Consumption Heterogeneity: Micro Drivers and Macro Implications

Edmund Crawley & Andreas Kuchler

August 6, 2018

Overview

What will this paper do?

1. Create a new method to estimate heterogeneity in consumption responses to permanent and transitory shocks to income
    - Clear negative relation between MPC and liquid wealth
2. Application: Redistribution Channel of Monetary Policy (Auclert (2017))
    - We find a transitory 1% interest rate rise decreases consumption by 0.24% through the interest rate exposure channel
    - This channel is likely far larger than the intertemporal substitution channel (1-4x as large)

How Are Consumption Responses Typically Measured?

Three methods:

1. (Natural) Experiments - stimulus checks, lotteries etc
    - Few true experiments, especially for permanent shocks
    - Data limitations
2. Ask people
    - Unclear how to interpret
3. Use covariance structure of income and consumption
    - Empirical methods (until now!) have been flawed

We develop a robust method based on 3

Evidence on Magnitude of Consumption Response

	Consumption Measure				
Permanent Shocks	Nondurables	Total PCE	Horizon	Method	Event/Sample
Blundell, Pistaferri, and Preston (2008)*	0.65		$\sim$	1	Estimation Sample: 1980–92
Gelman, Gorodnichenko, Kariv, Koustas, Shapiro, Silverman, and Tadelis (2016)		1.0	$\sim$	3	Gasoline Price Shock
Transitory Shocks					
Agarwal and Qian (2014)		0.90	10m	1	Growth Dividend Program Singapore 2011
Blundell, Pistaferri, and Preston (2008)*	0.05			3	Estimation Sample: 1980–92
Browning and Collado (2001)		~ 0		1	Spanish ECPF Data, 1985–95
Coronado, Lupton, and Sheiner (2005)		0.36	1y	1	2003 Tax Cut
Fuster, Kaplan, and Zafar (2018)		0.08–0.31	3m	2	NY Fed Survey Cons. Expectations
Gelman (2016)		0.13	3m	1	Tax refunds 2013-2016
Hausman (2012)		0.6–0.75	1y	1	1936 Veterans' Bonus
Hsieh (2003)*	~ 0	0.6–0.75		1	CEX, 1980–2001
Jappelli and Pistaferri (2014)	0.48			2	Italy, 2010
Johnson, Parker, and Souleles (2009)	~ 0.25		3m	1	2003 Child Tax Credit
Lusardi (1996)*	0.2–0.5			3	Estimation Sample: 1980–87
Parker (1999)	0.2		3m	1	Estimation Sample: 1980–93
Parker, Souleles, Johnson, and McClelland (2013)	0.12–0.30	0.50–0.90	3m	1	2008 Economic Stimulus
Sahm, Shapiro, and Slemrod (2010)		$\sim 1/3$	1y	1	2008 Economic Stimulus
Shapiro and Slemrod (2009)		$\sim 1/3$	1y	1	2008 Economic Stimulus
Souleles (1999)	0.045–0.09	0.34–0.64	3m	1	Estimation Sample: 1980–91
Souleles (2002)	0.6–0.9		1y	1	The Reagan Tax Cuts of the Early 1980s

* Elasticity. Methods: 1) Natural Experiment 2) Survey question 3) Covariance restrictions

Rough consensus on (3 month) transitory MPC $\sim 30\%$

Evidence on Distribution of Consumption Response

Most studies do not have enough power to say anything about how their MPC estimates vary in the population

Exceptions:

- Jappelli and Pistaferri (2014) Italian Survey Data
- Fagereng, Holm, and Natvik (2016) Norway Lottery Data
- Gelman (2016) Financial App Data
- Fuster, Kaplan, and Zafar (2018) NY Fed Survey

Liquid assets and **income** are key predictors of transitory MPC

Application: Auclert (2017)

Auclert (2017) identifies three ways in which **heterogeneity** affect monetary policy

