Savings and Consumption Responses to Persistent Income Shocks

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2. **Model:** Can standard consumption-savings explain the estimated responses?

Message from the today

1 **Average MPC is high** :

$$MPC^{data} = dc_t / d\tau = 0.91$$

- $MPC^{model} = MPC^{data}$ with 17 year shock

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→ Strong evidence of liquidity constraints

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3. **Heterogeneity in persistence:**
   - Novel source of heterogeneity: time-to-maturity upon impact
   - $>$ 10 years : $MPC^{data}_{10+} = 0.92$
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   - $MPC^{data}_{5} > MPC^{model}_{5}$

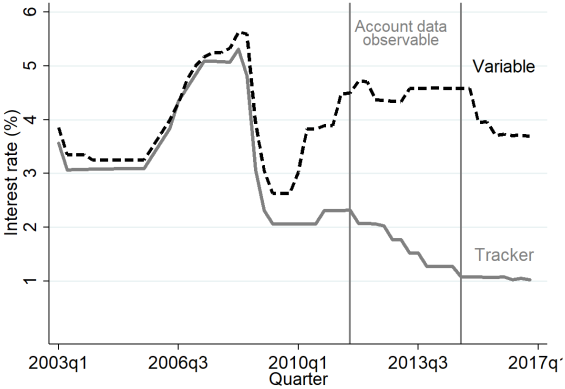
   → Consistent with transitory shock literature [Kaplan-Violante 14, 22]

1. Data and Consumption Response

2. Model of Consumption & Savings

Payment shock: variable and tracker mortgage interest rates

(a) Divergence in *ECB Tracker* and *Standard Variable*



(b) Share of new mortgages issued by interest rate

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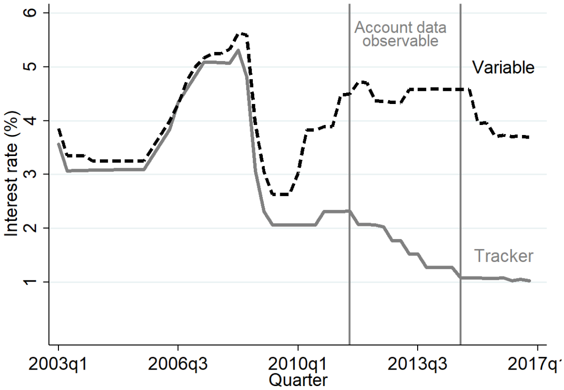

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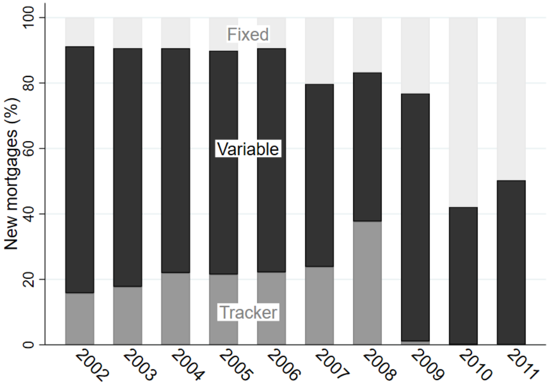

Data: mortgage and bank account data in Ireland

1. **Mortgage data**
   - *At origination:* age, income, county, house price, mortgage size, interest rate
   - *Over time:* outstanding balance, interest rate, days past due
   - 2000-2016 for origination data; 2012-2016 six-monthly updates
   - *Estimate:* current LTV w/ post code price index

2. **Bank account data**
   - Average balance over quarter (quarterly), balance at end date (6 monthly).
   - Checking and savings accounts
   - Quarterly, Q3 2011 - Q4 2014
   - Do not see accounts in multiple banks, or non-bank savings

3. **Cleaning**
   - **Household view:** Link all mortgages, bank accounts for household
   - Restrict to active (non-constant/zero) checking accounts (when using savings data)
   - Mortgages originated 2000-2008
   - Quarterly panel: Q3 2011 - Q4 2014
   - $N \approx 10,000$ households $\times$ 14 quarters $\approx 140,000$

Size of payment savings

Payment savings:

$$
\begin{aligned}
m_t^{flow} &= \text{pay}_t^{\text{variable}} - \text{pay}_t^{\text{tracker}} > 0 \quad \text{if tracker} \\
&= 0 \quad \text{if variable} \\
m_t^{stock} &= \sum_{j=0}^{t} m_j^{flow}
\end{aligned}
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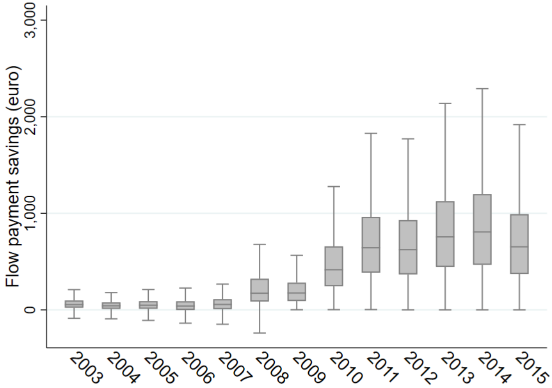

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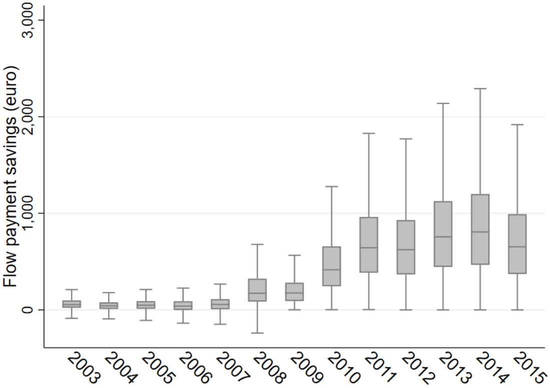

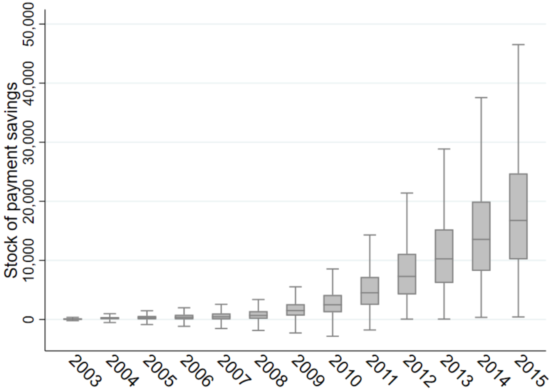

Regression: Savings Response

$$\Delta b_{i,t} \quad = \quad \beta_0 + \beta_1 \Delta m_{i,t}^{stock} + \eta_t(\mathbf{X}_i \times \gamma_t) + u_{i,t}$$

