Financial Fragility of Estonian Households: Evidence from Stress Tests on the HFCS Microdata

Jaanika Meriküll and Tairi Rõõm*

03.11.2017
Cluster 3 Workshop
Athens, Greece

Motivation

- Households' debt burden increased rapidly in the last decades

- … and became one of the triggers of the Great Recession (e.g. Mian and Sufi (2010))

- This has raised attention on distributional aspects of household debt

- By now, many central banks have their micro-level stress testing models for household sector, among others:

  - Europe: Johansson and Persson (2006) for SE, Herrala and Kauko (2007) for FI, Holló and Papp (2007) for HU, Albacete and Fessler (2010) for AT, Michelangeli and Pietrunti (2014) for IT, Banbula et al. (2015) for PL, Ampudia et al. (2016) for 10 euro area countries, Galuščák et al. (2016) for CZ

  - Other countries: Bilston et al. (2015) for Australia, Faruqui et al. (2012) for Canada, Martinez et al. (2013) for Chile

Aim and contribution

- The aim of this paper is to develop a micro-data based model for stress-testing Estonian households' financial fragility

- We employ Estonian Household Finance and Consumption Survey (HFCS) data from 2013

- Contributions of the paper:

  - Assessment of household financial distress on the basis of several alternative measures;

  - Comparison of financial fragility indicators that are based on survey and administrative data;

  - The case of a fast debt accumulation and its implications for loan quality

Fast household credit accumulation in Estonia

Eesti Pank
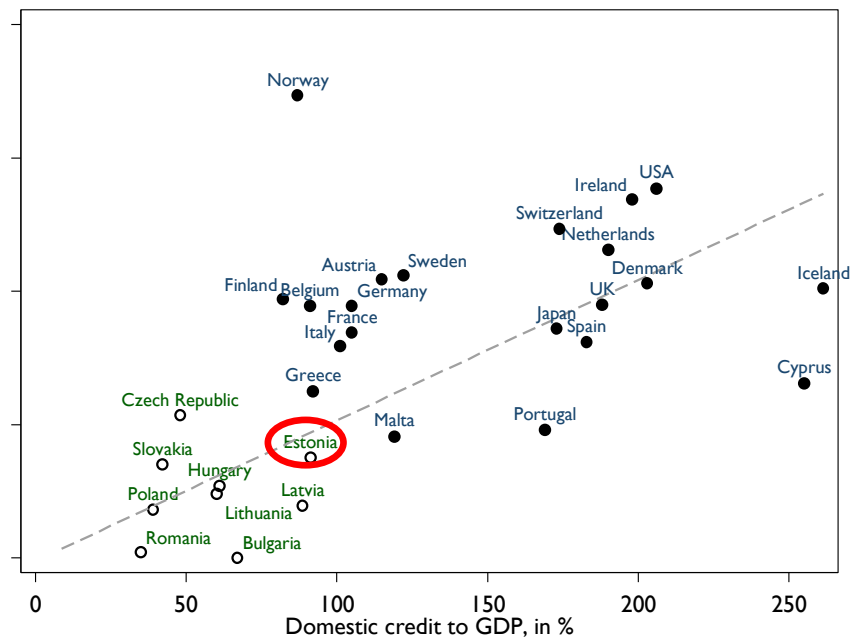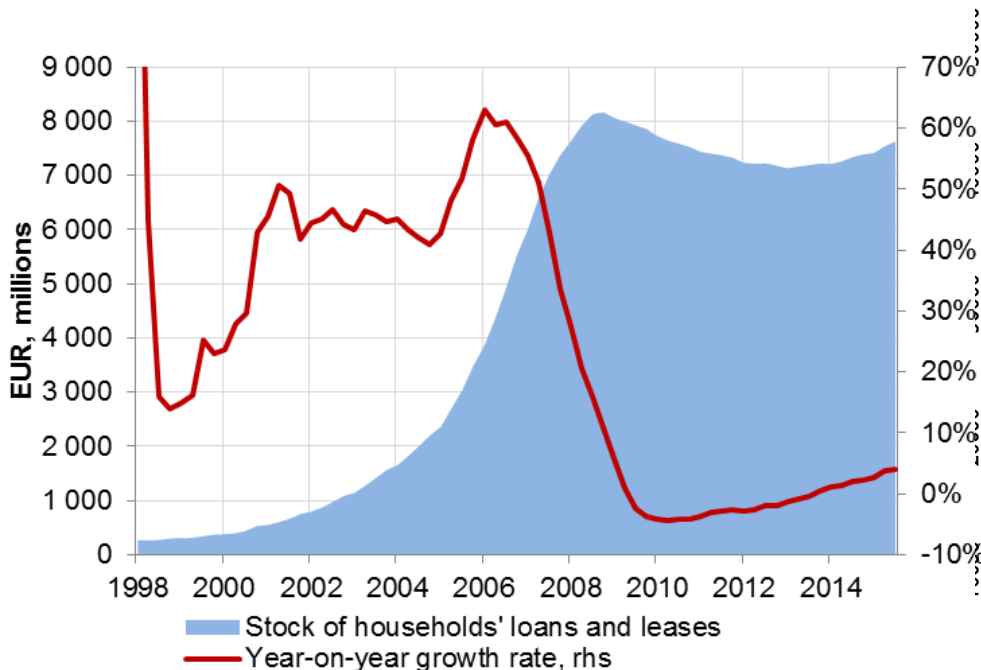
Sources: Bank of Estonia (left panel), The World Bank 2007 (right panel)

DEFINING THE FINANCIAL FRAGILITY INDICATORS IN THE MODEL

How to define household probability of default?

Eesti Pank

- The easiest way is to proceed from some threshold level of debt-service-to-income ratio, e.g. 30%, or some other debt burden ratio (Michelangeli and Pietrunti (2014), Faruqui et al. (2012), Martinez et al. (2013))
- A more sophisticated approach is to use financial margin and to assume that all households with negative financial margin will default (majority of studies)

   - Negative financial margin: Income is below basic consumption and debt servicing costs

- The above measures do not predict well household default rates (Ampudia et al. (2016))
- This paper uses a novel method by Ampudia et al. (2016) where the probability of default is assessed on the basis of financial margin and net liquid assets

Our baseline measure of probability of default

- Define financial margin: $FM_i = Y_i - DP_i - C_i$
- Where i denotes household
- FM_i is financial margin
- Y_i is disposable income <-> net labour income, capital income, pensions, and any other public or private transfers
- DP_i are total debt service costs <-> mortgages and non-collaterised loans
- C_i is essential consumption <-> Statistics Estonia official estimate of subsistence minimum, 128EUR + housing costs for single person households, higher for larger hhs
- Probability of default, pd_i, takes into account HH's net liquid assets, LIQ_i (Ampudia et al. 2016):

$$If\ FM_i \geq 0\ then\ pd_i = 0$$

$$If\ FM_i < 0\ \wedge\ LIQ_i \geq |FM_i| \times M\ then\ pd_i = 0$$
$$If\ FM_i < 0\ \wedge\ 0 < LIQ_i < |FM_i| \times M\ then\ pd_i = 1 - \frac{LIQ_i}{|FM_i|} \times \frac{1}{M}$$
$$If\ FM_i < 0\ \wedge\ LIQ_i = 0\ then\ pd_i = 1$$

- Calibrate M so that the estimated share of loans exposed to default matches the aggregate non-performing loan (NPL) rate

Probability of default: alternative measures

Eesti Pank

1) Essential consumption = actual HH expenditures on food and utilities

2) Essential consumption = actual HH expenditures on non-durables

3) Probability of default is assessed on the basis of households reporting problems with debt servicing within last 12 months

4) Households reporting that their expenses exceeded income in last 12 months are assigned negative financial margins

