Online Appendix for

"Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market,"

by

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This appendix contains six parts:

1. Details about refinancing in Denmark.
    a. This appendix provides answers to FAQs about access to refinancing in Denmark, obtained from the Association of Danish Mortgage Banks. These details confirm that refinancing is widely available, and largely unrestricted.
    b. Brief history of the Danish Mortgage Market

2. Additional Tables
    a. Table B1: Our estimated mortgage termination probabilities assuming three different definitions of our ranked variables. We model mortgage terminations that are driven by household-specific events, such as moves, death, or divorce, by predicting the probability of mortgage termination
    b. Table B2: The underlying distribution of our ranked variables
    c. Table B3: Simple logit model of refinancing.
    d. Figure B1: Refinancing activity by the coupon rate of new mortgages.
    e. Figure B2: Issuing Quarter Effects in Logit Refinancing Models
    f. Figure B3: Effects of Ranked Variables on Total Levelhead Probability
    g. Figure B4: Effects of Ranked Variables on Total Woodhead Refinancing Probability
    h. Figure B5: Proportionality of Mixing Proportions and Inertia

3. Appendix C: Replication of Table 7 and corresponding figures, assuming a constant mortgage termination probability of 10% across households.

4. Appendix D: Replication of Table 7 and corresponding figures, excluding all cash-out and maturity extension refinancing from the sample.

5. Appendix E: Replication of Table 7 and corresponding figures, including wake-up controls on the levelhead probability.

6. Appendix F: Estimating the persistence of type assignments using equation (14) in the paper.

[1]We are grateful to the Association of Danish Mortgage Banks for providing data, and for facilitating dialogue with the Mortgage Banks. We are particularly grateful to the senior economists Bettina Sand and Kaare Christensen at the Association of Danish Mortgage Banks for providing us with valuable institutional details.

Appendix A:

The following is a list of questions and answers resulting from our discussions with the Association of Danish Mortgage Banks regarding constraints on Danish households' ability to refinance mortgages.

The answers to several of these queries provide perspective on the controversy surrounding a recent article in The Economist newspaper, which has engendered some debate in Denmark.[2] This article suggests that the ability to refinance mortgages in Denmark is limited due to legal restrictions: "*Refinancing is an option for many, but not for the most precarious borrowers, due to legal restrictions on loans of more than 80% of a property's value.*" However, in Denmark, the article has been rebuffed by economists and market participants. For instance, the largest commercial bank Danske Bank wrote in April 2014: "*The Economist has renewed the focus on Danish households' debt in a recent article entitled 'Something rotten, Denmark's property market is built on rickety foundations'. We have looked into the arguments in the article and we conclude that it is based more on myths than realities with regard to the financial stability in Denmark."* [3]

The original correspondence with the Association of Danish Mortgage Banks is in Danish, and has been translated into English by the authors. The original correspondence will be included in a later version of this appendix.

	Question (by the authors)	**Answer (from the Association of Danish Mortgage Banks)**
A.1	*Can households always refinance their mortgages?*	Households can always refinance if they do not increase their principal.
A.2	*Can households add the refinancing costs to their principal?*	Households have the right to refinance their mortgage, adding costs and capital loss to the new principal, as long as they stay within the same house associated with the mortgage.
A.3	*Does refinancing trigger a credit evaluation?*	No credit evaluation is done in the event of refinancing.
A.4	*Can households refinance in a situation in which the LTV has risen above 80% of the property's value, on account of declining house prices?*	Yes, households are allowed to refinance in such a situation because the value of the property is not re-assessed when households refinance. As long as the household does not increase the principal (beyond adding costs and capital loss to the new principal as described in Question A.2), the LTV will not be re-assessed and households therefore have the option to refinance.
A.5	*Do the terms of the mortgage change in case of delinquencies or default? Do households owe the market value or the face value of the mortgage to the mortgage bank?*	The terms of the loan does not change for delinquent borrowers. Mortgages can be bought back on the same terms. Thus, in case of a forced sale due to foreclosure, the borrower owes the mortgage bank the Min[Face value, Market value] plus transaction costs – foreclosure proceeds.

[2] "Danish Mortgages: Something rotten, Denmark's property market is built on rickety foundations'", The Economist. April 19, 2014.
[3] "Research Denmark: Myths and realities about large household debt", Danske Bank, April 24, 2014.

History of the Danish mortgage system

The Danish mortgage system originated in 1795 when a huge fire burned one in four houses in Copenhagen to the ground. To finance the reconstruction, lenders formed a mortgage association in 1797 and the first Danish mortgages were issued on real property on the basis of joint and several liability to enhance credit quality. Over the past 200-plus years the market has experienced no mortgage bond defaults, and only in a very few cases have payments to investors been delayed. The last example of delayed payments to mortgage bond investors occurred in the 1930s.

This track record is partly attributable to the legal framework, which was first introduced in 1850, with successive changes resulting in the current framework, which dates from 2007. The legal framework is designed to protect mortgage bond investors and confines the activities of mortgage banks to mortgage lending funded only through the issuance of mortgage bonds. Mortgage loans serving as collateral must meet restrictive eligibility criteria including LTV limits and valuation of property requirements laid down in the legislation. For instance, for private residential properties the LTV limit is 80% and mortgage banks are obliged to assess the market value of pledged properties at the time of granting the loans. The maximum loan maturity is 30 years, with an option for interest-only periods of a maximum of 10 years for private residential properties. Mortgage banks may not grant loans exceeding these limits, even to borrowers who are extremely creditworthy. However, refinancing is relatively unconstrained even for loans exceeding the LTV limit, as we discuss in the paper.

Appendix B:

Table B1: Determinants of Mortgage Termination

This table shows results from simple probit specifications which seek to uncover the determinants of mortgage termination caused by moving, or other circumstances which result in full prepayment of the mortgage. The dependent variable takes the value of 1 if a household terminates its mortgage in a given month, and 0 otherwise. Model 1 estimates a probit, with no non-linear transformations of the independent variables. Models 2 and 3 include non-linear transformations, f(x), of several of the rank control variables in addition to their levels x. In Model 2, f(x) = |x|; and in Model 3, f(x) = $\sqrt{2x^2}$. As before, we estimate these specifications using all households in Denmark with an unchanging number of members, with a fixed rate mortgage in 2010 and 2011. The independent variables are indicated in the rows. The first set of variables is a set of dummy variables indicating the demographic status indicated in the row headers. The next set constitutes rank variables, which are normalized to take values between 0 and 1, and range between -0.5 and 0.5 once demeaned. All variables are described in greater detail in the header to Table 3. ***, **, and * indicate coefficients that are significant at the one, five, and ten percent level, respectively, using standard errors clustered at the level of households. We predict mortgage terminations using Model 3 in our estimation of refinancing choices in the paper.

	Model 1 - 2009	*Model 1 - 2010*	*Model 2 - 2009*	*Model 2 - 2010*	*Model 3 - 2009*	*Model 3 – 2010*
Single male household	0.121***	0.116***	0.179***	0.169***	0.183***	0.173***
Single female household	0.021***	0.015**	0.089***	0.079***	0.097***	0.085***
Married household	-0.231***	-0.245***	-0.214***	-0.226***	-0.202***	-0.214***
Children in family	-0.227***	-0.235***	-0.184***	-0.193***	-0.159***	-0.170***
Immigrant	0.139***	0.139***	0.150***	0.150***	0.153***	0.153***
Financially literate	-0.004	0.030***	-0.028***	0.004	-0.034***	-0.003
Family financially literate	0.021***	0.018***	0.000	-0.002	0.002	0.000
No education data	0.258***	0.239***	0.184***	0.178***	0.143***	0.141***
Getting married	0.109***	0.167***	0.080***	0.134***	0.078***	0.131***
Change to health	0.408***	0.457***	0.368***	0.409***	0.368***	0.411***
Having children	0.125***	0.161***	0.080***	0.115***	0.075***	0.109***
Region of Northern Jutland	-0.147***	-0.148***	-0.087***	-0.094***	-0.110***	-0.122***
Region of Middle Jutland	-0.112***	-0.133***	-0.067***	-0.090***	-0.072***	-0.097***
Region of Southern Denmark	-0.130***	-0.135***	-0.071***	-0.073***	-0.081***	-0.089***
Region of Zealand	-0.121***	-0.136***	-0.071***	-0.090***	-0.063***	-0.081***
Demeaned rank of:						
Age	-0.829***	-0.870***	-0.844***	-0.892***	-0.810***	-0.857***
Length of education	0.129***	0.164***	0.023***	0.053***	0.046***	0.078***
Income	-0.522***	-0.521***	-0.483***	-0.470***	-0.443***	-0.442***
Financial wealth	-0.070***	-0.116***	-0.008	-0.063***	0.026***	-0.035***
Housing wealth	-0.155***	-0.053***	-2.217***	-2.487***	-1.841***	-1.852***
Non-linear transformation f(x),where x is the demeaned rank of:						
Age			0.497***	0.512***	0.676***	0.693***
Length of education			0.089***	0.127***	0.064***	0.101***
Income			-0.088***	-0.114***	-0.062***	-0.075***
Financial wealth			0.905***	0.830***	0.852***	0.788***
Housing wealth			2.654***	2.998***	2.224***	2.276***
Constant	-0.980***	-0.513***	-1.575***	-1.096***	-1.299***	-0.784***
Issuing Quarter Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Current Quarter Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Mortgage Issuer Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.087	0.090	0.109	0.112	0.109	0.111
Log Likelihood	1,270,283	1,270,522	1,270,283	1,270,522	1,270,283	1,270,522
# of observations	-	-	-383,546.6	-	-	-

Table B2: Underlying Distribution of Ranked Variables

The percentiles of the distribution reported in the column headings are calculated across our sample of households in Denmark with a single fixed rate mortgage, pooling data over 2010 and 2011. The blocks of statistics are presented for income (total taxable income for each household in million DKK); financial wealth (the value of cash, bonds, stocks, and mutual funds less non-mortgage debt, in million DKK); Housing value (the value of properties, in million DKK); education (the number of years it takes to reach the highest level of education possessed by any individual in the household, where a rule of thumb is that 12 years is a high school diploma, 16 is a Bachelor's degree, 18 is a Master's degree, and 20 is a PhD); and age (measured in calendar years). Within each block of statistics, percentiles are calculated for all households, and separately for the sub-populations of refinancing and non-refinancing households. To preserve confidentiality, percentiles are calculated as the average of the five nearest observations to the percentile point.

