

What Calls to ARMs?

International Evidence on Interest Rates and the Choice of Adjustable-Rate Mortgages

Online Appendix

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This appendix contains four parts:

- A. Data sources
- B. Back-casting and imputation algorithm
- C. Description of the bootstrap procedure
- D. Figures and tables

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Appendix A: Data Sources

Belgium: National Bank of Belgium

- *MIR Survey on interest rates applied to customers.*
 - Volumes: Part II. Amounts of loans in EUR to households - New Business. Loans for house purchases.
 - Interest rates: Part I. Interest rates on loans in EUR to households - New Business. Loans for house purchases.

Denmark: Danmarks Nationalbank, *Table DNRNM*

- Volumes and interest rates: MFI sector's interest rates on new lending by data type, item, fixed-interest period, currency and sector.
- Options:
 - Business volume and effective interest rate
 - Housing purposes excluding overdraft facilities
 - Sector: Households (1415)

Ireland: Central Bank of Ireland, *Retail Interest Rates, Table B.2.1*

- Volumes and interest rates: "Loans to households for house purchases".

Italy: Bank of Italy, *Supplements to the Statistical Bulletin; Money and Banking*

- Volumes: Table VTI30200, euro-denominated loans to households: new business.
- Interest rates: Table TTI30200, bank interest rates on euro loans to households: new business.

Greece: Bank of Greece, *Bank deposit and loan interest rates*

- Volumes: Table 1a, Volume of new bank euro-denominated deposits and loans vis-a-vis euro area residents, Housing loans to households.
- Interest rates: Table 1, Bank interest rates on new euro-denominated deposits and loans vis-a-vis euro area residents, Housing loans to households.

Germany: Deutsche Bundesbank, *Housing loans to households*

- Volumes: BBK01.SUD216 to BBK01.SUD219, New business (volumes) of German banks, Housing loans to households with an initial rate fixation.

Spain: Banco de Espana

- Volumes: DN_CTI2TIE43 to DN_CTI2TIE46, New business. Credit entities, except official credit. Housing loans. Initial interest rate fixation periods.

Portugal: Banco de Portugal, *OMFIs' interest rates and profitability*

- Volumes: New loans to MU households, housing

Netherlands: De Nederlandsche Bank, *Interest rates*

- Volumes and interest rates: Table 5.2.7, Interest rates of MFIs on deposits and loans from households, Loans for house purchase. New business.

Finland: Bank of Finland *MFI balance sheet (loans and deposits) and interest rates*

- Volumes and interest rates: Finnish MFI's new business on housing loans by reference rate

Sweden: Statistics Sweden, *Financial Market Statistics*.

- Volumes: 4.26.4, Housing credit institutions' volumes of lending, new loans each month
- Interest rates: Table 5.5.2 (cont.), Housing credit institutions' lending rates on new agreements each month. For the period until September 2005, interest rate data is converted from quarterly to monthly frequency through linear interpolation.

Australia: Australian Bureau of Statistics, *Time Series Workbook, Housing Finance*

- Volumes: TABLE 9a. Housing Finance Commitments, by type of buyer and loan

Reserve Bank of Australia, *Statistical Tables*

- Interest rates: TABLE F5. Indicator lending rates, Housing loans by banks. Standard variable rate and 3-year fixed rate.

United States: Federal Housing Finance Agency, *Monthly Interest Rate Survey*

- Loan-level data. Survey waves: 1992 to 2013.

United Kingdom: Bank of England

- CFQB4VA to CFQB4VF, Quarterly percentage of UK resident monetary financial institutions' - loans secured on dwellings, new advances on floating rate to households.

Appendix B: Back-casting and imputation

We describe the procedure by which imputed values are obtained for $\overline{ARM}_{i,t-K,t}$ in the cases $K = 2$ and $K = 3$ years and for $ARM_{US,t}$ during the months in which the US MIRS survey data is not reliable.

Assume generically the following model for Y_t as a function of X_t :

$$Y_t = \alpha + \beta X_t + \varepsilon_t.$$

Let $t = T$ be the first observation for which we have data on Y_t , with the data on X_t going back to $t = 0$. The idea is to use fitted values \widehat{Y}_t wherever Y_t is not available. If the regression is estimated in levels, however, there would be a discontinuity at $t = T - 1$ because we suddenly change from the fitted values to the actual ones.

Therefore, we estimate the model in first-differences:

$$\Delta Y_t = \alpha + \beta \Delta X_t + \nu_t.$$

and obtain an implied fitted time series for $\widehat{\Delta Y}_t$. We then have:

$$\begin{aligned}\widehat{Y}_{T-1} &= Y_T - \widehat{\Delta Y}_T \\ \widehat{Y}_{T-2} &= \widehat{Y}_{T-1} - \widehat{\Delta Y}_{T-1} \\ &\text{etc.}\end{aligned}$$

Applied to our case, the variables are:

$$\begin{aligned}Y_t &= \overline{ARM}_{i,t-K,t} \\ X_t &= \overline{R}^f_{i,t-K,t}\end{aligned}$$

for back-casting past ARM rates when $K = 2$ and $K = 3$ years, and:

$$\begin{aligned}Y_t &= ARM_{i,t} \\ X_t &= R^f_{i,t}\end{aligned}$$

for generating imputed values of ARM rates in the US during the periods November 2008 to March 2009, August 2011 to November 2011 and October 2012 to April 2013.

Appendix C: Bootstrap procedure

Standard errors for all estimated coefficients are computed by using a non-parametric bootstrap procedure. The need to correct standard errors in this way arises because of the imputation and extrapolation carried out to correct for implausible observations towards the end of the sample in the US, as well as for the cases where $K = 2$ and $K = 3$ years. In addition, this provides a robust way to account for the two-stage instrumental-variables estimation.

The context in which we implement the bootstrap consists of an unbalanced panel of monthly observations which are serially and cross-sectionally correlated. We use a circular block bootstrap of random block length, along the lines of Politis and Romano (1994) and Ramadorai (2012). Consistency in terms of cross-sectional dependence is insured by having a unique re-sampling draw across countries and by re-ordering the time series such that the draw is consistent with the different sample coverages in each country. The algorithm starts by setting the value for a constant q and drawing a random number $t = 1, \dots, T$, where T is the length of the full sample. For the re-sampled observation corresponding to the next period, a random variable ξ is drawn from a uniform distribution defined on $(0,1)$. If ξ is smaller than q , the consecutive observation to the first bootstrap draw is also included (i.e., if $t = 4$ was first drawn, $t = 5$ is appended to it). When reaching the end of the sample, the procedure starts from the beginning with $t = 1$. If ξ is greater than or equal to q , a new observation $t = 1, \dots, T$ is drawn with replacement. At each step, only countries for which observation t is available are included in the sample. This procedure insures that the time series pattern is preserved through the choice of q , while the cross-sectional dependence is built into the simultaneous random draws. We report the results for $q = 0.1$, with 5,000 draws used to compute the final standard errors.

