by larger changes in yields, induces a faster reaction as a result of menu costs and banks' willingness to smooth interest rates for their customers. On the other hand, financial institutions might perceive larger changes in the target rate as transitory. This increases financial institutions' uncertainty and argues against a fast interest rate pass-through. In fact, in the presence of menu costs, it is rational for banks to ignore temporary market-rate changes.

they include present as well as expected future monetary policy actions taken by the central bank. A straightforward implication is that monetary policy impulses determine banks' costs of funds, which, in turn, directly affect mortgage rates.

It is found that the pass-through is complete but characterized by short-term rigidities for interest rates of mortgages with a fixed maturity. The recent literature on the interest rate transmission mechanism stresses the importance of incorporating expectations about future actions of the monetary policy stance. Excluding such information from the analysis would underestimate the completeness of the pass-through. By using swap rates as key drivers of the rates of mortgages with a fixed maturity, the forward-looking behavior of banks is considered. On the contrary, market rate changes are not fully transmitted to the rates of adjustable-rate mortgages. For this type of product, the 3M-Libor is chosen as a benchmark. Only roughly 24 percent of the initial change in the benchmark rate is passed on to rates of floating-rate mortgages in the long run. Moreover, the adjustment of these rates is very sluggish relative to that of mortgage rates with a fixed maturity because the immediate multiplier amounts to only 16 percent of a 100-percent change in the 3M-Libor. By contrast, fixed-rate-mortgage rates adjust more quickly on impact, with immediate pass-through coefficients between 60 and 70 percent. The particular characteristics of the Swiss rental market could explain these contrasting results. Until August 2008, rental payments were linked to the interest rate of adjustable-rate mortgages of cantonal banks. Consequently, a high volatility of adjustable mortgage rates was not admissible because large mortgage-rate increases would be rolled onto tenants' rents.

A second question analyzed in this paper is whether retail interest rates exhibit asymmetric behavior with regard to both the adjustment coefficient and the signs of changes in the product-specific benchmark rates. For both analyses, the threshold autoregressive model (TAR) developed by Tong (1983) is used. Over the full sample, no clear evidence in favor of asymmetries with respect to deviations of mortgage lending rates from their long-run equilibrium can be detected. When studying non-linearities over different sub-samples that result from a search for an endogenous structural change, interest rates for floating-rate mortgages are found to display upward price rigidity for the period between April 2001 and April 2005. A possible explanation is that financial institutions may have been reluctant to increase the interest rates of adjustable-rate mortgages in cases where marginal costs caused by rising deposit rates exceeded the additional interest receipts from higher adjustable mortgage rates. This is a plausible interpretation given the strong co-movement between the two bank retail rates. In contrast, interest rates of fixed-rate mortgages were found to adjust more sluggishly downward than upward in the time span between April 2001 and the end of 2006 (mortgages with a maturity of 10 years) as well as between April 2001 and the start of 2007 (mortgages with a maturity of 2, 5 or 7 years). This finding supports the *collusive-pricing* hypothesis, suggesting that Swiss banks had some degree of market power in the fixed-rate-mortgage business during the pre-break period. No evidence for asymmetries is generally found in the sample after the product-specific structural break.

Furthermore, banks clearly react more quickly on impact to falling benchmark rates than in the opposite case. This result is robust across products. Particularly, this effect is detected in the post-break period, where, for products with a long maturity, both the immediate and the long-term pass-through seem to be complete. Although the time span is quite short concerning fixed-rate-mortgage rates, this result points out that market-rate changes are transmitted more effectively when interest rates are falling, fueling competition in the mortgage segment. Alternatively, this result might merely be the consequence of an asymmetric monetary policy (Blinder (1998)). In other words, central banks' actions depend on the preferences for the tradeoff between unemployment and inflation and on whether the economy is in a phase of recession or in a boom. Schaling (2004) shows that the target rate is a nonlinear function of the deviation of the inflation rate from its target level and the output gap. For example, a faster interest rate pass-through when market rates are falling might reflect the central bank's policies of increasing the target rate by smaller steps and decreasing it more quickly.

