

# Consumption Heterogeneity: Micro Drivers and Macro Implications

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We estimate the **sensitivity of consumption**  
to permanent and transitory **shocks to income**  
for **different groups** of households

# Hasn't This Been Done Before?

Yes, but...

Our **method** addresses bias in previous results

Our **data** allows sharp focus on household heterogeneity

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Time Aggregation Problem



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Our **data** allows sharp focus on household heterogeneity



Sample size in millions  
Detailed balance sheet

# Why Do We Care? (as macroeconomists)

- 1) Heterogenous agent models have testable micro behavior
- 2) Quantify Macro Implications

# Why Do We Care? (as macroeconomists)

e.g. Consumption smoothing requires liquid wealth



1) Heterogenous agent models have testable micro behavior

2) Quantify Macro Implications



e.g. Redistribution in Monetary Policy

# What do we find? (Redistribution in Monetary Policy)



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Medium MPX  
 $\approx 0.5$



High MPX  
 $\approx 0.8$

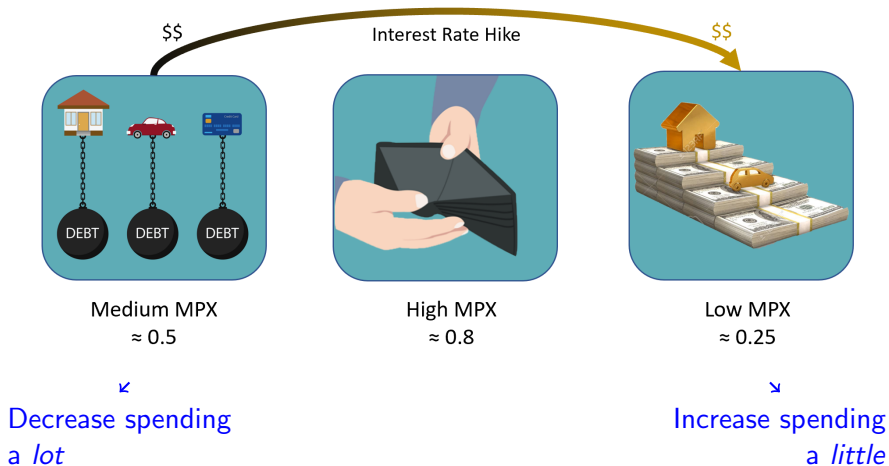


Low MPX  
 $\approx 0.25$

MPX: Marginal Propensity to eXpend (includes durables)



# What do we find? (Redistribution in Monetary Policy)



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1yr rate  $\uparrow$  1%

Aggregate Spending  $\downarrow$  26 basis points



Through this redistribution channel *alone*

# Reduced Form Approach

Identifying Restrictions on

**Income**

and

**Consumption**

In **Continuous** Time

# Reduced Form Approach

Identifying Restrictions on

**Income**  $\longrightarrow$  Permanent (random walk) shocks  
Transitory ( $<2$  years) shocks

and

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In **Continuous** Time

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Identifying Restrictions on



In **Continuous** Time

# Reduced Form Approach

Identifying Restrictions on

**Income** → Permanent (random walk) shocks  
Transitory (<2 years) shocks

and

**Consumption** → Permanent (random walk) response  
Transitory (<2 years) response

In **Continuous** Time → Time Aggregation Problem

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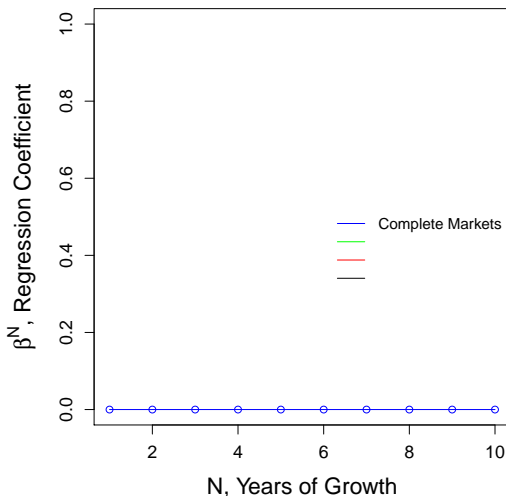
In **Continuous** Time  $\longrightarrow$  Time Aggregation Problem

But first some intuition: Naïvely Regress

Change in Consumption on Change in Income (over  $N$  years)