	1%	5%	25%	Median	75%	95%	99%
				Income			
All	0.136	0.188	0.359	0.565	0.741	1.095	1.610
Refinancing	0.147	0.232	0.429	0.615	0.770	1.117	1.617
Non-refinancing	0.135	0.182	0.351	0.556	0.736	1.092	1.609
				Financial Wealth			
All	-1.305	-0.616	-0.179	0.031	0.225	0.879	2.068
Refinancing	-1.408	-0.728	-0.289	-0.051	0.124	0.655	1.658
Non-refinancing	-1.285	-0.595	-0.161	0.039	0.239	0.906	2.118
				Housing Wealth			
All	0.390	0.560	0.940	1.350	1.943	3.300	5.600
Refinancing	0.429	0.614	1.012	1.432	2.000	3.323	5.420
Non-refinancing	0.390	0.550	0.930	1.350	1.943	3.300	5.624
				Education			
All	7	7	12	12	16	18	20
Refinancing	7	9	12	12	16	18	20
Non-refinancing	7	7	12	12	16	18	20
				Age			
All	26	31	42	53	63	76	84
Refinancing	26	30	38	48	59	71	79
Non-refinancing	27	32	43	53	63	76	85

Discussion of Table B3: Logit Refinancing Models

We begin by estimating a model that omits any information on the magnitude of the refinancing incentive, and simply uses household economic and demographic information to predict refinancing. In effect we treat all households as woodheads, and allow demographic variables to influence the refinancing coefficient. We cluster standard errors at the household level and report coefficients along with indications of significance levels in the first column of Appendix Table B3.

The demographic effects reported in the first column of Appendix Table B3 are broadly consistent with the simple differences in means discussed earlier in Table 2. However, certain effects are altered by the inclusion of all demographic variables simultaneously in this regression. For example, the effect of children in the family is now estimated to be insignificantly negative, whereas it was significantly positive in Table 2. In addition, there are interesting nonlinear effects of ranked variables. Older heads of household are less likely to refinance but the negative effect of age is much stronger among younger-than-average people than among older-than-average people. Education and income have hump-shaped effects on refinancing probability. This probability increases strongly with education and income among below-median households, but decreases among above-median households. Finally, the refinancing probability appears to decline virtually linearly with financial wealth, but it increases, albeit at a declining rate above the median, with housing wealth.

The second column of Appendix Table B3 adds dummies for the quarter of mortgage issuance, the current quarter, and the identity of the mortgage bank. These dummies add considerable explanatory power to the regression, increasing the pseudo-R^2 from 2.4% in the first column to 10.2% in the second column.

The use of cross-product dummies that multiply issuing quarter by current quarter adds almost no explanatory power to the regression, so for parsimony we exclude these cross-terms. The mortgage bank dummies do contribute to the explanatory power of the regression, but owing to confidentiality restrictions and the small number of mortgage banks in the dataset, we do not report these coefficients.

The issuing quarter dummies proxy for the refinancing incentive in this simple regression, as illustrated in the top panel of Appendix Figure B2. This panel shows the estimated coefficients on the issuing quarter dummies, with younger mortgages at the left and older mortgages at the right. The figure also shows the level of interest rates that prevailed in each issuing quarter (scaled on the right vertical axis), and the comovement of the two series is evident. However, some of the oldest mortgages in the sample have relatively low issuing-quarter coefficients despite the high level of interest rates that prevailed when they were issued, consistent with the idea that refinancing is more sluggish among older mortgages (a phenomenon known as "burnout" in the US prepayment literature, see for example Kang and Zenios 1992, Stanton 1995, or Hall 2000).

The third column of Appendix Table B3 adds the level of the refinancing incentive to the logit regression, further increasing the pseudo-R^2 to 15.4%. This has a considerable effect on the coefficients estimated on the issuing quarter dummies, as shown in the bottom panel of Appendix Figure B2. The refinancing incentive soaks up the direct effect of the level of interest rates, and the pattern of issuing-quarter coefficients is now increasing among mortgages three years old or less, and then gradually declining. This nonlinear age effect is similar to that assumed in standard US prepayment models. In particular, the increase in the dummies during the first three years of mortgage life is consistent with the PSA model established by the Public Securities Association, which has prepayments increasing linearly during the first 31 months of mortgage life and flat thereafter (Veronesi 2010, p. 296 and Figure 8.5). Note however that PSA and other US prepayment models apply to all prepayments, not just the refinancings we study in this paper.

The figure also shows the fraction of each mortgage cohort's life that has had positive refinancing incentives (scaled on the right vertical axis). Mortgages that were issued in 2002 or earlier experienced a significant fraction of positive incentives earlier in their history, and the decline in the issuing-quarter dummies appears to accelerate among these extremely old mortgages. This is consistent with the idea that the most attentive households refinanced out of the 2002 mortgage cohort before the beginning of our sample period. In the paper we use our mixture models to explore this possibility.

Table B3: Logit Refinancing Models

This table shows results from simple logit specifications which seek to uncover the determinants of refinancing. The dependent variable takes the value of 1 if a household refinances in a given month and 0 otherwise. The models include non-linear transformations, f(x), of several of the ranked control variables, in addition to their levels x, defined by f(x) = $\sqrt{2}x^2$. We estimate these specifications using all households in Denmark with an unchanging number of members, with a fixed rate mortgage in 2010 and 2011. The independent variables are indicated in the rows. The first set of variables is a set of dummy variables indicating the demographic status indicated in the row headers. The next set constitutes rank variables, which are normalized to take values between 0 and 1, and range between -0.5 and 0.5 once demeaned. All variables are described in greater detail in the header to Table 3. Model 1 is our baseline refinancing logit model with controls for demographics. Model 2 includes fixed effect controls for issuing quarter, current quarter, and mortgage issuer. Model 3 includes refinancing incentives as an additional regressor. Pseudo R^2 is calculated using the formula $R^2 = 1- L_1/L_0$, where L_1 is the log likelihood from the given model and L_0 is the log likelihood from a model including only a constant. ***, **, and * indicate coefficients that are significant at the one, five, and ten percent level, respectively, using standard errors clustered at the level of households.

	Model 1	Model 2	Model 3
Single male household	-0.097***	-0.015	0.116***
Single female household	0.065***	0.083***	0.140***
Married household	0.036***	0.070***	0.020*
Children in family	-0.015	0.003	-0.069***
Immigrant	-0.083***	-0.119***	-0.120***
Financially literate	0.048***	0.072***	0.086***
Family financially literate	0.018	0.044***	0.046***
No education information	-0.200***	-0.242***	-0.223***
Getting married	0.267***	0.175***	0.159***
Change to health	-0.003	-0.015	-0.012
Having children	0.210***	0.118***	0.125***
Region of Northern Jutland	0.125***	0.102***	0.185***
Region of Middle Jutland	0.145***	0.140***	0.222***
Region of Southern Denmark	0.099***	0.098***	0.180***
Region of Zealand	-0.016	-0.042***	-0.004
Demeaned rank of:			
Age	-0.670***	-0.358***	-0.300***
Length of education	0.062***	0.070***	0.038**
Income	0.218***	0.223***	-0.015
Financial wealth	-0.957***	-0.754***	-0.611***
Housing wealth	0.617***	0.671***	0.162***
Non-linear transformation f(x),where x is the demeaned rank of:			
Age	0.531***	0.362***	0.721***
Length of education	-0.288***	-0.330***	-0.407***
Income	-0.386***	-0.296***	-0.208***
Financial wealth	-0.090***	0.011	0.221***
Housing wealth	-0.331***	-0.273***	0.223***
Incentives			1.144***
Constant	-3.280***	-2.916***	-3.234***
Issuing Quarter Dummies	No	Yes	Yes
Current Quarter Dummies	No	Yes	Yes
Mortgage Issuer Dummies	No	Yes	Yes
Pseudo R2	0.024	0.102	0.154
Log Likelihood	-347,546.6	-319,618.6	-301,211.4
# of observations	2,146,395	2,146,395	2,146,395

Figure B1: Refinancing Activity by New Mortgage Coupon Rates

This figure illustrates the history of refinancing activity in our sample of Danish fixed-rate mortgages. In each plot, the bars (left vertical axis) represent the number of refinancing households, while the solid line (right vertical axis) shows the history of the mortgage interest rate. The figure shades each of the bars according to the coupon rate on the new fixed rate mortgage into which households refinance.

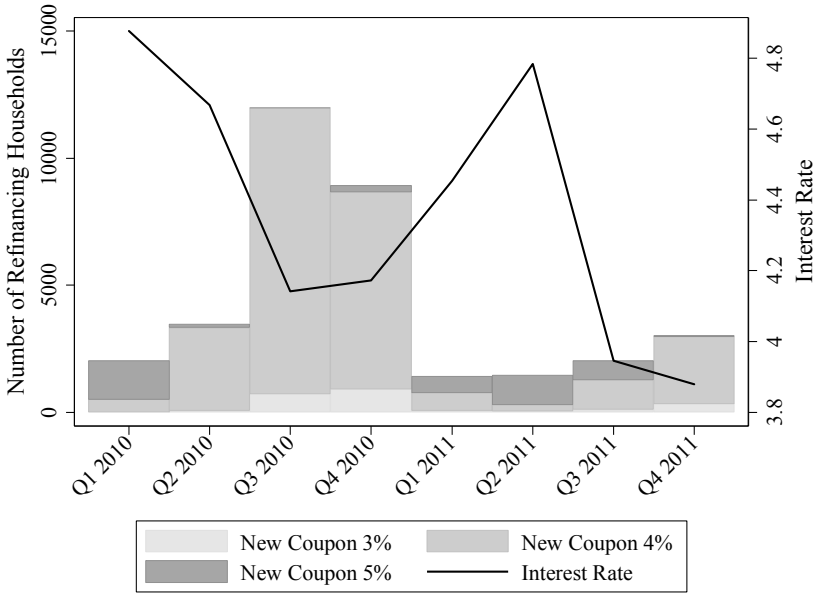
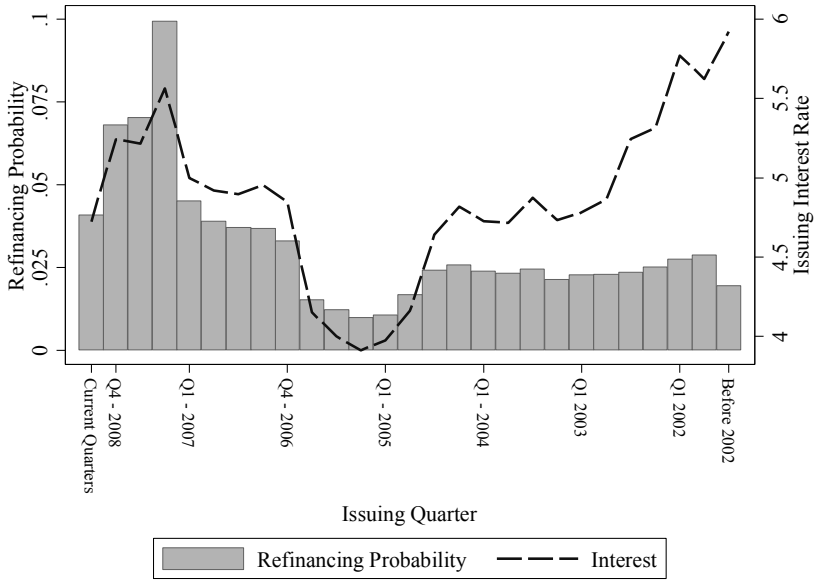