Each is potentially measurable in panel data

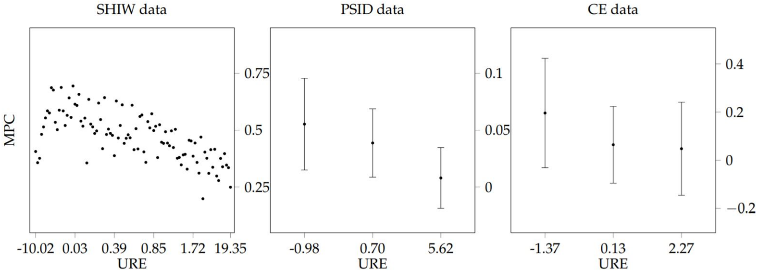
But...

Application: Auclert (2017)

Auclert (2017) identifies three ways in which **heterogeneity** affect monetary policy

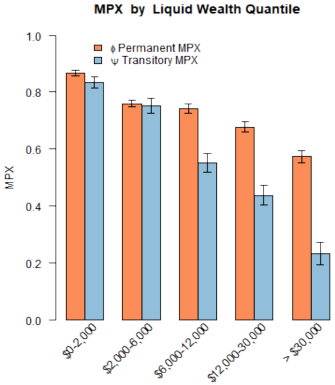
Each is potentially measurable in panel data

But...

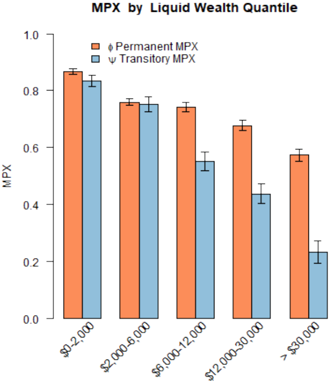


He doesn't have the right data or methods to be able to do this

Results Preview



Results Preview



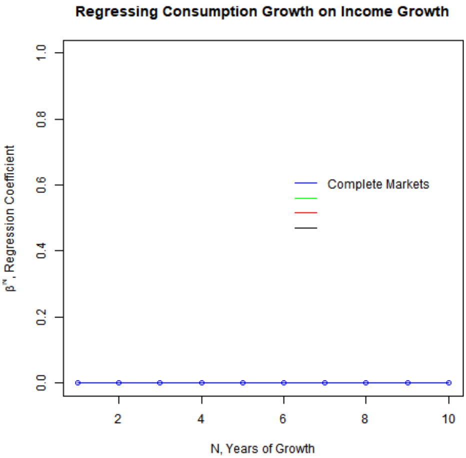
Monetary Policy Application

A 1% increase in R decreases consumption by 0.24% due to heterogeneity in interest rate exposure

This channel is 1 to 4x larger than intertemporal substitution

Methodology Intuition

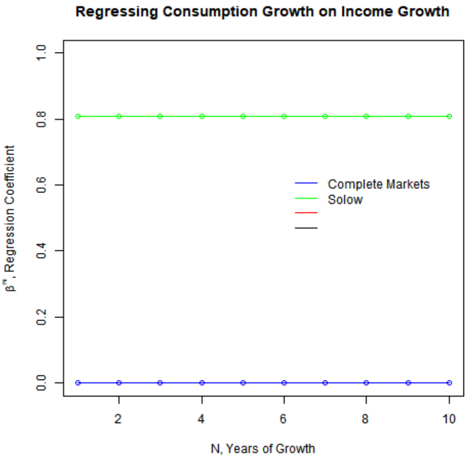
Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c = \beta^N \Delta^N y + \varepsilon$$

Methodology Intuition

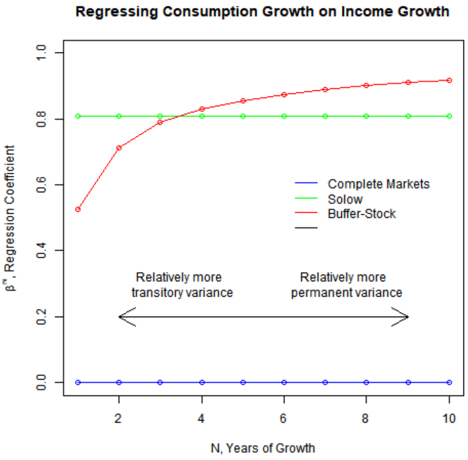
Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c = \beta^N \Delta^N y + \varepsilon$$