# Naïve Regression: Consumption Growth on Income Growth

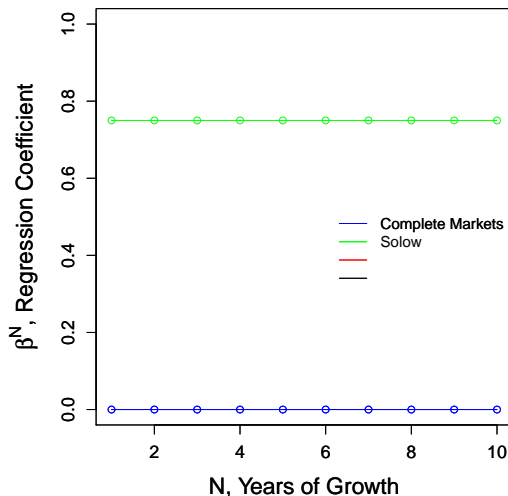
$$\Delta^N c_i = \alpha^N + \beta^N \Delta^N y_i + \varepsilon_i$$





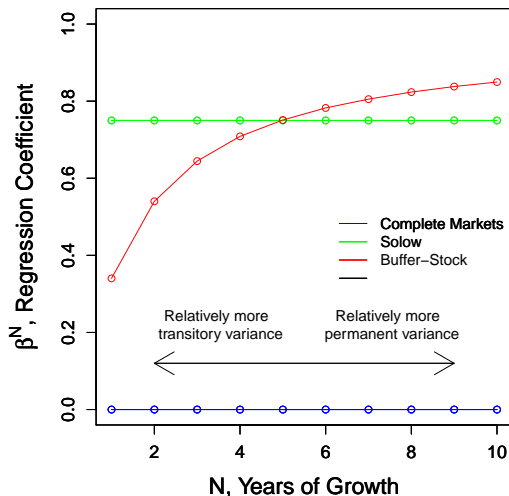
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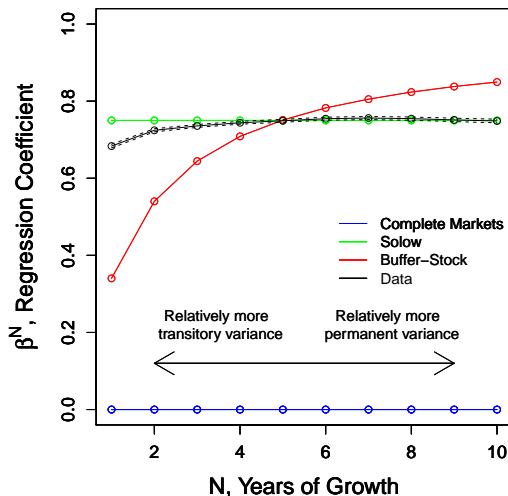
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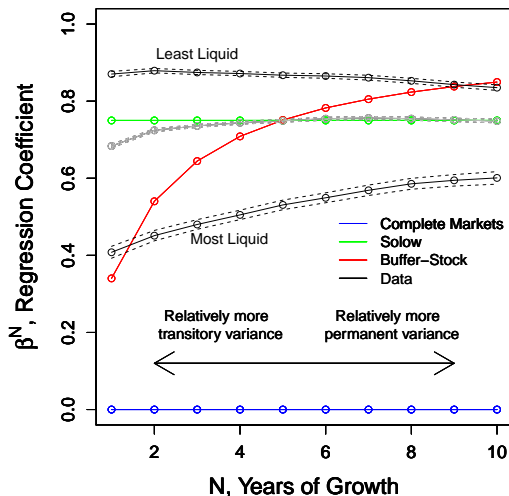
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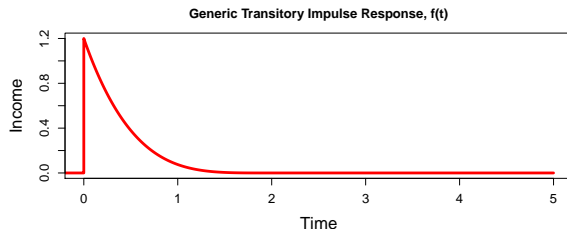
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# Identification Restrictions: Income Process

- Permanent Income (random walk)
- Transitory Income (persistence < 2 years)