Measuring loan quality and bank losses

- Exposure at default (EAD) ratio:

$$EAD = \frac{\sum_{i=1}^{N} pd_i D_i}{\sum_{i=1}^{N} D_i}$$

- Where D_i is total debt of household i

- EAD (baseline definition) is calibrated to meet non-performing loan (NPL) ratio of loans for which the payments were past due for more than 30 days

- Loss given default (LGD) ratio:

$$LGD = \frac{\sum_{i=1}^{N} pd_i[(D_i^M - W_i^M)c_i^M + D_i^{NC}]}{\sum_{i=1}^{N} D_i}$$

- Superscript M denotes mortgage loans, superscript NC non- collateralised loans

- W_i denotes assets that bank can liquidate in case of default

- c_i is equal to 1 if a household is "under water" and 0 otherwise

- LGD is compared to aggregate loan loss provisions (LLP)

ESTIMATED FINANCIAL FRAGILITY INDICATORS

Eesti Pank

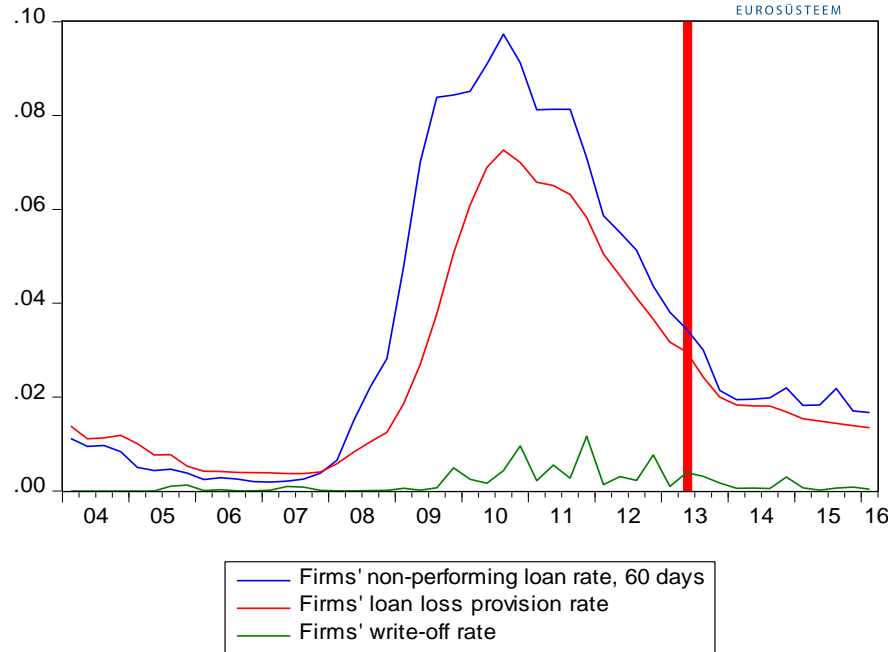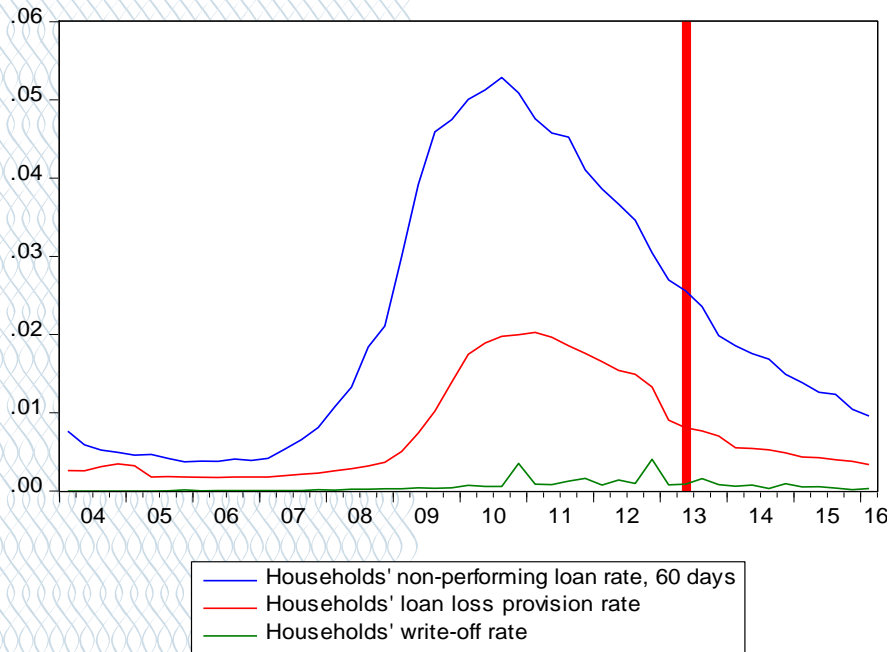# Households' financial fragility indicators, 2013q2

Eesti Pank

	Historical aggre-gates	Baseline: C = subsistence minimum	C = food and utilities	C = food, utilities and other non-durables	Debt repayment problems in last 12 months	Expenses exceeded income in last 12 months
Negative financial margin, %	.	13.0	24.8	37.4	.	16.0
Probability of default, %	.	5.2	10.8	15.8	17.2	7.8
Exposure at default, %	3.4	3.4	8.2	11.3	11.9	4.8
...mortgages, %	2.8	3.2	8.0	11.0	11.4	4.8
...non-collateralised loans, %	6.4	8.8	13.7	18.7	22.5	4.6
Loss given default, %	0.8	0.4	0.7	1.0	1.6	0.4
...mortgages, %	0.5	0.0	0.1	0.2	0.6	0.2
...non-collateralised loans, %	2.5	8.8	13.7	18.7	22.5	4.6
Loss given default, ml EUR	55.5	20.6	31.9	47.6	77.1	20.4
...mortgages, ml EUR	29.8	2.1	3.2	8.5	30.1	10.9
...non-collateralised loans, ml EUR	25.8	18.5	28.6	39.1	47.0	9.5
No of observations	.	769	769	769	769	760

Background: aggregate dynamics of NPL and LLP rates

Eesti Pank

Legend (left chart):
- Households' non-performing loan rate, 60 days
- Households' loan loss provision rate
- Households' write-off rate

Legend (right chart):
- Firms' non-performing loan rate, 60 days
- Firms' loan loss provision rate
- Firms' write-off rate

- Households' non-performing loan rate was relatively high, but provisions (and write-offs) were low
- The same tendency in microdata, many HHs with negative financial margin, but low % of loss given default

Sources: Bank of Estonia statistics table 3.3.11 for the non-performing loans; Bank of Estonia credit risk model for loan loss provisions and write-offs

# High share of HHs with negative FM but low loss given default: a puzzle?

How do households cope with negative financial margin when servicing their debts?

- Relatively high importance of social networks (self-reported assessments):

  - 45% got help from relatives or friends (euro area average 22%)

- Low reliance on short-term financing (self-reported assessments):

  - 10% financed expenses by credit-card loans in the case of difficulties (23% EA)

  - 5% got other loans (15% EA)