- $\Delta b_{i,t}$ is the change in bank balance of household i between quarter t and $t+1$
- $\Delta m_{i,t}^{stock}$ is change in stock payment savings between t and $t+1$
  - $\Delta m_{i,t}^{stock} > 0$ if tracker mortgage
  - $\Delta m_{i,t}^{stock} = 0$ if variable mortgage
- X_i is a vector of observable controls
- γ_t are time fixed effects
- Variations:
  - levels and logs
  - pooled and different time horizons

Result: Average Savings Response

	(1) Savings	(2) Log Savings	(3) Δ Savings	(4) Δ Log Savings	(5) Savings	(6) Log Savings	(7) Δ Savings	(8) Δ Log Savings
Payment Savings	0.083***				0.077***			
	(0.0210)				(0.0242)			
Log Payment Savings		0.067***				0.076**		
		(0.0241)				(0.0326)		
D.Payment Savings			0.086***				0.086***	
			(0.0221)				(0.0219)	
D.Log Payment Savings				0.056***				0.059**
				(0.0154)				(0.0217)
Observations	144914	144914	134563	134563	144914	144914	134563	134563
Adjusted R^2	0.902	0.907	0.001	0.001	0.903	0.907	0.002	0.002
Individual FE	Yes	Yes			Yes	Yes		
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\times$ Quarter FE					Yes	Yes	Yes	Yes
Prob($\beta = 1$)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

MPC heterogeneity

1. **Average** MPC = 0.913 (MPS= 0.087).

2. **Split samples**

   a. Liquid assets at 2011Q3: ‣ table
   - Lowest liquid assets quartile: 1.0
   - Quartile 2: 0.95
   - Quartile 3: 0.93
   - Highest balance quartile: 0.82

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   b. Mortage maturity at 2010Q1: ‣ table
   - $<=$ 5 years to maturity: 0.6
   - 6-10 years to maturity: 0.84
   - $>$10 years to maturity: 0.93

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- **Robustness**
  - Some evidence of selection ex-ante ‣ link
  - No evidence of selection ex-post ‣ link
  - No evidence of mortgage pre-payment
  - Other savings accounts ‣ link

1. Data & Consumption Response

2. Model of Consumption & Savings

Consumption-savings problem by households

Households solve infinite horizon problem

$$
\begin{aligned}
\max_{c,a} \sum_{t=0}^{\infty} \mathbf{E_0} \left[\beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right] \\
c_t + a_t = (1+r)a_{t-1} + e_t + \tau_t \\
a \geq 0 \\
\ln e_t = \rho_e \ln e_{t-1} + \epsilon_t \qquad \epsilon_t \sim \mathcal{N}(0, \sigma_e^2)
\end{aligned}
$$

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Perfect foresight for path $\{\tau_s\}_{s\geq 0}$.
Compare to stationary distribution with $\tau_{ss} = 0$

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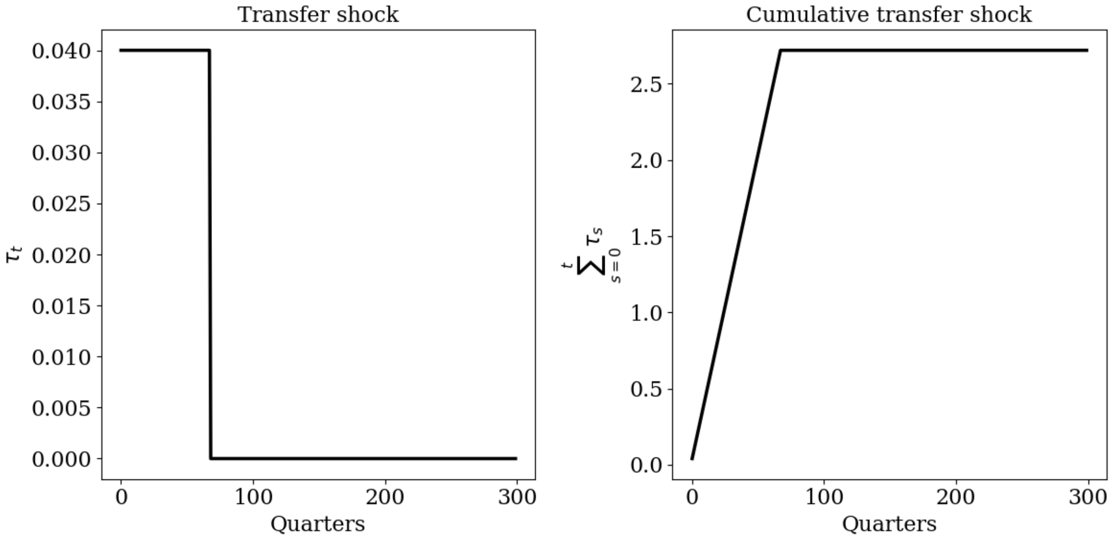
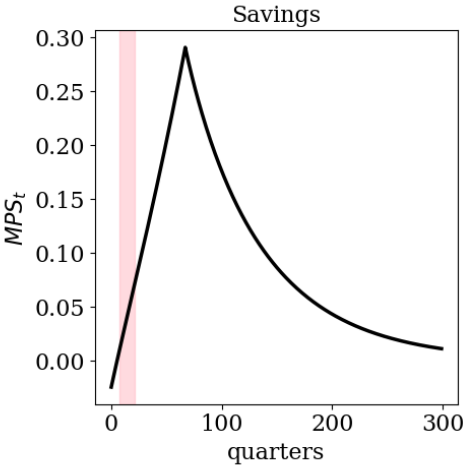
Calibration: $\sigma = 2$, $r = 0.01$, $\rho_e = 0.966$, $\sigma_e = 0.54$ [Auclert, et. al.; HFCS]
Calibrate discount factor to match average response: $\beta = 0.97$
$\tau = 0.04$

▸ Bellman

The model experiment



Comparing model and data



‣ One period shock at quarter 0 ‣ One period shock at quarter 40 ‣ Savings response ‣ Permanent income hypothesis