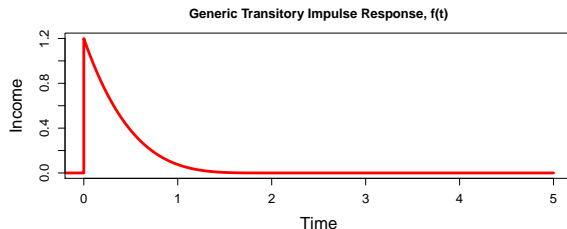


$$y_t = p_t + \int_{t-2}^t f(t-s) dq_s$$

Permanent income flow      Transitory income flow

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Observed Income

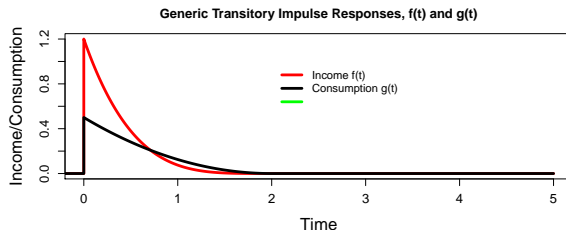
$$\bar{y}_T = \int_{T-1}^T y_t dt = \int_{T-1}^T p_t dt + \int_{T-1}^T \int_{t-2}^t f(t-s) dq_s dt$$

Time Aggregation

# Identification Restrictions: Consumption Response

- Permanent: Moves by fraction  $\phi$  of shock
- Transitory: Persistence  $< 2$  years

Evidence



$$c_t = \phi p_t + \int_{t-2}^t g(t-s) dq_s$$

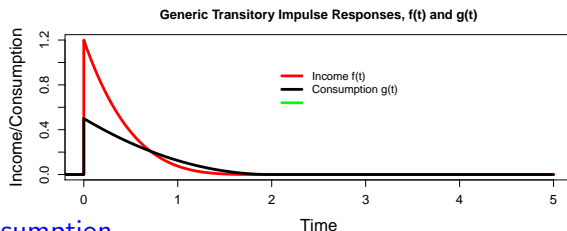
Permanent consumption flow

Transitory consumption flow

# Identification Restrictions: Consumption Response

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Evidence



Observed Consumption

$$\bar{c}_T = \int_{T-1}^T c_t dt = \int_{T-1}^T \phi p_t dt + \int_{T-1}^T \int_{t-2}^t g(t-s) dq_s dt$$

Time Aggregation



We use GMM on the equations:

$$\text{Var}(\Delta^N \bar{y}_T) = (N - \frac{1}{3})\sigma_p^2 + 2\sigma_{\tilde{q}}^2$$

$$\text{Cov}(\Delta^N \bar{c}_T, \Delta^N \bar{y}_T) = \phi(N - \frac{1}{3})\sigma_p^2 + 2\psi\sigma_{\tilde{q}}^2$$

with  $N = 3, 4, 5$  (and  $T = 2007, \dots, 2015$ ) to identify:

- $\sigma_p^2$ : Permanent shock variance
- $\sigma_{\tilde{q}}^2$ : (Time aggregated) transitory shock variance
- $\phi$ : MPX out of permanent income shocks
- $\psi$ : MPX out of transitory income shocks

where  $\psi$  is the regression coefficient of 'transitory' consumption on transitory income

## Aside: Why Not Blundell, Pistaferri and Preston 2008?

### Key to BPP Identification

Transitory shock year  $t$

$\Delta y_{t+1} = \Delta p_{t+1} + \Delta \varepsilon_{t+1}$  is a *valid instrument* for  $\varepsilon_t$



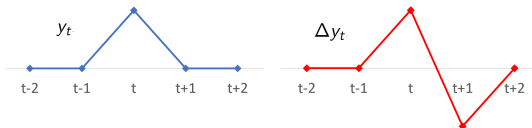
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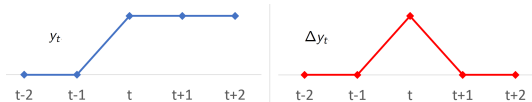
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- Uncorrelated with permanent shocks in year  $t$



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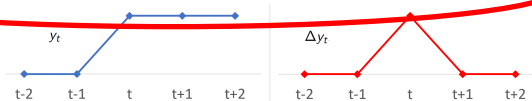
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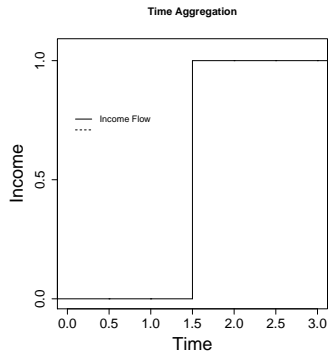