Figure B2: Estimated Issuing Quarter Effects in Logit Refinancing Models

This figure plots the predicted refinancing probability (left vertical axis) by issuing quarter (horizontal axis) using the estimated logit model 2 in Table B3, predicted at the mean for all other variables than the relevant issuing quarter. The first issuing quarter includes all issuing quarters within our refinancing period 2009-2011. The average coupon rate of issued bonds in each issuing quarter is plotted as a dashed line, scaled to the right vertical axis.



This figure plots the predicted refinancing probability (left vertical axis) by issuing quarter (horizontal axis) using model 3 in Table B3, predicted at the mean for all other variables than the relevant issuing quarter. Model 3 includes the refinancing incentive from the Agarwal et al. function. The first issuing quarter includes all issuing quarters within our refinancing period 2009-2011. The fraction of periods with positive incentives experienced by each issuing quarter is plotted as the dashed line, scaled to the right vertical axis.

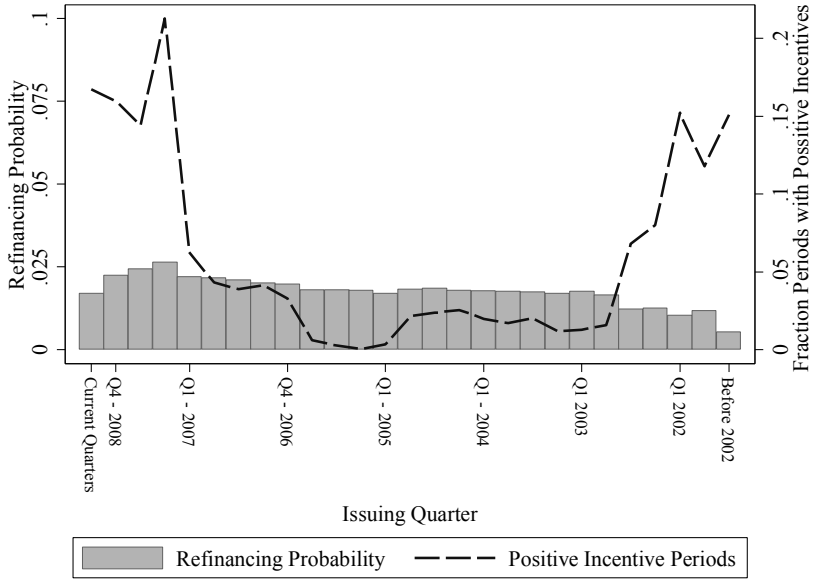


Figure B3: Effects of Ranked Variables on Total Levelhead Probability

This figure shows an estimate of the total probability of being a levelhead from the complete mixture model with levelheads and woodheads estimated in Table 7 in the paper, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

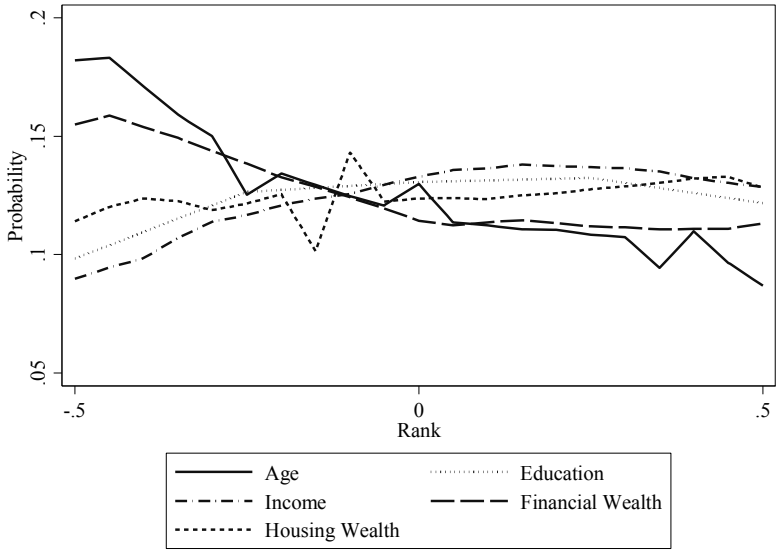


Figure B4: Effects of Ranked Variables on Total Woodhead Refinancing Probability

This figure shows an estimate of the total probability of woodhead refinancing from the complete mixture model with levelheads and woodheads estimated in Table 7 in the paper, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

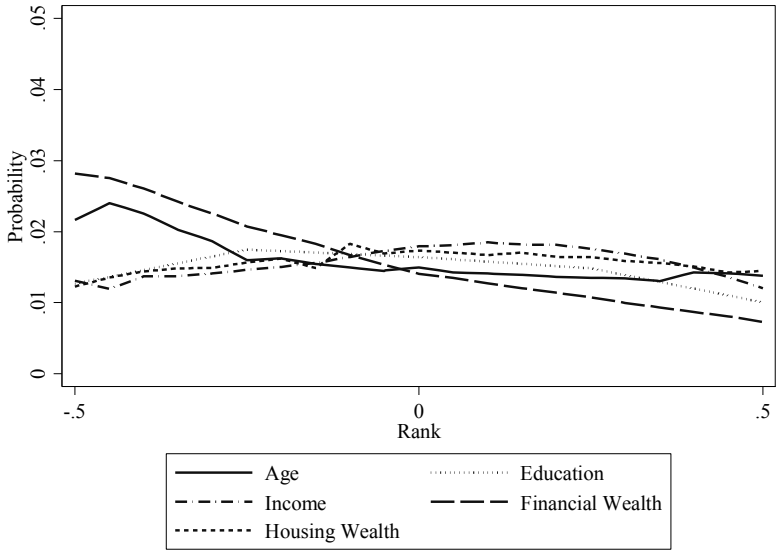
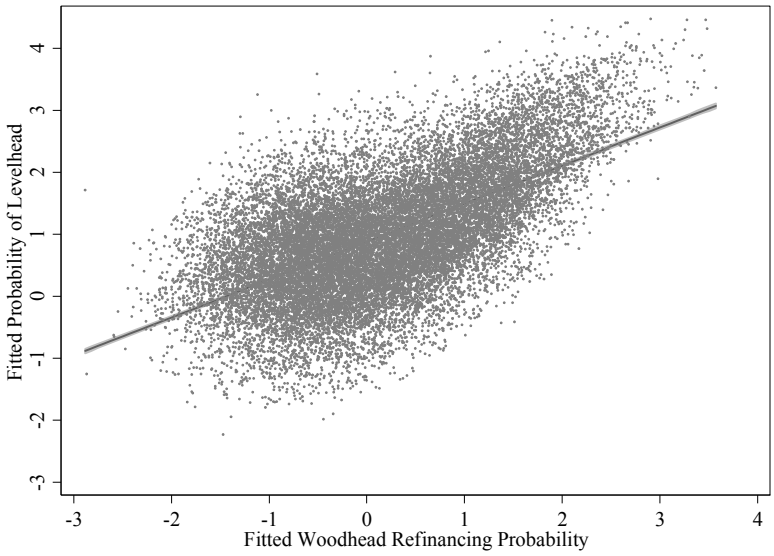


Figure B5: Proportionality of Mixing Proportions and Inertia

This figure plots the standardized fitted household demographic input into the probability of being a levelhead ($\xi = \chi' h$) on the Y-axis against the standardized fitted household demographic input into the woodhead refinancing probability (ν) on the X-axis from the complete mixture model with levelheads and woodheads estimated in Table 8. The plot is constructed using 1% of the sample. The solid line shows the fit of a univariate regression (with associated standard errors) to this cloud of points.



Appendix C:

Table C1: Mixture Models – Fixed Mortgage Termination Probability

In these specifications, the dependent variable continues to take the value of 1 for a refinancing in a given quarter, and 0 otherwise, using the same sample as in Table 7 in the paper. To calculate the Agarwal et al. (2013) threshold we use a fixed mortgage termination probability of 10% as proposed in Agarwal et al. (2013). In column 1 we estimate a simple baseline model with no demographics, in which we measure attention as the reaction to incentives computed as the interest rate spread between old and new mortgages less the Agarwal et al. (2013) function which quantifies the option value of waiting. Columns 2 and 3 estimate two separate specifications in which successively the woodhead refinancing probability and the probability of being a levelhead are allowed to depend on demographics as well as the dummies capturing issuing and current quarters, and mortgage issuers. Columns 4 and 5 present estimates from a mixture model in which both the woodhead refinancing probability and the probability of being a levelhead are allowed to depend on demographics and the above dummies. As before these models include non-linear transformations, f(x), of several of the rank control variables in addition to their levels, where f(x) = $\sqrt{2}x^2$. Pseudo R^2 is calculated using the formula $R^2 = 1 - L_1/L_0$, where L_1 is the log likelihood from the given model and L_0 is the log likelihood from a model including only woodheads with a constant refinancing probability. ***, **, and * indicate coefficients that are significant at the one, five, and ten percent level, respectively, using standard errors clustered at the level of households.