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A Tables

Table 1: Results of panel unit root tests for mortgage rates with different maturities and cointegration tests between the mortgage rates and their respective benchmark rates for a sample from April 2001 to December 2010

Mortgage rate	unit root test		cointegration tests:			Pedroni				Kao	N	obs
	LLC	IPS	Panel-ν	Panel-ρ	Panel-$t^\star$	Panel-t	Group-ρ	Group-$t^\star$	Group-t	t_{ADF}		
	(*i*)	(*ii*)	(*iii*)	(*iv*)	(*v*)	(*vi*)	(*vii*)	(*viii*)	(*ix*)	(*x*)	(*xi*)	(*xii*)
Floating rate	-3.06***	-1.09	-1.54	2.43**	2.34**	1.92*	3.45***	3.54***	3.05***	-3.76***	20	2,340
2-year fixed	-0.46	1.51	10.17***	-25.59***	-18.32***	-15.38***	-22.35***	-19.41***	-14.94***	-2.13**	17	1,989
5-year fixed	0.86	1.21	13.33***	-40.97***	-26.21***	-17.86***	-35.51***	-27.93***	-17.23***	-1.80**	20	2,340
7-year fixed	1.31	0.77	8.39***	-30.29***	-19.66***	-13.41**	-28.17***	-21.81***	-13.98***	-0.79	14	1,638
10-year fixed	0.78	-0.38	3.99***	-20.17***	-13.58***	-7.40***	-19.65***	-15.30***	-8.23***	-0.74	9	1,053

Notes: The optimal lag length is chosen according to the AIC criterion. Column *i* shows the results of the Levin et al. (2002) (LLC) unit root test, which assumes that there is a common unit root process, whereas column *ii* displays the results for the Im et al. (2003) (IPS) unit root test which allows for individual unit root processes in the alternative hypothesis. Both statistics are based on equation (3). Columns *iii*-*ix* present the results of the Pedroni residual-based cointegration test for the case of heterogeneous panels based on equation (5). This test builds on the null hypothesis that the interest rate series are not cointegrated against the alternative that they are. Pedroni's (1999) and Pedroni's (2004) Panel-$t^\star$ and Group-$t^\star$ statistics are the non-parametric versions of the respective panel t-statistics. Column x presents the results of Kao's (1999) ADF residual-based test statistics for homogeneous panels based on equation (4). This test builds on the null hypothesis that the interest rate series are not cointegrated against the alternative that they are. Pedroni's tests include individual fixed effects and a deterministic trend. Results including only individual effects are similar. Kao's test include only a fixed effect. Column *xi* and *xii* show the number of cross-sections and observations, respectively.
*, ** and *** stands for rejecting the null hypothesis at the 10%, 5% and 1%-level, respectively.
Source: SNB, VZ and own calculations.

Table 2: Interest rate pass-through of mortgage rates with different maturities

	Long-run equation	Short-run equation					
	λ	α_0	γ	θ	I	J	$\lambda = 1$
Floating rate	0.239***	0.163***	-0.024***	3.1	1	1	No
	(0.037)	(0.027)	(0.005)				
2-year fixed rate	0.966***	0.625***	-0.078***	4.4	2	2	Yes
	(0.023)	(0.032)	(0.015)				
5-year fixed rate	1.004***	0.660***	-0.067***	5.1	3	3	Yes
	(0.028)	(0.025)	(0.013)				
7-year fixed rate	1.016***	0.665***	-0.077***	4.6	2	2	Yes
	(0.037)	(0.035)	(0.015)				
10-year fixed rate	1.030***	0.697***	-0.076***	4.4	2	2	Yes
	(0.044)	(0.022)	(0.02)				

Notes: Results based on equations (1) and (2) using an error correction representation with a sample from April 2001 to December 2010. λ is the long-run pass-through coefficient. α_0 denotes the immediate pass-through, γ the adjustment coefficient, θ denotes the mean lag according to the formula $\frac{|\lambda - \alpha_0|}{|\gamma|}$. I and J denote the lag lengths of the first difference of mortgage rates and benchmark rates, respectively, in the short-run equation and were determined using AIC. The last column presents the results of the Wald test (χ^2 distributed) that the long-run coefficient is equal to unity. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***. Source: SNB, VZ and own calculations.