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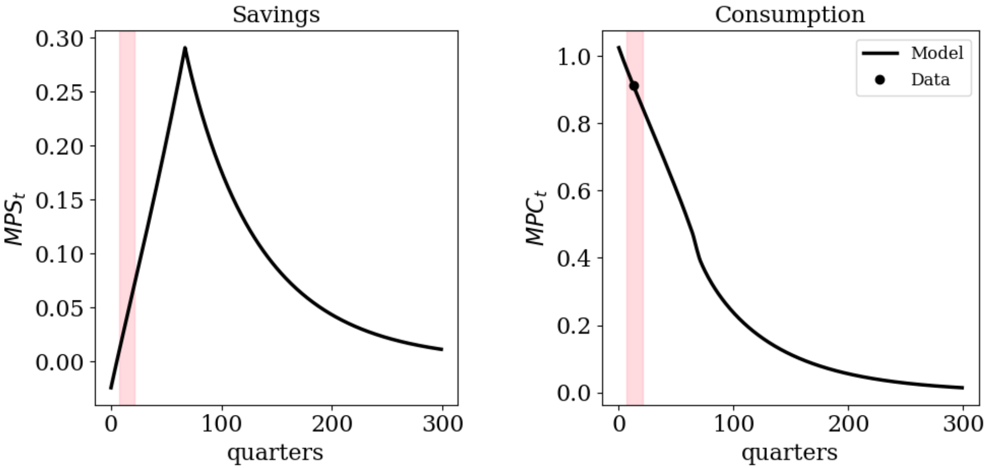

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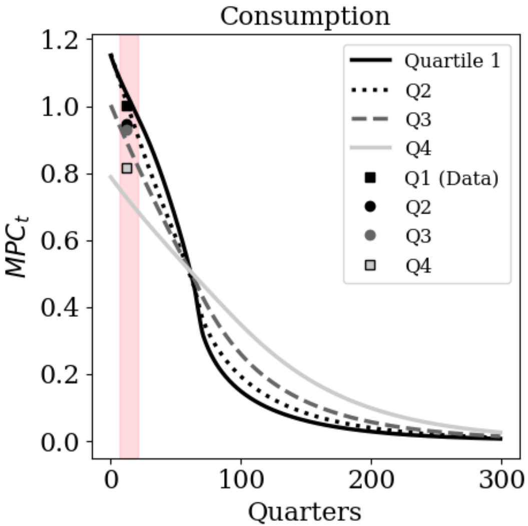
Comparing model and data: liquidity constraints



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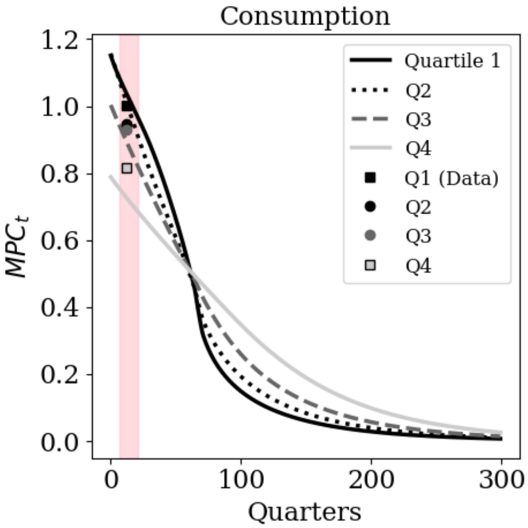
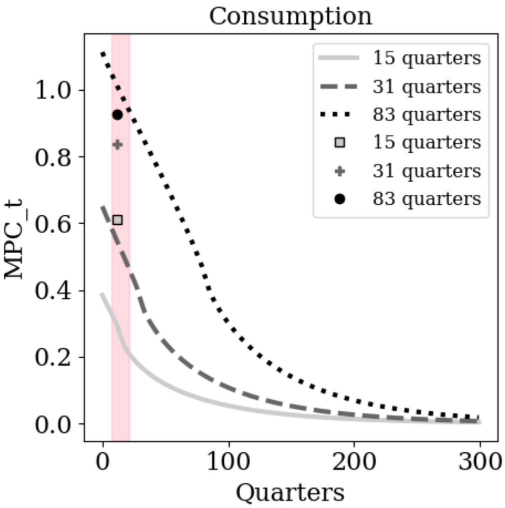


- **Errors:** $MPC^{data} - MPC^{model}$ =[-0.03, -0.05, 0.05, 0.1]
- Similar spread (20pp) as one-time shocks [Fagereng-Holm-Natvik 21]
- Good fit relative to one-time shocks

Comparing model and data: shock persistence



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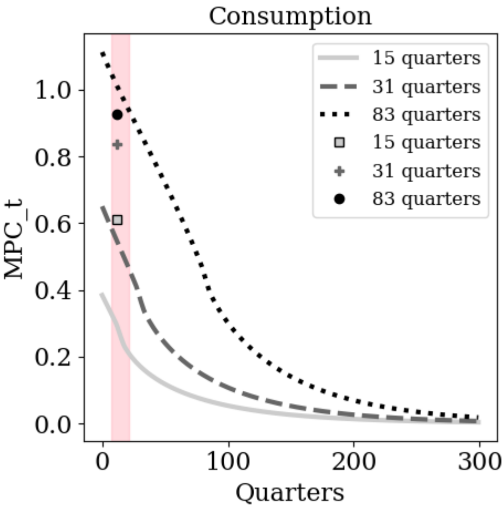

- **Errors:** $MPC^{data} - MPC^{model}$ =[-0.07, 0.31, 0.37]
- Worst fit for least persistent shock
- Consistent with evidence on one-time shocks [Fagereng-Holm-Natvik 21]

  ... and motivation for illiquid asset models [Kaplan-Violante 14, 22]

Conclusions

Compared savings response to persistent shocks in data and model

1 **Average MPC is high** : $MPC^{data} = 0.91$

- ... and consistent with model with 17 year shock

2 **Liquidity constraints:**

- Low liquid assets: $MPC^{data} = 1.0$
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- $\leq$ 5 years : $MPC^{data}_{5} = 0.61$

→ Worst fit for transitory shocks

Thank you!

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higginsbrian.github.io

Literature: MPCs

- **Quasi-Experimental.**
  Expected One-Time Shock. Shapiro & Slemrod (1995, 2003, 2009), Souleles (1999, 2002), Hsieh (2003), Johnson, Parker & Souleles (2006), Kueng (2018), Baugh, Ben-David, Park & Parker (2021), Lewis, Melcangi & Pilossoph (2021)
  Unexpected One-Time Shock. Bodkin (1959), Agarwal & Qian (2014), Fagereng, Holm & Natvik (2020)
  Expected Persistent Shock. Bernheim, Skinner & Weinburg (2001), Aguiar & Hurst (2005, 2007)
  Unexpected Persistent Shock. Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, & Yao (2017), Baker (2018), Ganong & Noel (2019)
- **Model Comparison.** Kaplan & Violante (2014)
- **Covariance Restrictions.** Hall & Mishkin (1982), Blundell, Pistaferri & Preston (2008)
- **Subjective Expectations.** Hayashi (1985), Pistaferri (2001)
- **Irish Household Finance.** Cussen, Lydon & O'Sullivan, (2018), Horan, Lydon & McIndoe-Calder (2020), Byrne, Kelly & O'Toole (2021), O'Malley (2021), Higgins (2021), Acharya, Bergant, Crosignani, Eisert and McCann, (2022), Le Blanc, Lydon (2022), Palmer, Byrne, Devine, King and McCarthy (2022).