	Baseline Model	*Models with Demographics Affecting:*		*Mixture Model*	
		Woodhead Refinancing Probability	Probability of Levelhead	Woodhead Refinancing Probability	Probability of Levelhead
Single male household		-0.019	0.051**	-0.088**	0.075***
Single female household		0.136***	0.143***	0.105***	0.108***
Married household		0.130***	0.100***	0.130***	0.062***
Children in family		0.003	0.008	-0.039*	0.014
Immigrant		-0.258***	-0.190***	-0.233***	-0.131***
Financially literate		0.120***	0.115***	0.096**	0.110***
Family financially literate		0.065***	0.065***	0.052*	0.054***
No education information		-0.496***	-0.327***	-0.559***	-0.187**
Getting married		0.285***	0.184***	0.390***	0.089*
Change to health		-0.036	-0.037	-0.099**	-0.023
Having children		0.190***	0.116***	0.222***	0.059**
Region of Northern Jutland		0.263***	0.298***	0.118***	0.315***
Region of Middle Jutland		0.307***	0.317***	0.173***	0.311***
Region of Southern Denmark		0.278***	0.242***	0.248***	0.178***
Region of Zealand		0.002	0.006	-0.027	0.018
Demeaned rank of:					
Age		-0.230***	-0.041	-0.169***	-0.057*
Length of education		0.023	0.056**	-0.047	0.100***
Income		0.091**	0.223***	-0.104**	0.343***
Financial wealth		-1.284***	-0.662***	-1.407***	-0.215***
Housing wealth		0.695***	0.352***	0.560***	0.232***
Non-linear transformation f(x), x is the demeaned rank of:					
Age		0.801***	0.567***	0.863***	0.287***
Length of education		-0.670***	-0.503***	-0.671***	-0.305***
Income		-0.421***	-0.493***	-0.382***	-0.461***
Financial wealth		-0.033	0.048	-0.132**	0.104**
Housing wealth		-0.345***	-0.184***	-0.313***	-0.158***
Intercept: Woodhead Refinancing Probability	-4.636***	-4.646***	-4.872***	-6.335***	
Intercept: Response of Levelheads	0.951***	1.265***	0.823***	1.146***	
Intercept: Proportion of Levelheads	-1.719***	-2.111***	-2.296***	-2.211***	
Issuing Quarter Dummies	No	Yes	Yes	Yes	
Current Quarter Dummies	No	Yes	Yes	Yes	
Mortgage Issuer Dummies	No	Yes	Yes	Yes	
Pseudo R^2	0.098	0.127	0.151	0.160	
Log Likelihood	-318,859.5	-308,491	-300,045.2	-296,843.2	
Observations	2,146,395	2,146,395	2,146,395	2,146,395	

Figure C1: Refinancing probability by types, and the fraction of refinancing.

This figure plots refinancing probabilities from the complete mixture model with levelheads and woodheads estimated in Table C1, as a function of refinancing incentives constructed in various ways. The solid line in the top panel of the figure shows the observed (raw) refinancing probability, the dashed line with long dashes shows the model-predicted refinancing probability, and the dashed line with shorter dashes shows the fraction of households classified as levelheads in each period.

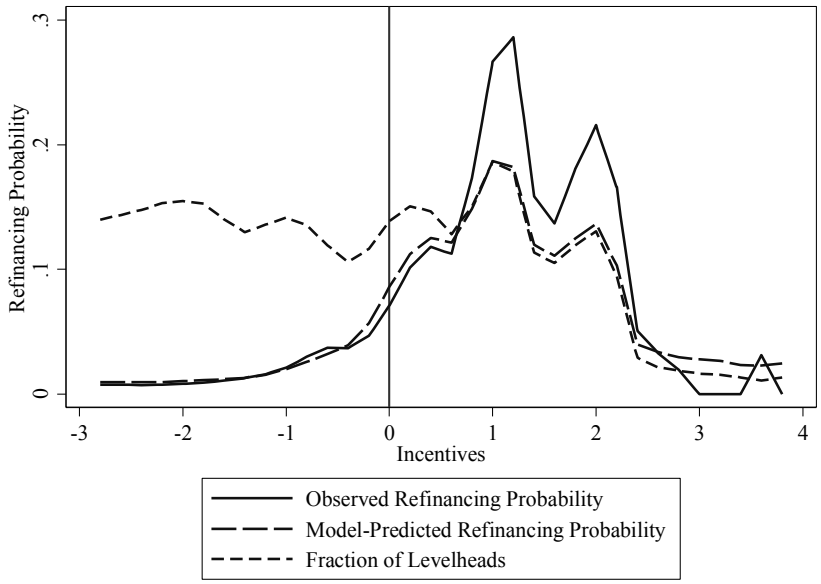


Figure C2: Fitted Refinancing Probability by Issuing Quarter

This figure plots the predicted refinancing probability of woodheads (Y-axis) by Issuing Quarter (X-axis) using the estimated mixture model in Table C1, predicted at the mean for all other variables than the relevant issuing quarter. The first Issuing quarter is issuing quarters within our refinancing period 2009-2011. The fraction of periods with positive incentives for each issuing quarter is plotted as the line and uses the scaled on the right axis.

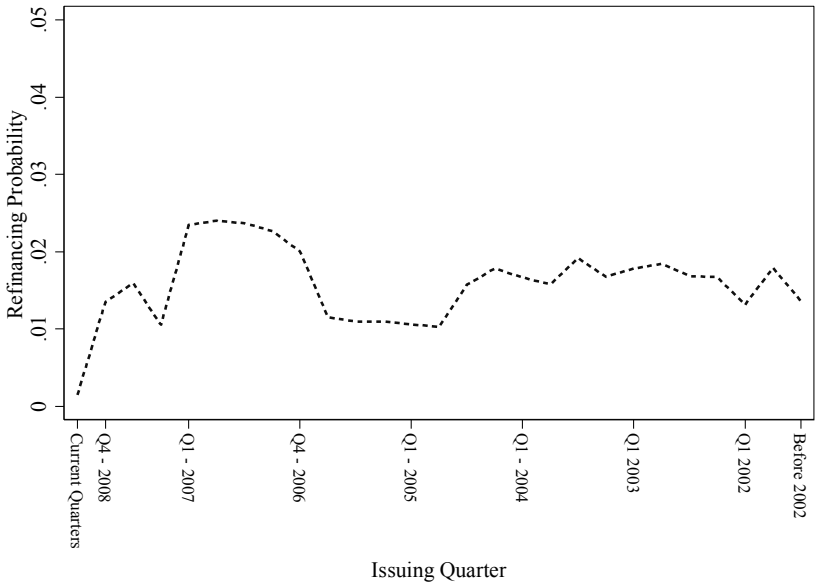


Figure C3: Fitted Refinancing probability by Issuing Quarter, Heterogeneous Types

This figure plots the Levelhead Probability (left Y-axis) by Issuing Quarter (X-axis) using the estimated mixture model in Table C7, predicted at the mean for all other variables than the relevant issuing quarter. The second line plots the fraction of periods with positive incentives using the Agarwal function for each issuing quarter and uses the scale on the right axis. The first Issuing quarter is issuing quarters within our refinancing period 2009-2011.

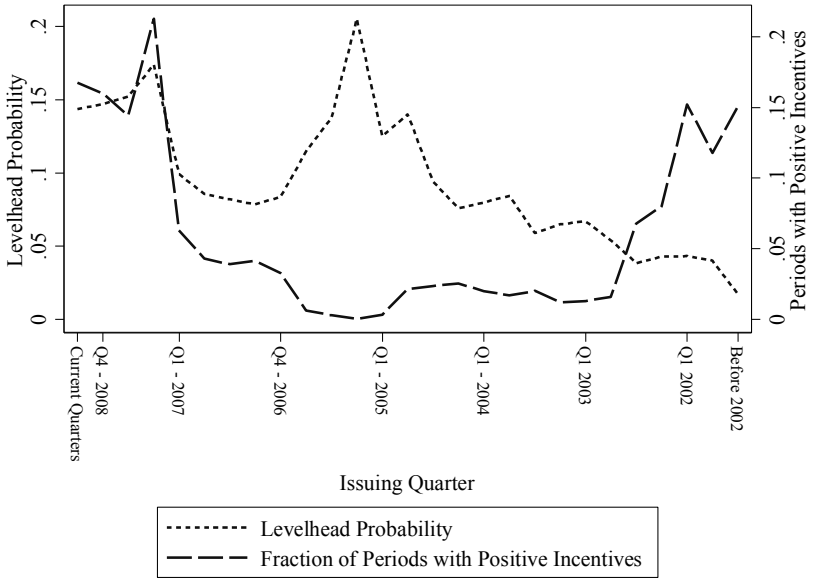


Figure C4: Marginal Effects of Ranked Variables on Woodhead Refinancing Probability

This figure shows the marginal change in the woodhead refinancing probability as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and woodheads estimated in Table C7.

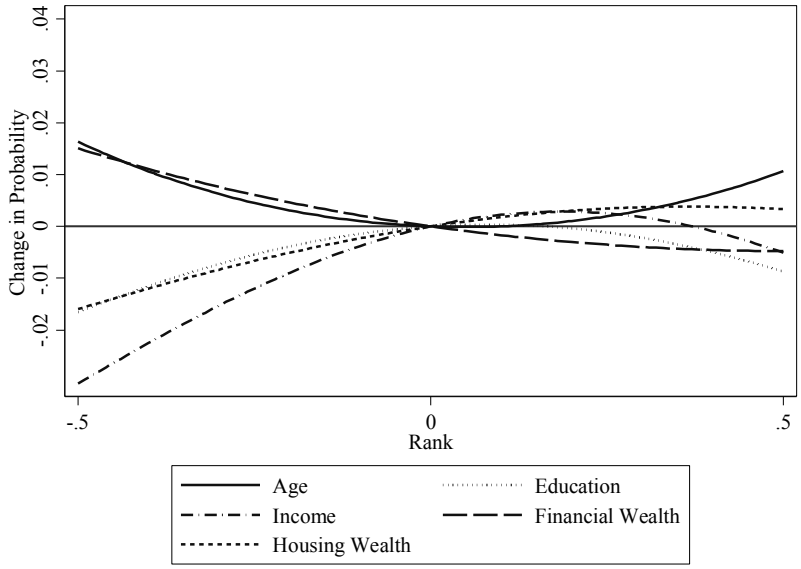


Figure C5: Marginal Effects of Ranked Variables on Levelhead Probability

This figure shows the marginal change in the probability of being a levelhead as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and woodheads estimated in Table C7.