Table 3: Asymmetric threshold adjustment of mortgage rates with different maturities with respect to the adjustment coefficient

	α_0	γ^+	γ^-	θ^+	θ^-	Asymmetric model
Floating rate	0.162***	0.008	-0.077***	9.2	1.0	Yes
	(0.027)	(0.01)	(0.012)			
2-year fixed rate	0.625***	-0.094**	-0.072*	3.6	4.7	No
	(0.032)	(0.037)	(0.039)			
5-year fixed rate	0.659***	-0.083**	-0.057	4.2	6.1	No
	(0.025)	(0.033)	(0.036)			
7-year fixed rate	0.663***	-0.128***	-0.027	2.8	12.9	No
	(0.035)	(0.037)	(0.035)			
10-year fixed rate	0.692***	-0.165***	0.012	2.0	28.0	Yes
	(0.021)	(0.045)	(0.04)			

Notes: Results based on equations (1) and (2) using an error correction representation with a sample from April 2001 to December 2010 and a dummy variable equal to unity if $u_{k,t-1} > 0$. α_0 denotes the immediate pass-through, γ^+, and θ^+ denote the adjustment coefficient and the mean lag, respectively, when $u_{k,t-1} > 0$. γ^- and θ^- denote the adjustment coefficient and the mean lag when $u_{k,t-1} \leq 0$. θ is computed as $\frac{|\lambda-\alpha_0|}{|\gamma|}$. The column *Asymmetric model* shows the results of the Wald test (χ^2 distributed) on the hypothesis that an asymmetric threshold model is the preferred specification. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***. Source: SNB, VZ and own calculations.

[1] significant at the 10 percent level.

Table 4: Asymmetric threshold adjustment of mortgage rates with different maturities with respect to the sign of benchmark rate changes

	α_0^+	α_0^-	γ	θ^+	θ^-	Asymmetric model
Floating rate	0.037	0.178***	-0.028***	7.1	2.1	Yes
	(0.035)	(0.03)	(0.005)			
2-year fixed rate	0.341***	0.771***	-0.065***	9.6	3.0	Yes
	(0.046)	(0.034)	(0.014)			
5-year fixed rate	0.348***	0.841***	-0.052***	12.5	3.1	Yes
	(0.038)	(0.027)	(0.013)			
7-year fixed rate	0.401***	0.823***	-0.072***	8.6	2.7	Yes
	(0.044)	(0.041)	(0.014)			
10-year fixed rate	0.510***	0.809***	-0.075***	6.9	2.9	Yes
	(0.046)	(0.032)	(0.019)			

Notes: Results based on equations (1) and (2) using an error correction representation with a sample from April 2001 to December 2010 and a dummy variable equal to unity if $\Delta m_t > 0$. α_0^+ denotes the immediate pass-through when contemporaneous changes in the benchmark rate are positive, whereas α_0^- is the immediate pass-through when changes in the benchmark rate are negative. γ is the adjustment coefficient. θ^+ denotes the mean lag when $\Delta m_t > 0$, whereas θ^- is the mean lag when $\Delta m_t \leq 0$. θ is computed as $\frac{|\lambda - \alpha_0|}{|\gamma|}$. The column *Asymmetric model* shows the results of the Wald test (χ^2 distributed) on the hypothesis that an asymmetric threshold model is the preferred specification. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***. Source: SNB, VZ and own calculations.