- Uncorrelated with permanent shocks in year  $t$

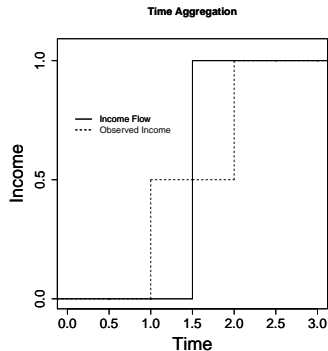


Fails due to the **Time Aggregation Problem**

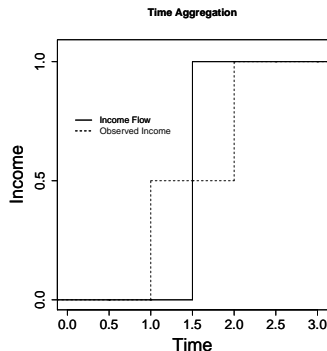
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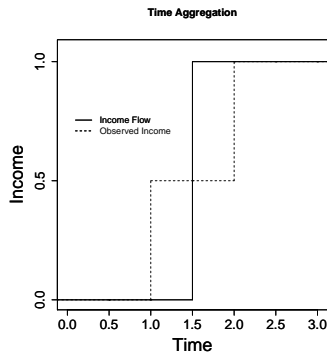
Observed permanent income growth is *positively* autocorrelated

BPP misinterprets *positive* permanent income shocks as *negative* transitory shocks

⇒ Thinks negative transitory shocks result in consumption *increasing*



# Aside: Time Aggregation Problem in BPP (Crawley 2018)



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If the Permanent Income Hypothesis holds, BPP will estimate the MPC to be -0.6

What we need:

- Panel Data on **Income** and **Expenditure**
- Household **Balance Sheets**

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What we have: Registry data for all Danish households

- **Income**

Third party reported

After-tax, restrict to heads aged 30-55

- **Balance Sheet**

Wealth on 31 Dec

Asset category, mortgage tenure

- **Expenditure**

No *direct* measure of spending

Intertemporal budget constraint

$$\text{Expenditure} = \text{Income} - \text{Saving}$$

Intertemporal budget constraint

$$\begin{aligned} \text{Expenditure} &= \text{Income} - \text{Saving} \\ &\quad \downarrow \\ &= \text{Change in Net Worth} \\ &\quad (\text{adj. for capital gains}) \end{aligned}$$

## Intertemporal budget constraint

$$\text{Expenditure} = \text{Income} - \text{Saving}$$

↓  
= Change in Net Worth  
(adj. for capital gains)

- Works well for households with simple financial lives
- Problem: Capital gains
  - Houses off balance sheet (exclude transaction years)
  - Exclude business owners
  - Capital gains based on a diversified index
- Noisy, but perhaps better than surveys (Kuchler et al. 2018)
- Huge sample size advantage: sample covers 7.6 million observations over 2004-2015

### Summary Statistics

# Data: When is Measurement Error a Problem?

We have the same issues as the regression:

$$\Delta c_i = \alpha + \beta \Delta y_i + \varepsilon_i$$

That is measurement error in:

$\Delta y_i$  leads to attenuation bias

$\Delta c_i$  should be uncorrelated with  $\Delta y_i$

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High quality income data

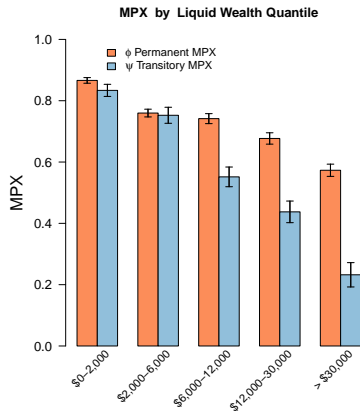
$\Delta c_i$  should be uncorrelated with  $\Delta y_i$

When might this fail?

