# Consumption Heterogeneity:
# Micro Drivers and Macro Implications

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SAIS October 10, 2018

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

# Hasn't This Been Done Before?

Yes, but...

Time Aggregation Problem

Our **method** addresses bias in previous results

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

Sample size in millions
Detailed balance sheet

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# 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

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

Medium MPX
≈ 0.5

High MPX
≈ 0.8

Low MPX
≈ 0.25

MPX: Marginal Propensity to eXpend (includes durables)

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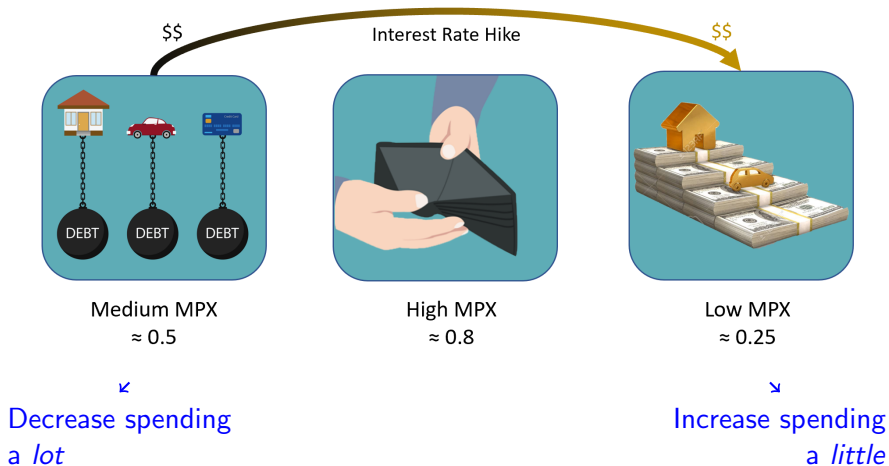


$$ Interest Rate Hike

**Medium MPX**
≈ 0.5

**High MPX**
≈ 0.8

**Low MPX**
≈ 0.25

Decrease spending
a *lot*

Increase spending
a *little*

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Interest Rate Hike

$$                                                                    $$

Medium MPX
≈ 0.5

High MPX
≈ 0.8

Low MPX
≈ 0.25

1yr rate ↑ 1%

*Aggregate* Spending ↓ 26 basis points

↙

Through this redistribution channel *alone*

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# Reduced Form Approach

Identifying Restrictions on

**Income**

and

**Consumption**

In **Continuous** Time

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# Reduced Form Approach

Identifying Restrictions on

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

and

**Consumption**

In **Continuous** Time

5

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Identifying Restrictions on

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

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**Consumption** $\longrightarrow$   Permanent   (random walk)   response
                                    Transitory   (<2 years)   response

In **Continuous** Time

# Reduced Form Approach

Identifying Restrictions on

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

and

**Consumption** $\longrightarrow$ Permanent (random walk) response
Transitory ($<$2 years) response

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

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# Reduced Form Approach

Identifying Restrictions on

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

and

**Consumption** $\longrightarrow$ Permanent (random walk) response
Transitory ($<$2 years) response

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

But first some intuition: Naïvely Regress

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

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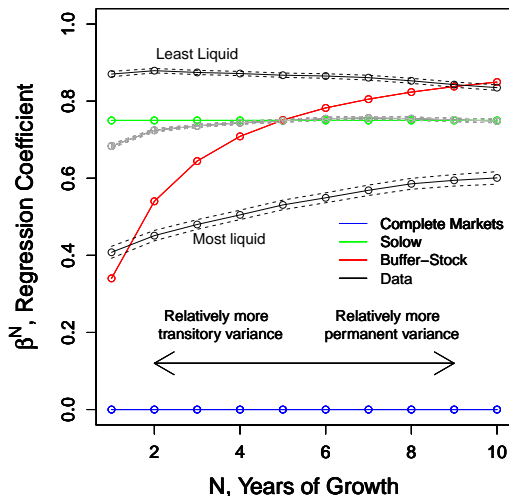oooo           ●oooooo              ooo    oo              ooooooo           oooooo  o