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- **Our contribution**
  1. Estimate MPC using a quasi-experimental persistent income shock
  2. New evidence that liquidity constraints matter
  3. Evaluate performance of standard consumption-savings model with persistent shocks

Household finances in Ireland

▸ back

How much of household savings are captured in our data:

1. How much of non-housing assets are in deposit savings
   - **Macro data:** 91% Quarterly Financial Accounts
   - **Micro data:** 55% HFCS, evidence of large ($\approx$ 66%) under reporting of deposits (Cussen, Lydon & O'Sullivan, 2018)

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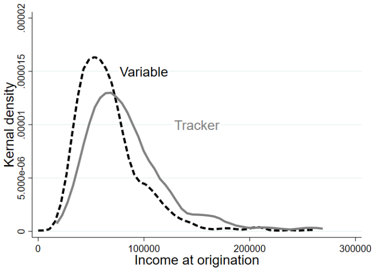
3. How much of bank deposits are in a single bank
   - **Bank accounts per household in Ireland:** 5.2
   - **Bank accounts per household in our data:** 4

- We can check results for households with both checking and savings accounts
  - Checking account MPC = 0.93; Savings account MPC = 0.95

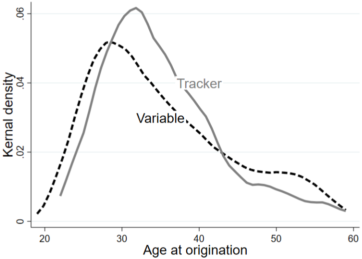
  $\rightarrow$ Results are similar

Comparing variable and tracker mortgage borrowers (ex-ante)

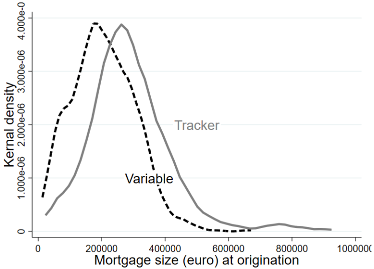
▸ back



(a) Income at origination



(b) Age at origination



(c) Mortgage balance at origination

Comparing variable and tracker mortgage borrowers (ex-post)

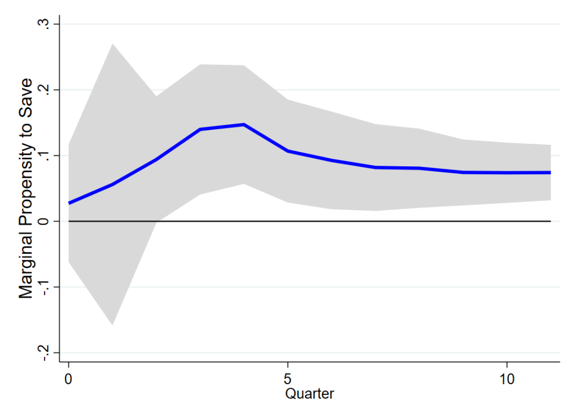
▸ back

Q. Were trackers more likely to get income shocks?

- Use survey of mortgage holders 2012Q2 – 2013Q1 (Byrne, Kelly, O'Toole, 2021)

	Income Change			Unemployed		
	(1)	(2)	(3)	(4)	(5)	(6)
Tracker	-0.254***	-0.129	0.029	-0.029	0.001	0.005
	(0.0683)	(0.0774)	(0.0611)	(0.0215)	(0.0244)	(0.0256)
Observations	616	616	593	626	626	593
Adjusted R^2	0.020	0.044	0.464	0.001	0.026	0.006
Origin year and bank FE		Yes	Yes		Yes	Yes
Controls			Yes			Yes

Result: Savings response at many horizons



- 12 quarter estimate
  - MPS_{t+12} = 0.074;
  - Implied MPC= 0.93
- $MPS_{t+h} = \sum_{s=0}^{h} (1+r)^{h-s}(1-MPC)$
- Average pooled estimate
  - MPS = 0.087;
  - Implied MPC = 0.913

Bellman

The value function at time t is

$$V_t(e, a_-) = \max_{c,a} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \beta \sum_{e'} V_{t+1}(e', a)\mathcal{P}(e, e') \right\}$$
$$c + a = (1 + r)a_- + e + \tau$$
$$a \geq 0$$
$$\ln e_t = \rho_e \ln e_{t-1} + \epsilon_t \qquad \epsilon_t \sim \mathcal{N}(0, \sigma_e^2)$$

Perfect foresight for aggregate path $\{\tau_s\}_{s\geq 0}$.
Compare against stationary dist with $\tau_{ss} = 0$

Policies $c_t^*(e, a_-; \boldsymbol{\tau})$ and $a_t^*(e, a_-; \boldsymbol{\tau})$
Distribution's law of motion $D_{t+1}(e', a) = \sum_{e'} D_t(e', a_t^{*-1}(e, a; \boldsymbol{\tau}))\mathcal{P}(e, e')$

back

Computing MPCs

Individual MPCs

$$MPC_t(e_t, a_{t-1}; \boldsymbol{\tau}) \quad = \quad \left[c_t^*(e_t, a_{t-1}; \boldsymbol{\tau}) - c_{ss}^*(e_t, a_{t-1}, 0)\right] / \tau$$

Computing MPCs

Individual MPCs

$$MPC_t(e_t, a_{t-1}; \boldsymbol{\tau}) \quad = \quad \left[c_t^*(e_t, a_{t-1}; \boldsymbol{\tau}) - c_{ss}^*(e_t, a_{t-1}, 0)\right] / \tau$$