Methodology Intuition

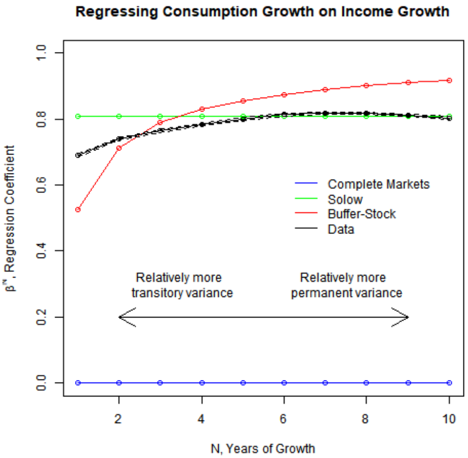
Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c = \beta^N \Delta^N y + \varepsilon$$

Methodology Intuition

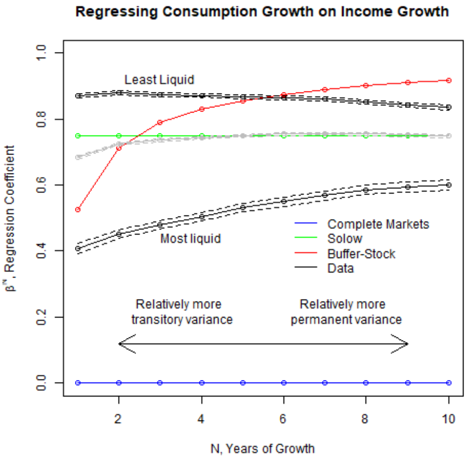
Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c = \beta^N \Delta^N y + \varepsilon$$

Methodology Intuition

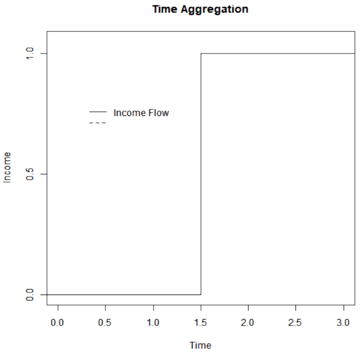
Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c = \beta^N \Delta^N y + \varepsilon$$

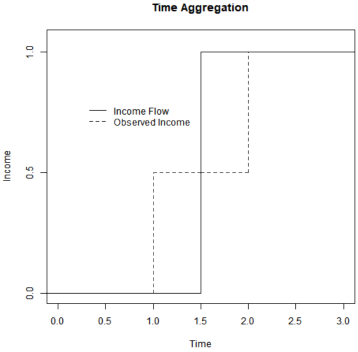
Aside: Why Not Blundell, Pistaferri and Preston 2008?

1) Time Aggregation Problem (Crawley 2018)



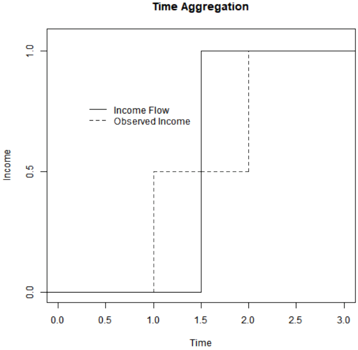
Aside: Why Not Blundell, Pistaferri and Preston 2008?

1) Time Aggregation Problem (Crawley 2018)



Aside: Why Not Blundell, Pistaferri and Preston 2008?

1) Time Aggregation Problem (Crawley 2018)



PIH Example:

- MPC out of Permanent Shocks $= 1$
- MPC out of Transitory Shocks $= 0$
- Variances approx. equal

BPP method estimates MPC out of transitory shocks to be -0.6

Aside: Why Not Blundell, Pistaferri and Preston 2008?