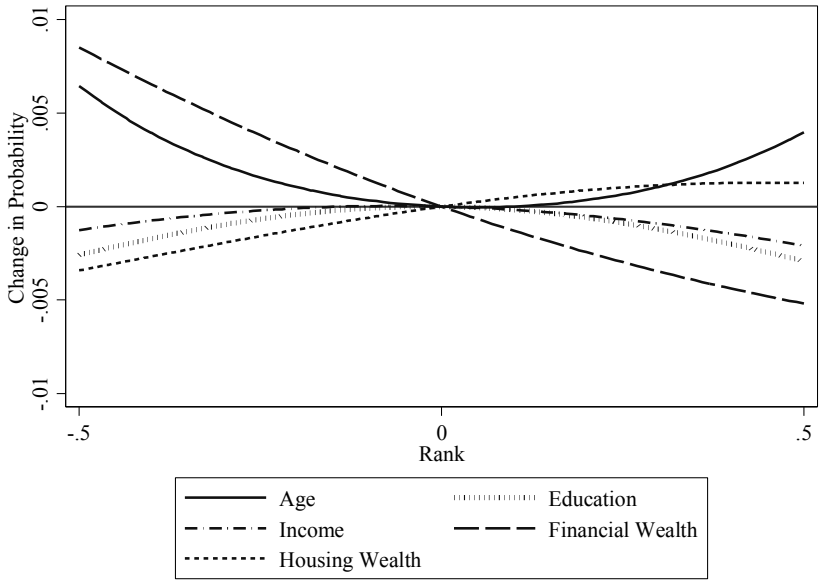


Figure C6: Effects of Ranked Variables on Total Levelhead Probability

This figure shows an estimate of the total probability of being a levelhead from the complete mixture model with levelheads and woodheads estimated in Table C1, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

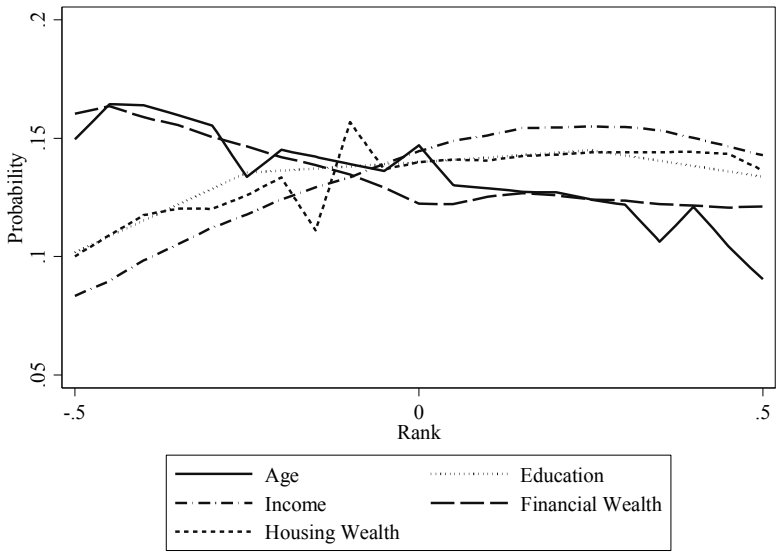


Figure C7: Effects of Ranked Variables on Total Woodhead Refinancing Probability

This figure shows an estimate of the total probability of woodhead refinancing from the complete mixture model with levelheads and woodheads estimated in Table C1, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

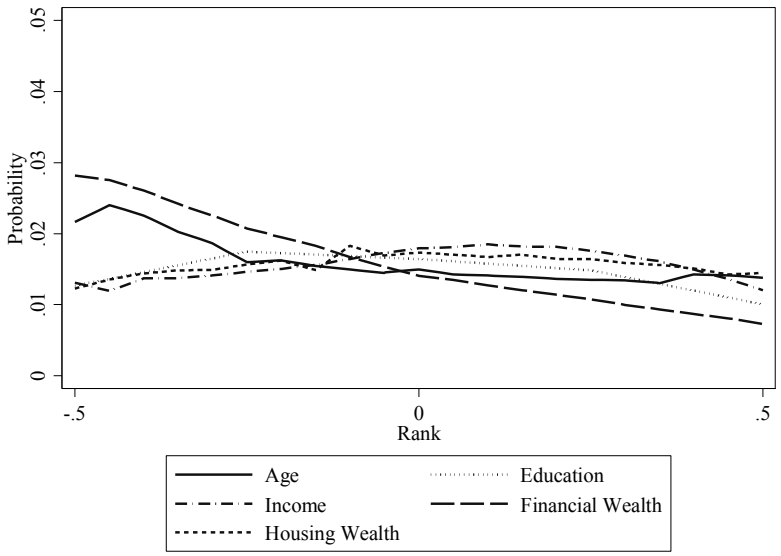
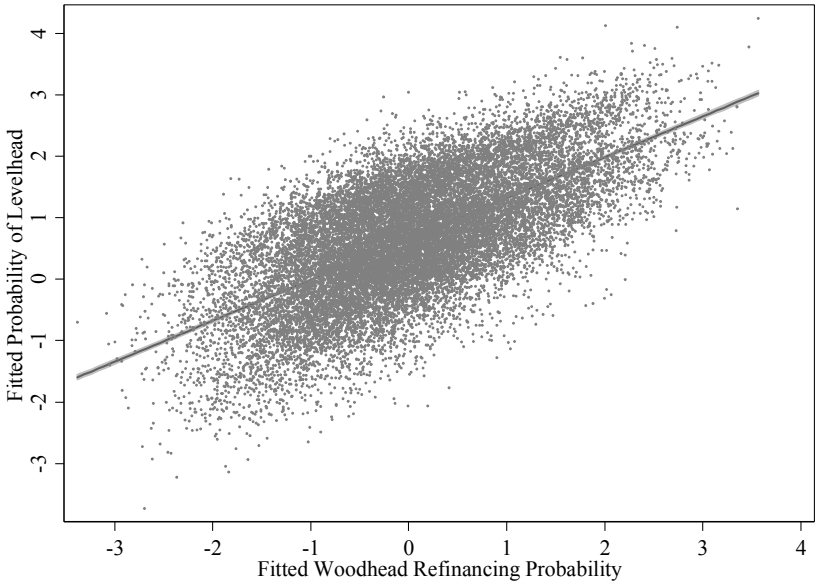


Figure C8: Proportionality of Mixing Proportions and Inertia

This figure plots the standardized fitted household demographic input into the probability of being a levelhead ($\xi = \chi' h$) on the Y-axis against the standardized fitted household demographic input into the woodhead refinancing probability (ν) on the X-axis from the complete mixture model with levelheads and woodheads estimated in Table C1. The plot is constructed using 1% of the sample. The solid line shows the fit of a univariate regression (with associated standard errors) to this cloud of points.



Appendix D:

Table D1: Mixture Models – Excluding Cash-out and Extension Refinancing

In these specifications, the dependent variable continues to take the value of 1 for a refinancing in a given quarter, and 0 otherwise. Using the same sample as in Table 7 in the paper, we now exclude all refinanced mortgages where either the principal changes by more than 10% (cash-outs or principal repayments) or if the maturity is either increased or lowered by more than 5 years. In column 1 we estimate a simple baseline model with no demographics, in which we measure attention as the reaction to incentives computed as the interest rate spread between old and new mortgages less the Agarwal et al. (2013) function which quantifies the option value of waiting. Columns 2 and 3 estimate two separate specifications in which successively the woodhead refinancing probability and the probability of being a levelhead are allowed to depend on demographics as well as the dummies capturing issuing and current quarters, and mortgage issuers. Columns 4 and 5 present estimates from a mixture model in which both the woodhead refinancing probability and the probability of being a levelhead are allowed to depend on demographics and the above dummies. As before these models include non-linear transformations, f(x), of several of the rank control variables in addition to their levels, where f(x) = $\sqrt{2}x^2$. Pseudo R^2 is calculated using the formula $R^2 = 1 - L_1/L_0$, where L_1 is the log likelihood from the given model and L_0 is the log likelihood from a model including only woodheads with a constant refinancing probability. ***, **, and * indicate coefficients that are significant at the one, five, and ten percent level, respectively, using standard errors clustered at the level of households.

	Baseline Model	*Models with Demographics Affecting:*		*Mixture Model*	
		Woodhead Refinancing Probability	Probability of Levelhead	Woodhead Refinancing Probability	Probability of Levelhead
Single male household		0.246***	0.277***	0.229***	0.225***
Single female household		0.265***	0.272***	0.312***	0.221***
Married household		0.057***	0.026*	0.083**	0.011
Children in family		-0.013	-0.100***	-0.114***	-0.088***
Immigrant		-0.214***	-0.138***	-0.230***	-0.109***
Financially literate		0.074*	0.084***	0.100	0.080**
Family financially literate		0.083***	0.070***	0.060	0.070***
No education information		-0.149	-0.175**	-0.253	-0.132
Getting married		0.150***	0.185***	0.193*	0.193***
Change to health		0.036	-0.020	0.008	-0.042
Having children		0.148***	0.146***	0.282***	0.101***
Region of Northern Jutland		0.072**	0.120***	-0.288***	0.221***
Region of Middle Jutland		0.204***	0.223***	-0.071*	0.282***
Region of Southern Denmark		0.036	0.086***	-0.024	0.107***
Region of Zealand		-0.018	0.017	-0.096**	0.043**
Demeaned rank of:					
Age		-0.713***	-0.291***	-0.534***	-0.184***
Length of education		0.074**	0.056**	-0.124**	0.108***
Income		0.399***	0.117***	-0.065	0.157***
Financial wealth		-0.941***	-0.526***	-1.133***	-0.314***
Housing wealth		0.926***	0.304***	0.909***	0.174***
Non-linear transformation f(x), x is the demeaned rank of:					
Age		0.508***	0.904***	1.041***	0.771***
Length of education		-0.627***	-0.500***	-0.918***	-0.318***
Income		-0.669***	-0.587***	-0.458***	-0.578***
Financial wealth		0.541***	0.644***	0.755***	0.507***
Housing wealth		-0.357***	0.130***	-0.192**	0.111**
Intercept: Woodhead Refinancing Probability	-6.070***	-4.212***	-6.296***	-5.923***	
Intercept: Response of Levelheads	0.989***	1.012***	0.873***	1.159***	
Intercept: Proportion of Levelheads	-2.002***	-2.702***	-2.364***	-2.428***	
Issuing Quarter Dummies	No	Yes	Yes	Yes	
Current Quarter Dummies	No	Yes	Yes	Yes	
Mortgage Issuer Dummies	No	Yes	Yes	Yes	
Pseudo R^2	0.127	0.176	0.215	0.221	
Log Likelihood	-214,721.7	-193,777.9	-193,132.0	-191,761.6	
Observations	2,042,735	2,042,735	2,042,735	2,042,735	

Figure D1: Refinancing probability by types, and the fraction of refinancing.