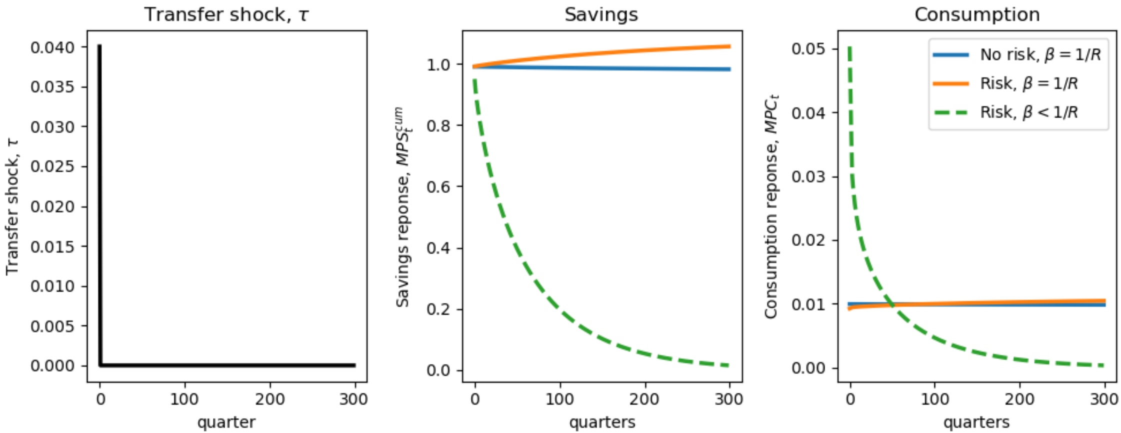
Average $C_t(\boldsymbol{\tau}) = \sum_e \int_a c_t^*(e_t, a_{t-1}; \boldsymbol{\tau}) D_t(e_t, a_{t-1})$

Average MPC

$$MPC_t(\boldsymbol{\tau}) \quad = \quad \left[C_t(\boldsymbol{\tau}) - C_{ss}(0)\right] / \tau$$

Warm up: one period shock

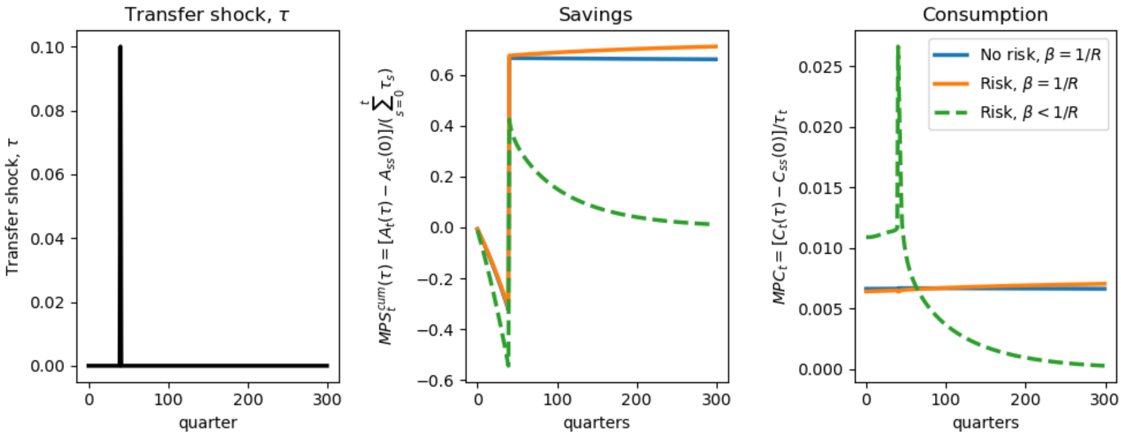
‣ Shock at quarter 40



- **Here:** $MPC_{t=0} = \frac{r}{1+r}$ when $\beta = 1/R$
  $MPC_{t=0}$ at impact 0.043 with risk and $\beta < 1/R$;
- **Kaplan Violante (2014)** One-asset: $MPC_{t=0} \approx 0.03$ (non-HtM), 0.15(HtM)
- **Data:** $MPC_{t=0} \approx 0.5$ Fagereng, Holm and Natvik (2020)

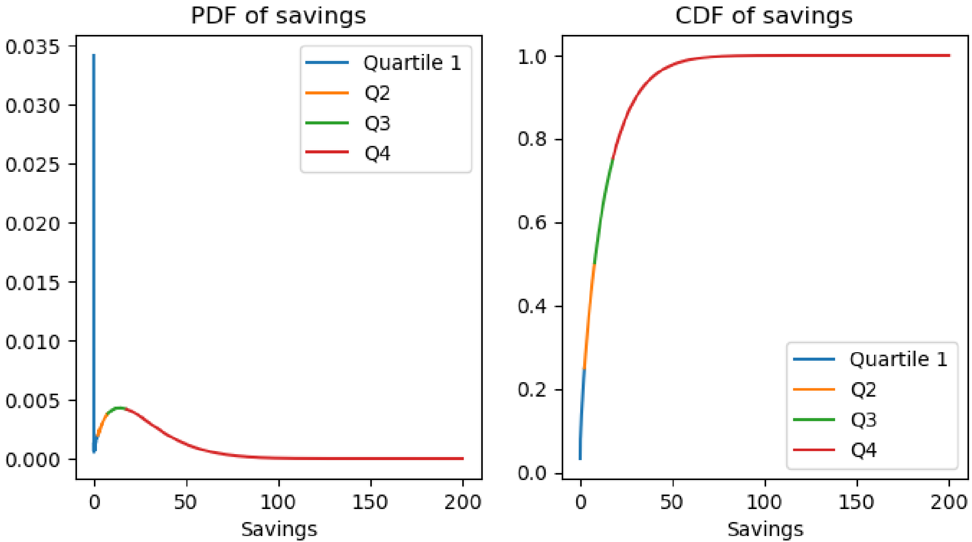
Warm up: one period shock

‣ back



Asset distribution in steady state

‣ back

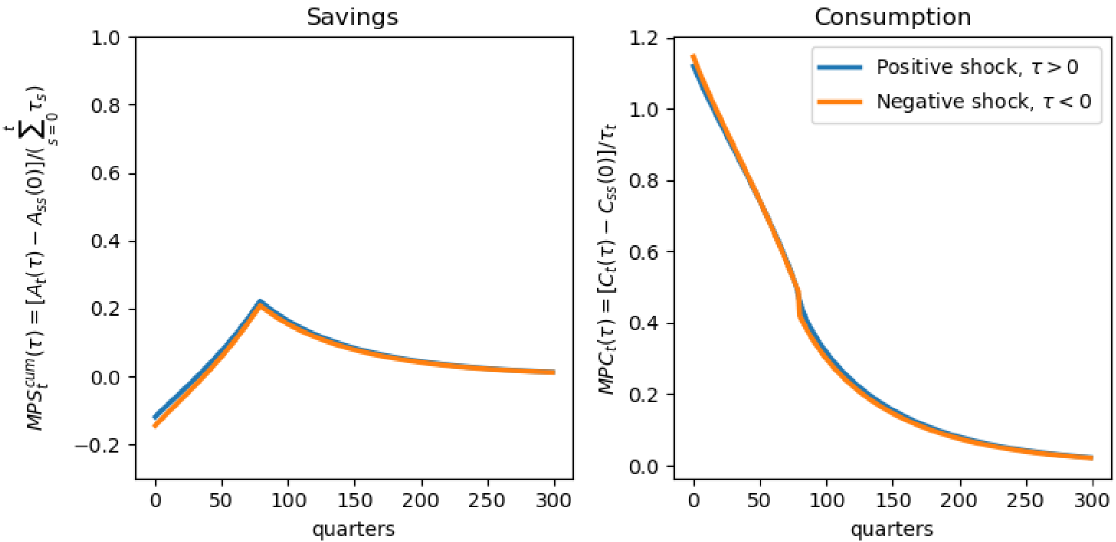


Other model experiments

- Responses are larger to negative shocks, though not by much for this shock size ‣ link