# Naïve Regression: Consumption Growth on Income Growth

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

# Naïve Regression: Consumption Growth on Income Growth

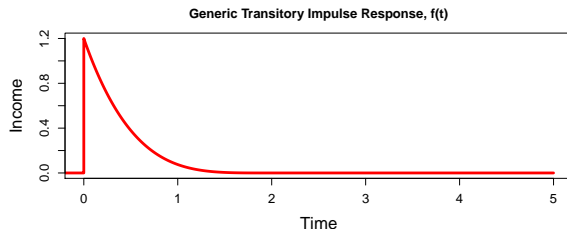$$\Delta^N c_i = \alpha^N + \beta^N \Delta^N y_i + \varepsilon_i$$

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# 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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# Naïve Regression: Consumption Growth on Income Growth

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# Identification Restrictions: Income Process

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



**Generic Transitory Impulse Response, f(t)**

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

Permanent income flow          Transitory income flow

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# Identification Restrictions: Income Process

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



Generic Transitory Impulse Response, f(t)

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

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# Identification Restrictions: Consumption Response

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



**Generic Transitory Impulse Responses, f(t) and g(t)**

Income/Consumption vs Time

- Income f(t)
- Consumption g(t)

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

<span style="color:blue">Permanent consumption flow</span>    <span style="color:blue">Transitory consumption flow</span>

# Identification Restrictions: Consumption Response

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

<span style="background:#9a8fb5;color:white;border-radius:10px;padding:2px 8px">Evidence</span>



Generic Transitory Impulse Responses, f(t) and g(t)

Observed Consumption

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

$\downarrow$

Time Aggregation

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# Full Identification

We use GMM on the equations:

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

$$\mathrm{Cov}(\Delta^N \bar{c_T}, \Delta^N \bar{y_T}) = \phi(N - \frac{1}{3})\sigma_p^2 + 2\psi\sigma_{\tilde{q}}^2$$

with $N = 3, 4, 5$ (and $T = 2007, .., 2015$) 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

**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 $\varepsilon_t$
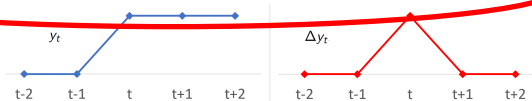
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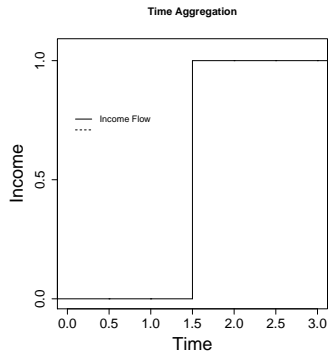
- Negatively correlated with transitory shocks in year $t$

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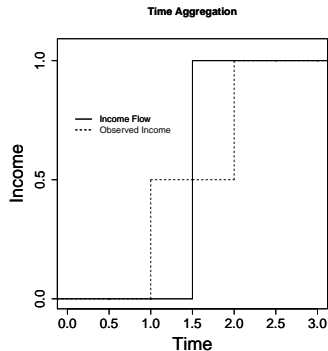


- Uncorrelated with permanent shocks in year $t$



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**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 $\varepsilon_t$

- Negatively correlated with transitory shocks in year $t$



- Uncorrelated with permanent shocks in year $t$



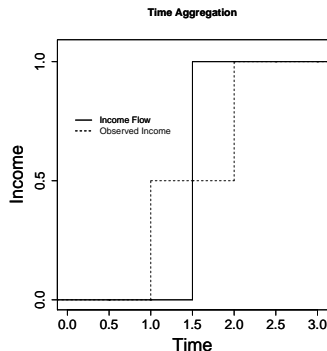Fails due to the **Time Aggregation Problem**