Appendix D: Figures and tables

- *Figure A.1 - Mortgage market structure and average fixation periods*
The figure illustrates the time series dynamics of the share of ARMs for the set of countries which we do not include in our panel analysis.
- *Figure A.2 - Imputation of the ARM rate for the United States*
The figure shows the different paths for the ARM rate implied by the imputation procedure.
- *Figure A.3 - Back-casting of average ARM rates*
The figure shows the different paths for the backward-looking average ARM rate implied by the back-casting procedure.
- *Figure A.4 - The relationship between ARM rates and nominal short rates*
The figure shows moving averages of the two variables at a backward-looking horizon of 3 years.
- *Figure A.5 - Realizations and forecasts of short-term interest rates*
The figure plots the time series of 3-month nominal interest rates and survey-based forecasts for a horizon of one year.
- *Figure A.6 - Fixation periods of new mortgage loans*
The figure shows the time series path of new mortgage loans to households, by interest rate fixation category.
- *Figure A.7 - Time series of average fixation periods and FRM-ARM spreads at the country level*
The figure plots the time series of average fixation periods.
- *Table A.1 - Determinants of the ARM share: rational forecasting*
The table reports results from pooled panel IV estimation, for the cases $T = 1, 2, 3$ years.
- *Table A.2 - Determinants of the ARM share: unit-root first-stage specification*
The table reports results from pooled panel IV estimation, when assuming a common unit root for interest rates.
- *Table A.3 - Determinants of the ARM share: country-by-country results*
The table reports detailed country-by-country estimates, distinguishing between first- and second-stage results.
- *Table A.4 - Average fixation period: IV approach*
The table reports panel estimation results when considering the average fixation period as dependent variable.

- *Table A.5 - Specifications with time fixed effects*

The table reports panel estimation results when including time fixed effects in our benchmark specification.

- *Table A.6 - Determinants of the ARM share: interest rate forecasts*

The table reports the results for the cases $K = 2$ and $K = 3$ years, when using consensus forecasts as additional instruments and explanatory variables.

- *Table A.7 - Rationality of one-year ahead interest rate forecasts*

The table reports panel regressions of survey forecasts and actual realizations of interest rates, controlling for the complete set of instrumental variables.

- *Table A.8 - Determinants of the ARM share in the US: Expectations of future rates based on Michigan survey data*

The table reports results from an instrumental-variables regression for the US, where we use one-year ahead interest rate forecasts from the Michigan survey of US consumers.

Figure A.1
Mortgage market structure and average fixation periods

The figure illustrates the time series dynamics of the share of ARMs for the set of countries which we do not include in our panel analysis. The series for the UK is only available at quarterly frequency.

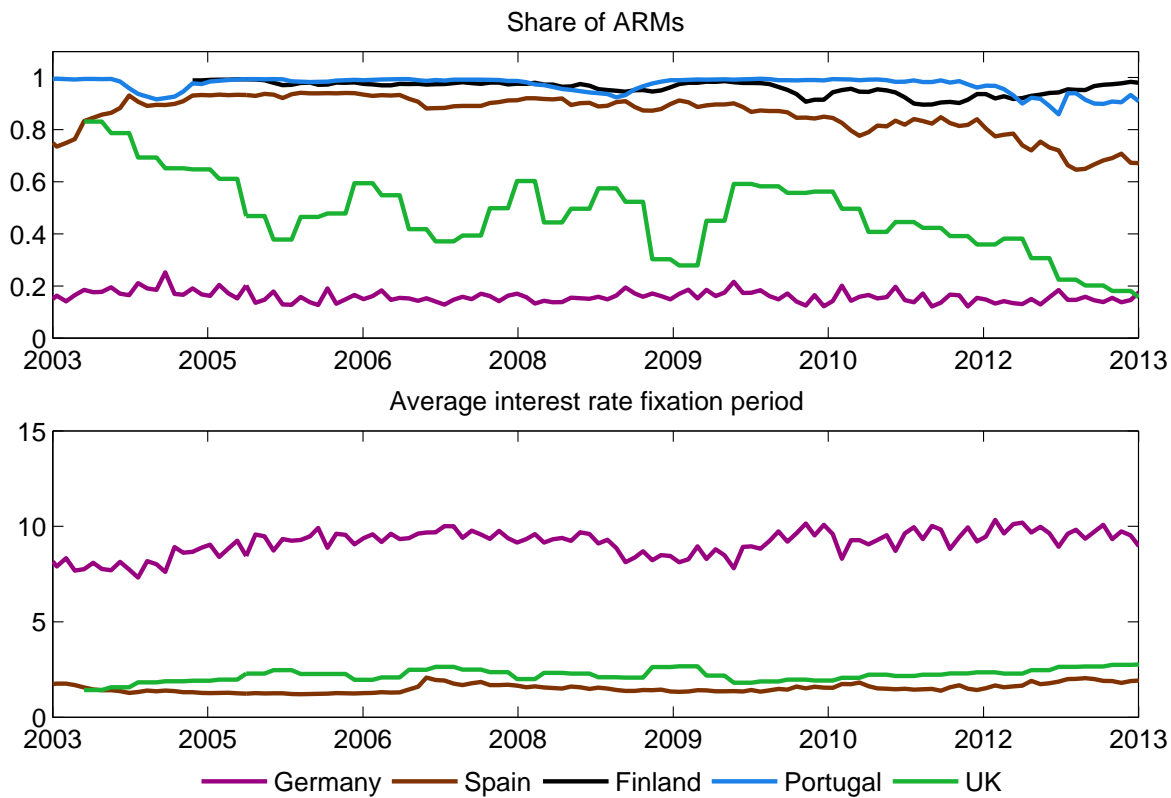


Figure A.2
Imputation of the ARM rate for the United States

The figure shows the different paths for the ARM rate implied by the imputation procedure, by using either the short rate or the FRM rate as reference variables. As mentioned above, we use the short rate as a reference in all estimated model specifications.

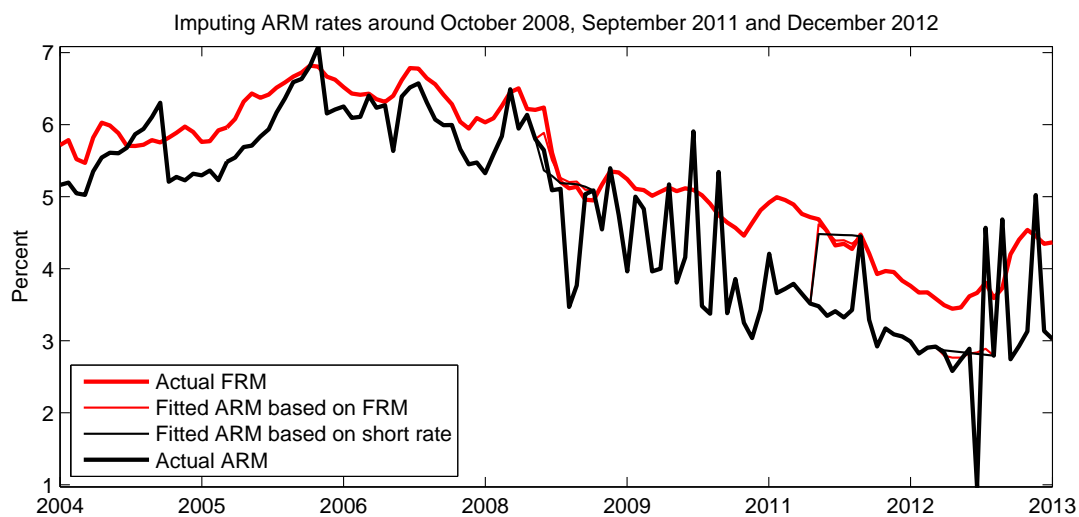


Figure A.3
Back-casting of average ARM rates

The figure shows the different paths for the backward-looking average ARM rate implied by the back-casting procedure, for three cases: first, when the relationship between the ARM rate and the nominal short rate is estimated separately for each country; second, when this relationship is constrained to be the same for the whole panel and third, for the case of a simple rule that the change in the ARM rate is equal to the change in the nominal short rate. In all our estimated model specifications we use the second variant, i.e. common coefficients across the panel.