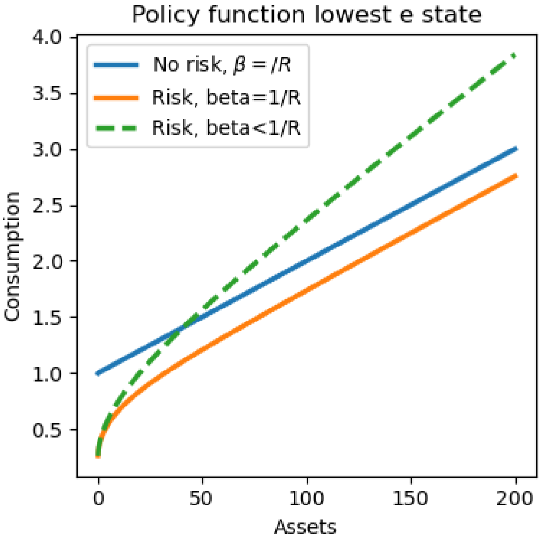
Positive versus negative shocks

‣ back



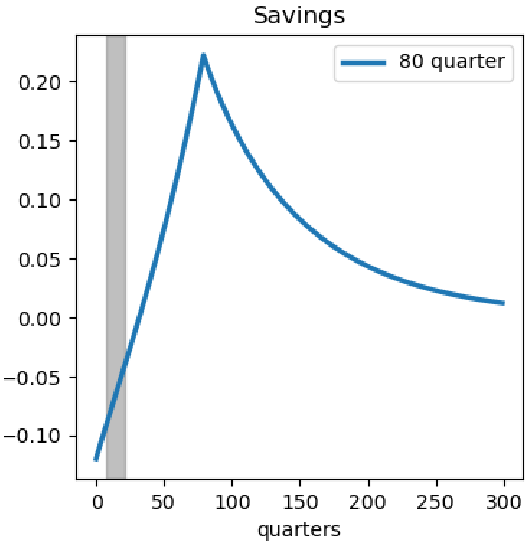
Policy functions

‣ back

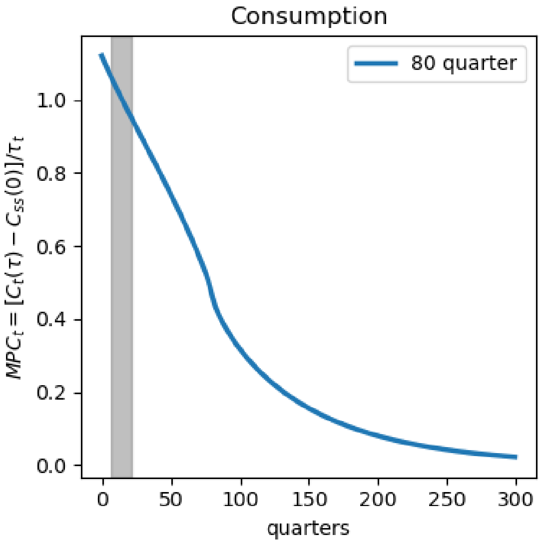


Average savings responses

‣ back



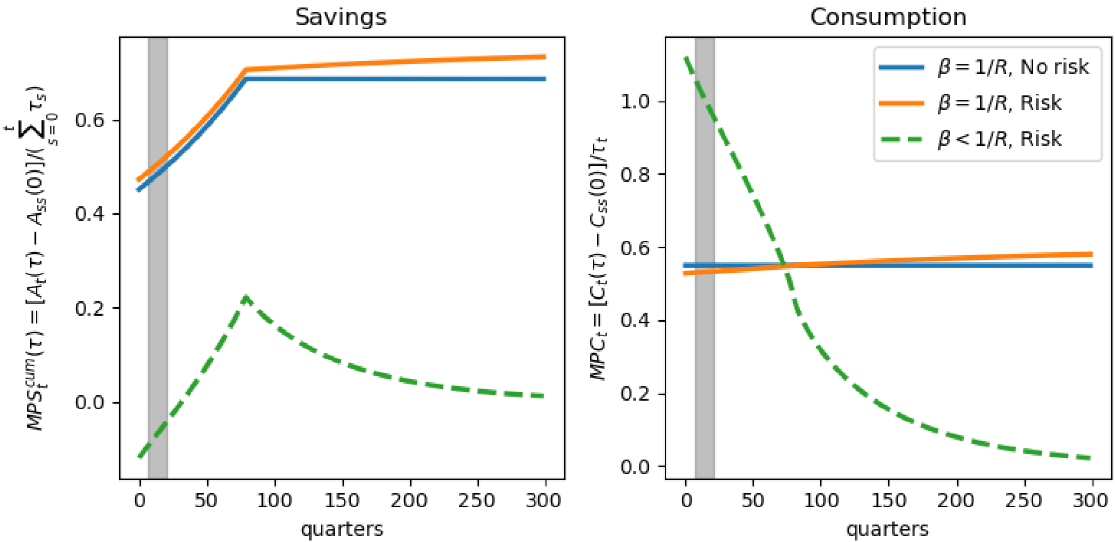
Average consumption responses



- One period shock at quarter 0
- One period shock at quarter 40
- Savings response
- Permanent income hypothesis

Average responses

‣ back

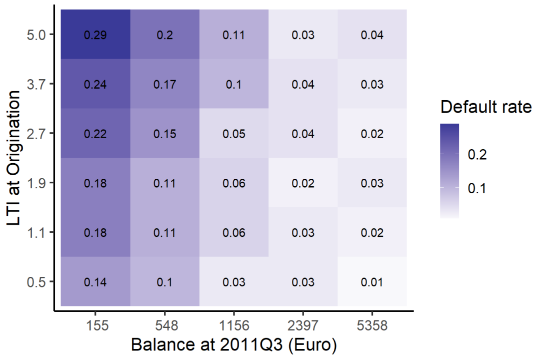


‣ One-period shock at quarter 0 ‣ One-period shock at quarter 40

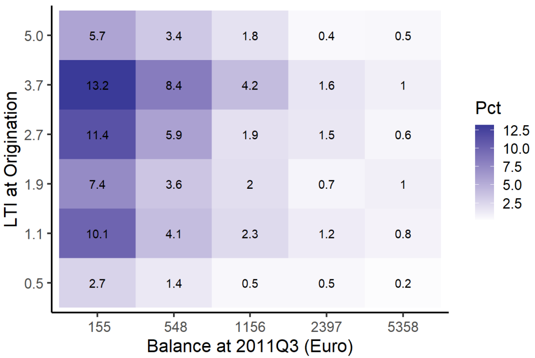
Tracing out the default threshold: LTI-balance space