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Time Aggregation

Time Aggregation

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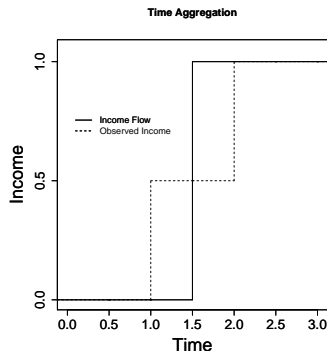| Introduction | Empirical Strategy | Data | Liquid Wealth | Monetary Policy | Model | Conclusion |
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Observed permanent income growth is *positively* autocorrelated

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

$\implies$ Thinks negative transitory shocks result in consumption *increasing*

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Time Aggregation

Observed permanent income growth is *positively* autocorrelated

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

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## Data

What we need:

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

What we need:

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

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

## Data: Expenditure

Intertemporal budget constraint

Expenditure $\quad=\quad$ Income $\quad-\quad$ Saving

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## Data: Expenditure

Intertemporal budget constraint

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

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

# Data: Expenditure

Intertemporal budget constraint

| Expenditure | = | Income | − | Saving |
|---|---|---|---|---|

$$= \text{Change in Net Worth}$$
$$\text{(adj. for capital gains)}$$

- 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

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## 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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# 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 ↗ 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

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# Results by Liquid Wealth

**Permanent and Transitory Variance by Liquid Wealth Quantile**



**MPX by Liquid Wealth Quantile**



MPX by Net Wealth

# MPX Results are Robust to Misspecification



Regressing Consumption Growth on Income Growth

$\beta^N$, Regression Coefficient

N, Years of Growth

Least Liquid

Most liquid

Relatively more transitory variance

Relatively more permanent variance

Complete Markets
Solow
Buffer-Stock
Data



MPX by Liquid Wealth Quantile

MPX

$\phi$ Permanent MPX
$\psi$ Transitory MPX

$0-2,000
$2,000-6,000
$6,000-12,000
$12,000-30,000
> $30,000

MPX by Net Wealth

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# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

$\Big\}$ Representative Agent Channels

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# Monetary Policy: Auclert's Decomposition

Dominates in Rep. Agent NK models

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

$\left.\right\}$ Representative Agent Channels

Large in Spender-Saver, or TANK models

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# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
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} Representative Agent Channels

- Fisher (Inflationary debt relief)
- Earnings Heterogeneity
- Interest Rate Exposure

} Redistribution Channels

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# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

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

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

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

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**Key assumption:**
Households treat redistribution like an income shock

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Households treat redistribution like an income shock

**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**

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## 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:

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

$$\implies \frac{dC}{C} = \mathbb{E}_I \Big( MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)} \Big) \frac{dR}{R}$$

Define sufficient statistic:

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

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

We can do that!

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# Interest Rate Exposure: MPX Distribution



MPX by URE Decile

ψ Transitory MPX

High MPX

Medium MPX

Low MPX

MPX

URE/Mean Expenditure

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MPX by URE Decile

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MPX by URE Decile

# 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 |
|-----------------------|-------------------|-----|---------------------------|
| **Estimation Sample** | **See Distribution** | **-61** | **-0.29** |
| 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  |
| **Total**             |                   | **0** | **-0.26** |

Notes: URE numbers are in billions of 2015 USD.

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# All Five Transmission Channels

$$\frac{dC}{C} = \overbrace{\mathcal{M}\frac{dY}{Y}}^{\text{Aggregate Income Channel}} \quad \overbrace{+\gamma\mathcal{E}_Y\frac{dY}{Y}}^{\text{Earnings Heterogeity Channel}} \quad \overbrace{-\mathcal{E}_P\frac{dP}{P}}^{\text{Fisher Channel}}$$

$$\underbrace{+\mathcal{E}_R\frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} \quad \underbrace{-\sigma\mathcal{S}\frac{dR}{R}}_{\text{Intertemporal Substitution Channel}}$$