This figure plots refinancing probabilities from the complete mixture model with levelheads and woodheads estimated in Table D1, as a function of refinancing incentives constructed in various ways. The solid line in the top panel of the figure shows the observed (raw) refinancing probability, the dashed line with long dashes shows the model-predicted refinancing probability, and the dashed line with shorter dashes shows the fraction of households classified as levelheads in each period.

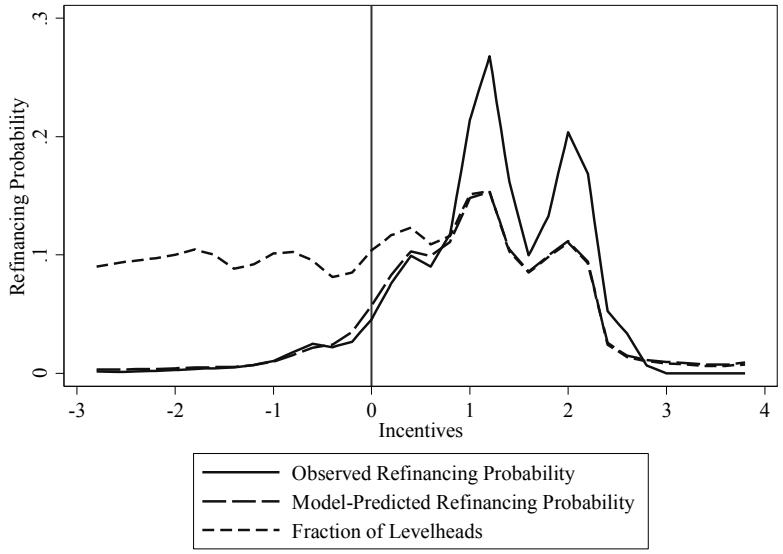


Figure D2: Fitted Refinancing Probability by Issuing Quarter

This figure plots the predicted refinancing probability of woodheads (Y-axis) by Issuing Quarter (X-axis) using the estimated mixture model in Table D1, predicted at the mean for all other variables than the relevant issuing quarter. The first Issuing quarter is issuing quarters within our refinancing period 2009-2011. The fraction of periods with positive incentives for each issuing quarter is plotted as the line and uses the scaled on the right axis.

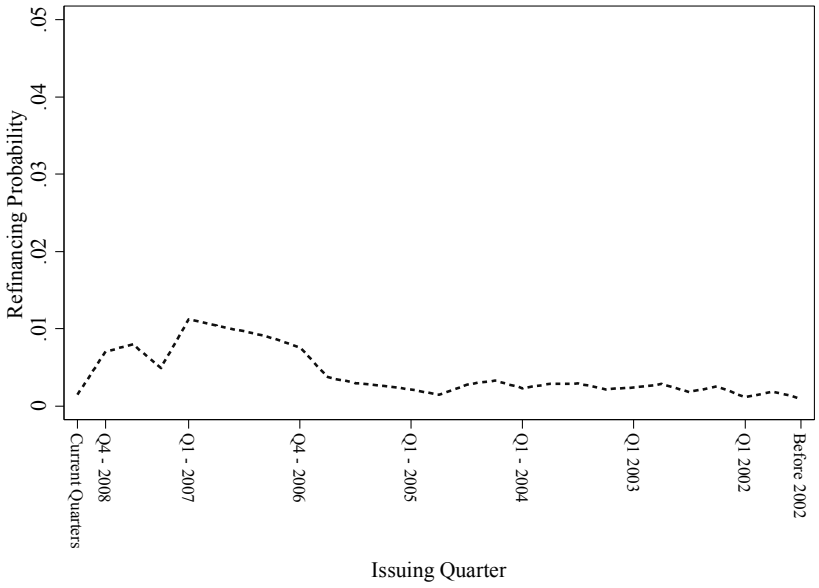


Figure D3: Fitted Refinancing probability by Issuing Quarter, Heterogeneous Types

This figure plots the Levelhead Probability (left Y-axis) by Issuing Quarter (X-axis) using the estimated mixture model in Table D1, predicted at the mean for all other variables than the relevant issuing quarter. The second line plots the fraction of periods with positive incentives using the Agarwal function for each issuing quarter and uses the scale on the right axis. The first Issuing quarter is issuing quarters within our refinancing period 2009-2011.

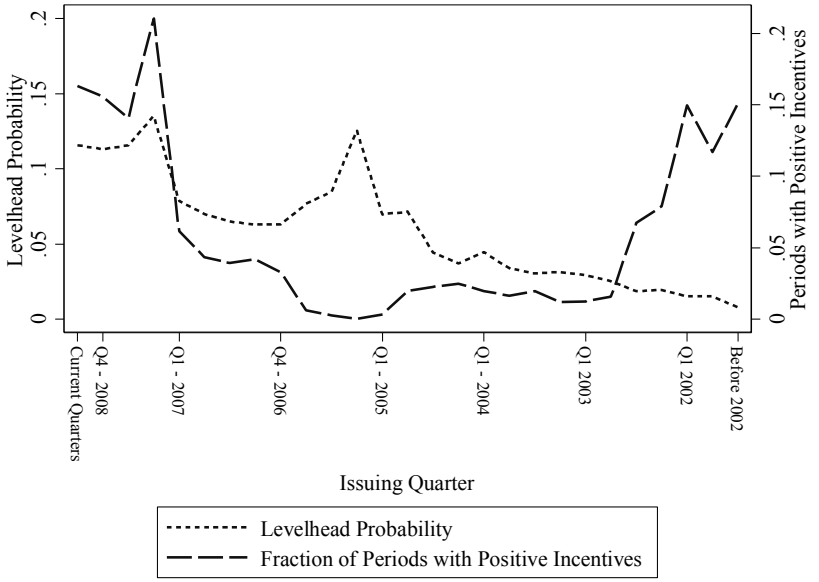


Figure D4: Marginal Effects of Ranked Variables on Woodhead Refinancing Probability

This figure shows the marginal change in the woodhead refinancing probability as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and woodheads estimated in Table D1.

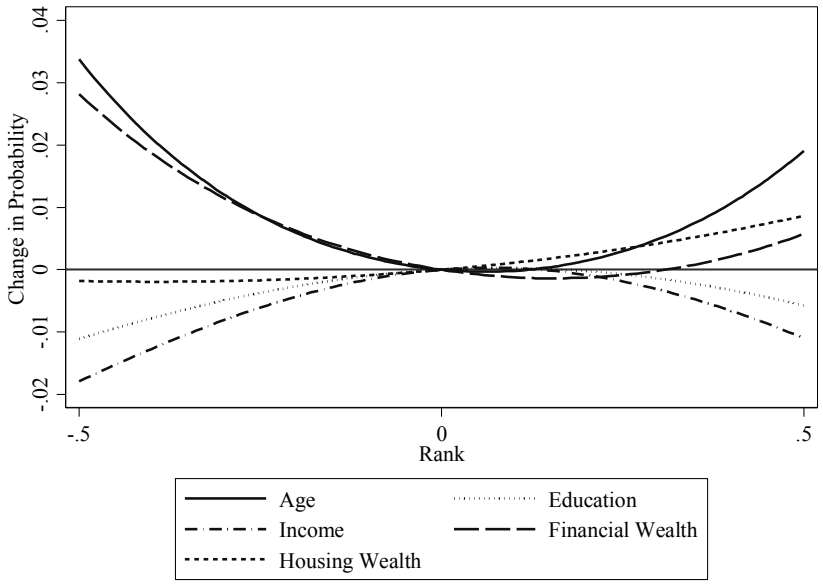


Figure D5: Marginal Effects of Ranked Variables on Levelhead Probability

This figure shows the marginal change in the probability of being a levelhead as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and woodheads estimated in Table D1.

