Income and Consumption Dynamics: Partial Insurance and Inequality

Lecture I, BU

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- But how important are each of these mechanisms? Can we explain the linkages?
- In this lecture the aim is to begin to add more structure to the distributional dynamics of wages, incomes and consumption.

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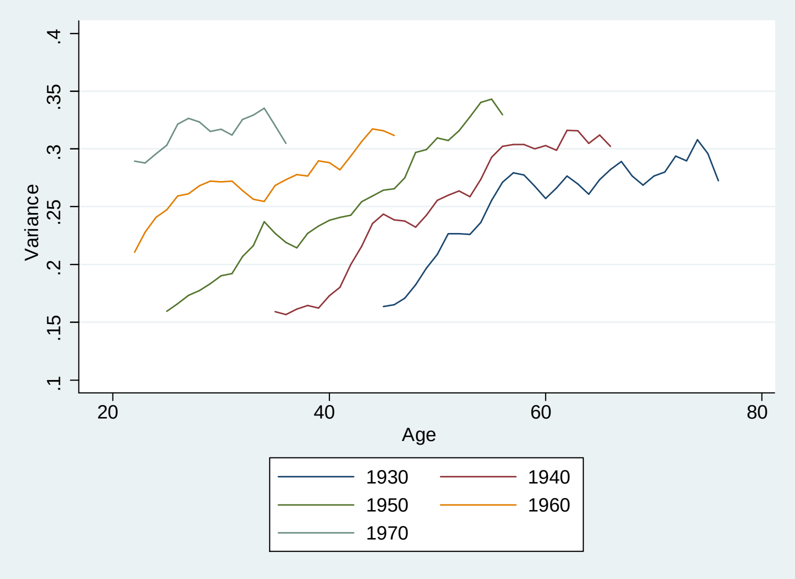
- First, and briefly, some broad evidence:

Consumption Inequality in the UK

By age and birth cohort



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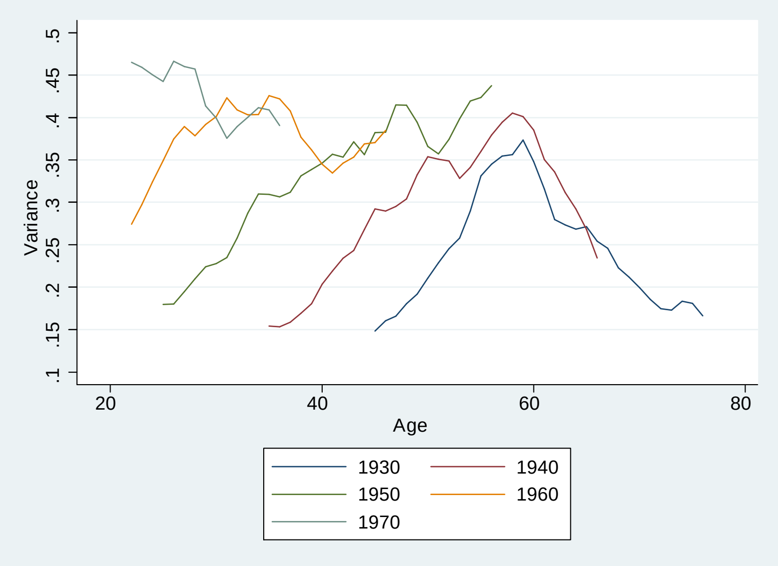

Consumption Inequality in the US

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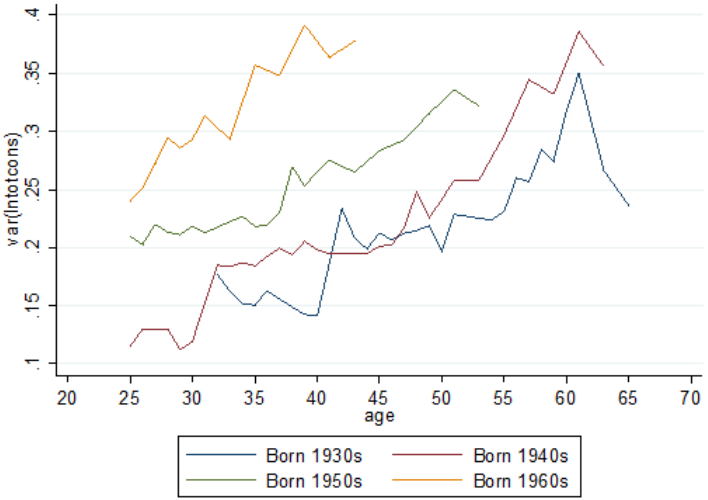

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- The existing literature (references in paper) usually relates movements in consumption to predictable and unpredictable income changes as well as persistent and non-persistent shocks to economic resources.
- One consistent, and somewaht puzzling, finding in most of this recent work is that household consumption appears significantly smoothed, even with respect to quite persistent shocks.