- Low level of liquid financial assets among indebted HHs

Liquid-assets-to-income ratio (%)
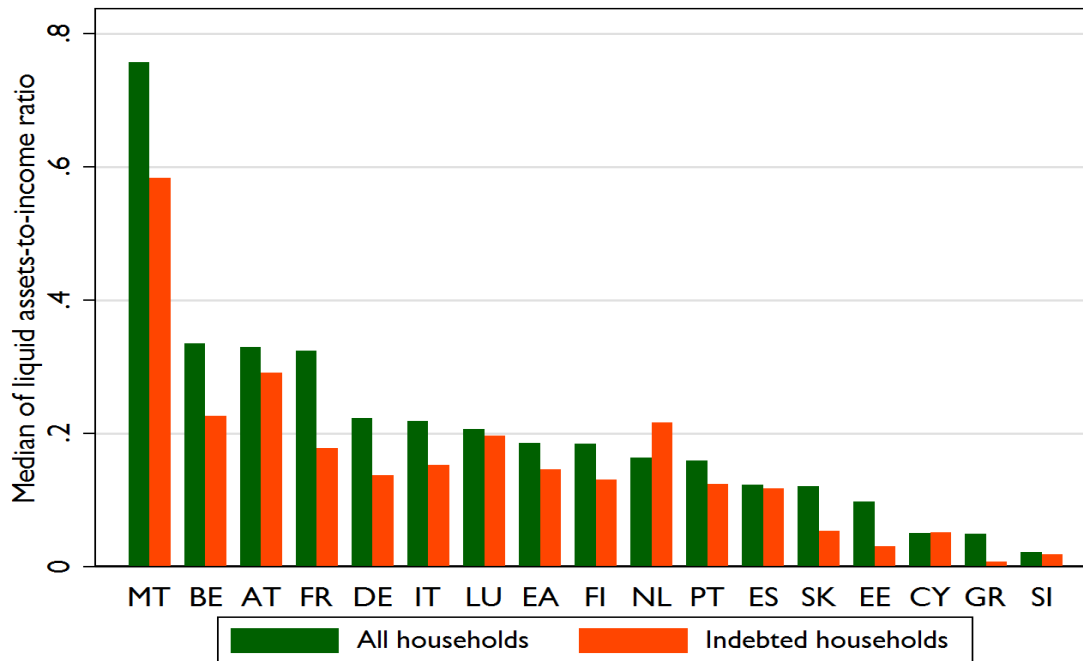
Financial fragility indicators: comparison of estimates based on survey and register data (2013q2)

Eesti Pank

	Historical aggre-gates	Baseline: Survey	Income from registers	Debt from registers	Assets from registers	All from registers
Negative financial margin, %	.	13.0	17.0	10.5	13.0	15.6
Probability of default, %	.	5.2	6.8	3.6	5.0	6.4
Exposure at default, %	3.4	3.4	3.8	3.8	3.4	5.8
...mortgages, %	2.8	3.2	3.5	4.0	3.1	5.9
...non-collateralised loans, %	6.4	8.8	12.0	1.5	9.2	5.0
Loss given default, %	0.8	0.4	0.8	0.5	1.5	1.1
...mortgages, %	0.5	0.0	0.3	0.4	1.1	0.7
...non-collateralised loans, %	2.5	8.8	12.0	1.5	9.2	5.0
Loss given default, ml EUR	55.5	20.6	39.5	28.5	71.4	61.5
...mortgages, ml EUR	29.8	2.1	14.4	20.6	52.2	35.9
...non-collateralised loans, ml EUR	25.8	18.5	25.1	7.8	19.3	25.6
No of observations	.	769	769	944	769	944

STRESS TESTS

- We apply standardized individual shocks to:

  - base interest rate

  - unemployment rate

  - real estate prices

- It is assumed that shocks occur instantaneously and that there is no feedback from the financial sector to the real economy

- We also consider the effects of simultaneous shocks mimicking the changes in these variables during the Great Recession in Estonia

  (2008q1 - 2010q2)

Interest rate shock: assumptions

- 6 months' Euribor is assumed to increase by 1, 2 or 3 standard deviations
- HHs' interest payments increase due to higher base rate
  - The share of adjustable interest rate mortgages is 82% of total mortgage stock in Estonia (HFCS)
  - 95% of all mortgage loans with adjustable interest rate are tied to 6m Euribor (HFCS)
    - Euribor shock has strong pass-through in Estonia
  - Non-collateralized loans are assumed to have fixed interest rates
- Household income from deposits increases
  - Has only minor effect on income

Interest rate shock: results

	Pre-stress, Euribor = 0.318%	1 sd shock, Euribor = 1.731%	2 sd shock, Euribor = 3.144%	3 sd shock, Euribor = 4.557%
Negative financial margin, %	13.0	13.8	14.6	15.3
Probability of default, %	5.2	5.9	6.1	6.4
Exposure at default, %	3.4	4.9	5.3	5.9
...mortgages, %	3.2	4.8	5.1	5.8
...non-collateralised loans, %	8.8	8.8	8.8	8.8
Loss given default, %	0.4	0.4	0.4	0.4
...mortgages, %	0.0	0.0	0.0	0.1
...non-collateralised loans, %	8.8	8.8	8.8	8.8
Loss given default, ml EUR	20.6	20.6	20.6	21.1
...mortgages, ml EUR	2.1	2.1	2.1	2.6
...non-collateralised loans, ml EUR	18.5	18.5	18.5	18.5
No of observations	769	769	769	769

☹ The share of loans exposed to default increases: 3.4% -> 5.9%

☺ Banks' losses are almost unaltered

Unemployment rate shock: assumptions

- Assumption: Increase in aggregate unemployment rate by 1, 2 or 3 sdev
- UE flow unaffected: persons who are unemployed stay in unemployment
- EU flow is affected: persons move from employment to unemployment so that the increase in unemployment rate meets the size of the shock
- Technicalities, shock given in three steps:
    1. The predicted probability of being unemployed is calculated for each individual using the logit model
    2. The constant term in unemployment equation is manipulated to meet the new aggregate post-shock value of unemployment
    3. A random probability is drawn for each individual and the model-based predicted unemployment probability is compared to the random probability for each employed individual. If the predicted probability is larger than the random value, person switches from employment to unemployment and income is dropped to match 15% replacement rate. Run 1000 Monte Carlo simulations and take average of FM.

Unemployment rate shock: results

	Pre-stress, unemployment rate = 10.9%	1 sd shock, unemployment rate =14.8%	2 sd shock, unemployment rate =18.8%	3 sd shock, unemployment rate = 22.8%
Negative financial margin, %	13.0	14.3	15.7	17.1
Probability of default, %	5.2	5.8	6.5	7.1
Exposure at default, %	3.4	3.8	4.3	4.8
...mortgages, %	3.2	3.6	4.1	4.5
...non-collateralised loans, %	8.8	9.4	9.9	10.5
Loss given default, %	0.4	0.5	0.5	0.6
...mortgages, %	0.0	0.1	0.1	0.1
...non-collateralised loans, %	8.8	9.4	9.9	10.5
Loss given default, ml EUR	20.6	22.7	25.1	27.2
...mortgages, ml EUR	2.1	3.1	4.3	5.4
...non-collateralised loans, ml EUR	18.5	19.6	20.8	21.9
No of obs	769	769	769	769

☺ Exposure at default is affected less than in response to interest rate shocks

☹ Losses for banks are larger

Real estate price shock: assumptions

- Assumption: decline in real estate prices by 1, 2 or 3 sdev

- Decline in real estate prices does not affect HHs' income and consumption, but only banks' losses as more loans are „under water"

- The size of the shock is large as the standard deviation of this variable has been historically very high

Real estate price shock: results

|	Pre-stress	1 sd shock, decrease = 24.4%	2 sd shock, decrease = 48.8%	3 sd shock, decrease = 73.2%
Negative financial margin, %	13.0	13.0	13.0	13.0
Probability of default, %	5.2	5.2	5.2	5.2
Exposure at default, %	3.4	3.4	3.4	3.4
...mortgages, %	3.2	3.2	3.2	3.2
...non-collateralised loans, %	8.8	8.8	8.8	8.8
Loss given default, %	0.4	0.6	1.1	1.9
...mortgages, %	0.0	0.3	0.8	1.6
...non-collateralised loans, %	8.8	8.8	8.8	8.8
Loss given default, ml EUR	20.6	31.0	55.3	91.6
...mortgages, ml EUR	2.1	12.6	36.8	73.1
...non-collateralised loans, ml EUR	18.5	18.5	18.5	18.5
No of obs	769	769	769	769

☺ The share of exposed HHs and EAD not affected

☹ Losses for banks are relatively large

     - However, banks' aggregate profits exceeded the simulated losses from the worst shock

