# Consumption Heterogeneity: Micro Drivers and Macro Implications

Edmund Crawley & Andreas Kuchler

# What Do We Do?

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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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

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e.g. Redistribution in Monetary Policy

# What do we find? (Liquid Wealth)

Low Liquid Wealth Households:

- Hand-to-Mouth
- Spend 85 cents out of every marginal dollar, both transitory and permanent

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High Liquid Wealth Households:

- Large Response to Transitory Shocks (25 cents per dollar)
- Small Response to Permanent Shocks (60 cents per dollar)

relative to Permanent Income Hypothesis or Buffer-Stock models

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


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Medium MPX
≈ 0.5

High MPX
≈ 0.8

Low MPX
≈ 0.25

MPX: Marginal Propensity to eXpend (includes durables)

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


Medium MPX
≈ 0.5

High MPX
≈ 0.8

Low MPX
≈ 0.25

↙

Decrease spending
a *lot*

↘

Increase spending
a *little*

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


1yr rate $\uparrow$ 1%

*Aggregate* Spending $\downarrow$ 26 basis points

Through this redistribution channel *alone*

# How Do We Do This? Reduced Form Approach

Identifying Restrictions on

**Income**

and

**Consumption**

In **Continuous** Time

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**Income** → Permanent (random walk) shocks
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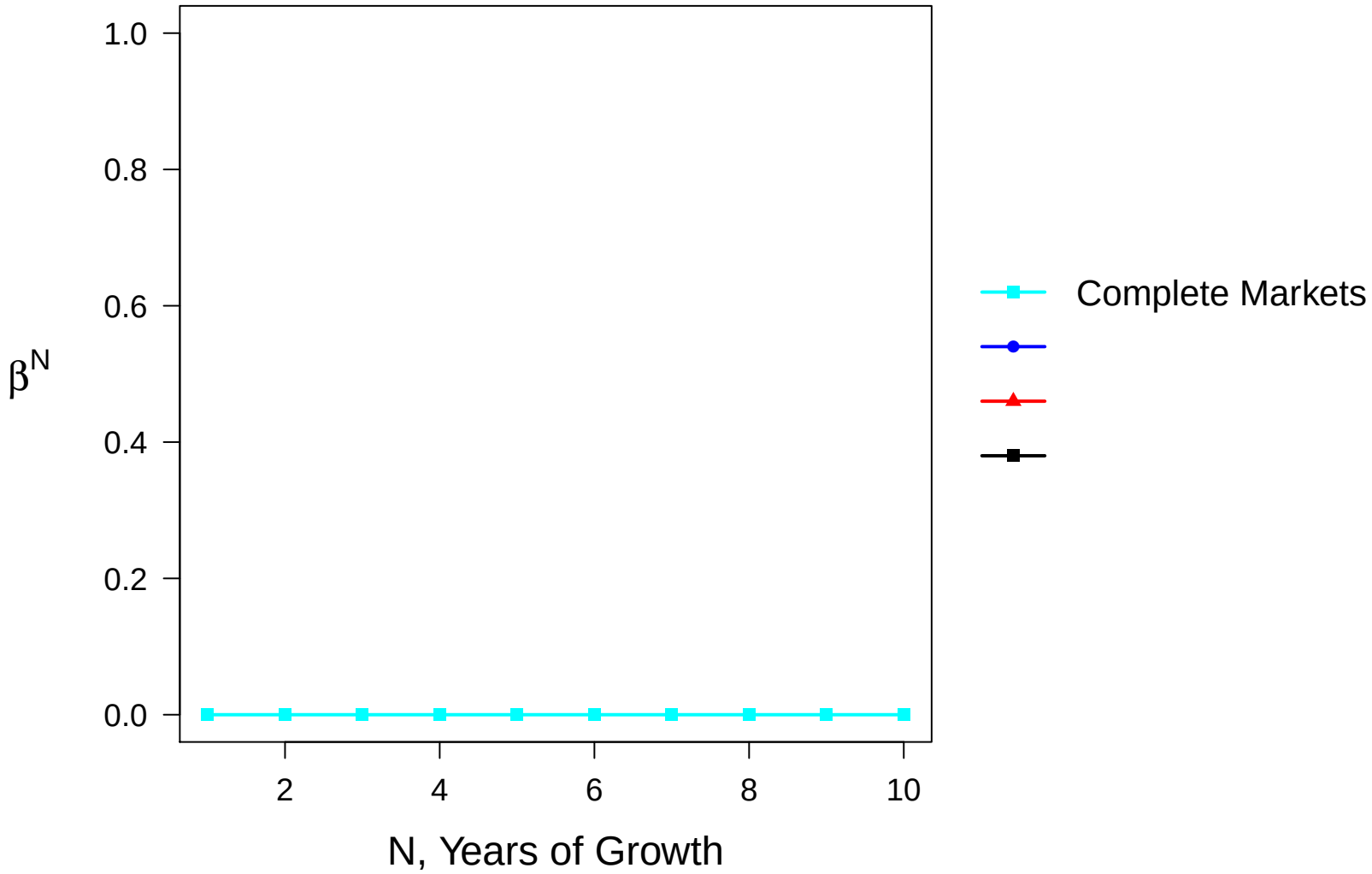
In **Continuous** Time ⟶ Time Aggregation Problem

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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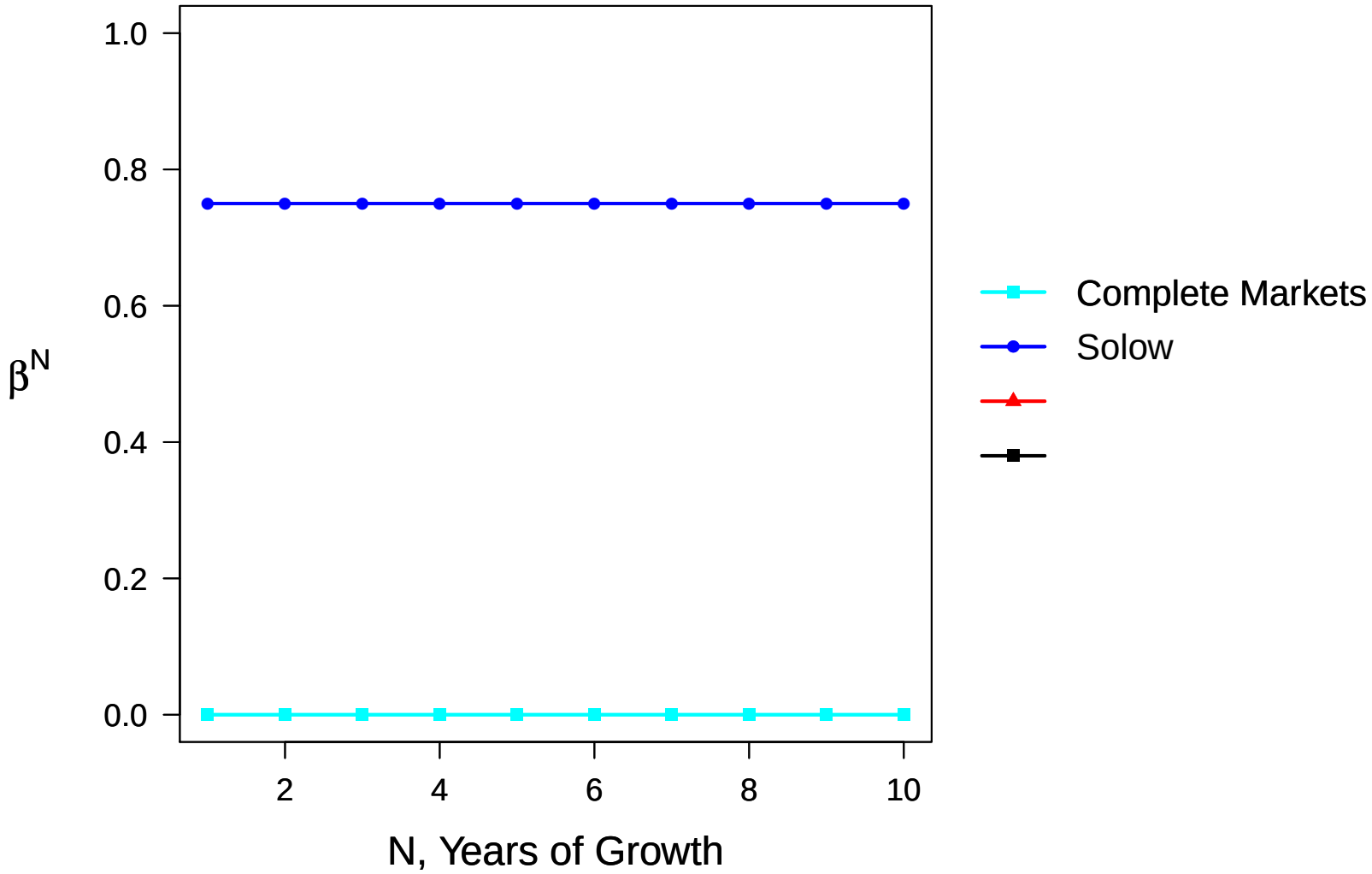

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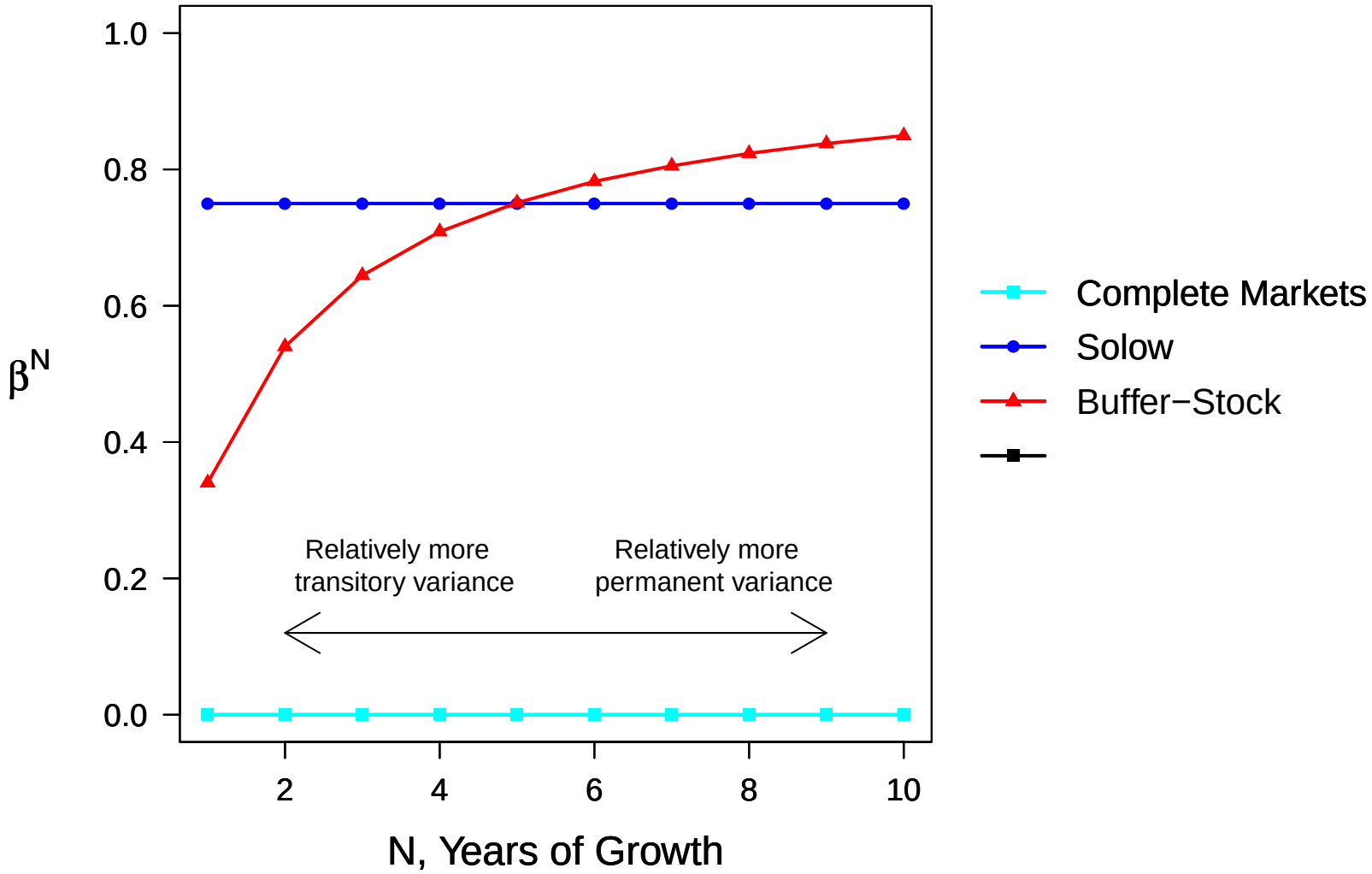