Income Dynamics

To set the scene, consider consumer i (of age a) in time period t, has log income $y_{it}(\equiv \ln Y_{i,a,t})$ written

$$y_{it} = Z'_{it}\varphi + f_{0i} + p_t f_{1i} + y^P_{it} + y^T_{it}$$

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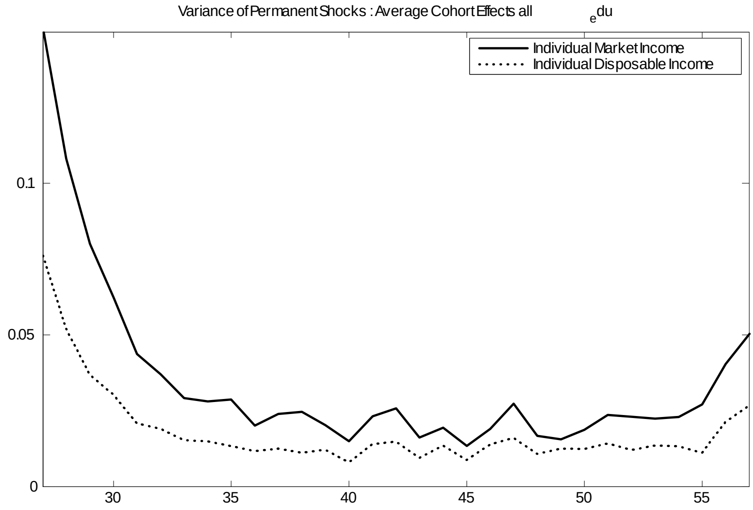
- Detailed work on Norwegian population register panel data....

Life-cycle Income Dynamics

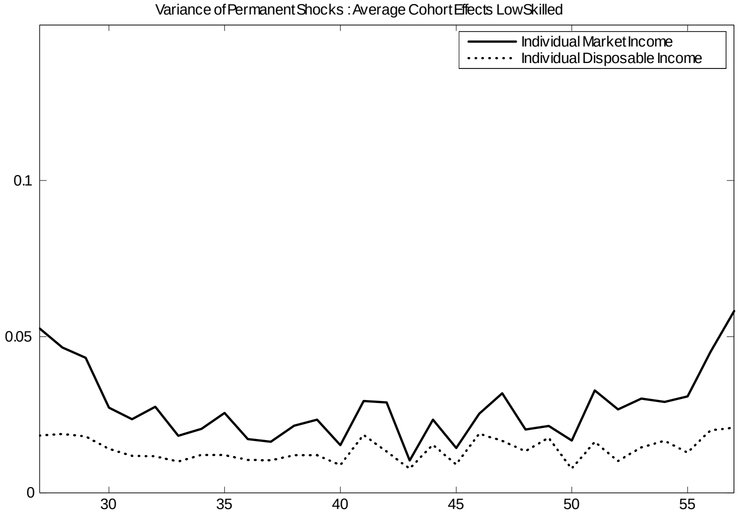
Norwegian pop panel: Var of perm shocks over the life-cycle



Source: Blundell, Graber and Mogstad (*JPubE*, 2015).

Life-cycle Income Dynamics

Norwegian population panel (low skilled)



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Consumption Growth and Income "Shocks"

To account for the impact of income shocks on consumption we introduce *transmission parameters*: κ_{cvt} and $\kappa_{c\varepsilon t}$, writing consumption growth as:

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- For example, in Blundell, Low and Preston (*QE*, 2013) show, for any birth-cohort,

$$\Delta \ln C_{it} \cong \Gamma_{it} + \Delta Z_{it}' \varphi^c + (1 - \pi_{it}) v_{it} + (1 - \pi_{it}) \gamma_{Lt} \varepsilon_{it} + \xi_{it}$$

where

$$\pi_{it} \approx \frac{\text{Assets}_{it}}{\text{Assets}_{it} + \text{Human Wealth}_{it}}$$

and γ_{Lt} is the annuity value of a transitory shock for an individual aged t retiring at age L.