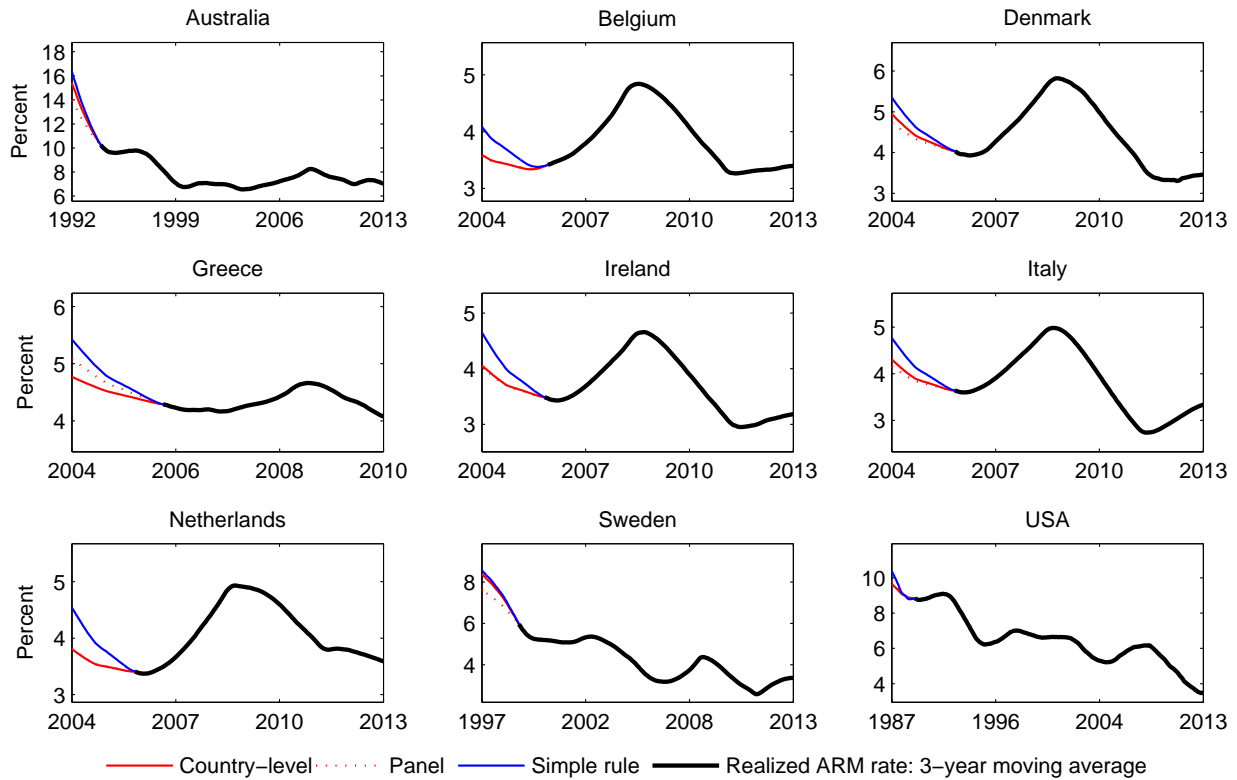


Figure A.4

The relationship between ARM rates and nominal short rates

The figure shows moving averages of the two variables at a backward-looking horizon of 3 years. It corroborates the proposed preferred imputation method illustrated in Figure A.3, by showing that a moving average of the short rate, appropriately adjusted, is a good approximation for the moving average of the ARM rate.

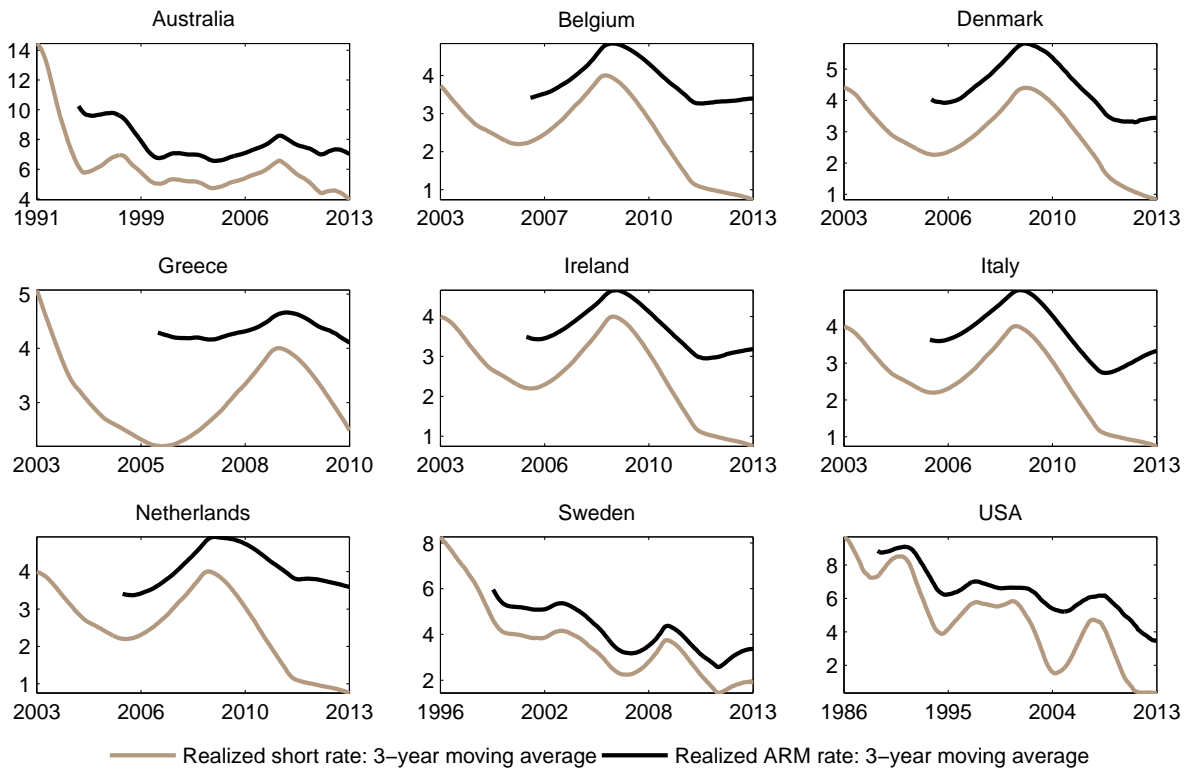


Figure A.5

Realizations and forecasts of short-term interest rates

The figure plots the time series of 3-month nominal interest rates (continuous line) and survey-based forecasts for a horizon of one year (dotted line). The timing of the plot is such that realizations and forecasts are depicted contemporaneously, i.e. they are plotted for the month during which the survey was conducted.