- Off balance sheet saving
- Returns correlated with *changes* in income (e.g. stock compensation)
- When insurance is provided by friends and family

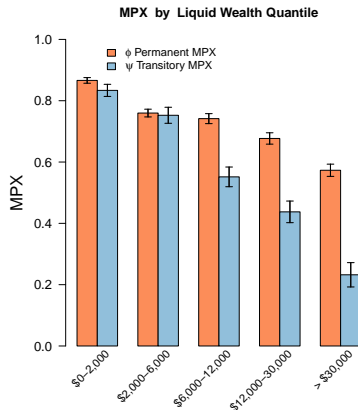
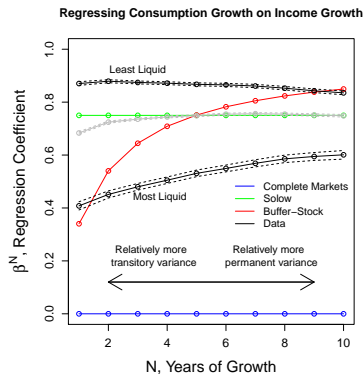


# Results by Liquid Wealth



MPX by Net Wealth

# MPX Results are Robust to Misspecification



MPX by Net Wealth

# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

# Monetary Policy: Auclert's Decomposition

→ Dominates in Rep. Agent NK models

How does Monetary Policy Effect Aggregate Consumption?

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→ Large in Spender-Saver, or TANK models

# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
  - Aggregate Income
  - Fisher (Inflationary debt relief)
  - Earnings Heterogeneity
  - Interest Rate Exposure
- } Representative Agent Channels
- } Redistribution Channels

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How can we *empirically* measure the size of the redistribution channels?

Need to know the distribution of MPCs along the relevant dimension of redistribution

## **Key assumption:**

Households treat redistribution like an income shock

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## Experiment

Short term real interest rate  $\uparrow 1\%$  for 1 year

Hold constant income and inflation

How does subsequent **redistribution** impact **aggregate consumption**?

Dimension of Redistribution: **Unhedged Interest Rate Exposure**



# Interest Rate Exposure: Dimension of Redistribution

Define **Unhedged Interest Rate Exposure** for household  $i$  as the total savings the household will invest at this year's interest rate:

$$URE_i = Y_i - C_i + A_i - L_i$$

Where

- $Y_i$  = Total after tax income
- $C_i$  = Total Expenditure, including interest payments
- $A_i$  = Maturing assets
- $L_i$  = Maturing liabilities

Following a change in the interest rate  $dR$ , the size of the Interest Rate Exposure channel on household  $i$ 's expenditure is:

$$dc_i = MPC_i URE_i \frac{dR}{R}$$

# Interest Rate Exposure: Aggregation

Aggregate to find size of channel:

$$\begin{aligned} dc_i &= MPC_i URE_i \frac{dR}{R} \\ \Rightarrow \frac{dC}{C} &= \mathbb{E}_I \left( MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)} \right) \frac{dR}{R} \end{aligned}$$

Define sufficient statistic:

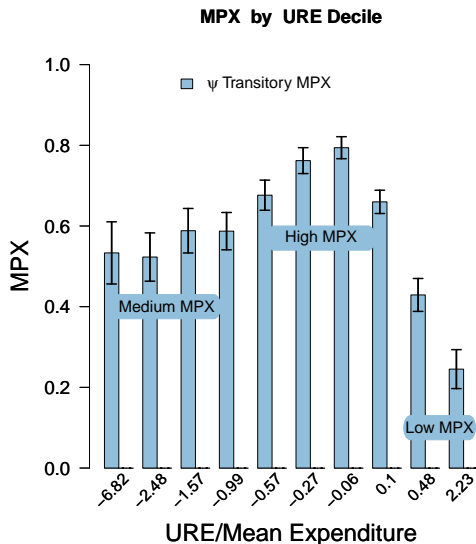
$$\mathcal{E}_R = \mathbb{E}_I \left( MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)} \right)$$

$\Rightarrow$  Need to know the distribution of  $MPC_i$  with  $URE_i$

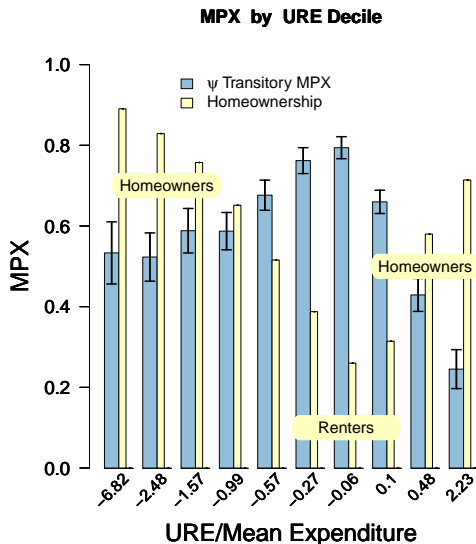
We can do that!