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- Note that these values for κ_{cvt} and $\kappa_{c\varepsilon t}$ pose potential puzzles! Is there excess insurance?

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  - *Asset* data collected in every wave.
- Then finish by considering the role of **non-linear dynamics**, see ABB (cemmap 2015).

NIPA-PSID Comparison

	1998	2000	2002	2004	2006	2008
PSID Total	3,276	3,769	4,285	5,058	5,926	5,736
NIPA Total	5,139	5,915	6,447	7,224	8,190	9,021
ratio	0.64	0.64	0.66	0.7	0.72	0.64
PSID Nondurables	746	855	887	1,015	1,188	1,146
NIPA Nondurables	1,330	1,543	1,618	1,831	2,089	2,296
ratio	0.56	0.55	0.55	0.55	0.57	0.5
PSID Services	2,530	2,914	3,398	4,043	4,738	4,590
NIPA Services	3,809	4,371	4,829	5,393	6,101	6,725
ratio	0.66	0.67	0.7	0.75	0.78	0.68

Note: PSID weights are applied for the non-sampled PSID data (47,206 observations for these years). Total consumption is defined as Nondurables + Services. PSID consumption categories include food, gasoline, utilities, health, rent (or rent equivalent), transportation, child care, education and other insurance. NIPA numbers are from NIPA table 2.3.5. All numbers are nonminal

Descriptive Statistics for Assets and Earnings

PSID Assets, Hours and Earnings

	1998	2000	2002	2004	2006	2008
Total assets	332,625	352,247	382,600	476,626	555,951	506,823
Housing and RE assets	159,856	187,969	227,224	283,913	327,719	292,910
Financial assets	173,026	164,567	155,605	192,995	228,805	214,441
Total debt	72,718	82,806	98,580	115,873	131,316	137,348
Mortgage	65,876	74,288	89,583	106,423	120,333	123,324
Other debt	7,021	8,687	9,217	9,744	11,584	14,561
First earner (head)						
Earnings	54,220	61,251	63,674	68,500	72,794	75,588
Hours worked	2,357	2,317	2,309	2,309	2,284	2,140
Second earner (wife)						
Participation rate	0.81	0.8	0.81	0.81	0.81	0.8
Earnings (conditional on participation)	26,035	28,611	31,693	33,987	36,185	39,973
Hours worked (conditional on participation)	1,666	1,691	1,697	1,707	1,659	1,648
Observarions	1,872	1,951	1,984	2,011	2,115	2,221

Notes: PSID data from 1999-2009 PSID waves. PSID means are given for the main sample of estimation: married couples with working males aged 30 to 65. SEO sample excluded. PSID rent is imputed as 6% of reported house value for homeowners. Missing values in consumption and assets sub-categories were treated as zeros.

Household Optimization in a Unitary Framework

To motivate the framework consider a household that chooses $\left\{C_{i,t+j}, H_{i,1,t+j}, H_{i,2,t+j}\right\}_{j=0}^{T-t}$ to maximize

$$\mathbb{E}_t \sum_{\tau=0}^{T-t} (1+\delta)^{-\tau} v\left(C_{i,t+\tau}, H_{i,1,t+\tau}, H_{i,2,t+\tau}; Z_{i,t+\tau}\right)$$

subject to

$$C_{i,t} + \frac{A_{i,t+1}}{1+r} = A_{i,t} + H_{i,1,t} W_{i,1,t} + H_{i,1,t} W_{i,2,t}$$

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Our approach

- Extend previous work and express the distributional dynamics of consumption and earnings growth as functions of Frisch elasticities, 'insurance parameters' and wage shocks

Wage Process

For earner $j = \{1, 2\}$ in household i, period t, wage growth is:

$$\Delta \log W_{i,j,t} = \Delta X'_{i,j,t}\beta_j + \Delta u_{i,j,t} + v_{i,j,t}$$

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$$\begin{pmatrix} u_{i,1,t} \\ u_{i,2,t} \\ v_{i,1,t} \\ v_{i,2,t} \end{pmatrix} \sim i.i.d. \left(\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_{u,1} & \sigma_{u_1,u_2} & 0 & 0 \\ \sigma_{u_1,u_2} & \sigma^2_{u,2} & 0 & 0 \\ 0 & 0 & \sigma^2_{v,1} & \sigma_{v_1,v_2} \\ 0 & 0 & \sigma_{v_1,v_2} & \sigma^2_{v,2} \end{pmatrix} \right)$$

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- Allow the variances to differ by gender and across the life-cycle.