‣ back

(a) Default propensity



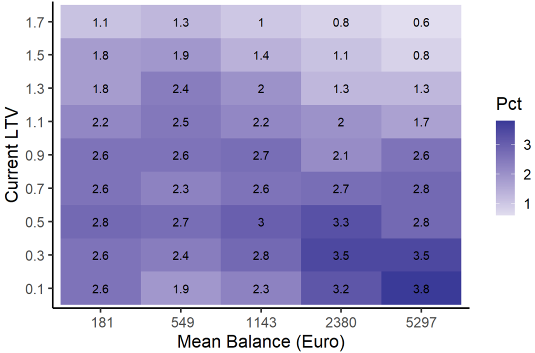
(b) Defaults



Distribution of observations

- back

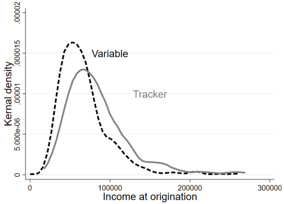
(a) Distribution of observations



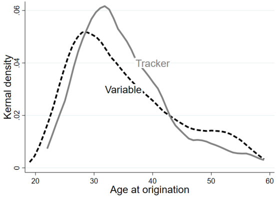
Distribution of variable and tracker mortgage borrowers

‣ back

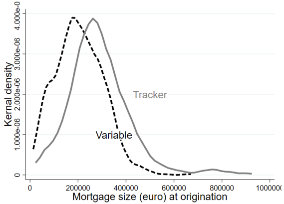
(a) Income



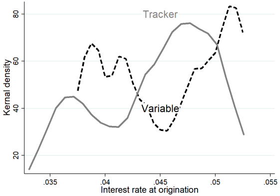
(b) Age



(c) Mortgage balance



(d) Annual interest rate



Note: All variables are at origination for new mortgages for house purchases originated in 2006 and 2007. Plots

Pooled Marginal Propensity to save (MPS)

▸ back

$$\Delta b_{i,t+1} = \beta_0 + \beta_1 m_{it} + \eta X_{it} + \gamma_t + u_{it} \quad (1)$$

	Δ Savings			Δ Log Savings		
	(1) ≤ 5 years	(2) $6-10$ years	(3) > 10 years	(4) ≤ 5 years	(5) $6-10$ years	(6) > 10 years
D.Payment Savings	0.389*	0.162	0.075**			
	(0.2053)	(0.1171)	(0.0252)			
D.Log Payment Savings				0.138***	0.003	0.041
				(0.0352)	(0.0352)	(0.0387)
Observations	11011	24232	99320	11011	24232	99320
Adjusted R^2	-0.002	0.006	0.003	-0.008	-0.004	0.003
Individual FE						
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls × Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Prob($\beta = 1$)	0.012	0.000	0.000	0.000	0.000	0.000

MPS heterogeneity: by balance quartiles

back

	Δ Savings				Δ Log Savings			
	(1) Lower	(2) Quartile 2	(3) Quartile 3	(4) Upper	(5) Lower	(6) Quartile 2	(7) Quartile 3	(8) Upper
D.Payment Savings	-0.001	0.052**	0.070	0.184***				
	(0.0106)	(0.0219)	(0.0416)	(0.0542)				
D.Log Payment Savings					-0.023	0.099	0.122***	0.066***
					(0.0596)	(0.0598)	(0.0350)	(0.0091)
Observations	35828	31057	32006	35672	35828	31057	32006	35672
Adjusted R^2	0.000	0.009	0.000	0.006	0.015	0.005	0.003	0.009
Individual FE								
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\times$ Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prob($\beta = 1$)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

MPS heterogeneity: by quarters to maturity

back

- Compute time to maturity when shock starts 2010Q1

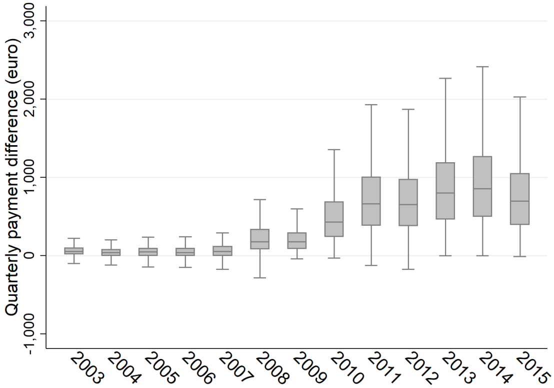
	Δ Savings			Δ Log Savings		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\leq 5 years$	$6 - 10 years$	$>$ 10 years	$\leq$ 5 years	6-10 years	$>$ 10 years
D.Cumulative Payment Difference	0.394	0.161*	0.076*			
	(0.2059)	(0.0651)	(0.0268)			
D.Log Cumulative Payment Difference				0.130***	0.022	0.031
				(0.0206)	(0.0332)	(0.0313)
Observations	10634	23153	94835	10632	23149	94826
Adjusted R^2	-0.004	0.003	0.003	-0.005	-0.006	0.003
Individual FE						
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls $\times$ Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Prob($\beta = 1$)	0.012	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses.

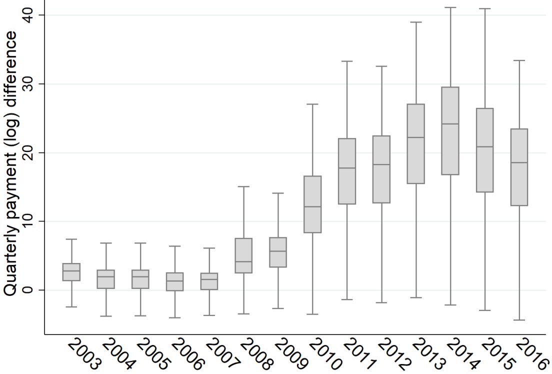
Size of payment shock

Figure: Box plot of size of payment difference

(a) Euro value



(b) Percent difference (relative to variable payment)

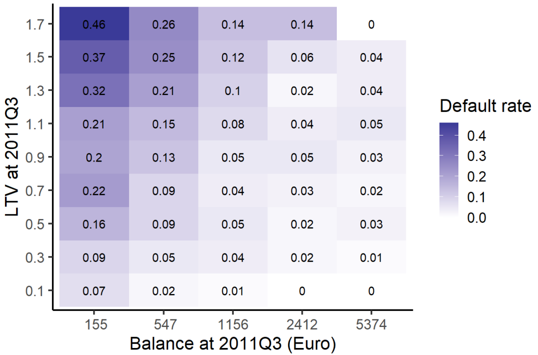


Note: Percent is relative to the first lien only.