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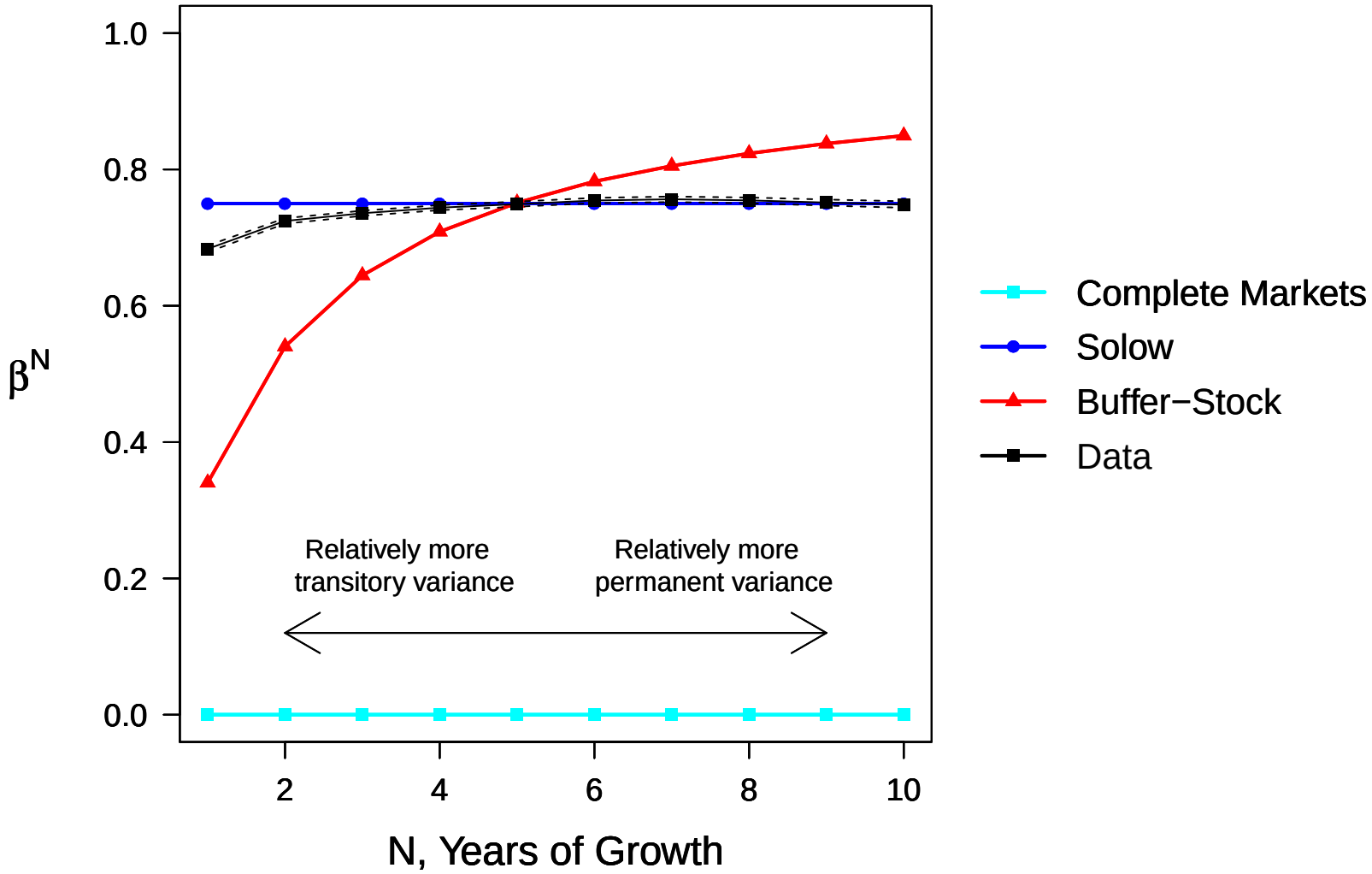

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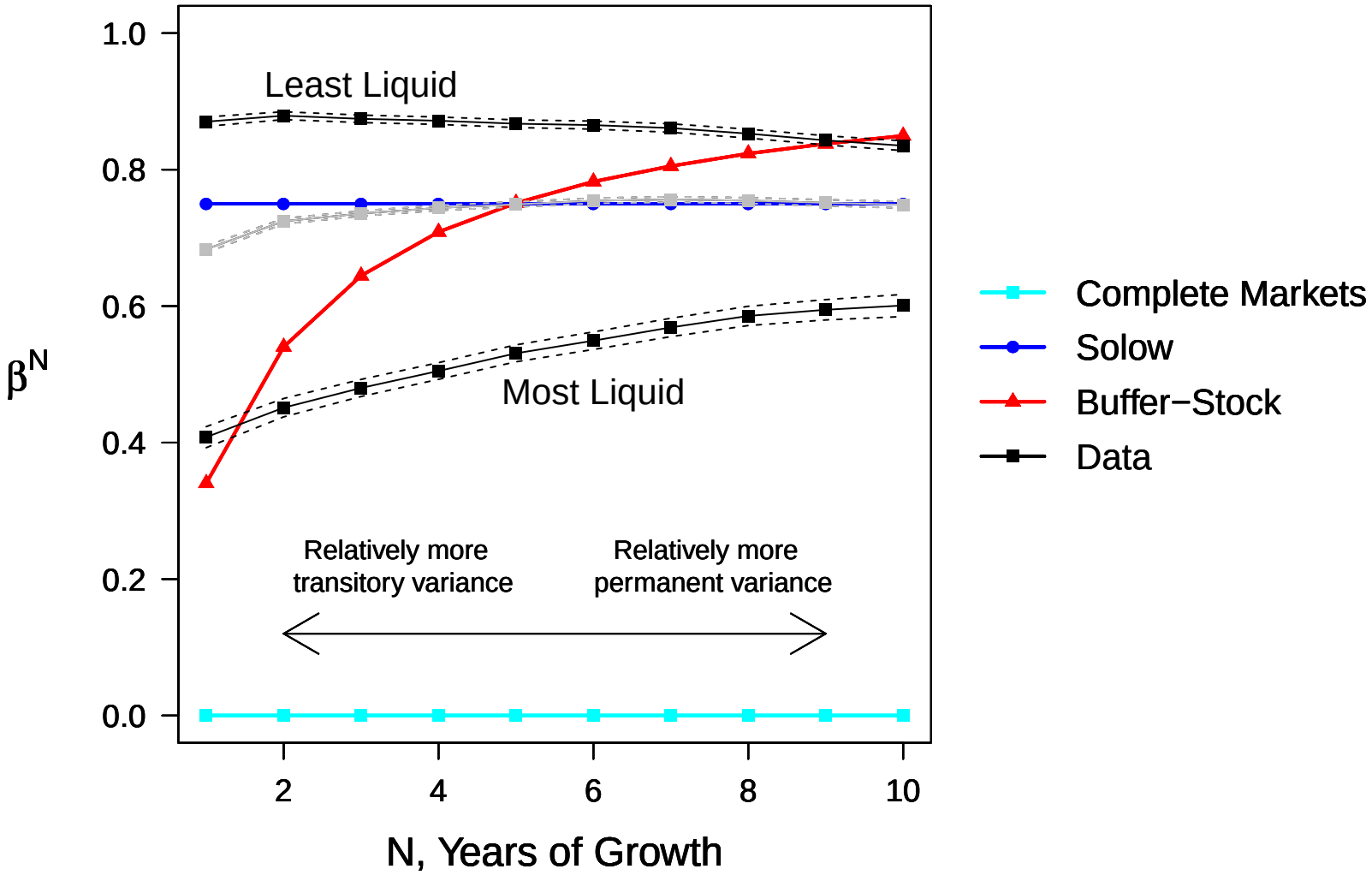
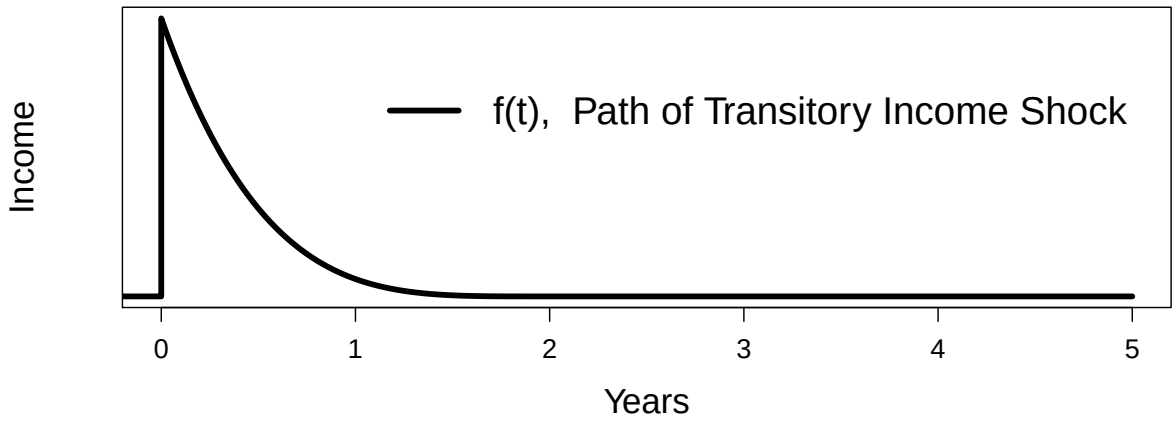


# Identification Restrictions: Income Process

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



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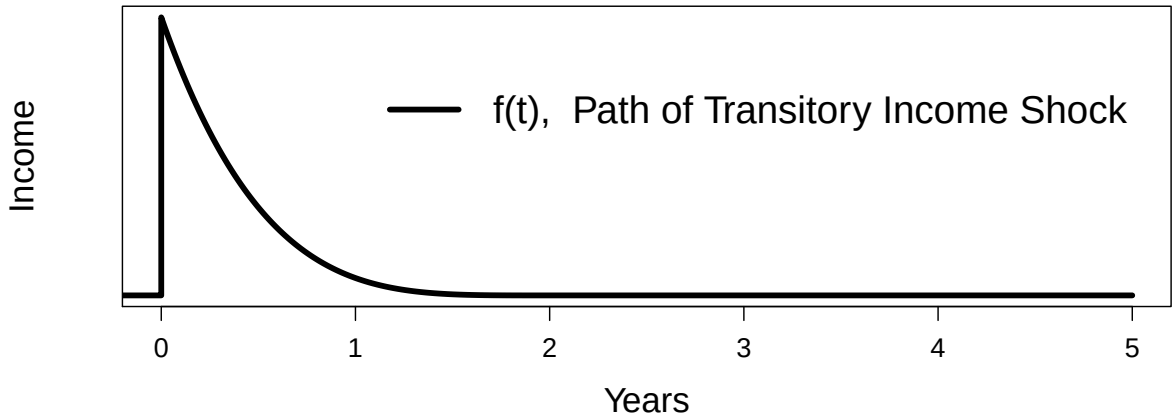


$$y_t = p_t + \int_{t-2}^{t} f(t-s)dq_s$$

Permanent income flow

Transitory income flow

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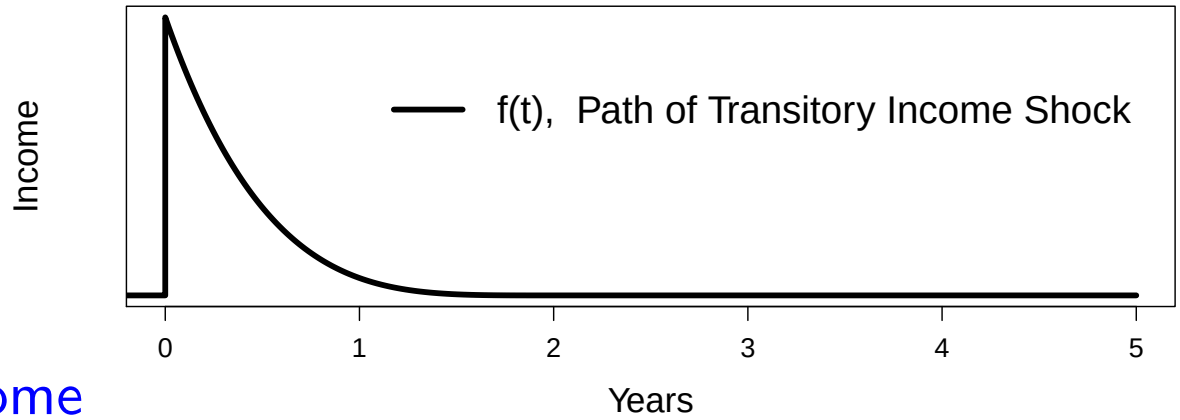