2) BPP assume consumption is a random walk

- High transitory MPCs are incompatible with consumption following a random walk

Identification of the Income Process

We follow the spirit of Carroll & Samwick (1997):

- Permanent income follows a random walk

$$p_t = p_{t-1} + \zeta_t$$

- Total income includes a transitory component

$$y_t = p_t + \varepsilon_t$$

Growth over N years is:

$$\Delta^N y_T = (\zeta_{T-N+1} + \ldots + \zeta_T) + \varepsilon_T - \varepsilon_{T-N}$$
$$\mathrm{Var}(\Delta^N y_T) = N\mathrm{Var}(\zeta) + 2\mathrm{Var}(\varepsilon)$$

Identification of the Income Process

We follow the spirit of Carroll & Samwick (1997):

- If transitory income follows an MA(2) process:

$$y_t = p_t + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$$
$$\implies \mathrm{Var}(\Delta^N y_T) = N \underbrace{\mathrm{Var}(\zeta)}_{\text{Perm var}} + 2 \underbrace{(1 + \theta_1^2 + \theta_2^2)\mathrm{Var}(\varepsilon)}_{\text{``Total'' trans var}} \text{ if } N \geq 3$$

Carroll & Samwick use $N = 3, 4, 5$ to identify permanent shock variance and "total" transitory shock variance

Identification of the Income Process

We follow the spirit of Carroll & Samwick (1997):

- If transitory income follows an MA(2) process:

$$y_t = p_t + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$$

$$\implies \mathrm{Var}(\Delta^N y_T) = N \underbrace{\mathrm{Var}(\zeta)}_{\text{Perm var}} + 2 \underbrace{(1 + \theta_1^2 + \theta_2^2)\mathrm{Var}(\varepsilon)}_{\text{“Total” trans var}} \text{ if } N \geq 3$$

Carroll & Samwick use $N = 3, 4, 5$ to identify permanent shock variance and “total” transitory shock variance

1. How does time aggregation affect this identification?
2. What might the equivalent of “robust to MA(2) transitory shocks” be in continuous time?

Identification of the Income Process

Carroll & Samwick in Continuous Time with Aggregation

- To begin assume no persistence in the transitory shock
- p_t and q_t are independent martingale processes with independent increments

$$\mathrm{Var}(p_t - p_{t-1}) = \sigma_p^2$$
$$\mathrm{Var}(q_t - q_{t-1}) = \sigma_q^2$$

- Instantaneous income is equal to the flow of permanent income plus the transitory income component

$$dy_t = p_t dt + dq_t$$

Identification of the Income Process

Carroll & Samwick in Continuous Time with Aggregation

- To begin assume no persistence in the transitory shock
- p_t and q_t are independent martingale processes with independent increments

$$\mathrm{Var}(p_t - p_{t-1}) = \sigma_p^2$$
$$\mathrm{Var}(q_t - q_{t-1}) = \sigma_q^2$$

- Instantaneous income is equal to the flow of permanent income plus the transitory income component

$$dy_t = p_t dt + dq_t$$

We observe $\bar{y}_T$, total income over year T:

$$\bar{y}_T = \int_{T-1}^{T} p_t dt + q_T - q_{T-1}$$

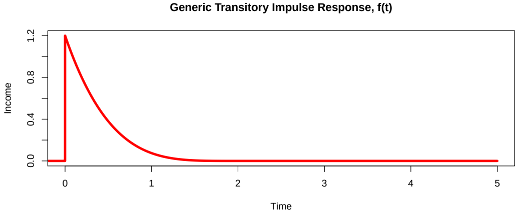
$$\implies \mathrm{Var}(\Delta^N \bar{y}_T) = (N - \frac{1}{3})\sigma_p + 2\sigma_q$$