| | |
|---|---|
| $\mathcal{M}$ | 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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$$\frac{dC}{C} = \overbrace{\mathcal{M}\frac{dY}{Y}}^{\text{Aggregate Income Channel}} \qquad \overbrace{+\gamma\mathcal{E}_Y\frac{dY}{Y}}^{\text{Earnings Heterogeity Channel}} \qquad \overbrace{-\mathcal{E}_P\frac{dP}{P}}^{\text{Fisher Channel}}$$

$$\underbrace{+\mathcal{E}_R\frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} \qquad \underbrace{-\sigma\mathcal{S}\frac{dR}{R}}_{\text{Intertemporal Substitution Channel}}$$

| | |
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| $\mathcal{M}$ | 0.52 |
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| $\mathcal{S}$ | 0.49 |

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?



**MPX by Liquid Wealth Quantile**

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, $\rho = 2$

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# 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)



Lorenz Curve in the Benchmark Model

# Benchmark Model: Results

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



Permanent MPX by Liquid Wealth Quantile: Model vs Data



Transitory MPX by Liquid Wealth Quantile: Model vs Data

## Taste Shock Model

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 taste shocks

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

# Taste Shock Model: Results



**Permanent MPX by Liquid Wealth Quantile: Model vs Data**

**Transitory MPX by Liquid Wealth Quantile: Model vs Data**

# Conclusion

- 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!

# Durables

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)

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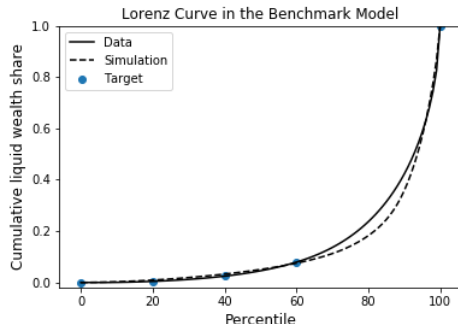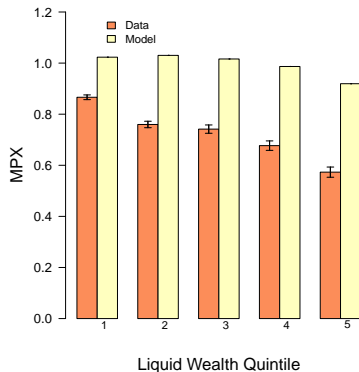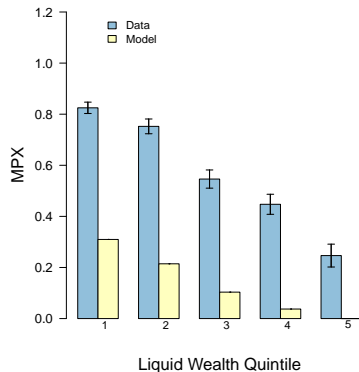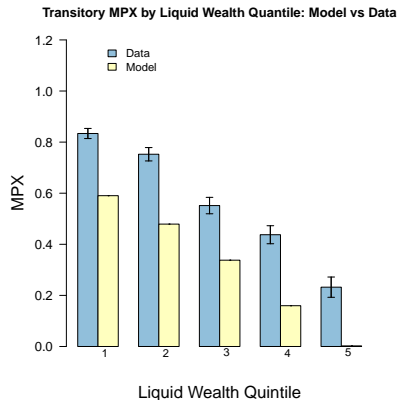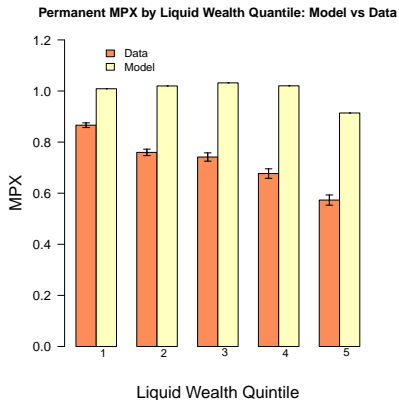
# Durables