Observed Income

$$\uparrow$$

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

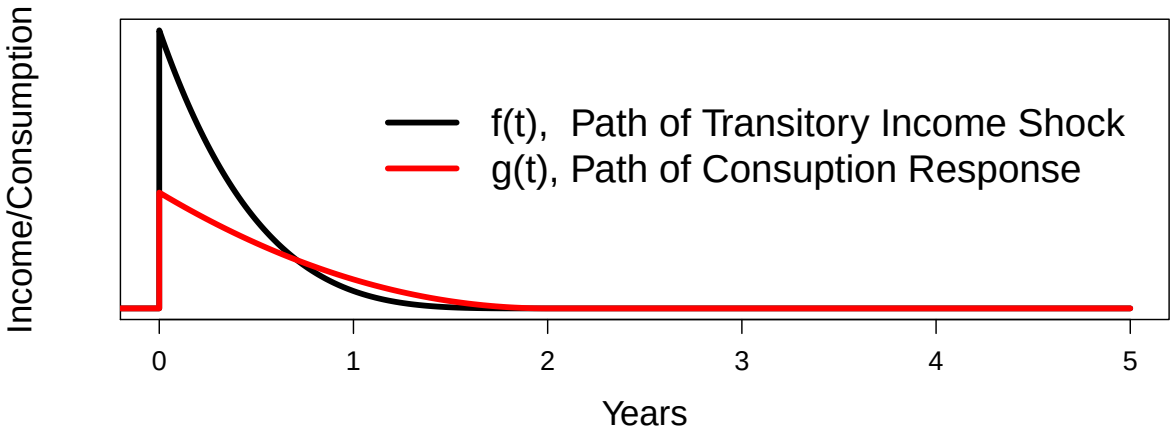
$$\downarrow$$

Time Aggregation

# Identification Restrictions: Consumption Response

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

Evidence



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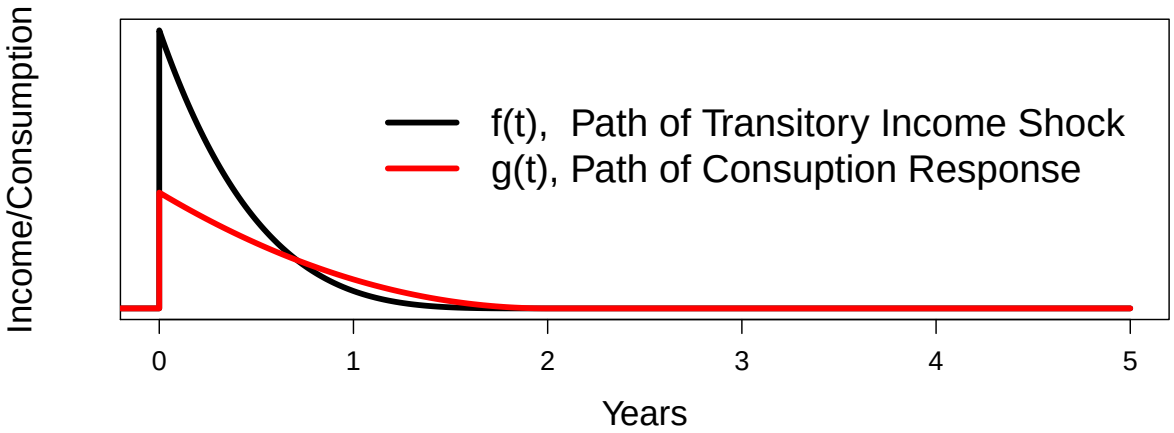


$$c_t = \phi p_t + \int_{t-2}^{t} g(t-s)dq_s$$

Permanent consumption flow

Transitory consumption flow

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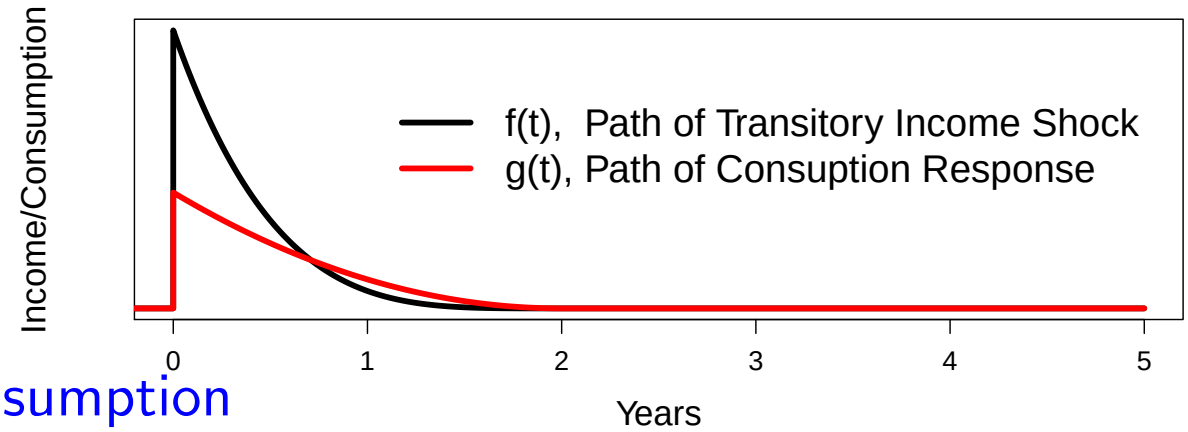


Observed Consumption

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

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Time Aggregation

# Full Identification

We use GMM on the equations:

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

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

# 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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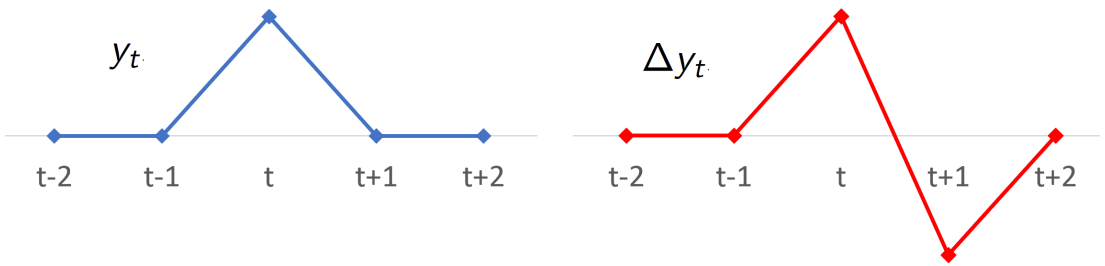

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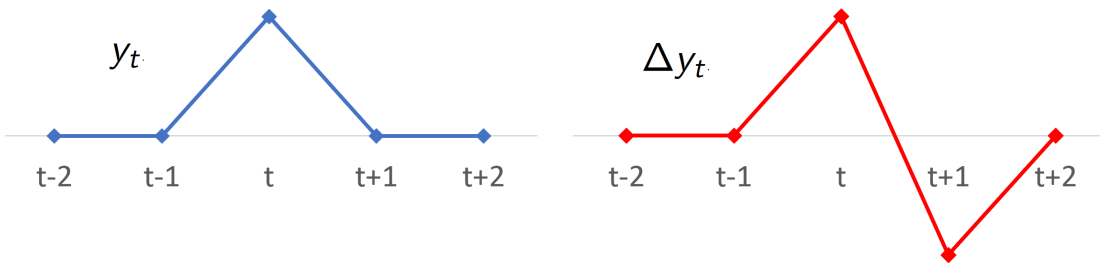


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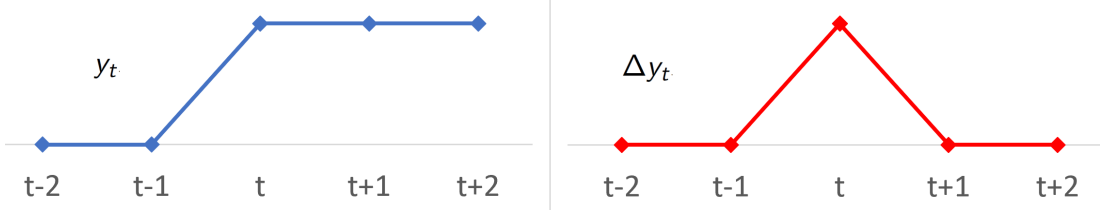

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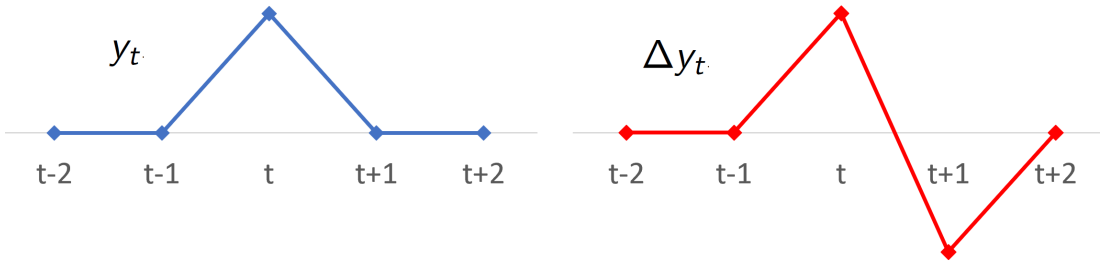