Identification of the Income Process

Allow a generic persistence in transitory shock

- Following shock, transitory income flow decays as:

$$f(t) \text{ where } f(t) = 0 \text{ if } t > 2$$



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

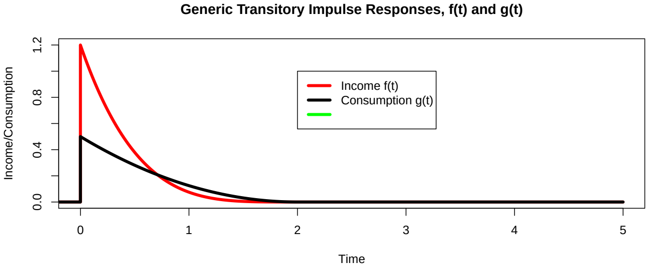
$$\implies \mathrm{Var}(\Delta^N \bar{y}_T) = (N - \frac{1}{3})\sigma_p^2 + 2\sigma_{\tilde{q}}^2 \text{ for } N \geq 3$$

where $\tilde{q_T} = \int_{T-1}^{T} \int_{t-2}^{t} f(t-s)dq_s dt$ is the time aggregated transitory component of income

Identification of the Consumption Response

Assumptions on Consumption

- Permanent: Consumption permanently moves by fraction ϕ of the income shock
- Transitory: Allow for generic impulse response $g(t)$ where $g(t) = 0$ for $t > 2$

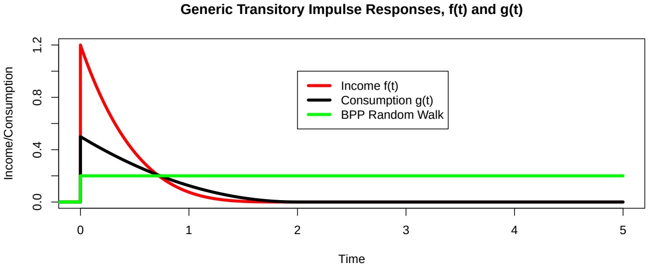


This is a key difference between what we assume and BPP

Identification of the Consumption Response

Assumptions on Consumption

- Permanent: Consumption permanently moves by fraction ϕ of the income shock
- Transitory: Allow for generic impulse response $g(t)$ where $g(t) = 0$ for $t > 2$



This is a key difference between what we assume and BPP

Identification of the Consumption Response

Consumption flow is given by:

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

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

where $\psi = \frac{\mathrm{Cov}(\tilde{c},\tilde{q})}{\mathrm{Var}(\tilde{q})}$, the regression coefficient of 'transitory' consumption on transitory income

Identification of the Consumption Response

Consumption flow is given by:

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

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

where $\psi = \frac{\mathrm{Cov}(\tilde{c},\tilde{q})}{\mathrm{Var}(\tilde{q})}$, the regression coefficient of 'transitory' consumption on transitory income

- ϕ: MPX out of permanent income shocks
- ψ: MPX out of transitory income shocks

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 $N = 3, 4, 5$ (total of six equations) to identify the four unknowns:

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

Threats to Identification

	Direction of Bias	
	Perm MPX	Tran MPX
Endogenous Income Shocks	Neutral	+ve
Persistent Consumption Response	+ve	-ve
Income Measurement Error	Neutral	+ve
Permanent Shocks are AR(1)	Neutral	+ve
Non-linear MPX	?	?

Data

- Starting point: Register based micro data for all Danish households made available by Statistics Denmark
- Really good income data
    - We use after-tax income for the household head, based on third-party reported tax data
- We divide through by permanent income (mean income over all observed years) and take the residual after controlling for age, education, marital status etc. (along with interactions of these)
- Expenditure data imputed from income and wealth
    - Deposit and brokerage accounts all third party reported
    - Less accurate than income data