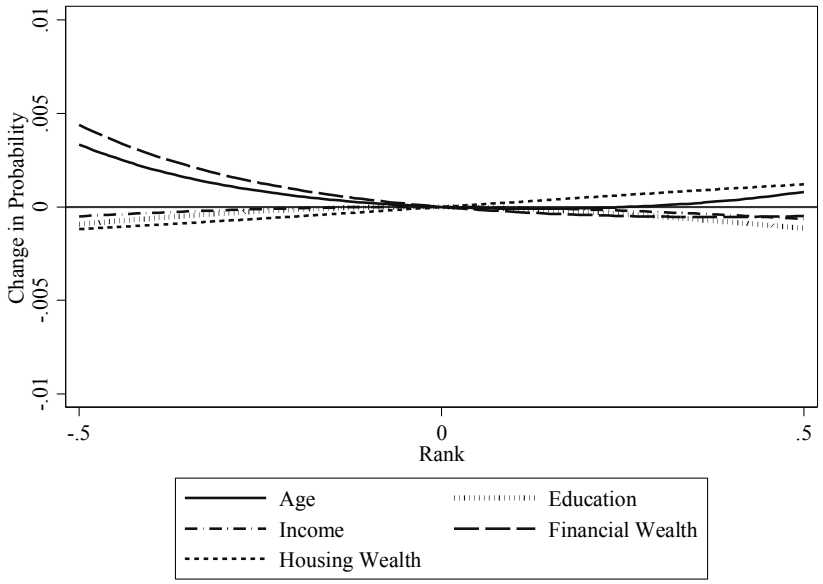


Figure D6: Effects of Ranked Variables on Total Levelhead Probability

This figure shows an estimate of the total probability of being a levelhead from the complete mixture model with levelheads and woodheads estimated in Table D1, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

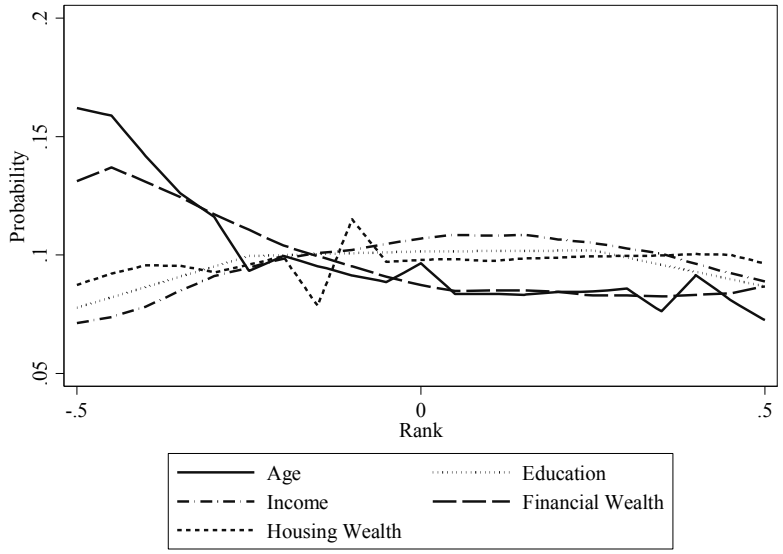


Figure D7: Effects of Ranked Variables on Total Woodhead Refinancing Probability

This figure shows an estimate of the total probability of woodhead refinancing from the complete mixture model with levelheads and woodheads estimated in Table D1, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

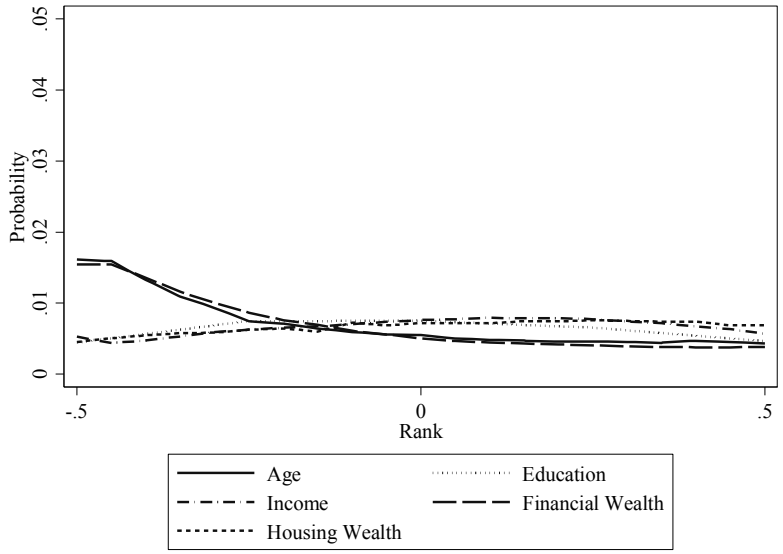
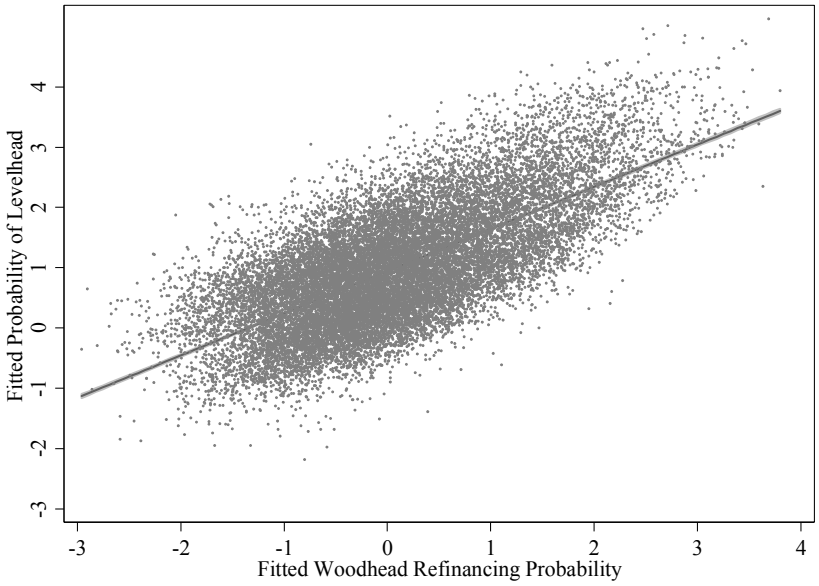


Figure D8: Proportionality of Mixing Proportions and Inertia

This figure plots the standardized fitted household demographic input into the probability of being a levelhead ($\xi = \chi' h$) on the Y-axis against the standardized fitted household demographic input into the woodhead refinancing probability (ν) on the X-axis from the complete mixture model with levelheads and woodheads estimated in Table D1. The plot is constructed using 1% of the sample. The solid line shows the fit of a univariate regression (with associated standard errors) to this cloud of points.



Appendix E:

Table E1: Mixture Models with Wake-up Controls

In these specifications, the dependent variable continues to take the value of 1 for a refinancing in a given quarter, and 0 otherwise. Using the same sample as in Table 7 we now add dummy variables if there are new mortgages in the market (i.e., those issued in the current quarter or the previous five quarters) with coupon differences of 200 or 300 basis points from the mortgage held by a household. We simply present estimates from a mixture model in which both the woodhead refinancing probability and the probability of being a levelhead are allowed to depend on demographics and the above dummies. As before these models include non-linear transformations, f(x), of several of the rank control variables in addition to their levels, where f(x) = $\sqrt{2}x^2$. Pseudo R^2 is calculated using the formula $R^2 = 1 - L_1/L_0$, where L_1 is the log likelihood from the given model and L_0 is the log likelihood from a model including only woodheads with a constant refinancing probability. ***, **, and * indicate coefficients that are significant at the one, five, and ten percent level, respectively, using standard errors clustered at the level of households.

	Mixture Model	
	Woodhead Refinancing Probability	Probability of Levelhead
Single male household	-0.05	0.190***
Single female household	0.112***	0.150***
Married household	0.084***	0.016
Children in family	-0.061***	-0.040***
Immigrant	-0.204***	-0.086***
Financially literate	0.066	0.123***
Family financially literate	0.036	0.064***
No education information	-0.504***	-0.109
Getting married	0.352***	0.082
Change to health	-0.038	-0.034
Having children	0.236***	0.054**
Region of Northern Jutland	0.109***	0.245***
Region of Middle Jutland	0.149***	0.277***
Region of Southern Denmark	0.245***	0.141***
Region of Zealand	0.000	-0.022***
Demeaned rank of:		
Age	-0.359***	-0.328***
Length of education	-0.046	0.118***
Income	-0.197***	0.313***
Financial wealth	-1.528***	-0.147***
Housing wealth	0.490***	0.294***
Non-linear transformation f(x), x is the demeaned rank of:		
Age	0.979***	0.461***
Length of education	-0.662***	-0.357***
Income	-0.408***	-0.310***
Financial wealth	-0.083	0.317***
Housing wealth	-0.270***	0.189***

Continues next page

Table E1 continued

New mortgages issued with coupon difference of 200 basis points	
Current quarter	-0.817***
Last quarter	-0.873***
Two quarters ago	-0.394***
Three quarters ago	0.017
Four quarters ago	0.319***
Five quarters ago	1.212***
New mortgages issued with coupon difference of 300 basis points	
Current quarter	0.089
Last quarter	0.096
Two quarters ago	0.319***
Three quarters ago	0.014
Four quarters ago	0.641***
Five quarters ago	0.865***
Intercept: Woodhead Refinancing Probability	-6.089***
Intercept: Response of Levelheads	1.001***
Intercept: Proportion of Levelheads	-2.275***
Issuing Quarter Dummies	Yes
Current Quarter Dummies	Yes
Mortgage Issuer Dummies	Yes
Pseudo R^2	0.166
Log Likelihood	-294,995.81
Observations	2,146,395

Figure E1: Refinancing Probability by Types.

This figure plots refinancing probabilities from the complete mixture model with levelheads and the woodheads estimated in Table 7 (baseline model), as well as those estimated from the "wake up" model estimated in table E1. The solid line in the top shows the observed (raw) refinancing probability, the dashed line with long dashes shows the model-predicted refinancing probability, and the dashed line with shorter dashes shows the model predicted refinancing probability under the wake up Model.

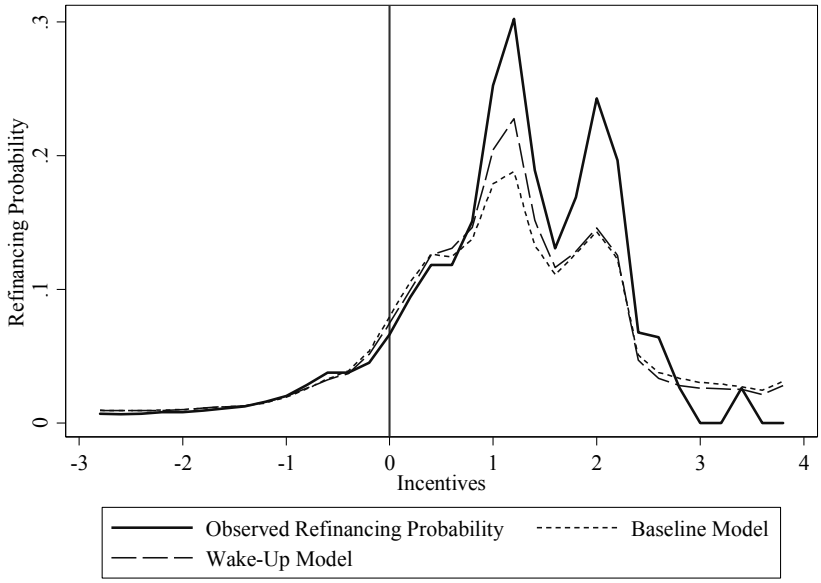


Figure E2: Marginal Effects of Ranked Variables on Woodhead Refinancing Probability

This figure shows the marginal change in the woodhead refinancing probability as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and wake ups estimated in Table E1.