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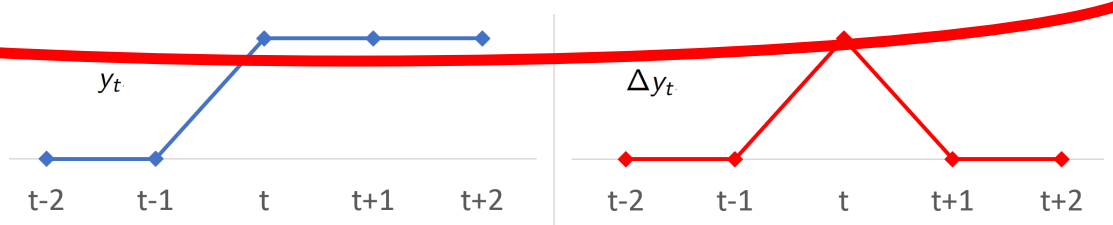
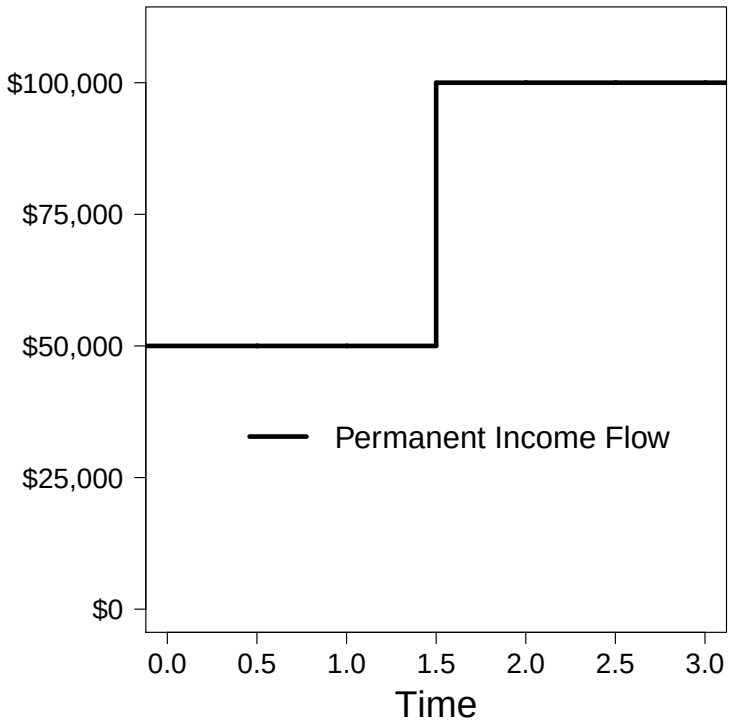



Fails due to the **Time Aggregation Problem**

# Time Aggregation Problem in BPP (Crawley 2018)



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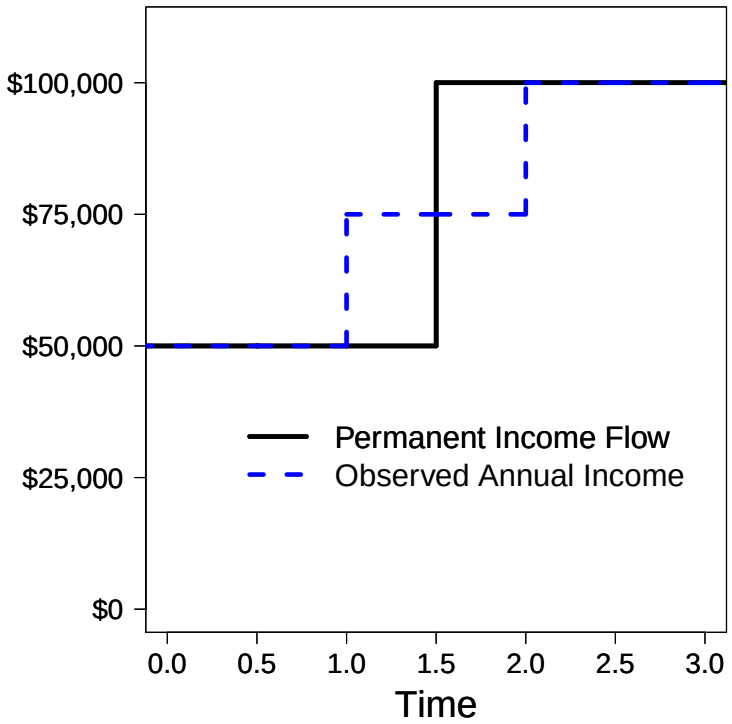

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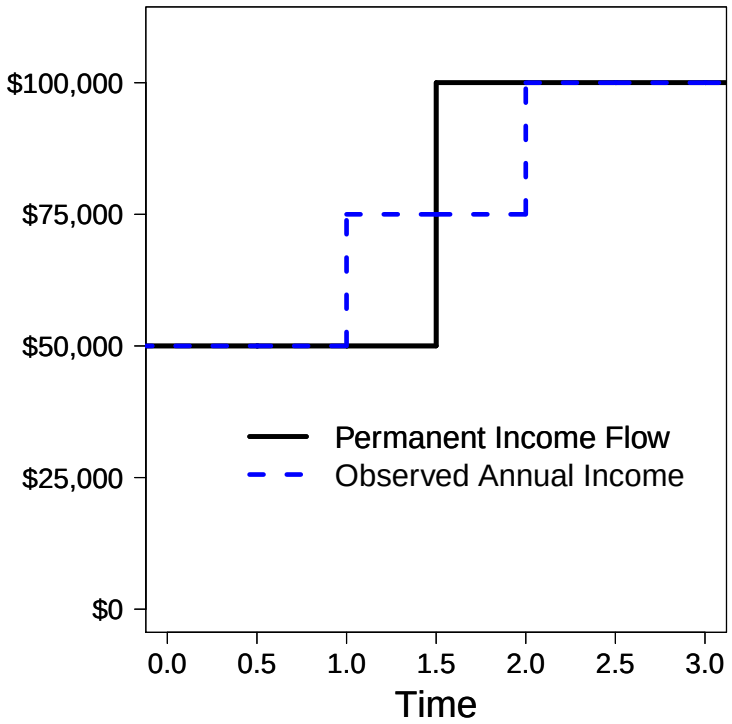


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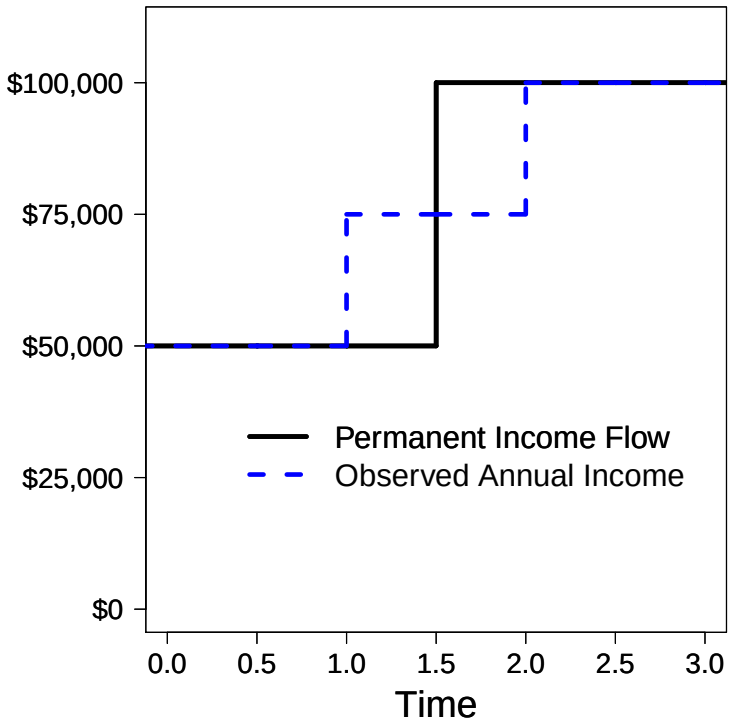


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If the Permanent Income Hypothesis holds, BPP will estimate the MPC to be -0.6

# Data

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

  Danish Mortgage Market

- **Expenditure**

  No *direct* measure of spending

# Data: Expenditure

Intertemporal budget constraint

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# Data: Expenditure

Intertemporal budget constraint

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

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

- 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:

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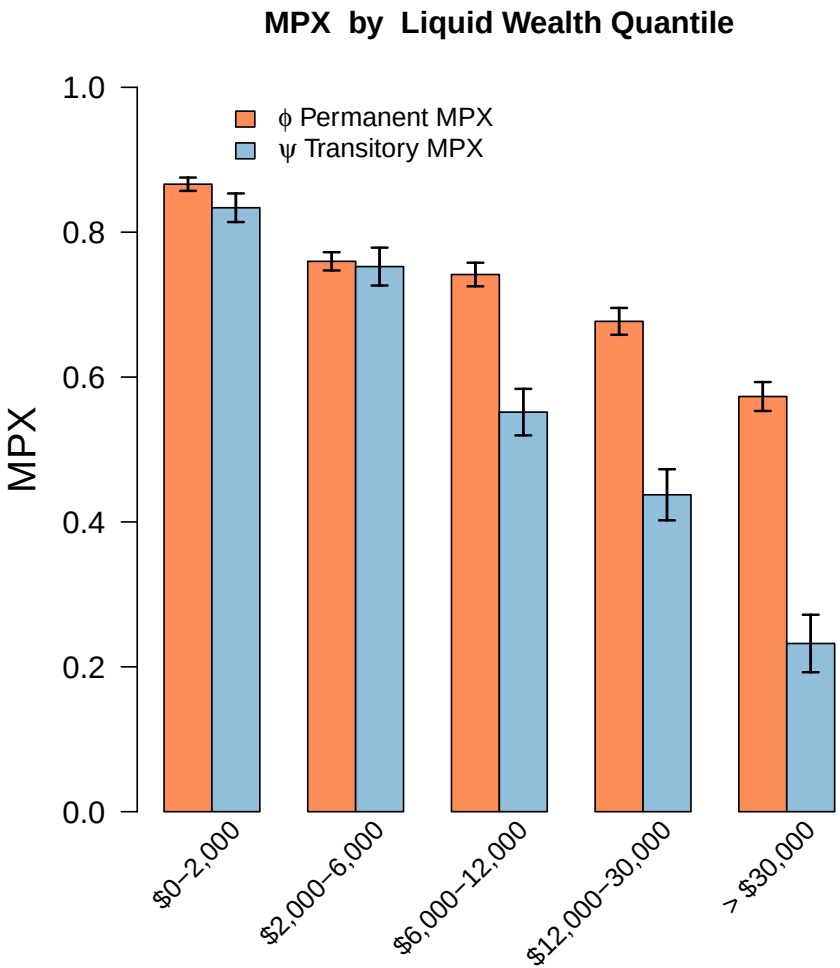
When might this fail?

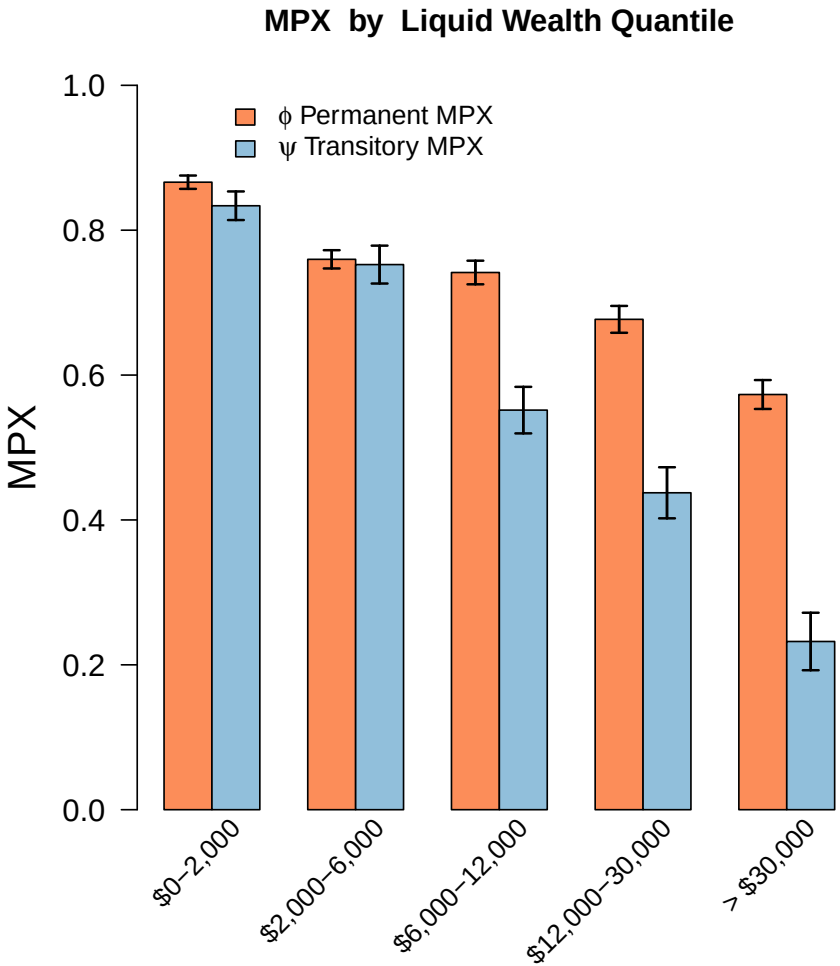
- Off balance sheet saving
- Returns correlated with *changes* in income (e.g. stock compensation)
- When insurance is provided by friends and family