     (profits in 2013q2 151ml EUR, average in 2011 - 2013 90ml EUR)

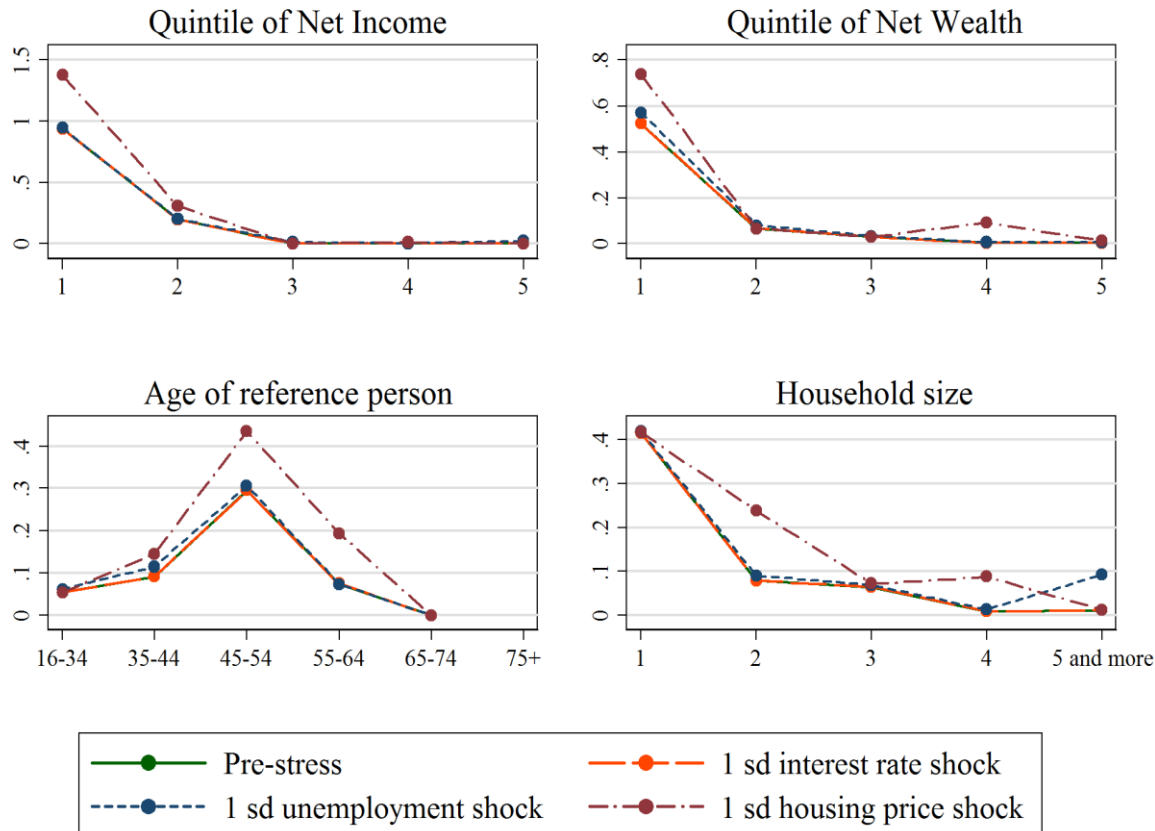# Probability of default over hhs characteristics: 1 sdev shock

Eesti Pank
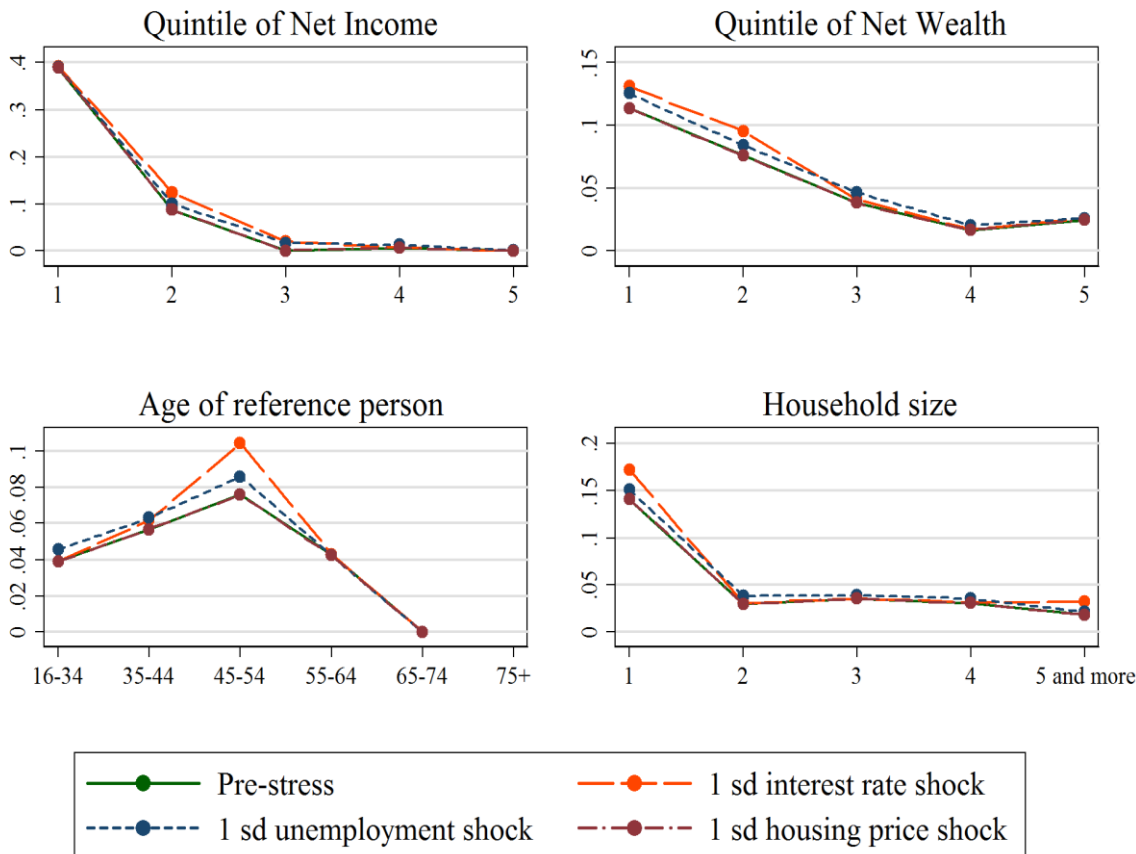
- Households that are the most affected by the shocks:
  - middle income
  - low wealth
  - middle aged
  - small size