Out of Sample Assumptions

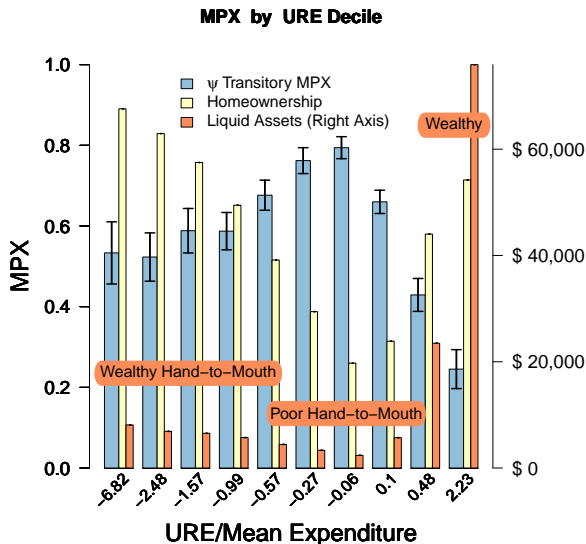
# Interest Rate Exposure: MPX Distribution



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# All Five Transmission Channels

$$\frac{dC}{C} = \underbrace{\mathcal{M} \frac{dY}{Y}}_{\text{Aggregate Income Channel}} + \underbrace{\mathcal{E}_R \frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} + \underbrace{+\gamma \mathcal{E}_Y \frac{dY}{Y}}_{\text{Earnings Heterogeity Channel}} + \underbrace{-\sigma \mathcal{S} \frac{dR}{R}}_{\text{Intertemporal Substitution Channel}} + \underbrace{-\mathcal{E}_P \frac{dP}{P}}_{\text{Fisher Channel}}$$

---

$\mathcal{M}$	0.52
$\mathcal{E}_Y$	-0.03
$\mathcal{E}_P$	-0.75
$\mathcal{E}_R$	-0.26
$\mathcal{S}$	0.49

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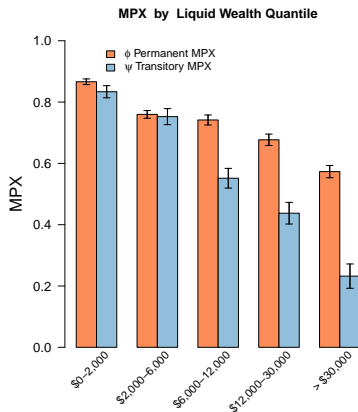
Compare  $\mathcal{E}_R$  to  $\sigma S$ :

$\sigma \approx 0.1$  Best, Cloyne, Ilzetzki, and Kleven (2018)

$$\sigma S \approx 0.05$$

# Aim of Modeling Exercise

Can we calibrate a standard Buffer-Stock saving model to fit the distribution of MPC with liquid wealth?



Key features:

- High overall Transitory MPC
- Decreasing with liquid wealth



Households maximize expected utility

$$\mathbb{E}_t \sum_{i=t}^{\infty} \beta^i u(\mathbf{c}_i)$$

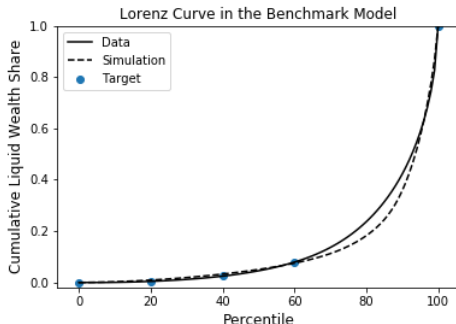
with:

- Permanent and Transitory shocks to income (calibrated to Danish data)
- Saving in one (liquid) asset
- No borrowing
- CRRA utility,  $\rho = 2$

# Benchmark Model: Fitting the Liquid Wealth Distribution

Ex-ante heterogeneity in the discount rate

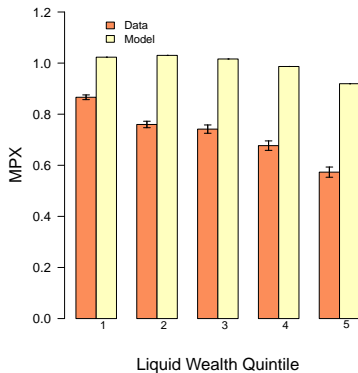
$\beta^i \sim \text{Unif}[\beta_{\text{low}}, \beta_{\text{high}}]$  Chosen to fit level and distribution of liquid wealth (especially at the low end)