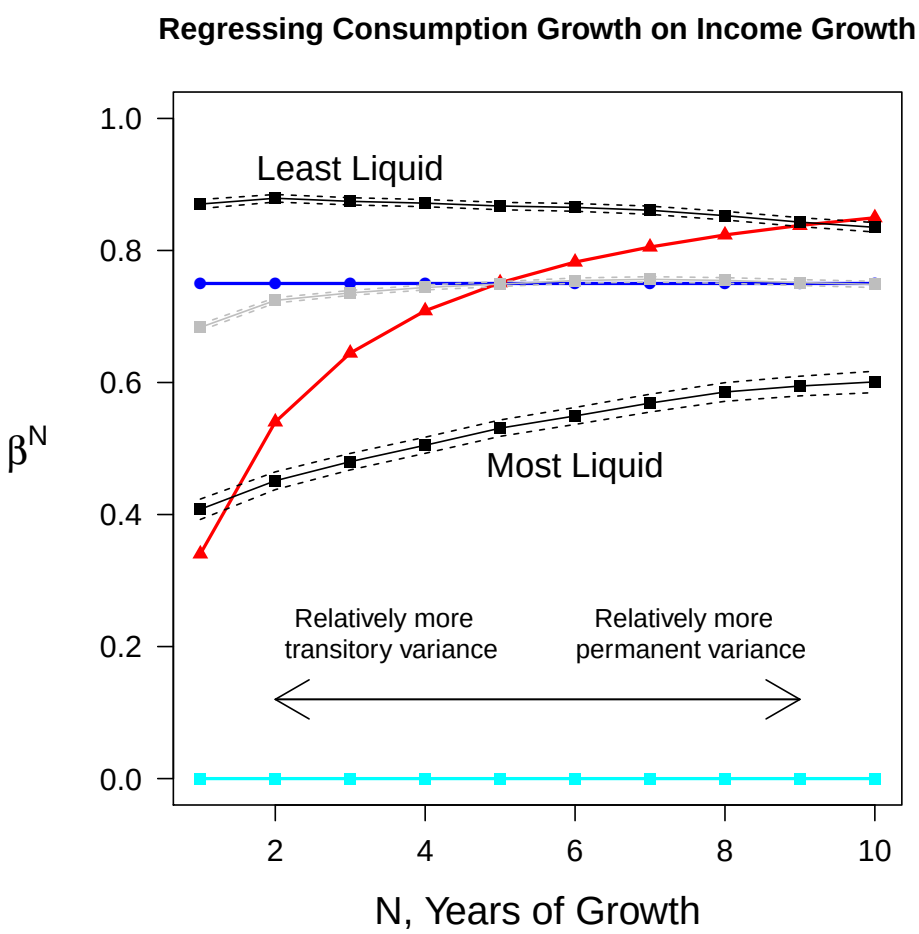
# Results by Liquid Wealth




MPX by Net Wealth

# MPX Results are Robust to Misspecification

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# Monetary Policy: Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

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→ Dominates in Rep. Agent NK models

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→ Large in Spender-Saver, or TANK models

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- Earnings Heterogeneity
- Interest Rate Exposure

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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

# Interest Rate Exposure Channel

**Key assumption:**
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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**

# Unhedged Interest Rate Exposure

URE Definition: Net savings made 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
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Interest rate change $dR \implies$ Household $i$'s spending changes by:

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

through the Interest Rate Exposure Channel *alone*.

# Interest Rate Exposure: Aggregation

Aggregate to find size of channel:

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

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

Define sufficient statistic:

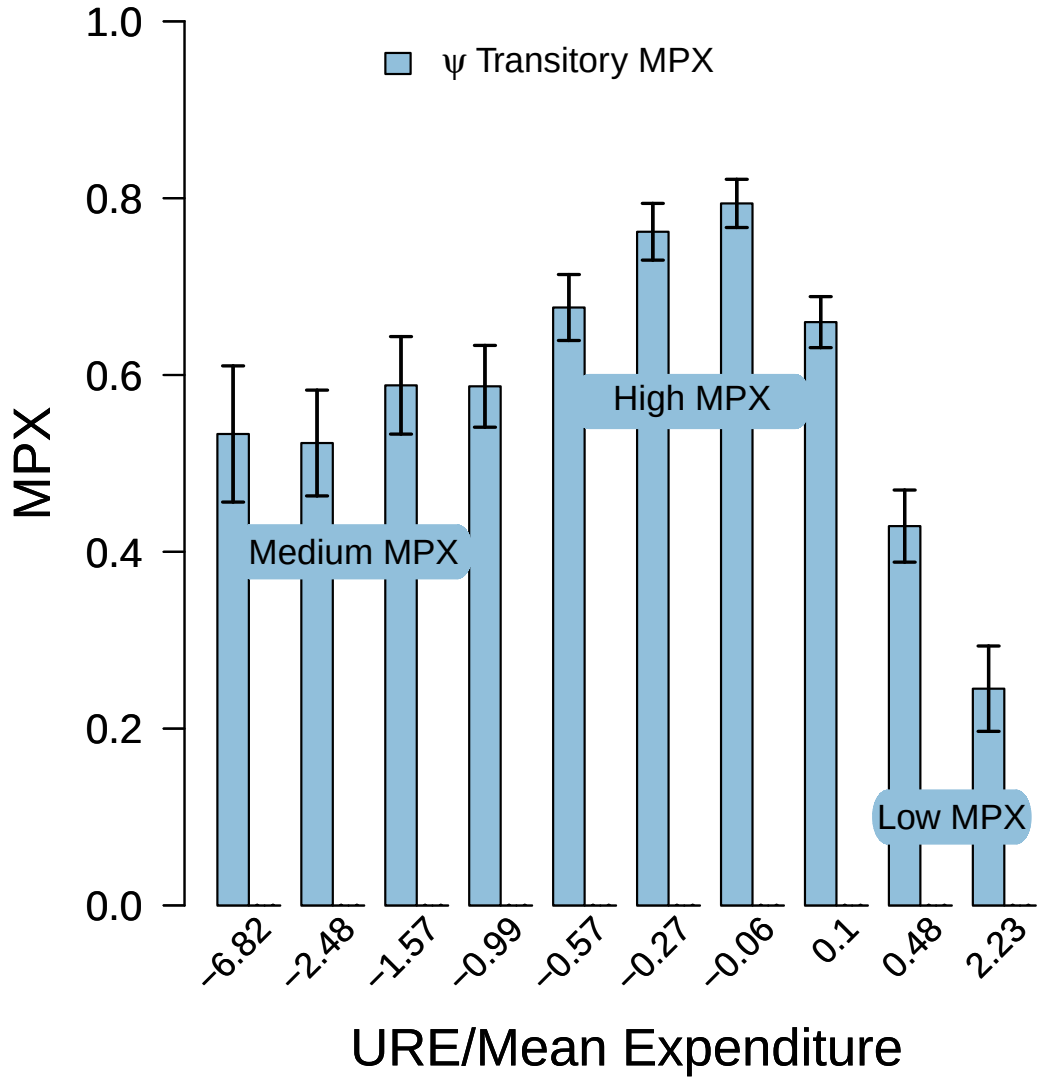
$$\mathcal{E}_R = \mathbb{E}_I\left(MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)}\right)$$

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

We can do that!

Out of Sample Assumptions

# MPX by Unhedged Interest Rate Exposure



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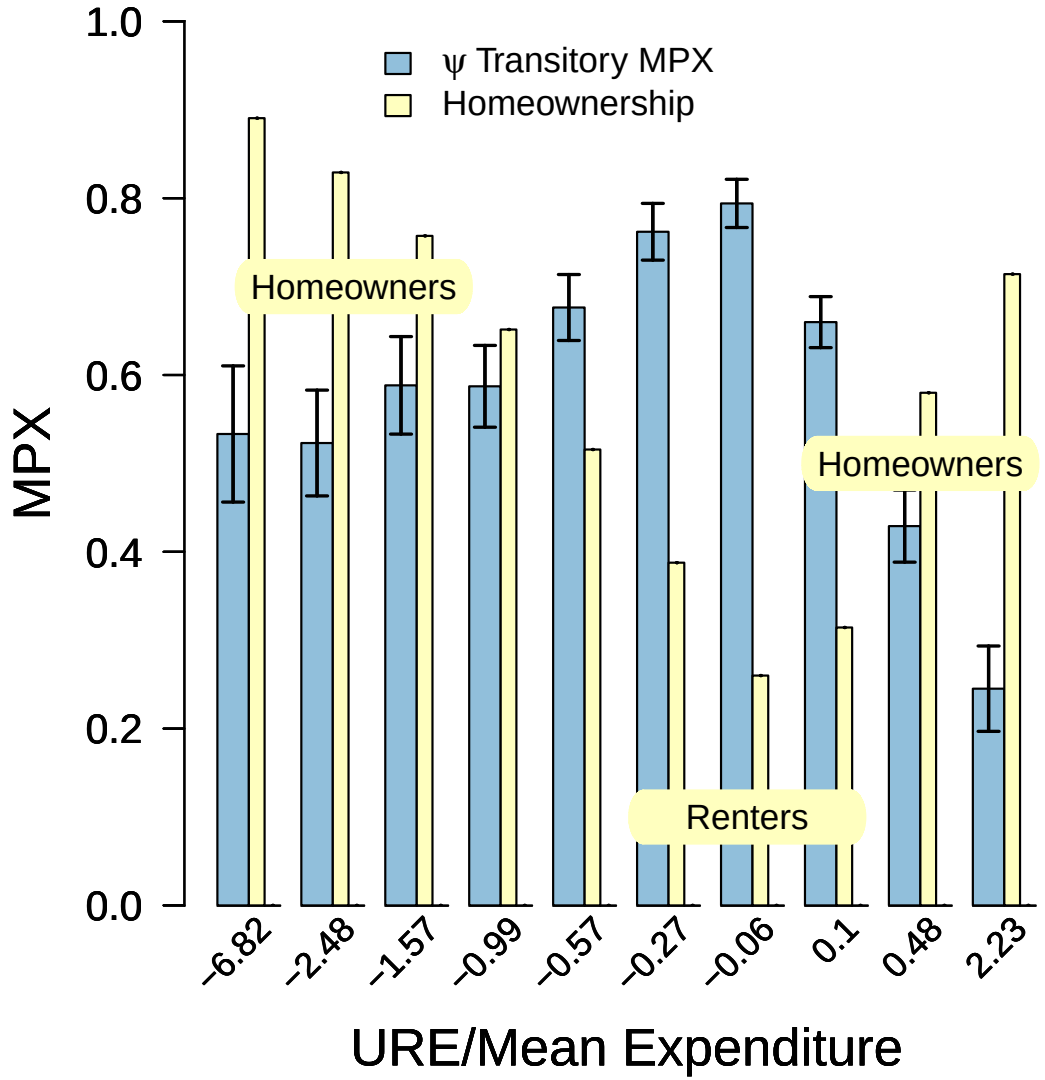