Tracing out the default threshold: LTV-balance space

- Stylized default decision: $V_t(y, b, \frac{m}{p}) = \max\{V_t^{pay}(y, b, \frac{m}{p}), V_t^{default}(y, b, \frac{m}{p})\}$

(a) Default propensity

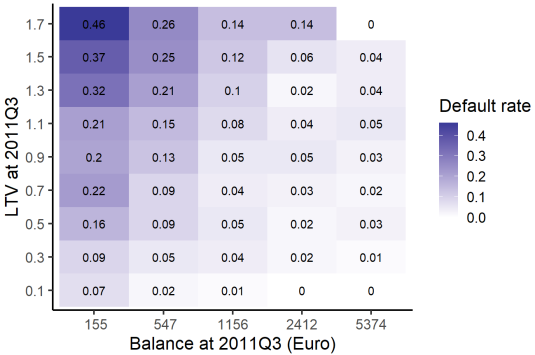


- Many other dimensions of heterogeneity: ▸ Balance-LTI-space ▸ Distribution ▸ Mean balances
- Do not observe income, but can use our "disposable income" shocks ▸ back

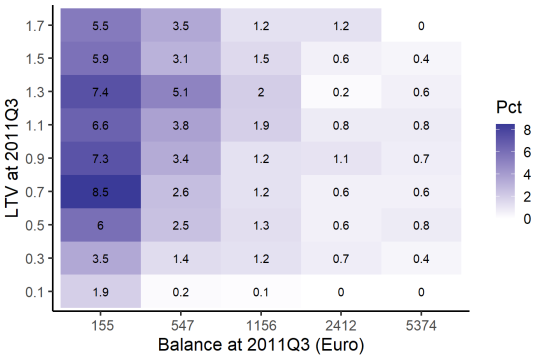
Tracing out the default threshold: LTV-balance space

- Stylized default decision: $V_t(y, b, \frac{m}{p}) = \max\{V_t^{pay}(y, b, \frac{m}{p}), V_t^{default}(y, b, \frac{m}{p})\}$

(a) Default propensity



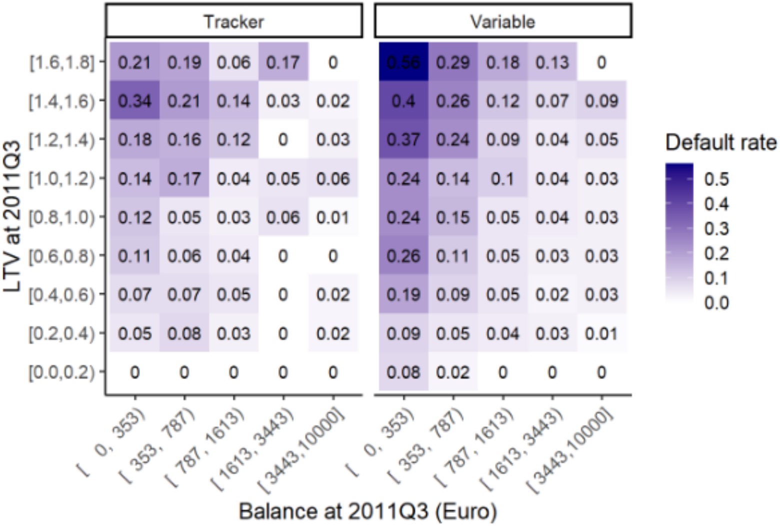
(b) Defaults



- Many other dimensions of heterogeneity: ▸ Balance-LTI-space ▸ Distribution ▸ Mean balances
- Do not observe income, but can use our "disposable income" shocks ▸ back

Comparing tracker and variable mortgages

‣ back

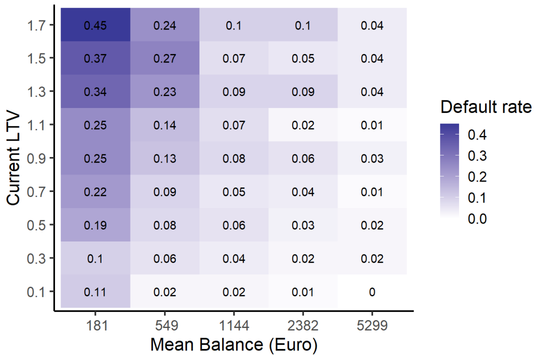


Tracing out the default threshold: LTV-balance space

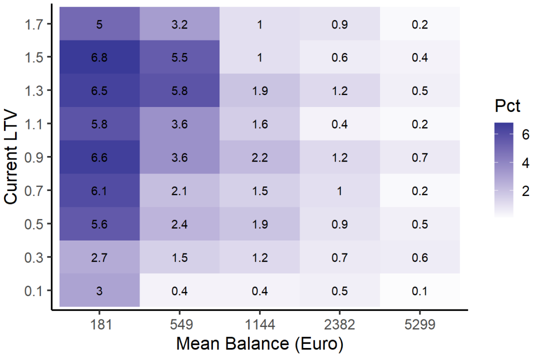
back

- Stylized default decision: $V_t(y, b, \frac{m}{p}) = \max\{V_t^{pay}(y, b, \frac{m}{p}), V_t^{default}(y, b, \frac{m}{p})\}$

(a) Default propensity



(b) Defaults



Summary statistics

	Mean	P10	P25	P50	P75	P90
No of liens	1.69	1	1	1	2	3
No of deposit accounts	3.97	3	3	3	5	6
Dublin (%)	51					
Borrower Age	46.32	35	40	46	52	59
Total Account Balance	8346	42.25	565.17	2230.16	8531.59	25823.85
Total Quarterly Average Account Balance	8060	245.53	619.77	2093.94	8315.22	24498.02
Current Loan-to-Value	72	7	23	59	109	156
Oustanding Balance	137508	16104	44148.76	109519.28	203884.44	300785.29
Quarterly Mortgage Payments	3050.06	973.3	1637.15	2642.15	3913.48	5656.83
Current Interest Rate (%)	4	2	5	5	5	5
Income at Origination	69796.72	31400	44632	62500	87562.18	120146.41
Quarters to Maturity	56.95	13	27	54	85	105
Tracker Rate (%)	18					
SVR Rate (%)	79					
Primary Dwelling Home (%)	83					

Comparing across asset quartiles

- Split SS distribution by asset quartiles ▸ distribution