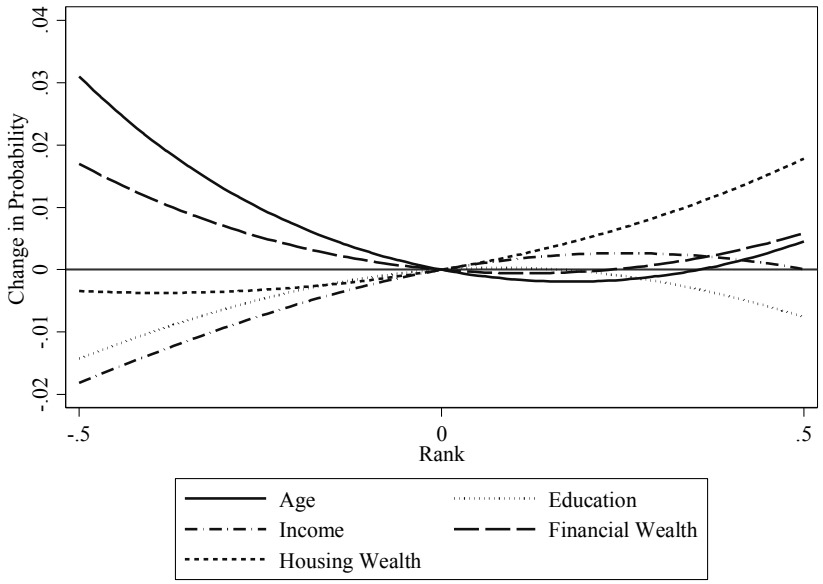


Figure E3: Marginal Effects of Ranked Variables on Levelhead Probability

This figure shows the marginal change in the probability of being a levelhead as a function of the ranked variables of age, education, income, financial wealth and housing wealth, fixing all other explanatory variables at their unconditional in-sample means, from the complete mixture model with levelheads and wake ups estimated in Table E1.

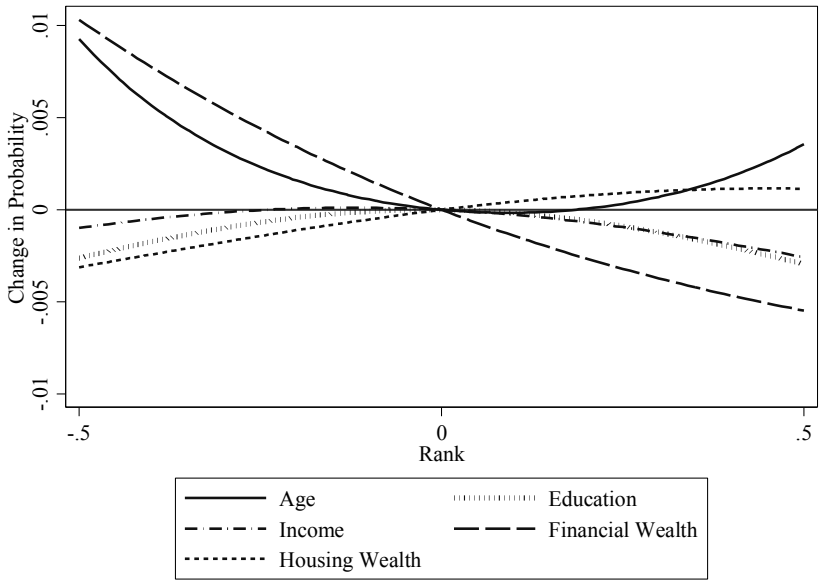


Figure E4: Effects of Ranked Variables on Total Levelhead Probability

This figure shows an estimate of the total probability of being a levelhead from the complete mixture model with levelheads, wake-ups and woodheads estimated in Table E1, as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.

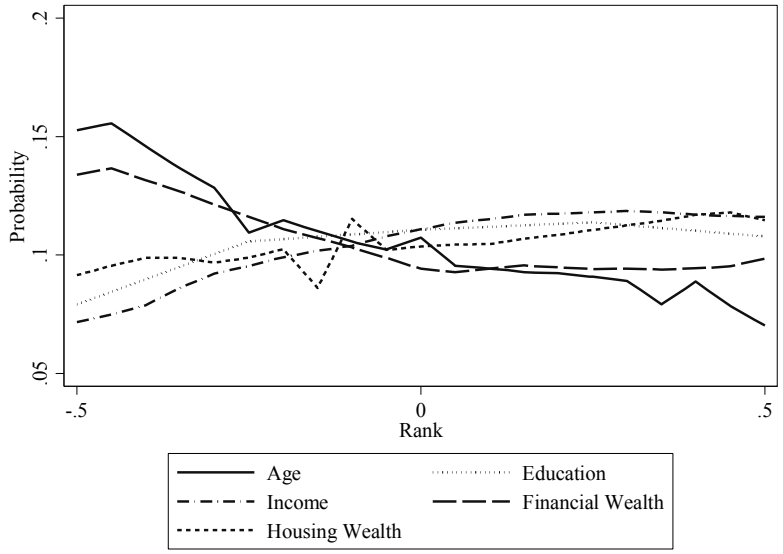
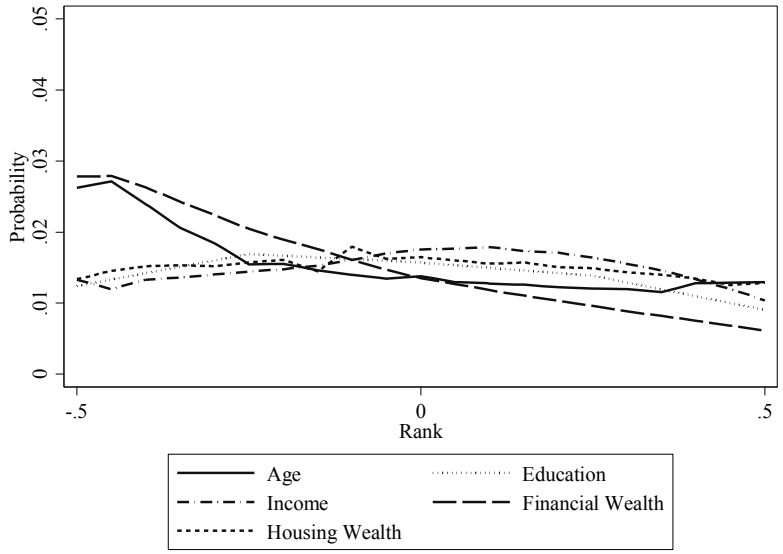


Figure E5: Effects of Ranked Variables on Total Woodhead Refinancing Probability

This figure shows an estimate of the total probability of woodhead refinancing from the complete mixture model with levelheads, wake-ups and woodheads estimated in Table E1, , as a function of the ranked variables of age, education, income, financial wealth and housing wealth of household as shown on the X-axis.



Appendix F:
Estimating the Persistence of Type Assignments using Equation (14) in the Paper.

Given a set of levelhead probabilities δ(t) and type-specific refinancing probabilities estimated from our model, we construct δ*(t) from equation (13) in the paper, and then estimate equation (14) by ordinary least squares regression. In each panel below, the final two columns either impose that $\bar{\delta}$ is the eight-quarter sample mean of δ(t) or estimate it from a free regression intercept. The three panels below correspond to three alternative sets of δ(t) and refinancing probabilities r_Lt, and r_Wt based on the simple model of the first column of Table 7 that includes no demographics (bottom panel, "unconditional estimation" below); the full model in the right two columns of Table 7, evaluated at the sample mean for all demographic variables (middle panel, "Estimated Probability of Average Household", below; and the full model where we take the cross-sectional mean of the levelhead probability and refinancing probabilities (top panel, "Average of Estimated Probabilities" below).

Average of Estimated Probabilities					Constraining $\bar{\delta}$	Estimating $\bar{\delta}$
Quarter	δ	r_Lt	r_Wt	δ*	γ	γ
2010Q1	0.224	0.131	0.029	0.206	0.663	0.649
2010Q2	0.163	0.166	0.019	0.142		
2010Q3	0.204	0.305	0.012	0.153	$\bar{\delta}$	$\bar{\delta}$
2010Q4	0.180	0.242	0.017	0.144	0.125	0.114
2011Q1	0.050	0.127	0.010	0.044		
2011Q2	0.057	0.063	0.009	0.054		
2011Q3	0.029	0.268	0.008	0.022		
2011Q4	0.094	0.307	0.018	0.068		

Estimated Probability of Average Household					Constraining $\bar{\delta}$	Estimating $\bar{\delta}$
Quarter	δ	r_Lt	r_Wt	δ*	γ	γ
2010Q1	0.208	0.131	0.019	0.189	0.696	0.682
2010Q2	0.150	0.166	0.013	0.129		
2010Q3	0.191	0.305	0.008	0.142	$\bar{\delta}$	$\bar{\delta}$
2010Q4	0.165	0.242	0.012	0.131	0.113	0.101
2011Q1	0.041	0.127	0.008	0.037		
2011Q2	0.047	0.063	0.007	0.044		
2011Q3	0.024	0.268	0.006	0.018		
2011Q4	0.078	0.307	0.015	0.056		

Unconditional Estimation					Constraining $\bar{\delta}$	Estimating $\bar{\delta}$
Quarter	δ	r_Lt	r_Wt	δ*	γ	γ
2010Q1	0.322	0.151	0.008	0.289	0.633	0.601
2010Q2	0.203	0.187	0.008	0.173		
2010Q3	0.213	0.320	0.008	0.157	$\bar{\delta}$	$\bar{\delta}$
2010Q4	0.193	0.261	0.008	0.151	0.147	0.115
2011Q1	0.058	0.150	0.008	0.050		
2011Q2	0.049	0.081	0.008	0.046		
2011Q3	0.028	0.285	0.008	0.021		
2011Q4	0.111	0.321	0.008	0.079		