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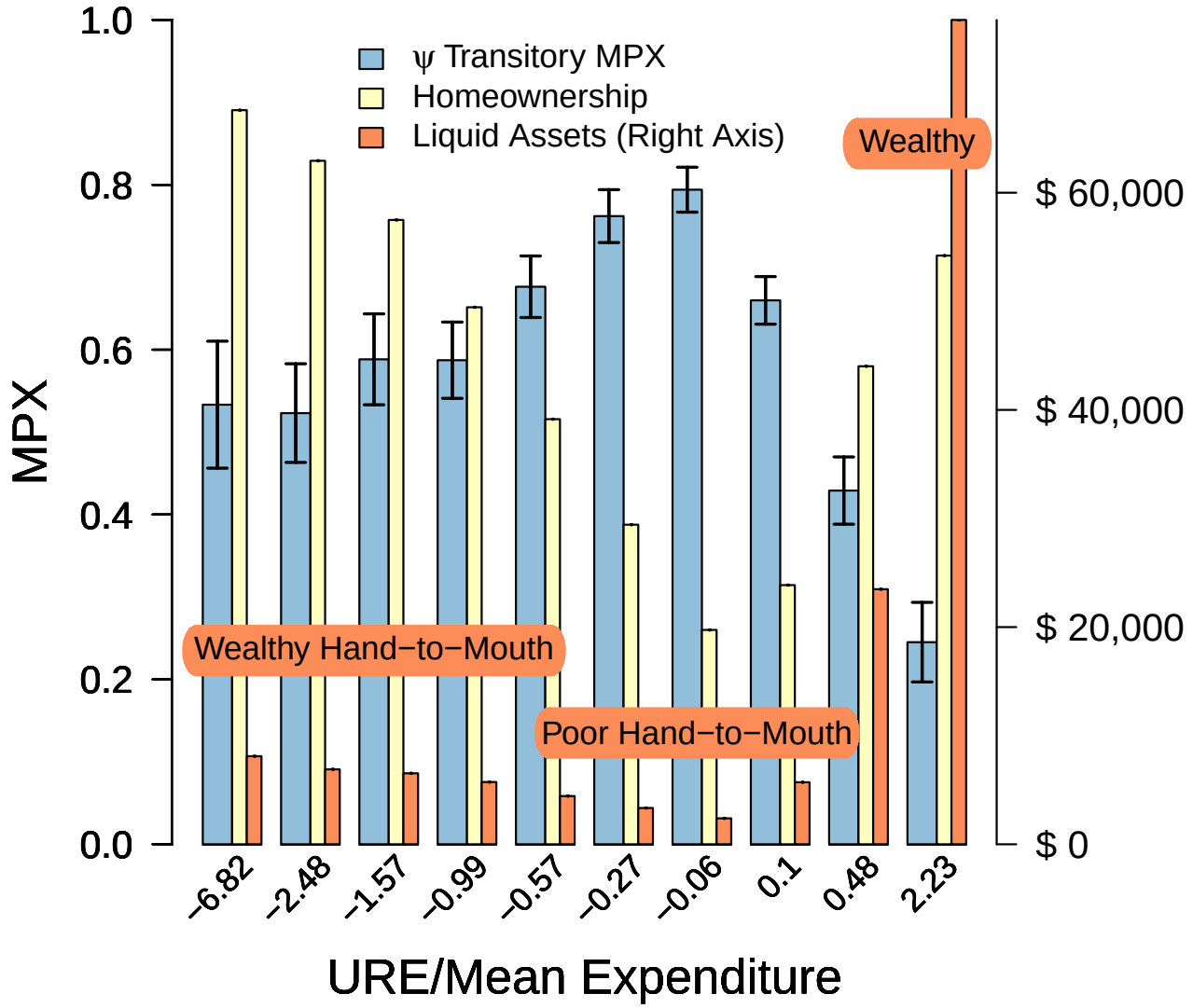

# All Five Transmission Channels

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

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

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

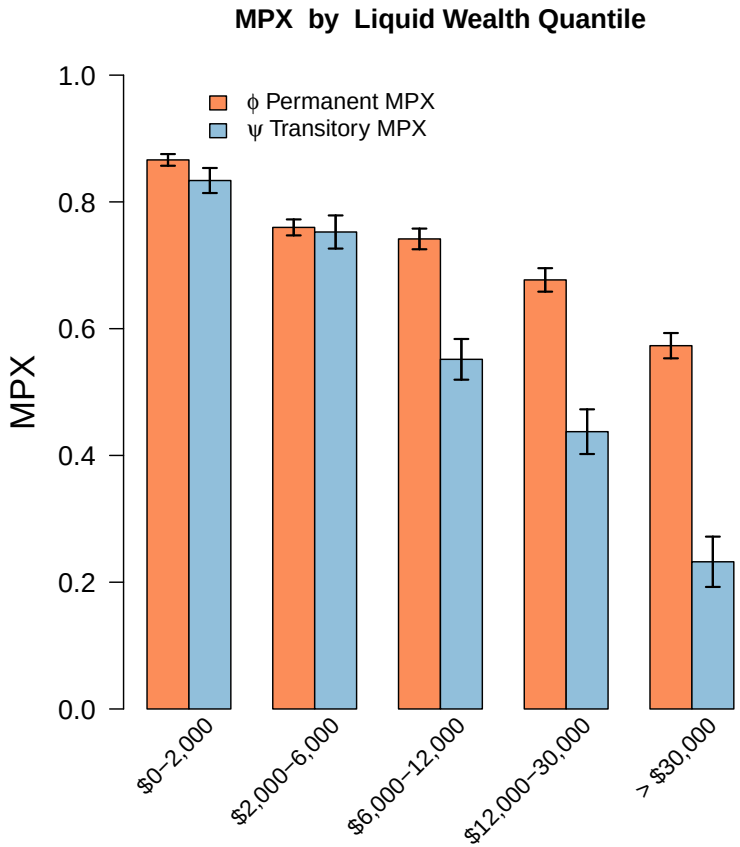
Compare $\mathcal{E}_R$ to $\sigma S$:

$\sigma \approx 0.1$ 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?




Key features:

- High overall Transitory MPC
- Decreasing with liquid wealth

# Benchmark Model

Households maximize expected utility

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

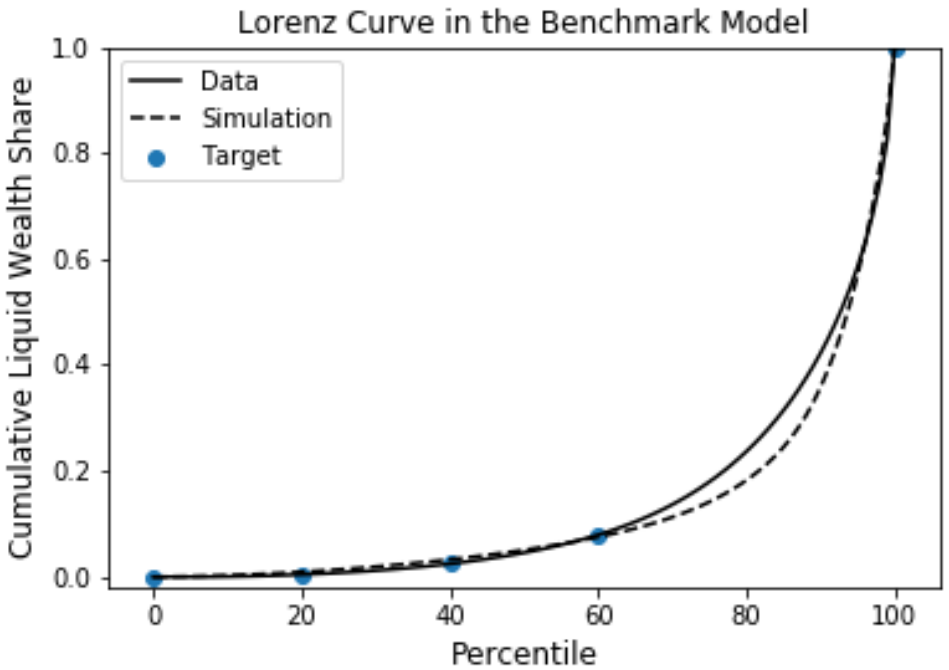
with:

- 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

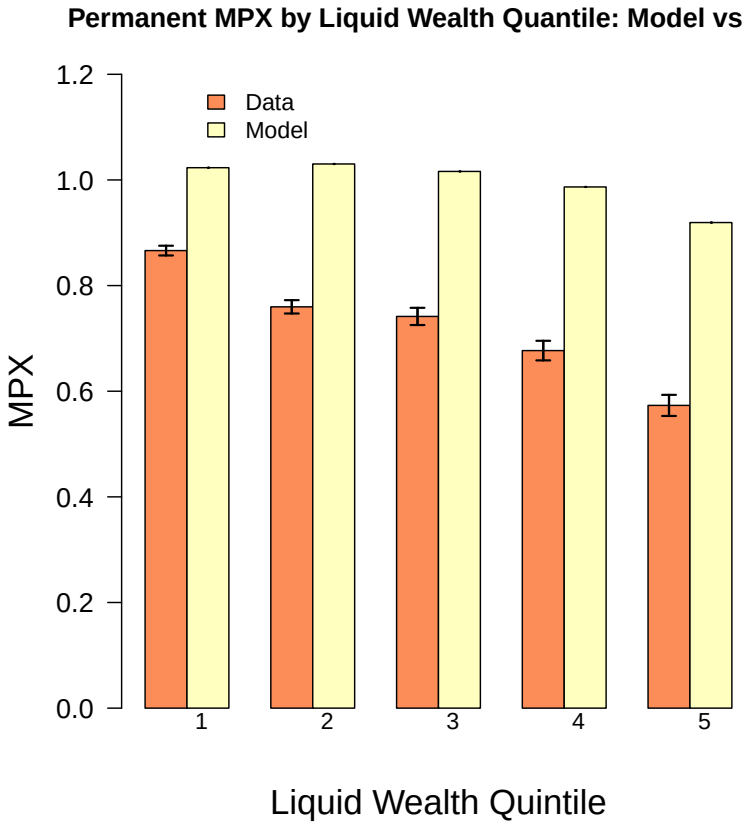
Ex-ante heterogeneity in the discount rate

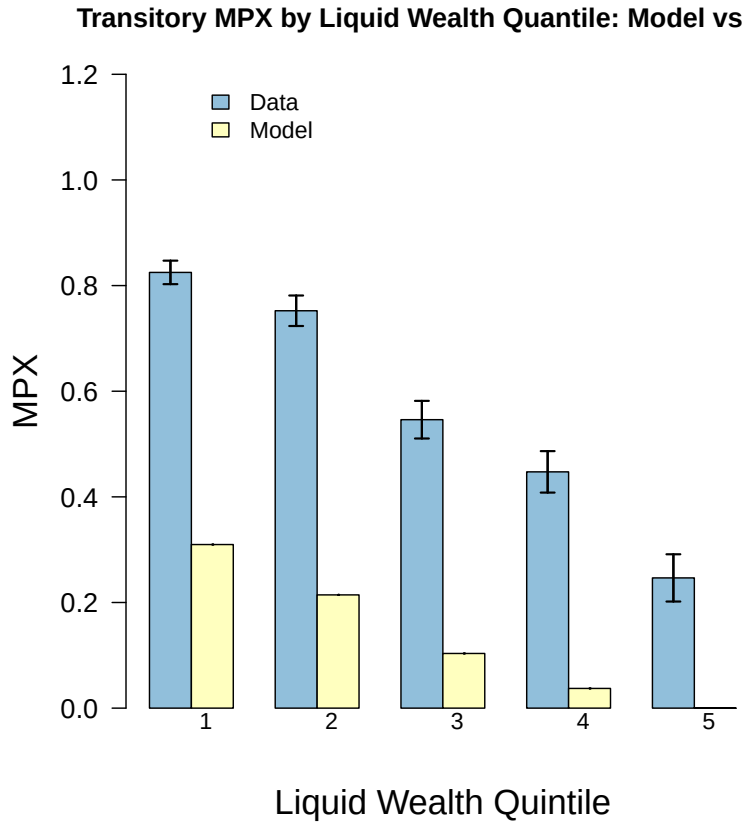
$\beta^i \sim \text{Unif}[\beta_{\text{low}}, \beta_{\text{high}}]$ Chosen to fit level and distribution of liquid wealth (especially at the low end)