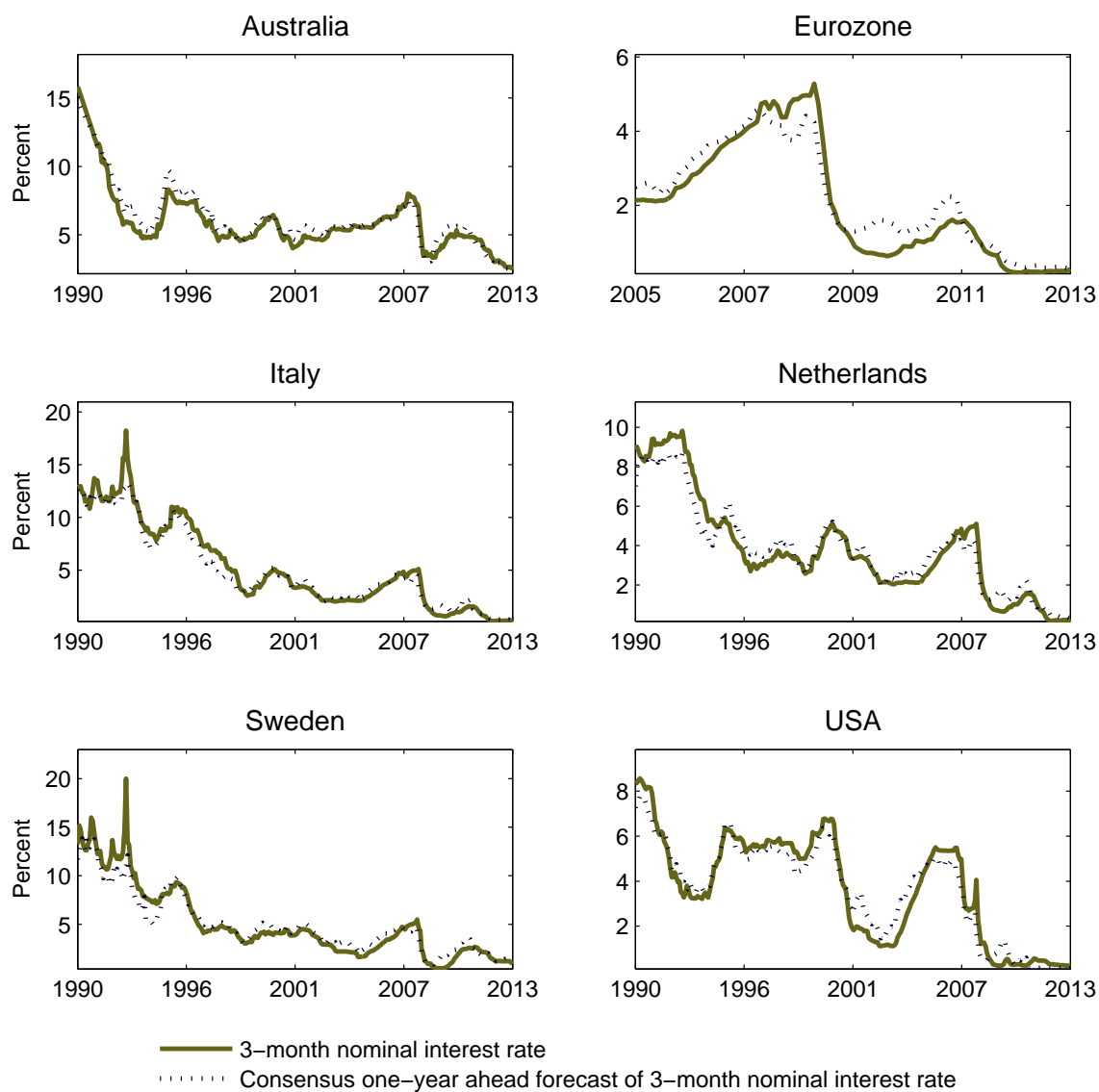


Figure A.6

Fixation periods of new mortgage loans

The figure shows the time series path of new mortgage loans to households, by interest rate fixation category. The volumes in each category are normalized by dividing through the size of total new mortgage lending.

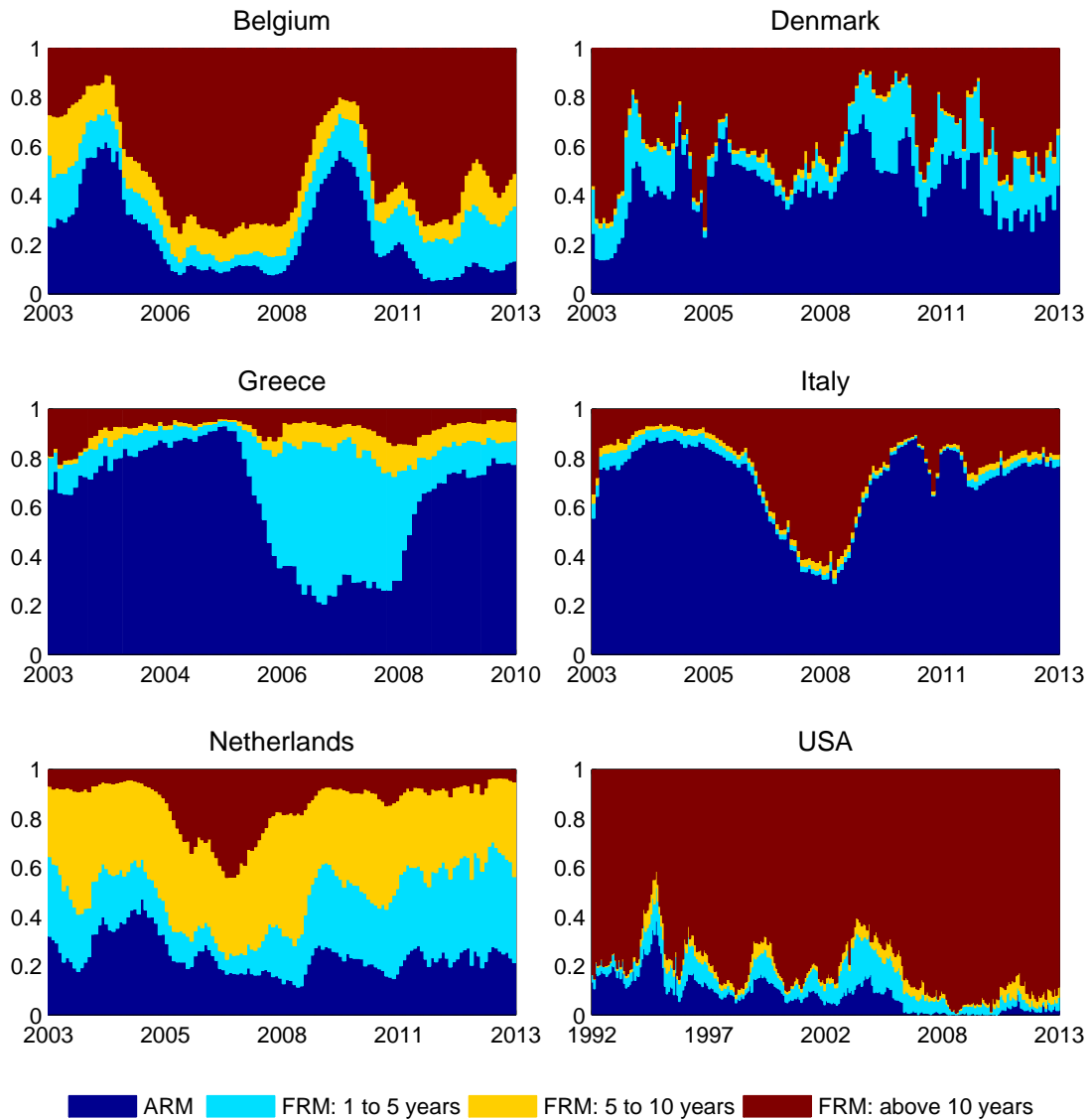


Figure A.7

Time series of average fixation periods and FRM-ARM spreads at the country level

The figure illustrates the dynamics of the average fixation period (in years, on the left axis) and the contemporaneous spread between the FRM rate for fixation periods above 10 years and ARM rates (in percent, on the right axis). For the US, imputed values are used for the ARM rate during the periods November 2008 to March 2009, August 2011 to November 2011 and October 2012 to April 2013.