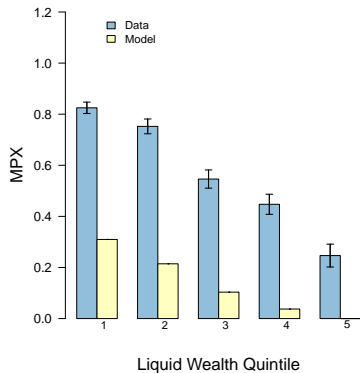
# Benchmark Model: Results

Simulate panel of data and estimate  $\phi$  and  $\psi$

Permanent MPX by Liquid Wealth Quintile: Model vs Data



Transitory MPX by Liquid Wealth Quintile: Model vs Data



First order problem: Transitory MPCs are too low

Need to lower  $\beta$ 's without reducing savings

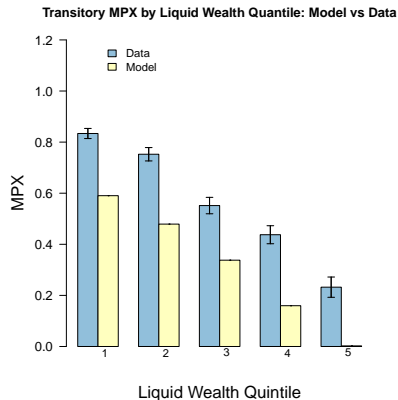
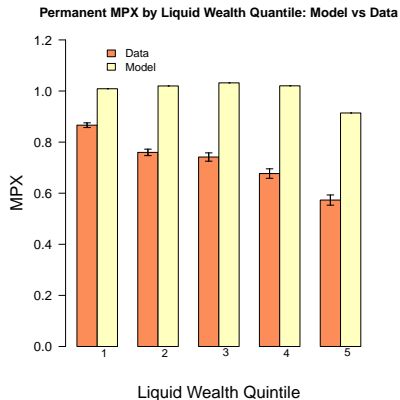
Is income risk the only source of precautionary saving?

- In the data, expenditure FAR for volatile than income
- Surprise expenses can be large

Simple extension - add large preference shocks

$$\mathbb{E}_t \sum_{i=t}^{\infty} \beta^i \chi_i u(\mathbf{c}_i)$$

# Preference Shock Model: Results



- We have designed a new method to estimate consumption responses to income shocks
- It appears to work well, both in theory and practice
- We can use it to show that heterogeneity plays a key role in monetary policy transmission

Thank you!

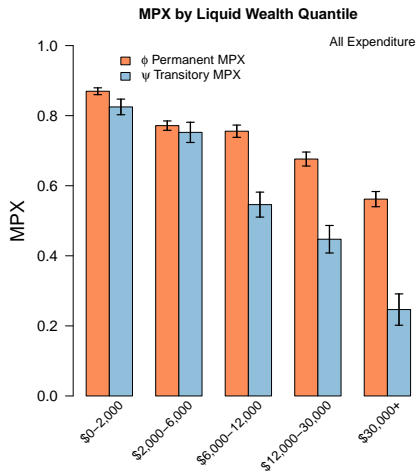
We have data on value of household cars

- Construct expenditure excluding car purchases and sales

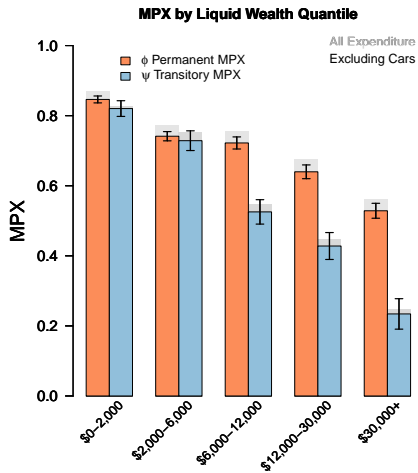
$$C_T^{\text{nocar}} = C_T - \Delta\text{CarValue}$$