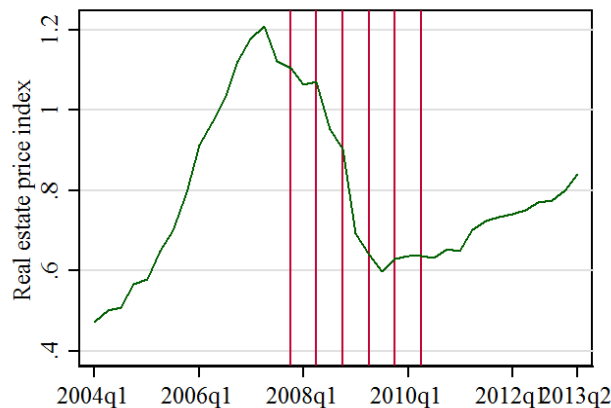# Losses for banks over hhs characteristics: 1 sdev shock
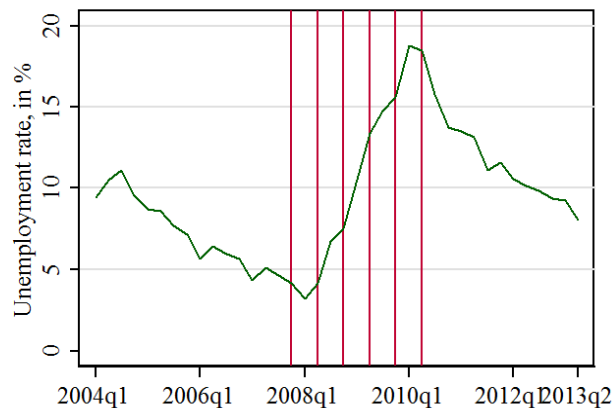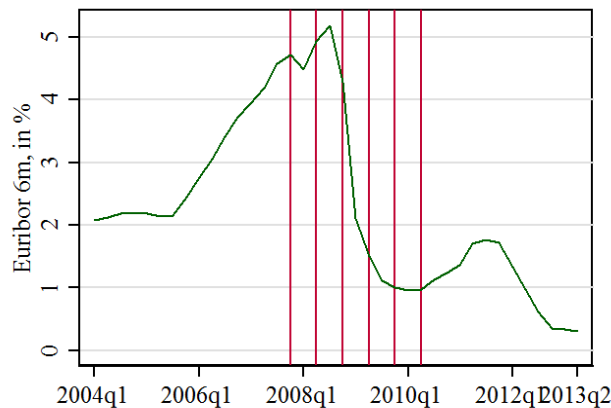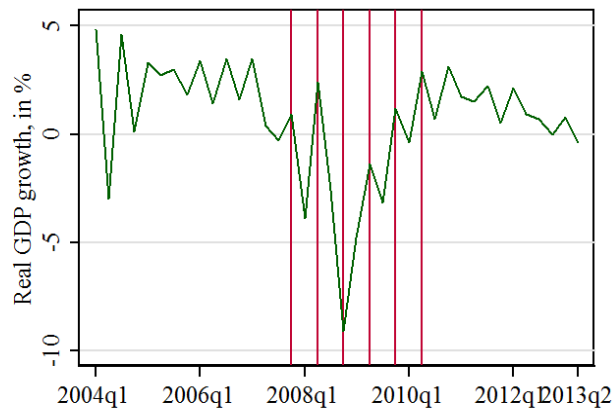
- Greatest losses for banks come from real estate price shock

- Greatest losses come from:
  - Low-income hhs
  - Low-wealth hhs
  - Middle-aged hhs
  - Small hhs

Simultaneous shock assumptions: mimic the dynamics in red grid

Eesti Pank

Simultaneous shock results: simulation vs historical data

Eesti Pank

Non-performing loan rate, in %

— Simulated EAD using 2013q2 data   — NPL rate during the Great Recession

Loss given default rate, in %

— Simulated LGD using 2013q2 data   — LLP rate during the Great Recession
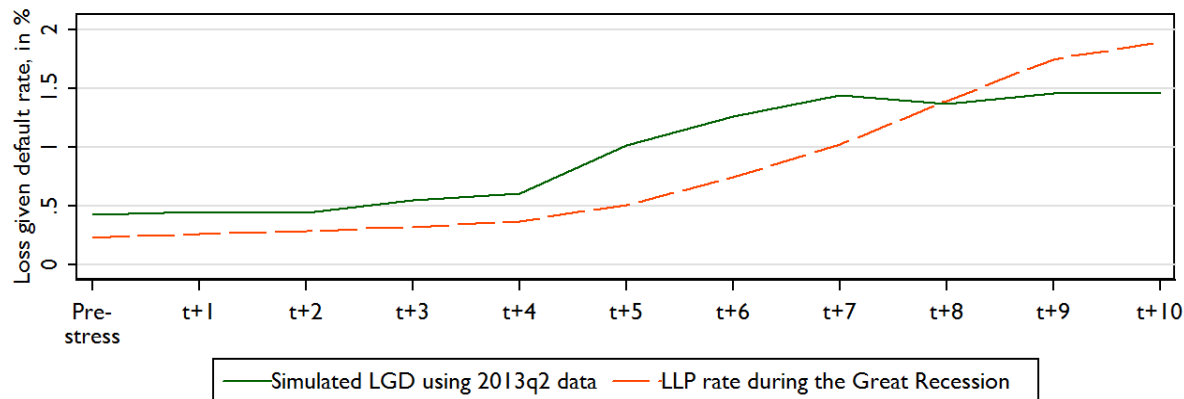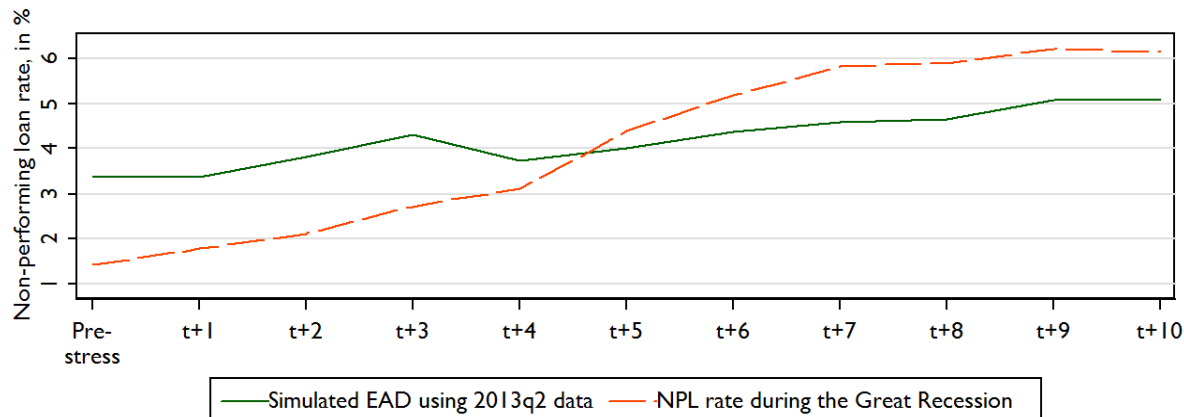
- Simulation results are milder than movements in the historical data

- Probable reasons:
  – Indebted households are more financially solvent after the crisis
  – Static model, duration of shocks is not taken into account

PROBABILITY OF DEFAULT: MULTIVARIATE ANALYSIS

Probability of default: the role of income and education

Dependent variable: probability of default

	Baseline: C = subsistence minimum	C = food and utilities	C = food, utilities and other non-durables	Debt repayment problems in last 12 months [a]	Expenses exceeded income in last 12 months
Percentile of Income (base less than 20)					
20-39	-0.242***	-0.091	0.057	-0.090	-0.010
	(0.088)	(0.108)	(0.099)	(0.105)	(0.084)
40-59	-0.409***	-0.371***	-0.301***	-0.152	-0.036
	(0.074)	(0.086)	(0.089)	(0.114)	(0.083)
60-79	-0.398***	-0.432***	-0.332***	-0.208	-0.103
	(0.076)	(0.086)	(0.086)	(0.127)	(0.082)
80-100	-0.404***	-0.457***	-0.389***	-0.271**	-0.151*
	(0.076)	(0.084)	(0.085)	(0.116)	(0.079)
Percentile of Net Wealth (base less than 20)					
20-39	-0.039	-0.032	-0.022	-0.018	-0.032
	(0.042)	(0.067)	(0.065)	(0.077)	(0.067)
40-59	-0.019	-0.092	-0.083	-0.123	-0.062
	(0.044)	(0.067)	(0.064)	(0.079)	(0.051)
60-79	-0.034	-0.078	-0.070	-0.138	-0.034
	(0.037)	(0.061)	(0.057)	(0.086)	(0.060)
80-100	-0.020	-0.058	-0.058	-0.096	-0.033
	(0.038)	(0.063)	(0.060)	(0.082)	(0.056)
Education of Reference Person (base primary or less)					
Secondary	-0.060	-0.071	-0.137***	0.016	-0.090*
	(0.042)	(0.048)	(0.053)	(0.072)	(0.054)
Tertiary	-0.081*	-0.116**	-0.198***	-0.057	-0.104*
	(0.042)	(0.048)	(0.052)	(0.073)	(0.053)
No of observations	737	737	737	737	728

Notes: Ordinary least square estimates using multiply imputed data of five implicates and 1000 replicate weights. [a] Logit model marginal effects using mimrgns command for Stata. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels of significance.