**MPX by Liquid Wealth Quantile**

All Expenditure

# Durables



MPX by Liquid Wealth Quantile

# Durables



MPX by Liquid Wealth Quantile
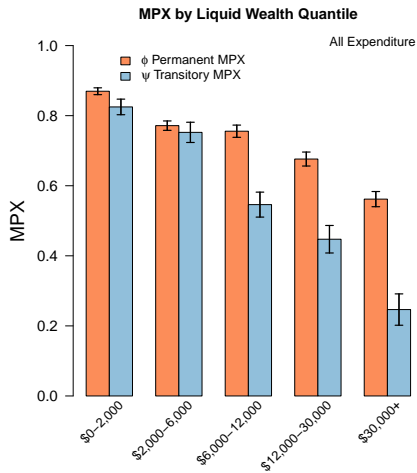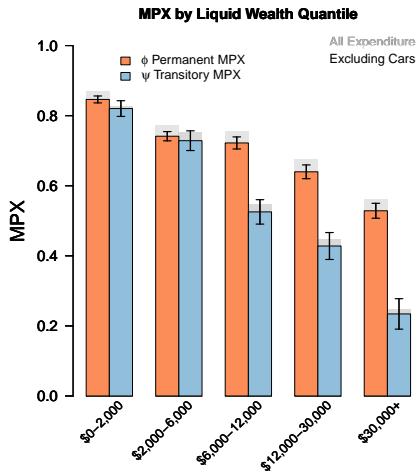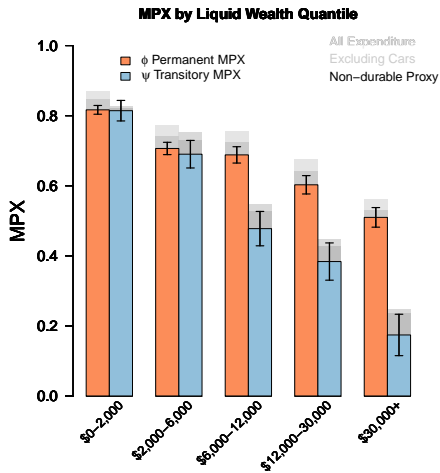
From Fagereng, Holm,
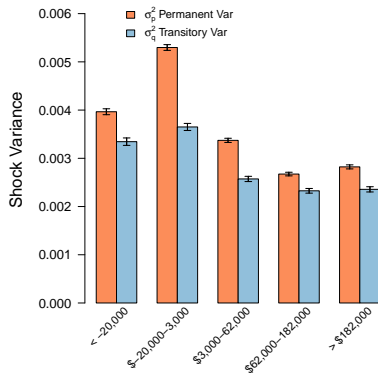and Natvik (2016)
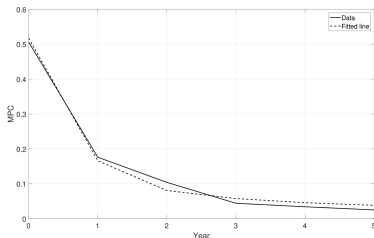


From Gelman (2016)



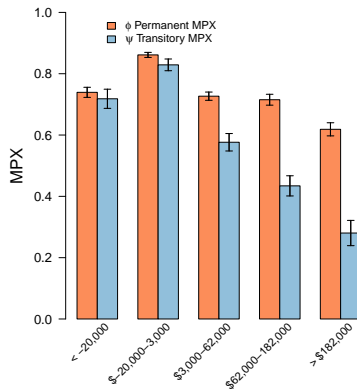Figure 10: Tax refund impulse response function
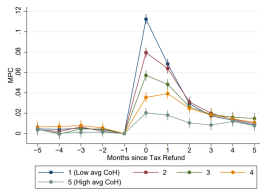
Notes: 1,445,560 observations from 48,059 individuals. The vertical bars on each
coefficient represent 95% confidence intervals using heteroskedasticity robust errors
clustered at the individual level.

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# MPX by Net Wealth



**Permanent and Transitory Variance by Net Wealth Quantile**

**MPX by Net Wealth Quantile**

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