# Benchmark Model: Results

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



# Preference Shock Model

First order problem: Transitory MPCs are too low

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

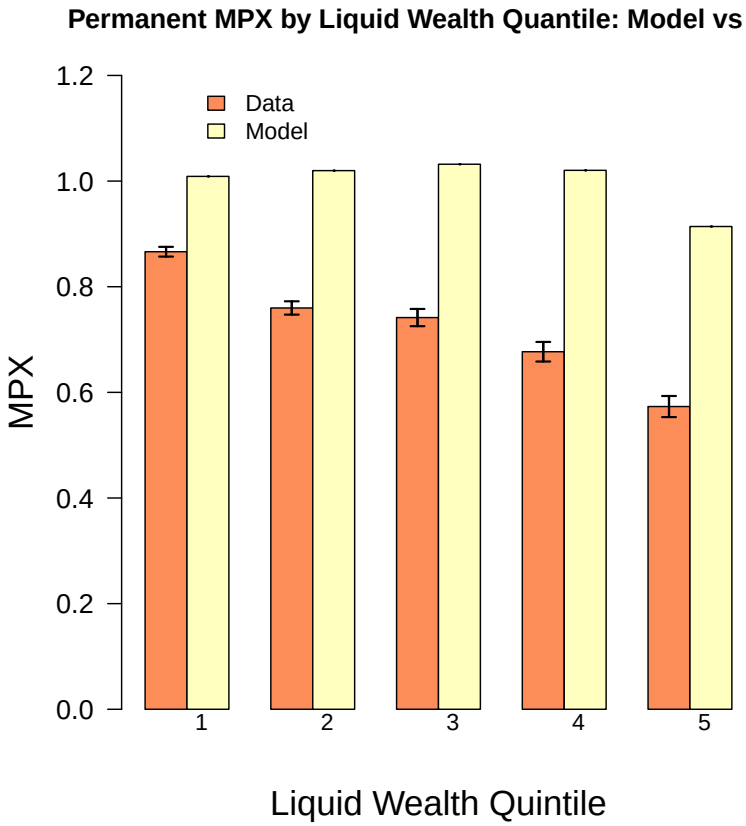
Is income risk the only source of precautionary saving?

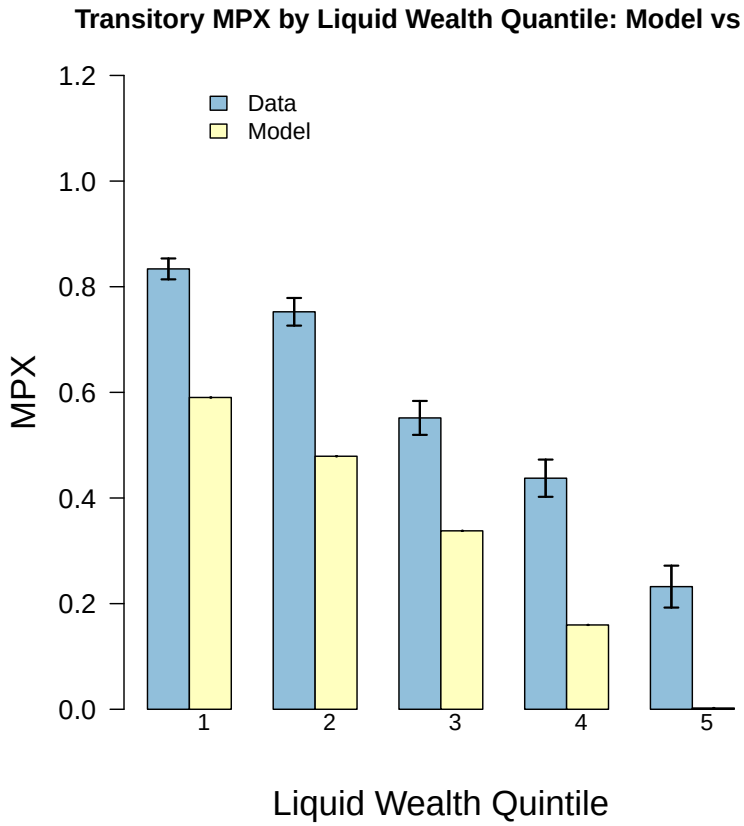
- In the data, expenditure FAR for volatile than income
- Surprise expenses can be large

Simple extension - add large preference shocks

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

# Preference Shock Model: Results



# Durables

We have data on value of household cars

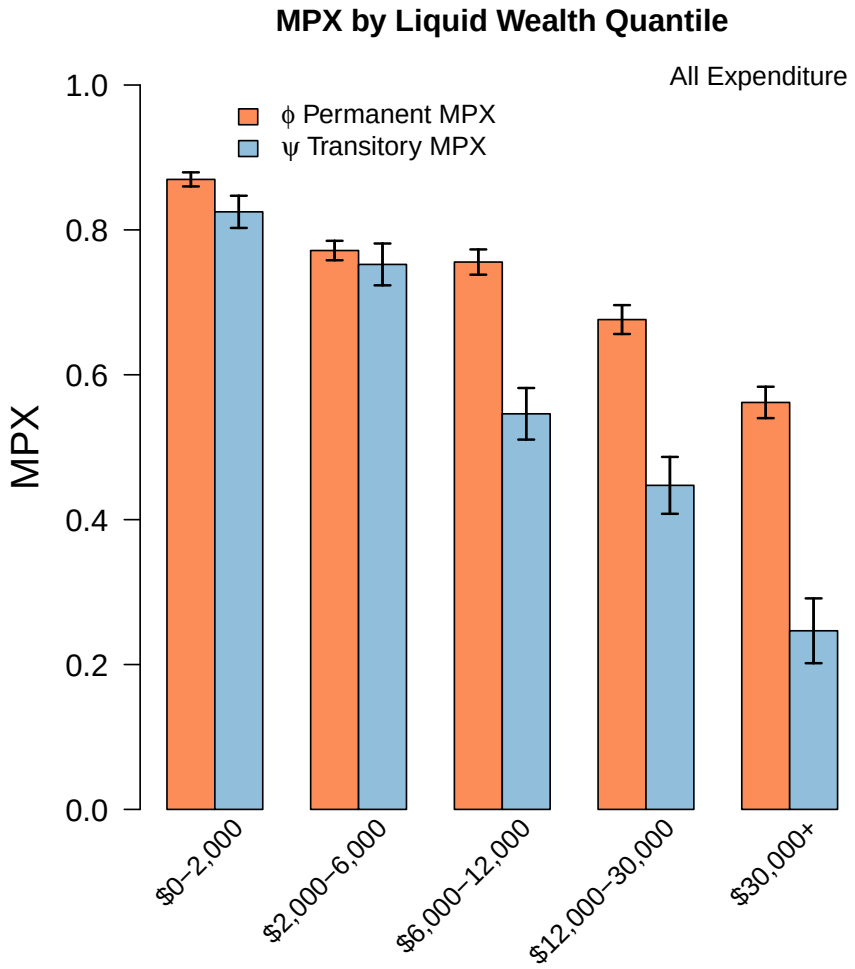
- Construct expenditure excluding car purchases and sales

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

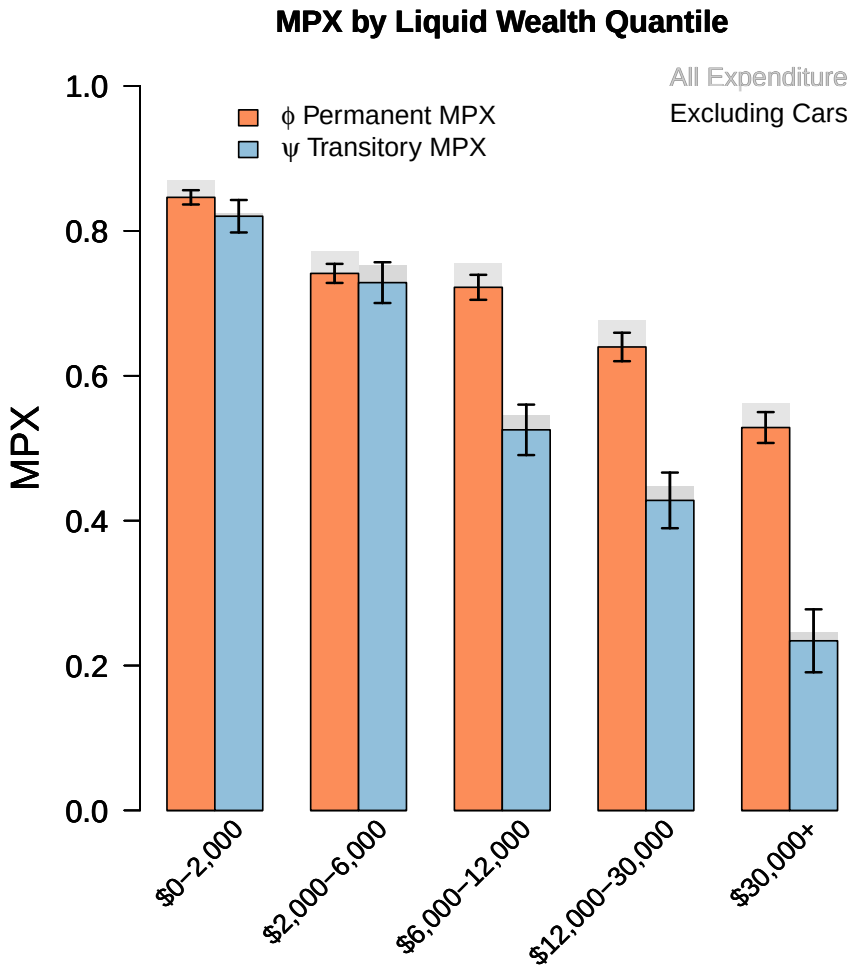
- Construct proxy for non durable consumption (Cars $\approx 42.1\%$ durable expenditure)

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

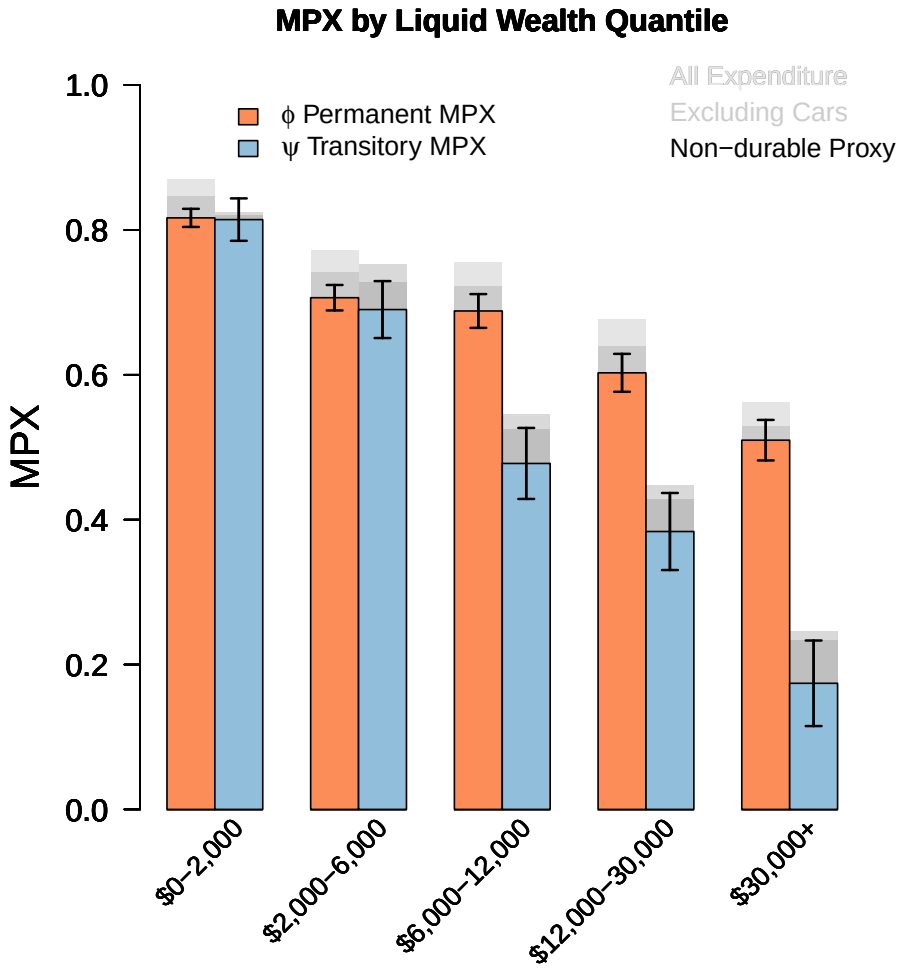
# Durables


MPX by Liquid Wealth Quantile
All Expenditure
ϕ Permanent MPX
ψ Transitory MPX
MPX
1.0
0.8
0.6
0.4
0.2
0.0
$0–2,000
$2,000–6,000
$6,000–12,000
$12,000–30,000
$30,000+