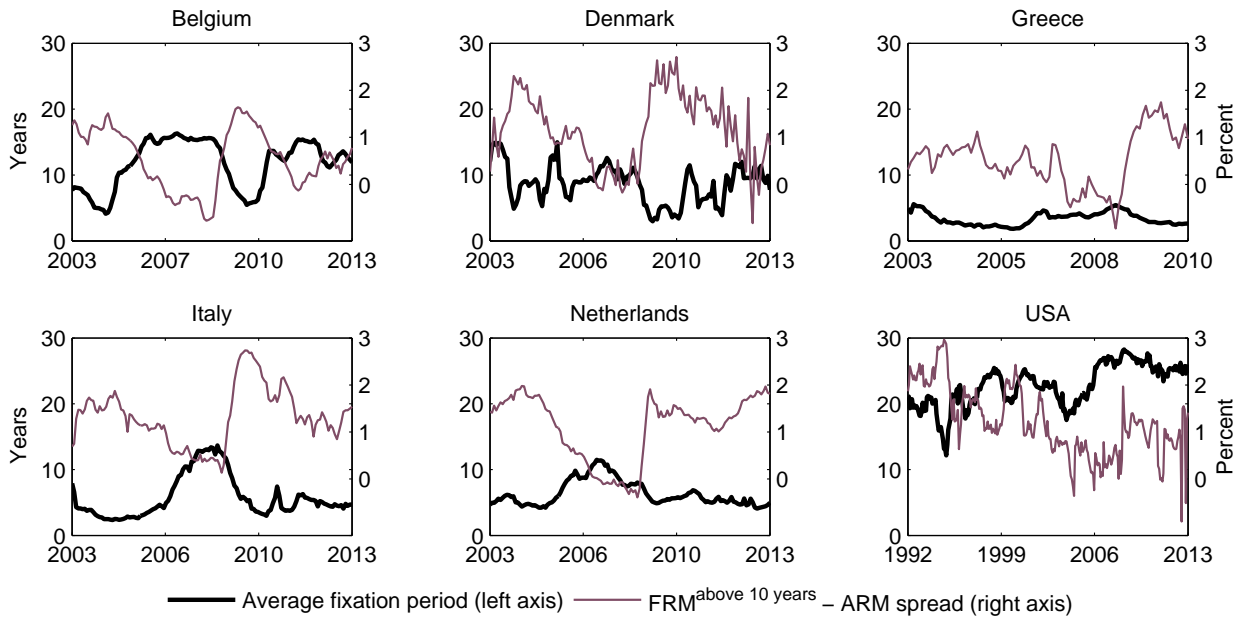


Table A.1

Determinants of the ARM share in a cross-country panel:
Current mortgage rates vs. rational expectations of future rates

In Panel A, we report estimation results from pooled panel regressions of the form:

$$ARMSHARE_{i,t} = \mu_i + \rho ARMSHARE_{i,t-1} + \beta_C(FRM_{i,t} - ARM_{i,t}) + \beta_L(FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \nu_{i,t},$$

where μ_i are country-specific fixed effects. $ARM_{i,t}$, $FRM_{i,t}$ and $\overline{ARM}_{i,t-K,t}$ are used as instruments for $\overline{ARM}_{i,t,t+T}$, with T and K varying as indicated (in years). The first-stage model specification is given by:

$$\overline{ARM}_{i,t,t+T} = \alpha_i + \gamma_1 ARM_{i,t} + \gamma_2 FRM_{i,t} + \gamma_3 \overline{ARM}_{i,t-K,t} + \gamma_4 B_{i,t}^5 + \gamma_5 R_{i,t}^f + \varepsilon_{i,t}.$$

All estimations cover the same sample as the one with $T = 3$ years. When $K = 2$ or $K = 3$ years, extrapolated values are calculated for the part of the sample where $\overline{ARM}_{i,t-K,t}$ is missing.

In Panel B, we report estimation results from pooled panel regressions of the form:

$$ARMSHARE_{i,t} = \mu_i + \rho ARMSHARE_{i,t-1} + \beta_C(FRM_{i,t} - ARM_{i,t}) + \beta_L(FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \beta_S(R_{i,t}^f - R_{i,t,t+12}^{f,CF}) + \nu_{i,t},$$

where μ_i are country-specific fixed effects and $R_{i,t,t+12}^{f,CF}$ is the consensus forecast of the one-year ahead nominal interest rate. The first-stage model specification is given by:

$$\overline{ARM}_{i,t,t+T} = \alpha_i + \gamma_1 ARM_{i,t} + \gamma_2 FRM_{i,t} + \gamma_3 \overline{ARM}_{i,t-K,t} + \gamma_4 B_{i,t}^5 + \gamma_5 R_{i,t}^f + \gamma_6 R_{i,t,t+12}^{f,CF} + \varepsilon_{i,t}.$$

We report the case $K = 1$. Statistical significance is indicated through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively.

Panel A

		Panel			Panel (excl. USA)		
		$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample							
$K = 1$	β_C	-0.08	0.57*	0.74***	-0.11	0.65**	0.87***
	β_L	1.23***	0.55**	0.31	1.53***	0.76**	0.46*
$K = 2$	β_C	0.24	0.66**	0.77***	0.22	0.73**	0.89***
	β_L	0.78*	0.35	0.21	1.02*	0.52*	0.32
$K = 3$	β_C	0.50	0.72**	0.79***	0.48	0.81**	0.91***
	β_L	0.44	0.22	0.16	0.66	0.35	0.24
Post-2001							
$K = 1$	β_C	-0.37	0.54*	0.83***	-0.22	0.73**	1.05***
	β_L	1.74***	0.93***	0.71***	1.85***	1.00***	0.74**
$K = 2$	β_C	-0.14	0.58*	0.83***	-0.01	0.77**	1.04***
	β_L	1.42**	0.80***	0.65**	1.52***	0.86**	0.68**
$K = 3$	β_C	0.12	0.65**	0.84***	0.26	0.83**	1.04***
	β_L	1.05*	0.61*	0.51*	1.13*	0.66	0.54

Table A.1

Determinants of the ARM share in a cross-country panel:
 Current mortgage rates vs. rational expectations of future rates
 (continued)

Panel B

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	-0.08	0.67**	0.92***	0.66	1.34***	1.59***
β_L	1.26***	0.50*	0.18	1.07***	0.46*	0.22
β_S	0.13	0.28	0.48*	0.86**	1.10***	1.32***
Post-2001						
β_C	-0.18	0.66	1.08**	1.23	1.85***	2.11***
β_L	1.51***	0.79**	0.47	0.85	0.33	0.15
β_S	0.06	0.17	0.49	1.21	1.49**	1.76***

Table A.2

Determinants of the ARM share in a cross-country panel:
Unit-root first-stage specification

The table presents results from the panel instrumental-variables context, when accounting for possible non-stationarity in interest rates and an associated unique cointegration relationship.