Probability of default: cyclical effects

	Baseline: C = subsistence minimum	C = food and utilities	C = food, utilities and other non-durables	Debt repayment problems in last 12 months [a]	Expenses exceeded income in last 12 months
Dependent variable: probability of default					
Year when the largest loan is taken (base 2002 or before)					
2003	0.038	0.039	0.064	0.153	-0.102*
	(0.037)	(0.056)	(0.077)	(0.115)	(0.056)
2004	0.059	0.052	0.065	0.029	-0.076
	(0.037)	(0.052)	(0.067)	(0.063)	(0.057)
2005	0.047	0.124**	0.153**	0.145*	0.037
	(0.039)	(0.058)	(0.062)	(0.084)	(0.064)
2006	0.073*	0.076	0.079	0.169***	-0.061
	(0.038)	(0.054)	(0.059)	(0.053)	(0.056)
2007	0.067*	0.068	0.053	0.118**	-0.039
	(0.039)	(0.051)	(0.058)	(0.058)	(0.058)
2008	0.068	0.008	-0.021	0.136*	-0.049
	(0.044)	(0.054)	(0.062)	(0.081)	(0.064)
2009	0.088**	0.034	0.040	0.230***	-0.024
	(0.044)	(0.051)	(0.067)	(0.080)	(0.070)
2010	0.065*	0.046	0.022	0.070	-0.054
	(0.039)	(0.052)	(0.058)	(0.114)	(0.064)
2011	0.050	0.051	0.062	0.139	0.005
	(0.044)	(0.062)	(0.073)	(0.086)	(0.074)
2012	0.055	0.048	0.058	0.099*	-0.067
	(0.042)	(0.054)	(0.067)	(0.051)	(0.062)
2013	0.076*	0.060	0.040	0.055	-0.100
	(0.046)	(0.057)	(0.068)	(0.056)	(0.064)
No. of observations	737	737	737	737	728

Notes: Ordinary least square estimates using multiply imputed data of five implicates and 1000 replicate weights. [a] Logit model marginal effects using mimrgns command for Stata. *, **, and *** refer to statistical significance at the 10%, 5%, and 1% levels of significance.

Summary: stress tests

- Estonian households are equally strongly affected by interest rate and unemployment shocks

  - Western European and Scandinavian countries find usually the interest rate shock to be the most harmful (Johansson and Persson (2006)), while Central and Eastern European countries are more seriously hit by unemployment shock (Galuščák et al. (2016))

  - Probable reason: Low replacement rate in CEE

  - The replacement rate is low in Estonia, but this is counterbalanced by the high pass-through of the interest rate shock

- Losses for banks are the most strongly affected by the real estate price shock

  - Probable reasons: High LTV ratios due to the fast and recent mortgage accumulation, strong boom-bust cycle in the real estate market

- The risks to financial stability from the household sector are modest

Summary: survey vs administrative sources

- Comparison of survey and administrative data points to:
  - underestimation of income in registers
  - underestimation of debt in the survey
  - overestimation of assets in the survey

  $\Rightarrow$ The use of administrative data leads to higher estimated household default rates and larger losses for banks

Summary: what next?

- Possible additional simulations:
  - Income and consumer price shocks
  - Tax rate shocks, mortgage interest deduction abolition, additional tax benefits for third pillar pensions

- Regular re-running of the stress tests:
  - With three-year frequency using the survey data (2-year lag)
  - With yearly frequency using administrative data (1-year lag) or simulated data (0.5 – 1 year lag)
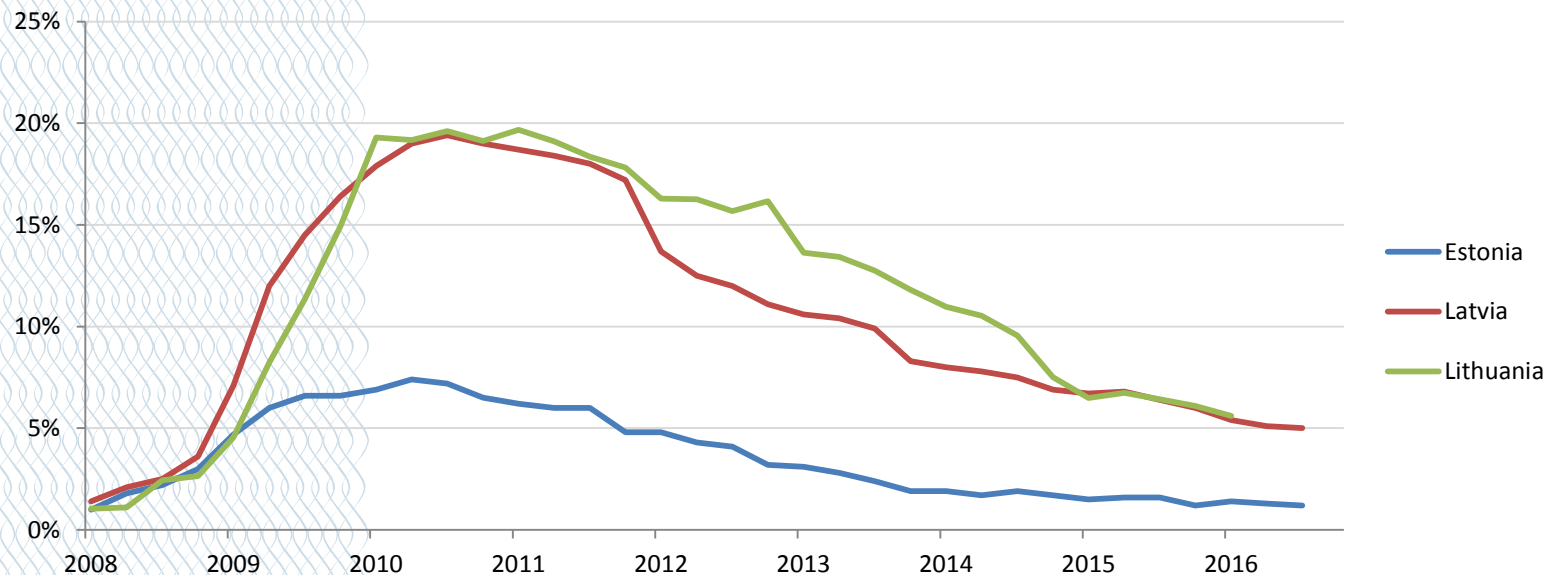
THANK YOU!
COMMENTS, QUESTIONS…

The study is published as Bank of Estonia Working Paper no 4/2017

Authors' e-mail addresses:
Jaanika.Merikyll@eestipank.ee, Tairi.Room@eestipank.ee

Post-Great-Recession NPL rates in the Baltic states: more puzzles?

- The graph presents the NPL rate for corporate and household loans
- The magnitude of the GDP decline during the Great Recession was similar in the Baltic states, yet in Estonia the increase in the NPL rate in response to the crisis was considerably smaller
- Possible explanation for corporations: Estonian corporate tax system
- Possible explanation for households ???