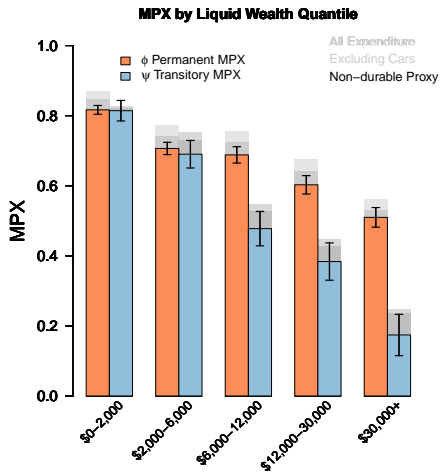
- Construct proxy for non durable consumption (Cars  $\approx$  42.1% durable expenditure)

$$C_T^{\text{nondurable}} = C_T - \frac{1}{0.421} \Delta\text{CarValue}$$



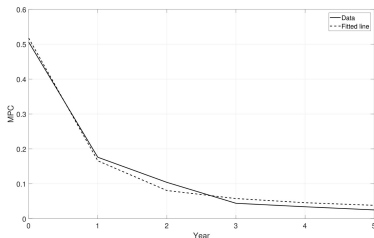






# Evidence of Consumption Decay Within 2 Years

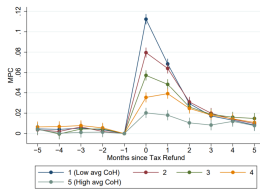
From Fagereng, Holm,  
and Natvik (2016)



Back

From Gelman (2016)

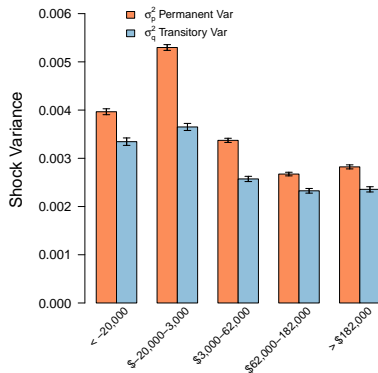
Figure 10: Tax refund impulse response function



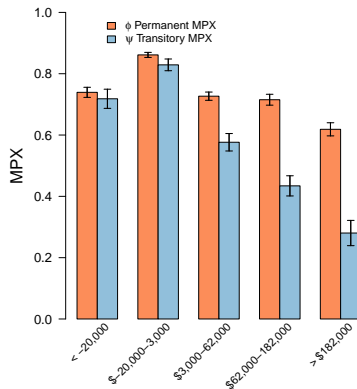
Notes: 1,445,560 observations from 48,050 individuals. The vertical bars on each coefficient represent 95% confidence intervals using heteroskedasticity robust errors clustered at the individual level.

# MPX by Net Wealth

Permanent and Transitory Variance by Net Wealth Quantile



MPX by Net Wealth Quantile



Back

# Interest Rate Exposure: Out of Sample

*Total* URE sums to zero - this is not true for our household sample

	MPX	URE	$\mathcal{E}_R$ component
<b>Estimation Sample</b>	<b>See Distribution</b>	<b>-61</b>	<b>-0.29</b>
Young	0.5	-15	-0.06
Old	0.5	6	0.02
Pension Funds	0.1	37	0.03
Government	0.0	-23	0.00
Non-financial Corp.	0.1	-13	-0.01
Financial Sector	0.1	61	0.05
Rest of World	0.0	9	0.00
<b>Total</b>		<b>0</b>	<b>-0.26</b>

**Notes:** URE numbers are in billions of 2015 USD.

[Back](#)

# Summary Statistics

	Estimation Sample			Population (Age 30-55)		
	Mean	Median	Std Dev	Mean	Median	Std Dev
After Tax Income	59,261	57,804	28,819	58,312	53,304	68,799
Consumption	52,680	48,344	28,581	54,022	46,373	38,126
Liquid Assets	18,438	6,856	33,016	23,331	6,578	81,473
Net Worth	74,937	19,115	157,295	85,799	12,952	564,404
Homeowner	0.57	1.00	0.50	0.50	1.00	0.50
Car Owner	0.66	1.00	0.47	0.55	1.00	0.50
Higher Education	0.31	0.00	0.46	0.33	0.00	0.47
Age	43.5	44.0	7.1	42.5	42.0	7.3
URE	-28,052	-12,627	108,382	-47,589	-19,374	243,604
NNP	-109,685	-65,810	156,523	-158,321	-85,207	542,498
No. Household-year obs	7,664,360			18,050,340		

**Notes:** Values are 2015 USD. Age refers to the age in 2008 of the main income earner in the household. For the purposes of calculation of consumption in the population, top and bottom 1% in terms of consumption have been excluded. URE and NNP can only be calculated in the period 2009-2015 due to mortgage information being insufficiently detailed in the previous years.

Back