In Panel A, the estimation consists in running pooled panel regressions of the form:

$$ARM SHARE_{i,t} = \mu_i + \rho ARM SHARE_{i,t-1} + \beta_C (FRM_{i,t} - ARM_{i,t}) + \beta_L (FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \nu_{i,t},$$

where $FRM_{i,t} - ARM_{i,t}$, $\overline{ARM}_{i,t-K,t} - ARM_{i,t}$ and the 5-year bond yield spread $B_{i,t}^5 - R_{i,t}^f$ are used as instruments for $\overline{ARM}_{i,t,t+T} - ARM_{i,t}$. In this case, the first-stage specification is given by:

$$\overline{ARM}_{i,t,t+T} - ARM_{i,t} = \varphi_i + \phi_1 (FRM_{i,t} - ARM_{i,t}) + \phi_2 (\overline{ARM}_{i,t-K,t} - ARM_{i,t}) + \phi_3 (B_{i,t}^5 - R_{i,t}^f) + \xi_{i,t}.$$

In Panel B, the estimation consists in running pooled panel regressions of the form:

$$ARM SHARE_{i,t} = \mu_i + \rho ARM SHARE_{i,t-1} + \beta_C (FRM_{i,t} - ARM_{i,t}) + \beta_L (FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \beta_S (R_{i,t}^f - R_{i,t,t+12}^{f,CF}) + \nu_{i,t},$$

where the first-stage model is given by:

$$\overline{ARM}_{i,t,t+T} - ARM_{i,t} = \varphi_i + \phi_1 (FRM_{i,t} - ARM_{i,t}) + \phi_2 (\overline{ARM}_{i,t-K,t} - ARM_{i,t}) + \phi_3 (B_{i,t}^5 - R_{i,t}^f) + \phi_4 (R_{i,t}^f - R_{i,t,t+12}^{f,CF}) + \xi_{i,t}.$$

We report the case $K = 1$ year. Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively, based on bootstrap standard errors.

Panel A

		Panel			Panel (excl. USA)		
		$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample							
$K = 1$	β_C	-0.51	0.31	0.74	-0.51	0.33	0.98
	β_L	1.90***	1.30*	0.48	2.24***	2.37***	3.98
$K = 2$	β_C	0.09	0.55	0.83*	0.09	0.42	0.95
	β_L	1.05	0.69	0.01	1.31	1.97	1.62
$K = 3$	β_C	0.94	0.68	0.79**	0.66	0.24	0.95***
	β_L	-0.15	0.37	0.25	0.42	2.62	0.72
Post-2001							
$K = 1$	β_C	-0.70	0.46	0.92***	-0.73	0.62	1.33***
	β_L	2.30***	1.45**	1.09	2.75***	2.11***	2.19*
$K = 2$	β_C	-0.21	0.57	0.91***	-0.32	0.67	1.28***
	β_L	1.61	1.10	0.73	2.14**	1.87**	1.76
$K = 3$	β_C	0.26	0.67	0.90***	-0.24	0.67	1.17***
	β_L	0.93	0.74	0.48	1.99	1.69	0.98

Table A.2

Determinants of the ARM share: unit-root first-stage specification
(continued)

Panel B

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	-0.95*	-0.54	1.34	0.28	0.97	2.20***
β_L	2.34***	2.42*	-0.67	1.51*	1.04	-1.20
β_S	-0.30	-0.99	1.04	0.60	0.60	2.27*
Post-2001						
β_C	-0.77	1.68	2.45	0.34	6.36	3.21***
β_L	2.11**	-0.31	-1.68	1.61	-3.93	-1.42
β_S	-0.31	1.30	2.75	0.54	7.36	3.75***

Table A.3

Determinants of the ARM share: country-by-country results for the unit-root first-stage specification

The table presents results from the panel instrumental-variables context, when accounting for possible non-stationarity in interest rates and an associated unique cointegration relationship. The estimation consists in running both country-by-country and pooled panel regressions of the form:

$$ARMSHARE_{i,t} = \mu_i + \rho ARM SHARE_{i,t-1} + \beta_C (FRM_{i,t} - ARM_{i,t}) + \beta_L (FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \nu_{i,t},$$

where $FRM_{i,t} - ARM_{i,t}$, $\overline{ARM}_{i,t-K,t} - ARM_{i,t}$ and the 5-year bond yield spread $B_{i,t}^5 - R_{i,t}^f$ are used as instruments for $\overline{ARM}_{i,t,t+T} - ARM_{i,t}$, with $T = 3$ years and $K = 1$ year. The first-stage specification is given by:

$$\overline{ARM}_{i,t,t+T} - ARM_{i,t} = \varphi_i + \phi_1 (FRM_{i,t} - ARM_{i,t}) + \phi_2 (\overline{ARM}_{i,t-K,t} - ARM_{i,t}) + \phi_3 (B_{i,t}^5 - R_{i,t}^f) + \xi_{i,t}.$$

Correlation coefficients among regressors are reported under the heading Γ . φ^{FE} and μ^{FE} capture estimated country-specific fixed effects in the pooled panel setup. $\overline{ARM}_{i,t-K,t}$ is extrapolated as mentioned above. Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively, based on bootstrap standard errors.

	φ^{FE}	ϕ_1	ϕ_2	ϕ_3	Γ_{ϕ_1, ϕ_2}	Γ_{ϕ_1, ϕ_3}	R^2	μ^{FE}	ρ	β_C	β_L	$\Gamma_{\beta_1, \beta_2}$	R^2	obs.
Full sample														
Australia	-0.30**	0.95***	0.34**	-0.25	0.09	0.71	0.20	5.06***	0.90***	0.63	-0.73	0.55	0.84	222
Belgium	-0.41**	1.89***	-1.07***	0.01	0.71	0.87	0.68	0.34	0.94***	1.39	3.24***	-0.17	0.97	72
Denmark	-0.51**	1.08***	-0.56***	0.80***	0.39	0.77	0.65	1.95*	0.77***	1.67	2.20	-0.59	0.64	83
Greece	-0.41***	-0.43	1.51***	0.24	0.82	0.82	0.39	2.11	0.94***	5.51	-2.50	0.87	0.98	47
Ireland	-0.52**	-0.94	-0.13	0.40**	0.55	0.89	0.14	4.05***	0.89***	0.34	1.90	0.30	0.75	84
Italy	-0.90***	-0.10	-0.92***	1.37***	0.67	0.91	0.57	2.47	0.99***	1.52*	1.16	0.12	0.99	84
Netherlands	-0.43**	1.31***	-1.03***	0.05	0.71	0.92	0.47	0.58	0.90***	1.50**	0.48	0.37	0.93	84
Sweden	-0.94***	1.23***	-0.08	0.48**	0.42	0.87	0.56	2.14	0.95***	-0.09	-0.41	-0.90	0.93	166
USA	-0.99***	0.23*	0.13	0.29*	0.51	0.34	0.36	-1.05	0.92***	1.32	-0.98	0.89	0.93	216
Panel		-0.94***	-0.99***	0.56***	0.37	0.53	0.27		0.94***	0.74	0.48	0.74	0.99	1058
Panel (excl. USA)		-0.56***	-1.11***	0.83***	0.33	0.65	0.28		0.94***	0.98*	3.98	0.54	0.98	842
Post-2001														
Australia	0.19	-0.35	0.22**	0.89***	0.08	0.77	0.53	5.67***	0.98***	-0.08	1.01***	0.28	0.93	120
Sweden	-1.02***	1.67***	-0.25*	0.46	0.49	0.91	0.65	1.29	0.91***	5.36	4.20	-0.93	0.89	120
USA	-1.04***	-0.34	0.35	0.44*	0.91	0.38	0.37	-1.53**	0.94***	0.40	-0.94	0.86	0.94	120
Panel		-1.02***	-1.04***	0.59***	0.53	0.66	0.36		0.94***	0.92***	1.09	0.57	0.99	814
Panel (excl. USA)		-0.59***	-1.09***	0.67***	0.41	0.73	0.37		0.93***	1.33***	2.19*	0.43	0.98	694