Sources: Eesti Pank, FCMC, Lietuvos Bankas

Financial burden indicators: HFCS II wave (2013 or 2014)

Eesti Pank

Loan-to-asset ratio (%)

Euro area, Netherlands, Ireland, Portugal, Finland, Germany, Latvia, Cyprus, Spain, Luxembourg, France, Hungary, Austria, Belgia, Italy, Greece, Estonia, Slovakia, Malta, Slovenia
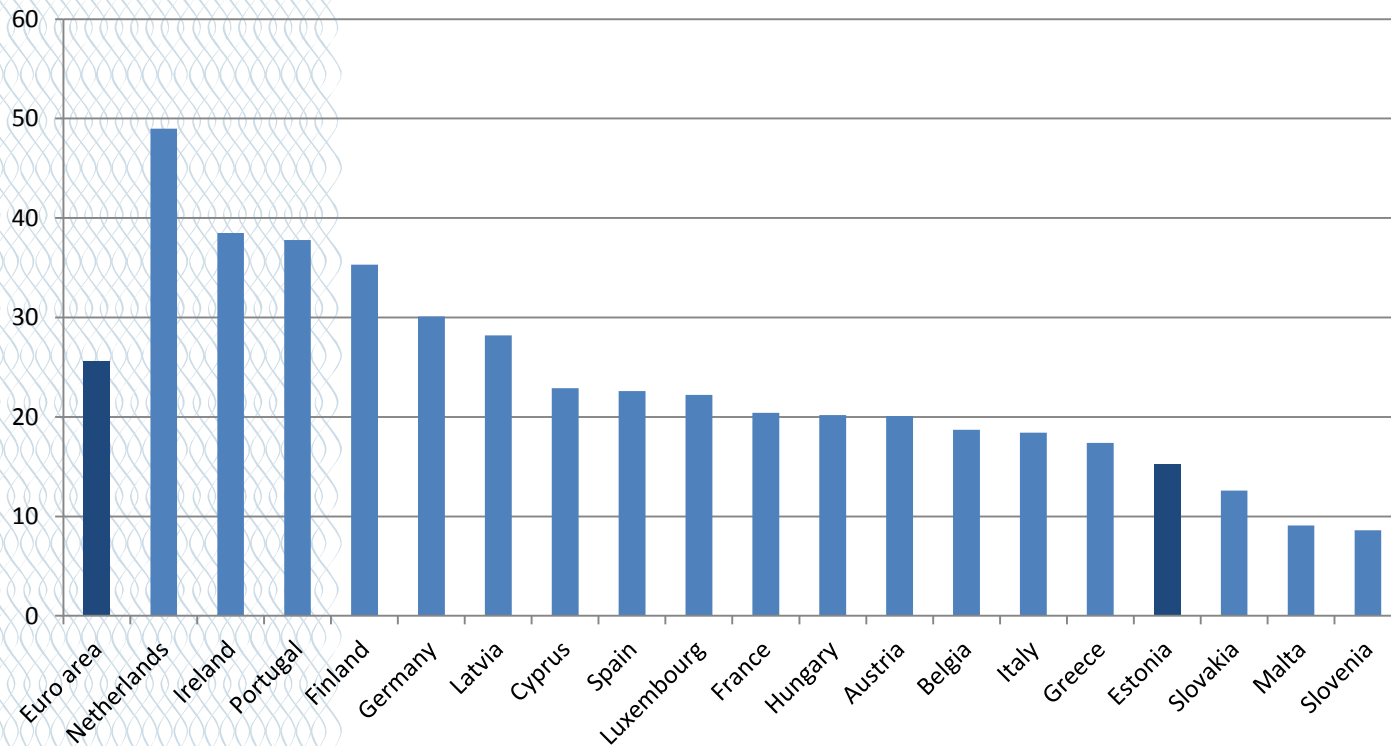
Financial burden indicators: HFCS II wave

Eesti Pank

Loan-to-value ratio of HMR (%)

Distribution of financial margin, baseline definition

Eesti Pank
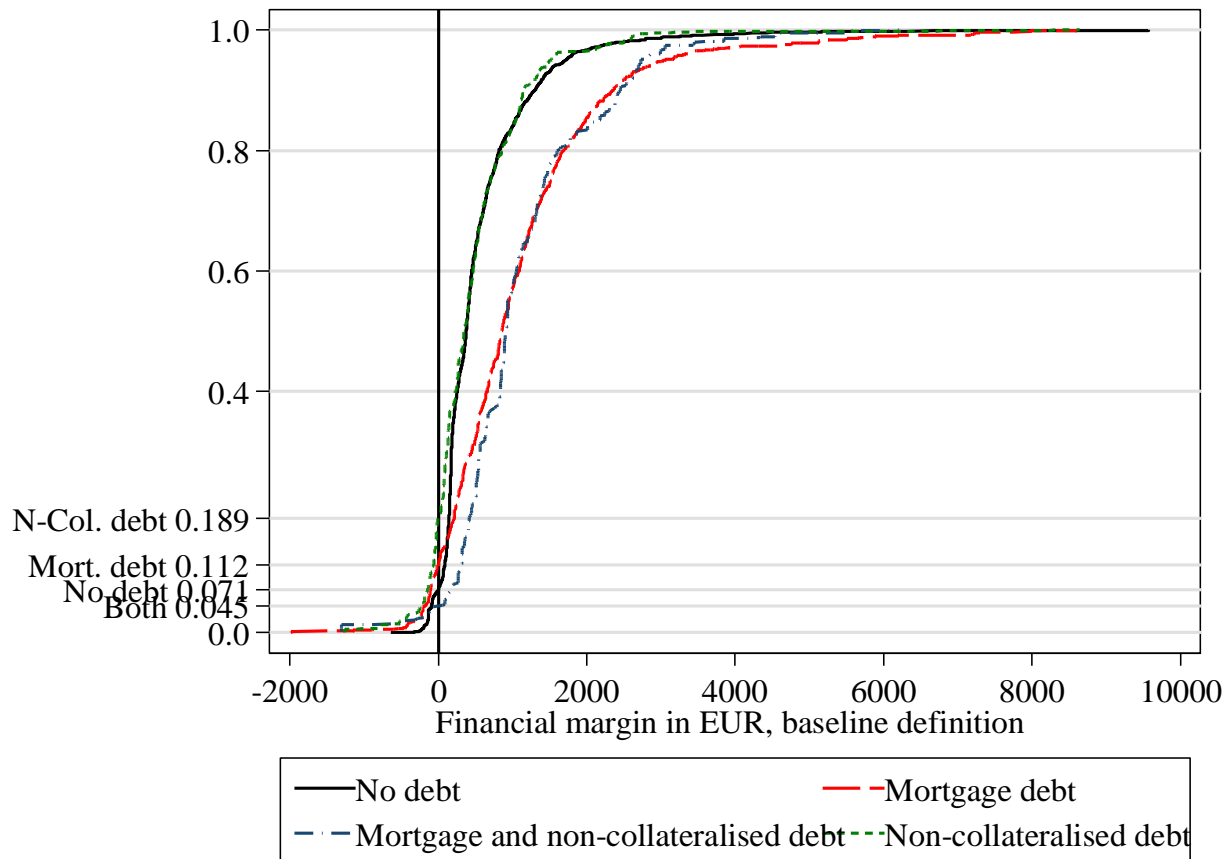
- Households with mortgage debt have the highest financial margin (median ≈ 900 EUR)

- Households without debt or with only consumer debt have on average much lower financial margin (median ≈ 400 EUR)