Table 5: Interest rate pass-through of mortgage rates with different maturities: structural change analysis

	Sample	Structural change?	Long-run equation λ	$\lambda = 1$	α_0	Short-run equation $\alpha_0 = 1$	γ	θ	I	J
Floating rate	2001/04-2005/04	Yes	0.399***	No	0.024*	No	-0.135***	2.8	0	0
			(0.037)		(0.014)		(0.011)			
	2005/05-2010/12		0.239***	No	0.208***	No	-0.105***	0.3	2	2
			(0.017)		(0.04)		(0.017)			
2-year fixed rate	2001/04-2007/01	Yes	0.905***	No	0.345***	No	-0.361***	1.6	1	1
			(0.022)		(0.038)		(0.051)			
	2007/02-2010/12		0.998***	Yes	0.899***	No	-0.707***	0.1	0	0
			(0.011)		(0.037)		(0.053)			
5-year fixed rate	2001/04-2007/01	Yes	0.955***	No[1]	0.398***	No	-0.453***	1.2	1	1
			(0.027)		(0.031)		(0.06)			
	2007/02-2010/12		0.994***	Yes	0.922***	No	-0.745***	0.1	0	0
			(0.013)		(0.023)		(0.061)			
7-year fixed rate	2001/04-2007/01	Yes	0.958***	Yes	0.396***	No	-0.407***	1.4	1	1
			(0.038)		(0.039)		(0.08)			
	2007/02-2010/12		0.990***	Yes	0.936***	No[1]	-0.704***	0.1	0	0
			(0.016)		(0.034)		(0.061)			
10-year fixed rate	2001/04-2006/10	Yes	0.968***	Yes	0.427***	No	-0.365***	1.5	1	1
			(0.043)		(0.033)		(0.097)			
	2006/11-2010/12		0.977***	Yes	0.933***	No	-0.543***	0.1	0	0
			(0.021)		(0.026)		(0.082)			

Notes: Results based on equations (1) and (2) using an error correction representation with an endogenous break-date for the long-run pass-through. In the column *Sample* the sample sub-periods before and after the structural break are displayed. The column *Structural change*? shows the results of the test for a single unknown break date in the long-run model using a supremum F (supF) test on equation (1). λ is the long-run pass-through coefficient. The column $\lambda = 1$ presents the results of the Wald test (χ^2 distributed) that the long-run coefficient is equal to unity. α_0 denotes the immediate pass-through, γ the adjustment coefficient and θ the mean lag according to the formula $\frac{|\lambda-\alpha_0|}{|\gamma|}$. The column $\alpha_0 = 1$ shows the results of the Wald test (χ^2 distributed) on the hypothesis that the impact coefficient is equal to unity. I and J denote the lag lengths of the first difference of mortgage rates and benchmark rates, respectively, in the short-run equation and were determined using AIC. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***. Source: SNB, VZ and own calculations.

[1] significant at the 10 percent level.

Table 6: Asymmetric threshold adjustment of mortgage rates with different maturities with respect to the adjustment coefficient: structural change analysis

	Sample	α_0	γ^+	γ^-	θ^+	θ^-	Asymmetric model
Floating rate	2001/04-2005/04	0.021	-0.203***	-0.035	1.9	10.7	Yes
		(0.014)	(0.023)	(0.027)			
	2005/05-2010/12	0.207***	-0.102***	-0.108***	0.3	0.3	No
		(0.041)	(0.028)	(0.034)			
2-year fixed rate	2001/04-2007/01	0.341***	-0.305***	-0.443***	1.9	1.3	Yes
		(0.039)	(0.054)	(0.061)			
	2007/02-2010/12	0.897***	-0.741***	-0.727***	0.1	0.1	No
		(0.037)	(0.113)	(0.105)			
5-year fixed rate	2001/04-2007/01	0.386***	-0.304***	-0.641***	1.9	0.9	Yes
		(0.031)	(0.048)	(0.083)			
	2007/02-2010/12	0.922***	-0.655***	-0.872***	0.1	0.1	No
		(0.023)	(0.084)	(0.102)			
7-year fixed rate	2001/04-2007/01	0.387***	-0.283***	-0.551***	2.0	1.0	Yes
		(0.038)	(0.068)	(0.108)			
	2007/02-2010/12	0.938***	-0.586***	-0.890***	0.1	0.1	Yes[1]
		(0.032)	(0.078)	(0.125)			
10-year fixed rate	2001/04-2006/10	0.419***	-0.274***	-0.483***	2.0	1.1	No
		(0.033)	(0.081)	(0.135)			
	2006/11-2010/12	0.935***	-0.328***	-0.932***	0.1	0.0	Yes
		(0.025)	(0.079)	(0.156)			