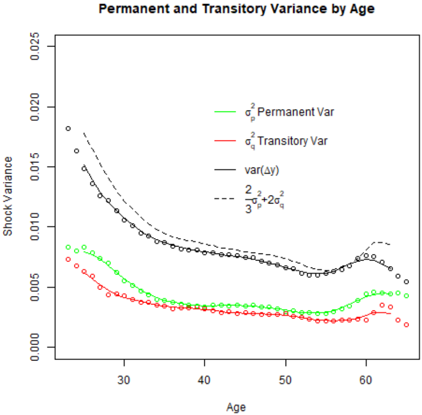
Imputing Expenditure

We use the identity

$$C_t \equiv Y_t - S_t = Y_t - P_t - \Delta NW$$

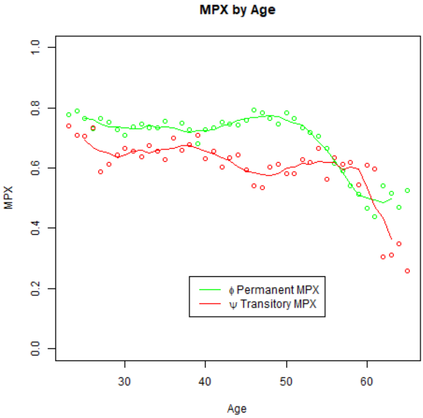
- Works well for households with simple financial lives
- Main issue: Capital gains and losses
  - Exclude households where methodology will not work well (eg Business owners)
  - Exclude housing wealth and years with housing transactions
  - Capital gains for stocks based on a diversified index
- Noisy, but perhaps better than surveys (Kuchler et al. 2018)
- Huge sample size advantage: sample covers 23.3 million observations over 2004-2015 (approx 1.9 million per year)

Shock Variance by Age



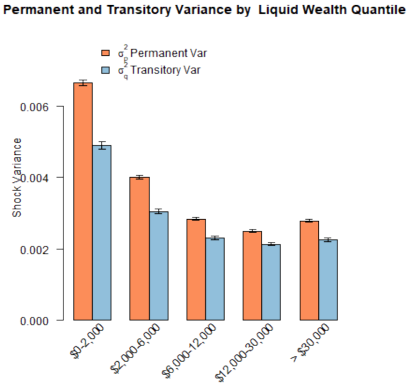
The assumption of constant variance works reasonably well from mid-30's to retirement

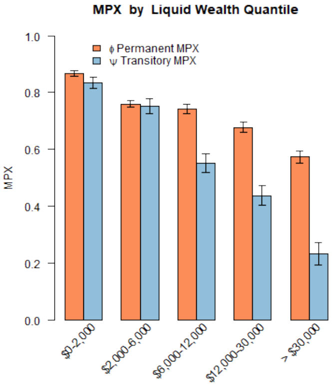
MPX by Age



- $\phi \approx 0.8$, declines towards retirement
- $\psi \approx 0.5$, constant

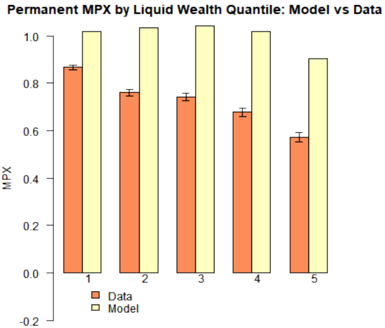
MPX by Liquid Wealth

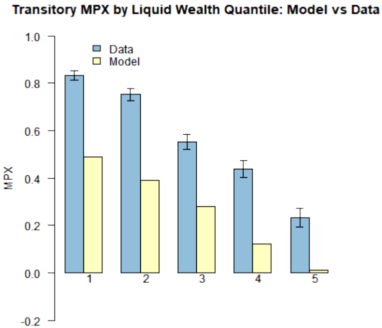




Model vs Data

How does a standard model compare with the data?