Correlation btw various probability of default measures

Eesti Pank

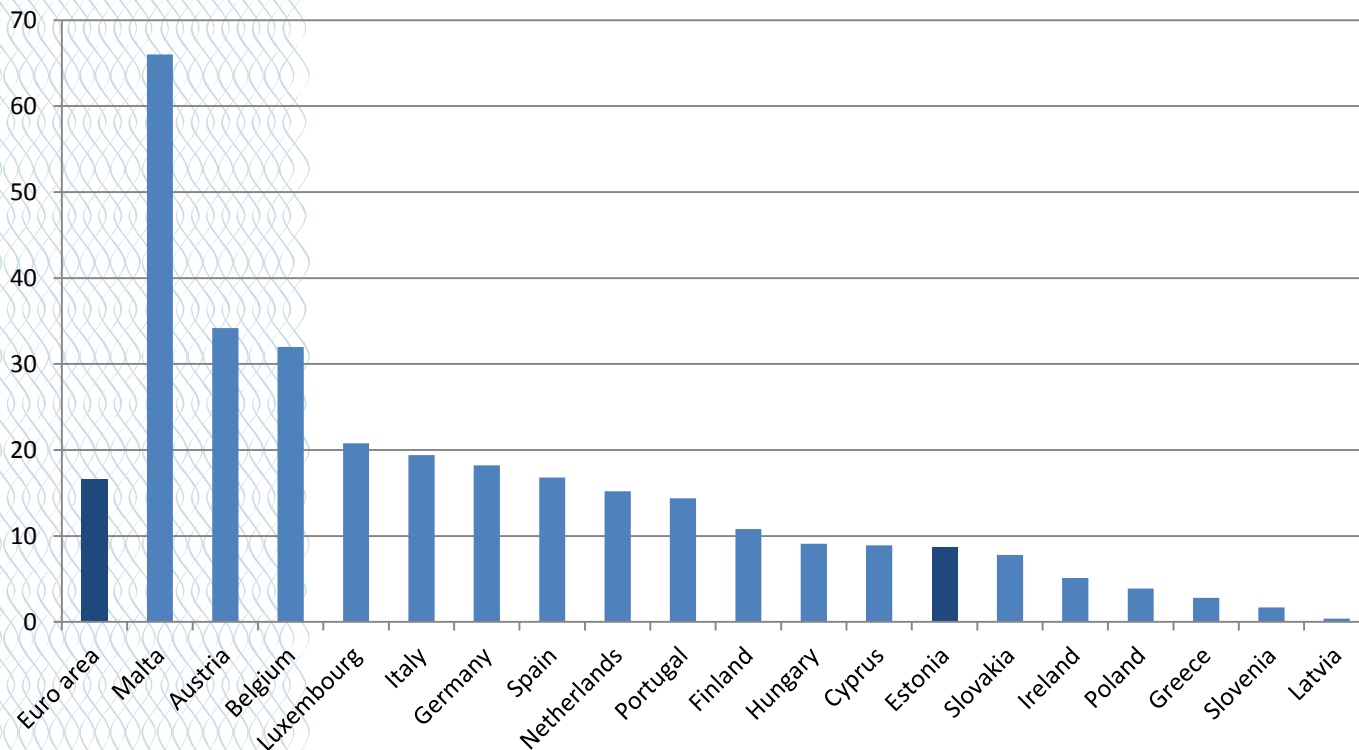|	**Baseline: C = subsistence minimum**	**C = food and utilities**	**C = food, utilities and other non-durables**	**Debt repayment problems in last 12 months**	**Expenses exceeded income in last 12 months**	**All from registers**
Baseline: C = subsistence minimum	1.000					
C = food and utilities	0.671	1.000				
C = food, utilities and other non-durables	0.551	0.823	1.000			
Debt repayment problems in last 12 months	0.298	0.289	0.296	1.000		
Expenses exceeded income in last 12 months	0.214	0.363	0.415	0.296	1.000	
All from registers	0.291	0.255	0.206	0.157	0.098	1.000

Simultaneous shock results

Eesti Pank

	Pre-stress	t+1	t+2	t+3	t+4	t+5	t+6	t+7	t+8	t+9	t+10
Negative financial margin, %	13.0	13.0	13.4	14.3	14.0	15.0	16.0	16.8	17.1	18.3	18.3
Probability of default, %	5.2	5.1	5.4	5.9	5.7	6.1	6.6	6.9	7.0	7.5	7.5
Exposure at default, %	3.4	3.4	3.8	4.3	3.7	4.0	4.4	4.6	4.7	5.1	5.1
...mortgages, %	3.2	3.1	3.6	4.1	3.5	3.8	4.1	4.3	4.4	4.8	4.8
...non-collateralised loans, %	8.8	8.8	8.8	9.2	9.3	9.7	10.1	10.4	10.5	10.9	10.9
Loss given default, %	0.4	0.4	0.4	0.5	0.6	1.0	1.3	1.4	1.4	1.5	1.5
...mortgages, %	0.0	0.1	0.1	0.2	0.2	0.6	0.9	1.0	1.0	1.0	1.0
...non-collateralised loans, %	8.8	8.8	8.8	9.2	9.3	9.7	10.1	10.4	10.5	10.5	10.9
Loss given default, ml EUR	20.6	21.7	21.5	26.6	29.6	49.3	61.3	70.2	66.5	71.0	71.3
...mortgages, ml EUR	2.1	3.2	3.0	7.3	10.2	29.1	40.2	48.5	44.6	48.2	48.5
...non-collateralised loans, ml EUR	18.5	18.5	18.5	19.3	19.4	20.2	21.1	21.7	21.9	22.8	22.8
No of obs	769.0	769.0	769.0	769.0	769.0	769.0	769.0	769.0	769.0	768.9	768.9

Financial margin: survey vs register

Financial margin, monthly

Legend: Confidence bounds 95% — Linear trend, r=0.478 — 45°
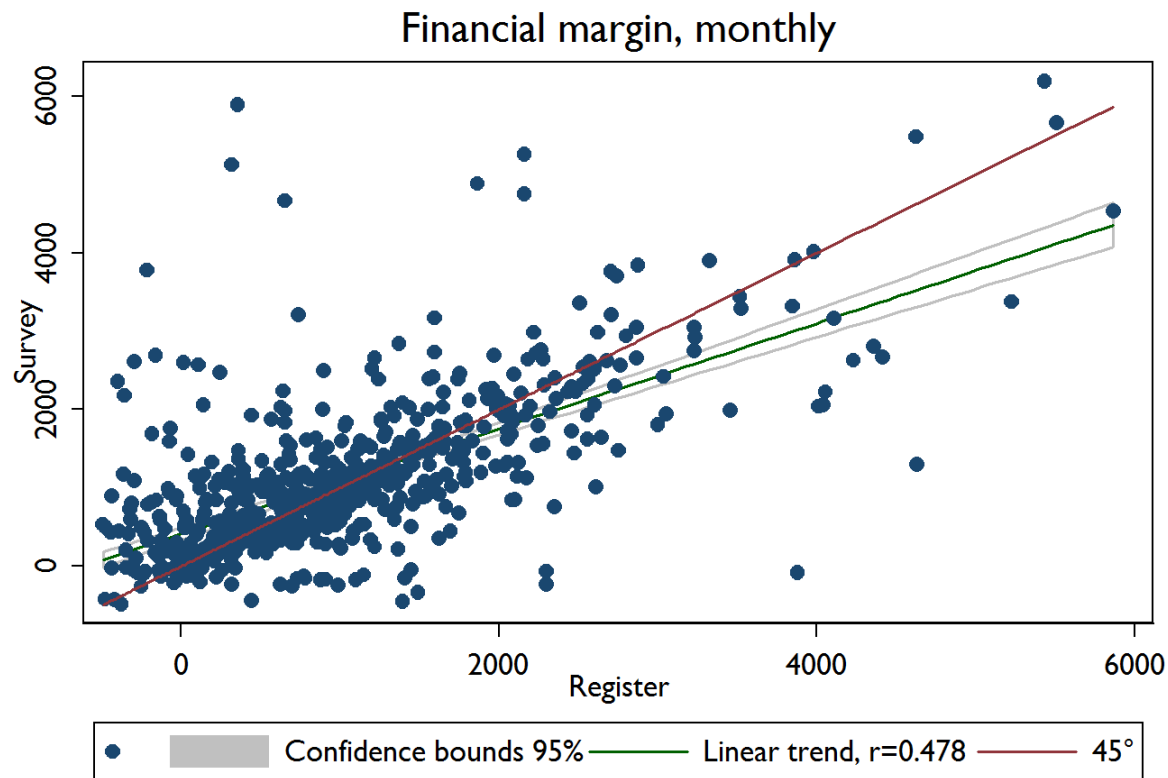
1% of the smallest and largest observations are excluded