# Durables


MPX by Liquid Wealth Quantile
All Expenditure
Excluding Cars
ϕ Permanent MPX
ψ Transitory MPX
MPX
1.0
0.8
0.6
0.4
0.2
0.0
$0–2,000
$2,000–6,000
$6,000–12,000
$12,000–30,000
$30,000+

# Durables


MPX by Liquid Wealth Quantile
All Expenditure
Excluding Cars
Non−durable Proxy
ϕ Permanent MPX
ψ Transitory MPX
MPX
1.0
0.8
0.6
0.4
0.2
0.0
$0−2,000
$2,000−6,000
$6,000−12,000
$12,000−30,000
$30,000+

# Conclusion

New Method to Estimate Consumption Behavior

- Corrects for Bias in BPP
- Estimates align with natural experiment literature
- Potential to use on a wide variety of datasets and applications

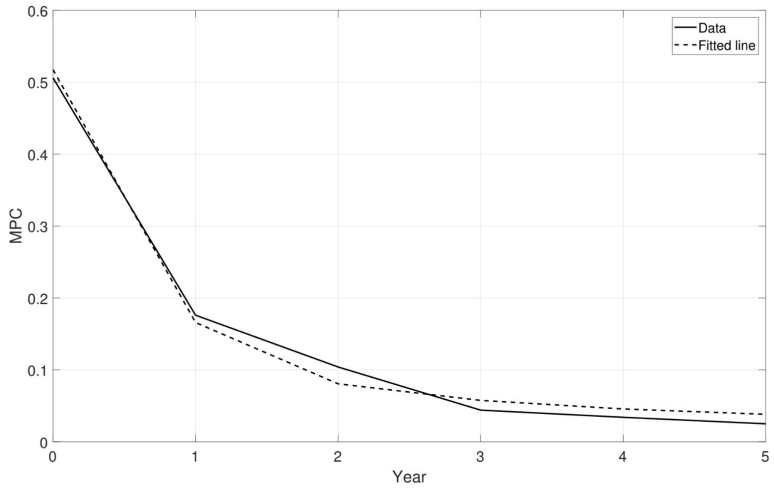
Applied to Danish Registry Data

- Sample Size $\Longrightarrow$ Sharp Focus on Heterogeneity
- Test Model Microfoundations
- Quantify Monetary Policy Transmission Channels

Thank you!

# Evidence of Consumption Decay Within 2 Years

## From Fagereng, Holm, and Natvik (2016)

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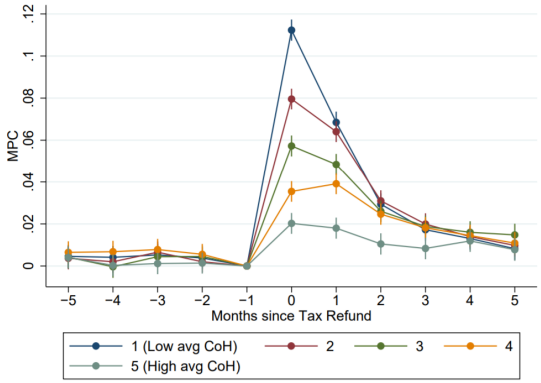
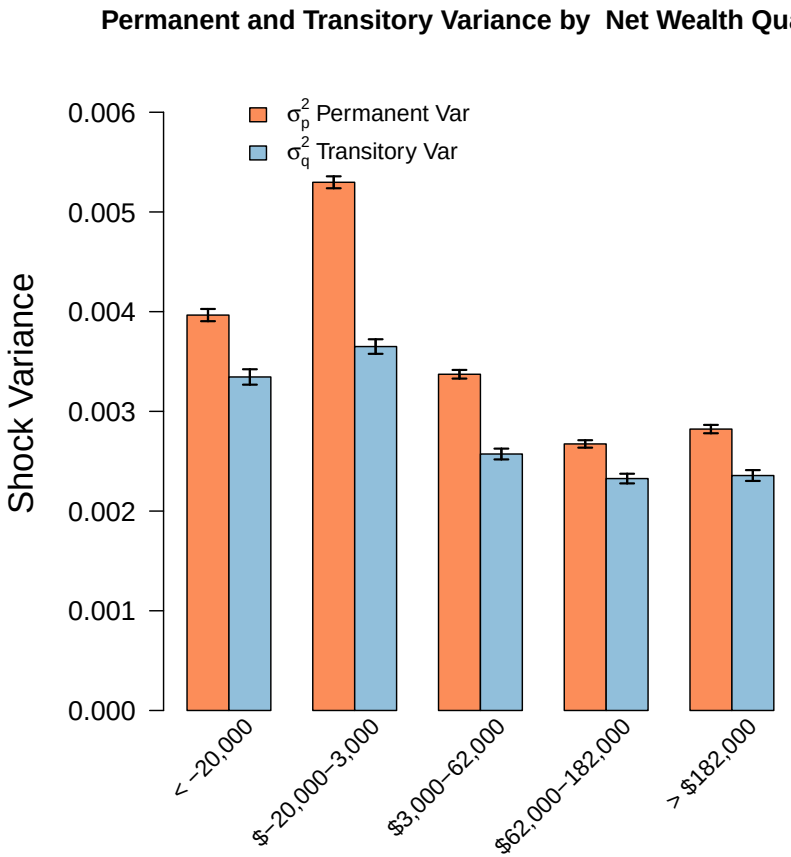
## From Gelman (2016)

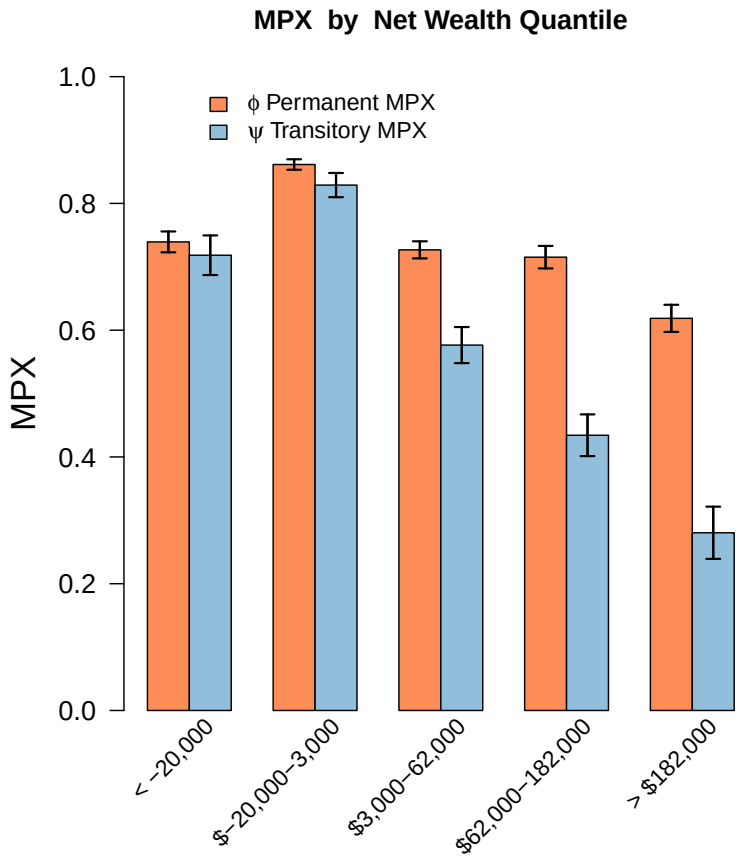
Figure 10: Tax refund impulse response function




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.

# MPX by Net Wealth

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# 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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# 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.

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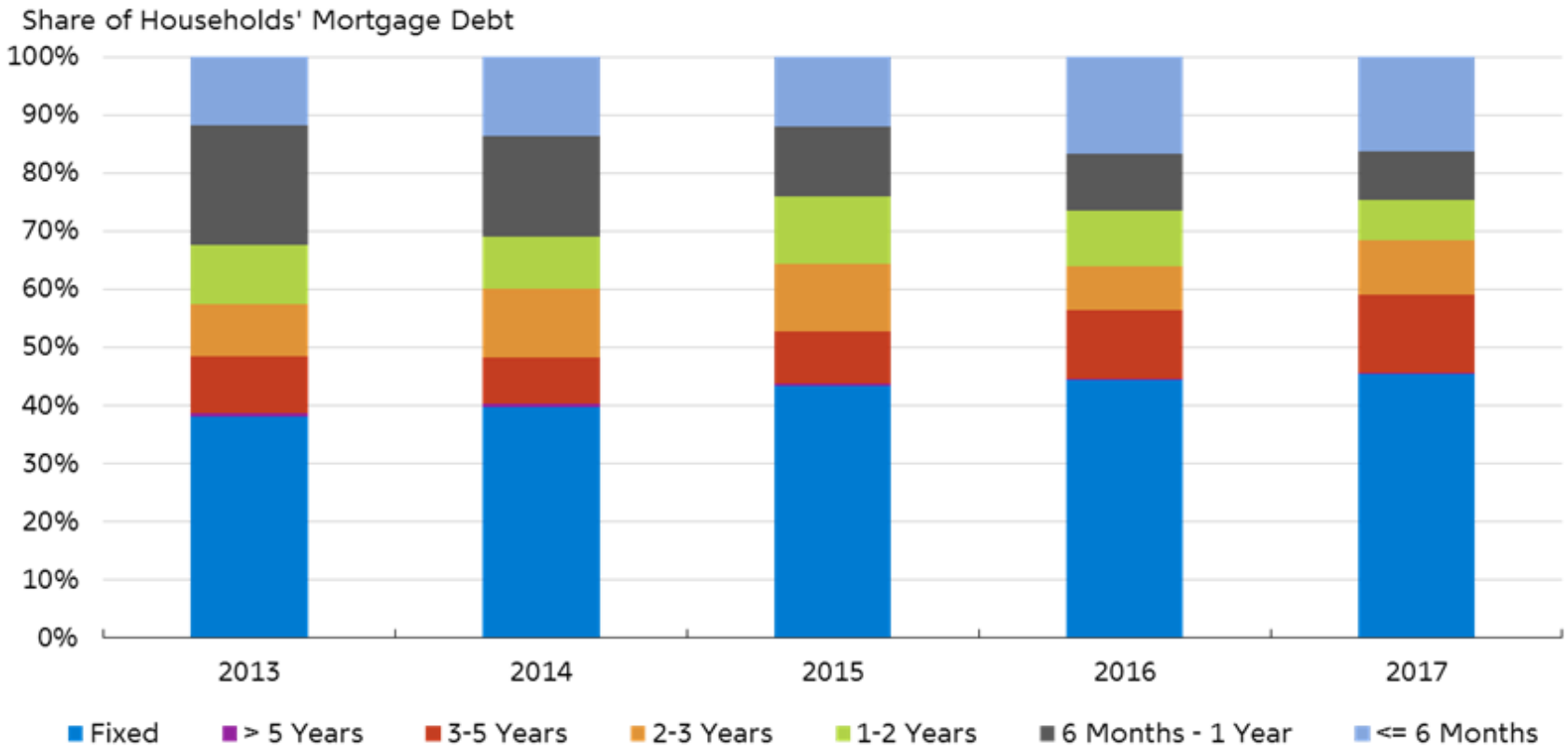
# Danish Mortgage Market

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