Monetary Policy: Measuring Redistribution

We calculate the sufficient statistics from Auclert (2017)

Here we will focus on the *Interest Rate Exposure* channel:

If

1. Households that *owe* a lot of floating rate debt have *high* MPCs
2. Households that *own* a lot of floating rate debt have *low* MPCs

Then lowering interest rates will on average *increase* consumption through redistribution

Monetary Policy: Measuring Redistribution

We calculate the sufficient statistics from Auclert (2017)

Here we will focus on the *Interest Rate Exposure* channel:

If

1. Households that *owe* a lot of floating rate debt have *high* MPCs
2. Households that *own* a lot of floating rate debt have *low* MPCs

Then lowering interest rates will on average *increase* consumption through redistribution

Do we know if 1 and 2 hold? How can we measure the size of this effect?

Monetary Policy: Measuring 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:

$$dc_i = MPC_i URE_i \frac{dR}{R} \tag{1}$$

Monetary Policy: Measuring Redistribution

In aggregate, the size of this channel is given by:

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

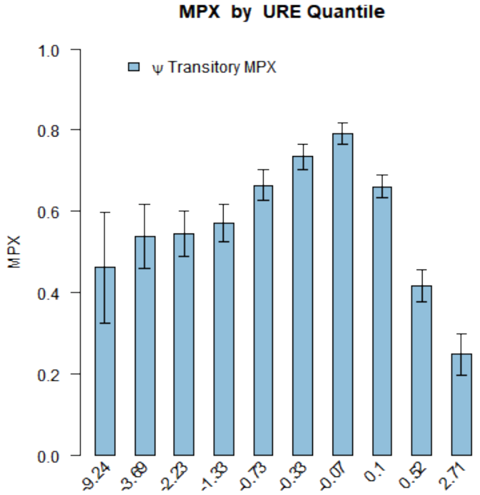
Define sufficient statistic:

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

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

We can do that!

Monetary Policy: Measuring Redistribution



Monetary Policy: Measuring Redistribution

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

- -338bn Kr

Group	Total URE (bn Kr)	MPC	$\mathcal{E}_R$ component
Our sample (head age 35-55)	-338	See Distribution	-0.42
Head $<$ 30	-38	0.5	-0.02
Head $>$ 55	-10	0.2	0.00
Pension Funds	143	0.1	0.02
Government	-120	0	0.00
Non-financial Corporate	-66	0.1	-0.01
Financial Sector	380	0.1	0.05
Rest of World	45	0	0.00
Total	**0**		**-0.40**

Monetary Policy: Measuring Redistribution

The Five Transmission Channels:

$$\frac{dC}{C} = \left(\mathcal{M} + \gamma \mathcal{E}_Y\right)\frac{dY}{Y} - \mathcal{E}_P \frac{dP}{P} + \left(\mathcal{E}_R - \sigma S\right)\frac{dR}{R}$$

We calculate

- $\mathcal{E}_R \approx -0.24$
- $S \approx 0.6$, 1-consumption-weighted MPC
- σ in the range of 0.1 to 0.5

$\Longrightarrow$ the intertemporal substitution channel, $\sigma S \approx 0.06 - 0.3$, is potentially much smaller than the interest rate exposure channel

Durables

Our expenditure measure include ALL expenditure

- Household goods (electronics, kitchen equipment, etc)
- Cars
- Home improvements (roof repair, extensions)

Durables make up 10.05% of total expenditure in Denmark

Durables

Our expenditure measure include ALL expenditure

- Household goods (electronics, kitchen equipment, etc)
- Cars
- Home improvements (roof repair, extensions)

Durables make up 10.05% of total expenditure in Denmark

But theory suggests durable expenditures should not be proportional to permanent income changes

- This may bias our results

Durables

Suppose households *instantaneously* upgrade their durable goods and then pay a constant flow of depreciation:

$$dc_t = \phi p_t dt + \phi_d dp_t + \psi dq_t$$

- ϕ can be interpreted as the MPC to permanent shocks, where consumption includes non-durables and the service *flow* from durable goods
- ϕ_d is the proportion of the (annual) permanent shock that is spent instantaneously on durables
- ψ is the MPX out of transitory income, exactly as before