Table A.4
Average fixation period: IV approach

The estimation consists in running pooled panel regressions of the form:

$$AVGFIX_{i,t} = \mu_i + \rho AVGFIX_{i,t-1} - \beta_C(FRM_{i,t}^\eta - ARM_{i,t}) - \beta_L(FRM_{i,t}^\eta - \overline{ARM}_{i,t,t+T}) + \nu_{i,t},$$

with country-specific fixed effects. $AVGFIX_{i,t}$ is the average fixation period and $FRM_{i,t}^\eta$ is the rate on mortgage loans corresponding to a fixation period η . For all countries, we choose $\eta =$ 'above 10 years'. $ARM_{i,t}$, $FRM_{i,t}^\eta$ and $\overline{ARM}_{i,t-K,t}$ are used as instruments for $\overline{ARM}_{i,t,t+T}$, with T and K varying as indicated (in years). The first-stage model specification is given by:

$$\overline{ARM}_{i,t,t+T} = \alpha_i + \gamma_1 ARM_{i,t} + \gamma_2 FRM_{i,t}^\eta + \gamma_3 \overline{ARM}_{i,t-K,t} + \gamma_4 B_t^5 + \gamma_5 R_t^f + \varepsilon_{i,t}.$$

Alternatively, when accounting for possible non-stationarity in interest rates and an associated unique cointegration relationship, the first-stage model is:

$$\overline{ARM}_{i,t,t+T} - ARM_{i,t} = \varphi_i + \phi_1(FRM_{i,t}^\eta - ARM_{i,t}) + \phi_2(\overline{ARM}_{i,t-K,t} - ARM_{i,t}) + \phi_3(B_t^5 - R_t^f) + \xi_{i,t}.$$

All estimations cover the same sample as the one with $T = 3$ years. Except in the case $K = 1$ year, extrapolated values are calculated for the part of the sample where $\overline{ARM}_{i,t-K,t}$ is missing. Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively, based on bootstrap standard errors.

		Benchmark specification			Unit root specification		
		$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample							
$K = 1$	β_C	-0.10	0.12*	0.18***	0.05	0.24***	0.27***
	β_L	0.38***	0.20***	0.16***	0.20	0.00	-0.08
$K = 2$	β_C	-0.08	0.12*	0.18***	0.32*	0.35***	0.32***
	β_L	0.35***	0.19***	0.15***	-0.08	-0.16	-0.19**
$K = 3$	β_C	-0.02	0.14**	0.19***	1.04***	0.52***	0.35***
	β_L	0.29***	0.15***	0.13***	-0.89***	-0.43***	-0.28***
Full sample excl. US							
$K = 1$	β_C	-0.18	0.12	0.22***	-0.28*	0.09	0.21***
	β_L	0.50***	0.27***	0.23***	0.60***	0.33***	0.33***
$K = 2$	β_C	-0.15	0.12	0.22***	-0.15	0.13	0.24***
	β_L	0.45***	0.26***	0.23***	0.48***	0.28***	0.28***
$K = 3$	β_C	-0.10	0.14*	0.22***	-0.06	0.18*	0.26***
	β_L	0.40***	0.23***	0.20***	0.40**	0.23**	0.24**
Post-2001							
$K = 1$	β_C	-0.23**	0.04	0.13**	-0.25*	0.05	0.14**
	β_L	0.46***	0.25***	0.22***	0.47***	0.21**	0.16**
$K = 2$	β_C	-0.19**	0.05	0.13**	-0.06	0.12	0.17***
	β_L	0.42***	0.23***	0.20***	0.26*	0.11	0.08
$K = 3$	β_C	-0.14	0.07	0.14**	0.44*	0.29***	0.23***
	β_L	0.36***	0.20***	0.17***	-0.27	-0.17	-0.15

Table A.5
Specifications with time fixed effects

The table reports estimation results from panel regressions of the form:

$$\begin{aligned} ARMSHARE_{i,t} = & \mu_i + \delta_t + \rho ARMSHARE_{i,t-1} + \beta_C(FRM_{i,t} - ARM_{i,t}) \\ & + \beta_L(FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \nu_{i,t}, \end{aligned}$$

where δ_t are time fixed effects and μ_i are country-specific fixed effects. $ARM_{i,t}$, $FRM_{i,t}$ and $\overline{ARM}_{i,t-K,t}$ are used as instruments for $\overline{ARM}_{i,t,t+T}$, with T and K varying as indicated (in years). The first-stage model specification is given by.

$$\overline{ARM}_{i,t,t+T} = \alpha_i + \gamma_1 ARM_{i,t} + \gamma_2 FRM_{i,t} + \gamma_3 \overline{ARM}_{i,t-K,t} + \gamma_4 B_{i,t}^5 + \gamma_5 R_{i,t}^f + \varepsilon_{i,t}.$$

All estimations cover the same sample as the one with $T = 3$ years. Except in the case $K = 1$ year, extrapolated values are calculated for the part of the sample where $\overline{ARM}_{i,t-K,t}$ is missing. Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively, based on bootstrap standard errors.

		Panel			Panel (excl. USA)		
		$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
<hr/>							
Full sample							
$K = 1$	β_C	0.48	0.73*	0.83**	1.09	1.30**	1.34**
	β_L	0.67	0.49	0.48	0.59	0.36	0.36
$K = 2$	β_C	0.73	0.80*	0.85**	1.34	1.39**	1.38**
	β_L	0.33	0.36	0.43	0.27	0.24	0.33
$K = 3$	β_C	0.64	0.74*	0.81*	1.07	1.26**	1.29**
	β_L	0.45	0.49	0.53*	0.67	0.46	0.46
<hr/>							
Post-2001							
$K = 1$	β_C	0.52	0.79	0.89	1.20	1.36**	1.42**
	β_L	0.82	0.52	0.46	0.52	0.30	0.27
$K = 2$	β_C	0.89	0.96*	0.99*	1.55**	1.52***	1.51**
	β_L	0.36	0.32	0.34	0.05	0.10	0.16
$K = 3$	β_C	1.04	1.02*	1.03*	1.63*	1.57**	1.54***
	β_L	0.13	0.20	0.24	-0.07	0.02	0.09
<hr/>							

Table A.6
Determinants of the ARM share: interest rate forecasts

The table reports estimation results from panel regressions of the form:

$$ARMSHARE_{i,t} = \mu_i + \rho ARMSHARE_{i,t-1} + \beta_C(FRM_{i,t} - ARM_{i,t}) + \beta_L(FRM_{i,t} - \overline{ARM}_{i,t,t+T}) + \beta_S(R_{i,t}^f - R_{i,t,t+12}^{f,CF}) + \nu_{i,t},$$

where μ_i are country-specific fixed effects and $R_{i,t,t+12}^{f,CF}$ is the consensus forecast of the one-year ahead nominal interest rate. The first-stage model specification is given by (A):

$$\overline{ARM}_{i,t,t+T} = \alpha_i + \gamma_1 ARM_{i,t} + \gamma_2 FRM_{i,t} + \gamma_3 \overline{ARM}_{i,t-K,t} + \gamma_4 B_{i,t}^5 + \gamma_5 R_{i,t}^f + \gamma_6 R_{i,t,t+12}^{f,CF} + \varepsilon_{i,t}.$$

Alternatively, when accounting for possible non-stationarity in interest rates and an associated unique cointegration relationship, the first-stage model is (B):

$$\overline{ARM}_{i,t,t+T} - ARM_{i,t} = \varphi_i + \phi_1(FRM_{i,t} - ARM_{i,t}) + \phi_2(\overline{ARM}_{i,t-K,t} - ARM_{i,t}) + \phi_3(B_{i,t}^5 - R_{i,t}^f) + \phi_4(R_{i,t}^f - R_{i,t,t+12}^{f,CF}) + \xi_{i,t}.$$

We report the cases $K = 2$ year and $K = 3$ years. Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively, based on bootstrap standard errors.