Notes: Results based on equations (1) and (2) using an error correction representation with an endogenous break-date for the long-run pass-through and a dummy variable equal to unity if $u_{k,t-1} > 0$. α_0 denotes the immediate pass-through, γ^+, and θ^+ denote the adjustment coefficient and the mean lag, respectively, when $u_{k,t-1} > 0$. γ^- and θ^- denote the adjustment coefficient and the mean lag, respectively, when $u_{k,t-1} \leq 0$. θ is computed as $\frac{|\lambda - \alpha_0|}{|\gamma|}$. The column *Asymmetric model* shows the results of the Wald test (χ^2 distributed) that an asymmetric threshold model is the preferred specification. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***.
Source: SNB, VZ and own calculations.
[1] significant at the 10 percent level.

Table 7: Asymmetric threshold adjustment of mortgage rates with different maturities with respect to the sign of benchmark rate changes: structural change analysis

	Sample	α_0^+	$\alpha_0^+ = 1$	α_0^-	$\alpha_0^- = 1$	γ	θ^+	θ^-	Asymmetric model
Floating rate	2001/04-2005/04	0.049	No	0.022	No	-0.134***	2.6	2.8	No
		(0.058)		(0.015)		(0.012)			
	2005/05-2010/12	0.014	No	0.238***	No	-0.109***	2.1	0.0	Yes
		(0.039)		(0.045)		(0.017)			
2-year fixed rate	2001/04-2007/01	0.406***	No	0.293***	No	-0.372***	1.3	1.6	Yes[1]
		(0.046)		(0.051)		(0.052)			
	2007/02-2010/12	0.678***	No	0.970***	Yes	-0.685***	0.5	0.0	Yes
		(0.057)		(0.039)		(0.05)			
5-year fixed rate	2001/04-2007/01	0.416***	No	0.380***	No	-0.456***	1.2	1.3	No
		(0.034)		(0.047)		(0.059)			
	2007/02-2010/12	0.742***	No	0.987***	Yes	-0.732***	0.3	0.0	Yes
		(0.044)		(0.024)		(0.061)			
7-year fixed rate	2001/04-2007/01	0.404***	No	0.387***	No	-0.409***	1.4	1.4	No
		(0.042)		(0.06)		(0.08)			
	2007/02-2010/12	0.786***	No	0.994***	Yes	-0.696***	0.3	0.0	Yes
		(0.053)		(0.036)		(0.062)			
10-year fixed rate	2001/04-2006/10	0.476***	No	0.385***	No	-0.369***	1.3	1.6	No
		(0.054)		(0.067)		(0.097)			
	2006/11-2010/12	0.795***	No	0.988***	Yes	-0.544***	0.3	0.0	Yes
		(0.057)		(0.028)		(0.094)			