Durables

Suppose households *instantaneously* upgrade their durable goods and then pay a constant flow of depreciation:

$$dc_t = \phi p_t dt + \phi_d dp_t + \psi dq_t$$

- ϕ can be interpreted as the MPC to permanent shocks, where consumption includes non-durables and the service *flow* from durable goods
- ϕ_d is the proportion of the (annual) permanent shock that is spent instantaneously on durables
- ψ is the MPX out of transitory income, exactly as before

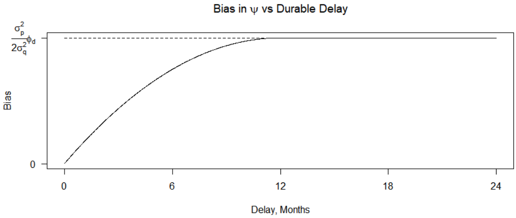
Then our estimates of ϕ and ψ are unbiased. We have no way of estimating ϕ_d

Durables

If households act with some delay things are different. Suppose they wait 1 year

$$dc_t = \phi p_t dt + \phi_d dp_{t-1} + \psi dq_t$$

- $\mathbb{E}(\hat{\phi}) = \phi$ Permanent MPC is unbiased
- $\mathbb{E}(\hat{\psi}) = \psi + \frac{\sigma_p^2}{2\sigma_q^2}\phi_d$ Transitory MPX is upward biased



Durables

We have data on value of household cars

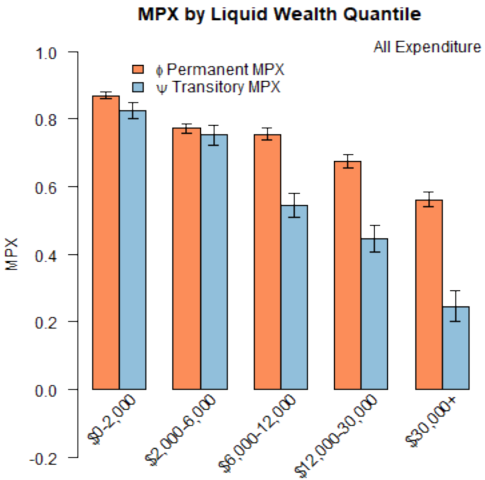
- Construct expenditure excluding car purchases and sales

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

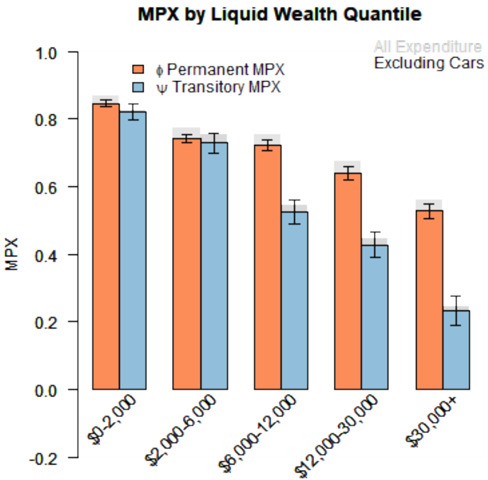
- Construct proxy for non durable consumption (Cars $\approx$ 42.1% durable expenditure)

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

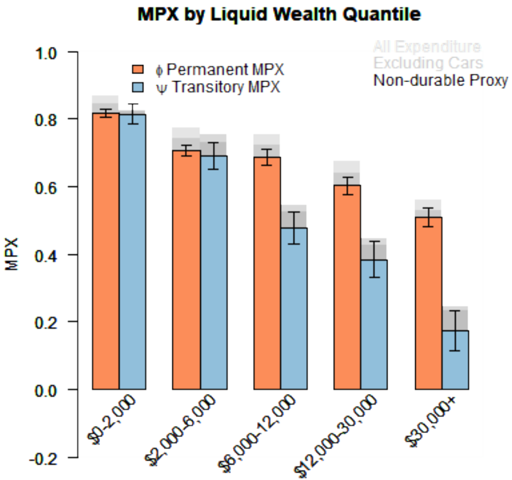
Durables


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

Durables


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

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!