Panel A
Benchmark specification ($K = 2$ years)

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	0.13	0.72**	0.92***	0.99**	1.44***	1.61***
β_L	1.01***	0.42	0.18	0.73*	0.33	0.20
β_S	0.22	0.33	0.48*	1.05***	1.20***	1.33***
Post-2001						
β_C	0.01	0.69	1.06**	1.43	1.91***	2.11***
β_L	1.33***	0.75*	0.50*	0.67	0.28	0.14
β_S	0.17	0.21	0.45	1.37*	1.57**	1.76***

Panel B
Unit-root specification ($K = 2$ years)

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	-0.41	-0.35	0.96***	1.30***	1.28***	1.72***
β_L	1.70***	2.12***	0.14	0.44	0.60**	-0.03
β_S	-0.05	-0.80***	0.50*	1.21***	0.96***	1.47***
Post-2001						
β_C	-0.10	0.95*	1.65***	1.65	3.99***	2.54***
β_L	1.46***	0.50	-0.38	0.50	-1.67***	-0.46
β_S	0.08	0.45	1.38***	1.51*	4.25***	2.52***

Table A.6
Determinants of the ARM share: interest rate forecasts
(continued)

Panel C
Benchmark specification ($K = 3$ years)

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	0.10	0.67**	0.87***	1.02*	1.42***	1.57***
β_L	1.05**	0.49*	0.29	0.70	0.37	0.27
β_S	0.21	0.28	0.41*	1.07***	1.17***	1.28***
Post-2001						
β_C	0.25	0.78	1.08**	1.79*	2.09***	2.17***
β_L	1.09*	0.66*	0.47	0.37	0.12	0.08
β_S	0.32	0.30	0.49	1.62**	1.78**	1.85***

Panel D
Unit-root specification ($K = 3$ years)

	Panel			Panel (excl. USA)		
	$T = 1$	$T = 2$	$T = 3$	$T = 1$	$T = 2$	$T = 3$
Full sample						
β_C	-0.41	-0.09	0.73**	1.99***	0.95***	1.48***
β_L	1.69***	1.73***	0.65***	-0.29	1.07***	0.59***
β_S	-0.05	-0.54**	0.15	1.62***	0.58	1.05**
Post-2001						
β_C	-0.07	0.31	1.02**	3.64***	1.39*	1.94***
β_L	1.43**	1.21***	0.61*	-1.20	0.79	0.41
β_S	0.10	-0.28	0.33	2.99***	0.86	1.43**

Table A.7

Rationality of one-year ahead interest rate forecasts

The table reports estimation results from regressions of the form:

$$R_{i,t+12}^f - R_{i,t}^f = \alpha_i + \beta_i(R_{i,t,t+12}^{f,S} - R_{i,t}^f) + \tau_{i,1}ARM_{i,t} + \tau_{i,2}FRM_{i,t} + \tau_{i,3}B_{i,t}^5 + \tau_{i,4}R_{i,t}^f + \tau_{i,5}\overline{ARM}_{i,t-K,t} + \varepsilon_{i,t+12}.$$

In this specification, $R_{i,t}^f$ is the 3-month interest rate in country i in period t and $R_{i,t,t+12}^{f,S}$ is the one-year ahead average consensus forecast in country i in period t . Disaggregated forecast data are not available for Denmark, Belgium, Greece and Ireland. In our panel estimation, we use forecasts at the level of the Eurozone for the latter three of these countries. In Panel A, we estimate the coefficients unrestricted country-by-country. In Panel B, we consider the Eurozone to be a single unit and restrict the slope coefficients β to be identical across i . Standard errors are reported in parentheses below the coefficients. Statistical significance is indicated through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively.

Panel A

Country-by-country estimation

	Intercept		Slope					Instruments				
	α_i	β_i	$\tau_{i,1}$	$\tau_{i,2}$	$\tau_{i,3}$	$\tau_{i,4}$	$\tau_{i,5}$	$\tau_{i,1}$	$\tau_{i,2}$	$\tau_{i,3}$	$\tau_{i,4}$	$\tau_{i,5}$
Australia	4.83*** (0.78)	-0.77** (0.33)	1.06*** (0.31)	-1.03*** (0.37)	1.59*** (0.24)	-1.89*** (0.30)	-0.52*** (0.12)					
Eurozone	7.85*** (1.43)	2.40*** (0.51)	-1.14*** (0.31)	-1.93*** (0.39)	-0.31** (0.13)	1.16*** (0.20)	0.64*** (0.18)					
Italy	2.90 (1.86)	2.24*** (0.42)	1.36*** (0.42)	-1.15*** (0.40)	-0.40** (0.17)	-0.28* (0.16)	-0.24 (0.26)					
Netherlands	4.71*** (1.72)	2.01*** (0.49)	-0.09 (0.44)	-1.47** (0.71)	0.20 (0.39)	0.08 (0.43)	0.31 (0.28)					
Sweden	-0.43 (0.37)	1.48*** (0.29)	-0.96** (0.41)	0.85*** (0.29)	-0.25 (0.23)	0.08 (0.35)	0.01 (0.15)					
USA	7.07*** (1.50)	0.56 (0.42)	-0.34 (0.65)	-1.09 (0.72)	1.52*** (0.56)	-0.26 (0.39)	-0.60* (0.36)					

Table A.7
Rationality of one-year ahead interest rate forecasts
(continued)

		Panel B					
		Panel estimation with fixed effects					
Slope	β	Instruments					p-Value
		τ_1	τ_2	τ_3	τ_4	τ_5	$\{\tau_j = 0\}_{j=1,\dots,5}$
Panel	1.29*** (0.35)	-0.51* (0.29)	-0.18 (0.25)	0.23 (0.14)	0.14 (0.18)	-0.09 (0.17)	0.00

Table A.8

Determinants of the ARM share in the US:
 Expectations of future rates based on Michigan survey data

In Panel A, we report the correlation coefficient between $M_{t,t+12}$ and $R_{t+12}^f - R_t^f$. Here, $M_{t,t+12}$ captures one-year ahead interest rate forecasts from the Michigan survey. $M_{t,t+12}$ is calculated as a balance statistic of categorical answers. It ranges between -1 (i.e. the entire population expects an interest rate decrease) and 1 (i.e. the entire population expects an interest rate increase). Higher values of $M_{t,t+12}$ correspond to higher interest rate forecasts. In Panel B, we report estimation results from instrumental-variables regressions for the US, where ARM_t , FRM_t and $\overline{ARM}_{t-K,t}$ are used as instruments for $\overline{ARM}_{t,t+T}$, with $T = 3$ years and $K = 1$ year:

$$\overline{ARM}_{t,t+T} = \alpha + \gamma_1 ARM_t + \gamma_2 FRM_t + \gamma_3 \overline{ARM}_{t-K,t} + \gamma_4 B_t^5 + \gamma_5 R_t^f + \gamma_6 M_{t,t+12} + \varepsilon_t.$$

The second-stage model specification is given by:

$$ARM_{SHARE}_t = \mu + \rho ARM_{SHARE}_{t-1} + \beta_C (FRM_t - ARM_t) + \beta_L (FRM_t - \overline{ARM}_{t,t+T}) - \beta_M M_{t,t+12} + \nu_t.$$

Statistical significance is reported through at most three stars, referring to confidence levels of 10%, 5% and 1% respectively.

Panel A

Correlation between Michigan survey forecasts and one-year ahead
 realized future changes in interest rates:

0.47

PanelB

First-stage estimation						Second-stage estimation		
γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	β_C	β_L	β_M
0.26***	-0.26**	0.44***	0.61***	-0.24***	0.65***	1.31**	-0.62	-1.95*