Notes: Results based on equations (1) and (2) using an error correction representation with an endogenous break-date for the long-run pass-through and a dummy variable equal to unity if $\Delta m_t > 0$. α_0^+ denotes the immediate pass-through when the contemporaneous changes in the benchmark rate are positive, whereas α_0^- is the immediate pass-through when changes in the benchmark rate are negative. The columns $\alpha_0 = 1$ show the results of the Wald test (χ^2 distributed) on the hypothesis that the impact coefficient is equal to unity. γ^+ is the adjustment coefficient and θ^+ denotes the mean lag, respectively, when $\Delta m_t > 0$. θ^- denotes the mean lag when $\Delta m_t \leq 0$. θ is computed as $\frac{|\lambda - \alpha_0|}{|\gamma|}$. The column *Asymmetric model* shows the results of the Wald test (χ^2 distributed) that an asymmetric threshold model is the preferred specification. Standard errors (in parentheses) are reported below the point estimates. Significance at the 10%, 5% and 1%-level is, respectively, denoted by *, ** and ***. Source: SNB, VZ and own calculations.

[1] significant at the 10 percent level.

B Figures

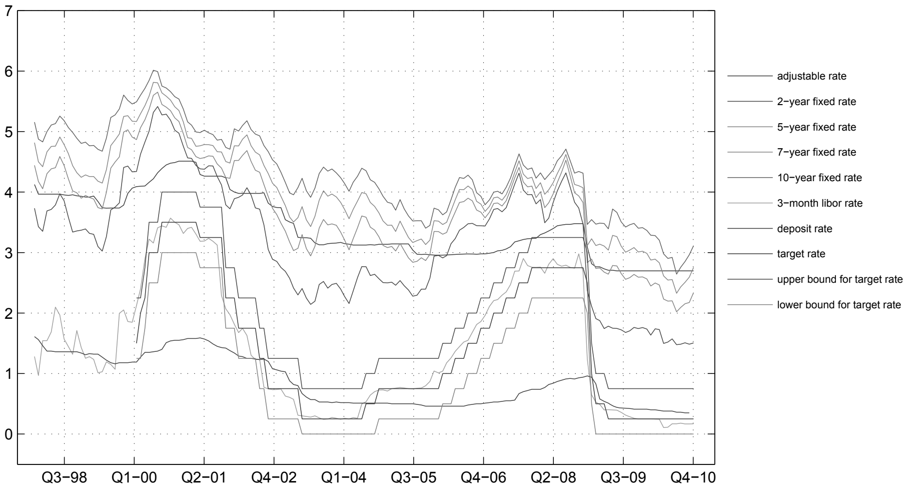

Figure 1: Evolution of interest rates: mortgage rates, deposit rate and three-month Libor rate

The Figure displays the evolution of interest rates (mean) for mortgage loans with different maturities, the deposit rate, the 3-month Libor rate and the operational target range for the 3-month Libor set by the Swiss National Bank. Source: VermoegensZentrum and SNB.

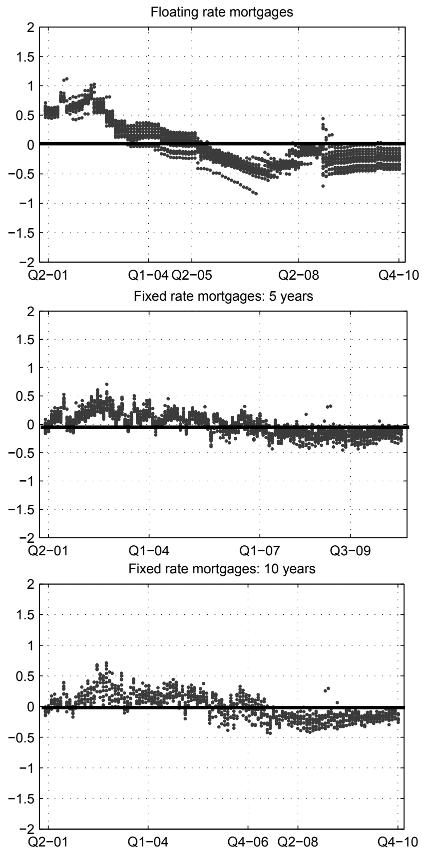

Figure 2: Scatter plot of the residuals from the long-run equation against time

The figure displays the regression residuals resulting from the bank-specific cointegrating equations against time for mortgage loans with different maturities. Source: own calculations.

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