Wage Parameters Estimates

Sample			All
Males	Trans.	$\sigma^2_{u_1}$	0.033 (0.007)
	Perm.	$\sigma^2_{v_1}$	0.032 (0.005)
Females	Trans.	$\sigma^2_{u_2}$	0.012 (0.006)
	Perm.	$\sigma^2_{v_2}$	0.043 (0.005)
Correlation of shocks	Trans.	ρ_{u_1,u_2}	0.244 (0.22)
	Perm	ρ_{v_1,v_2}	0.113 (0.07)
Observations			8,191

Consumption and Earnings Growth

The 'Simple' Separable Case

$$\begin{pmatrix} \Delta c_t \\ \Delta y_{1,t} \\ \Delta y_{2,t} \end{pmatrix} \simeq \begin{pmatrix} 0 & 0 & \kappa_{c,v_1} & \kappa_{c,v_2} \\ \kappa_{y_1,u_1} & 0 & \kappa_{y_1,v_1} & \kappa_{y_1,v_2} \\ 0 & \kappa_{y_2,u_2} & \kappa_{y_2,v_1} & \kappa_{y_2,v_2} \end{pmatrix} \begin{pmatrix} \Delta u_{1,t} \\ \Delta u_{2,t} \\ v_{1,t} \\ v_{2,t} \end{pmatrix} + \begin{pmatrix} \Delta e_{c,t} \\ \Delta e_{y_1,t} \\ \Delta e_{y_2,t} \end{pmatrix}$$

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where the key transmission parameters:

$$\kappa_{c,v_j} = (1-\beta)\left(1-\pi_{i,t}\right) s_{i,j,t} \frac{\eta_{c,p}\left(1+\eta_{h_j,w_j}\right)}{\eta_{c,p} + (1-\beta)\left(1-\pi_{i,t}\right)\overline{\eta_{h,w}}}$$

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- β is 'insurance' over above savings, taxes and labour supply.

Transmission Parameters:

Consumption response to j's permanent wage shock:

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- declines with $\eta_{h_{-j},w_{-j}}$ ("added worker" effect)
- declines with η_{h_j,w_j} only if j's labor supply responds negatively to own permanent shock. In one-earner case, true if

$$(1-\beta)(1-\pi_{i,t}) - \eta_{c,p} > 0$$

IDENTIFICATION WITH ASSET DATA

- Note that β is not identified separately from π
- Back out π from the data and estimate β

$$\pi_{i,t} \approx \frac{\overbrace{\text{Assets}_{i,t}}^{\textit{Observed in PSID}}}{\underbrace{\text{Human Wealth}_{i,t}}_{\textit{Projected lifetime earnings}} + \text{Assets}_{i,t}}$$

- Human wealth is projected using observables that evolve deterministically (e.g. age).

Identification with non-separability

- When preferences are non-separable, we have:

$$\begin{pmatrix} \Delta c_t \\ \Delta y_{1,t} \\ \Delta y_{2,t} \end{pmatrix} \simeq \begin{pmatrix} \kappa_{c,u_1} & \kappa_{c,u_2} & \kappa_{c,v_1} & \kappa_{c,v_2} \\ \kappa_{y_1,u_1} & \kappa_{y_1,u_2} & \kappa_{y_1,v_1} & \kappa_{y_1,v_2} \\ \kappa_{y_2,u_1} & \kappa_{y_2,u_2} & \kappa_{y_2,v_1} & \kappa_{y_2,v_2} \end{pmatrix} \begin{pmatrix} \Delta u_{1,t} \\ \Delta u_{2,t} \\ v_{1,t} \\ v_{2,t} \end{pmatrix}$$

- $\kappa_{c,u_j} \rightarrow$ non-separability between consumption and leisure j
  $\kappa_{y_j,u_k} \rightarrow$ non-separability between spouses' leisures

Data and Sample Selection

- PSID biennial 1999-2009:
  - PSID consumption went through a major revision in 1999
    - ~70% of consumption expenditures. Good match with NIPA
    - The sum of food at home, food away from home, gasoline, health, transportation, utilities, etc.
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- Methodology: Use structural restrictions that 'theory' imposes on the variance covariance structure of $\Delta c_{i,t}$, $\Delta y_{i,1,t}$ and $\Delta y_{i,2,t}$

Some Econometrics Issues

- Measurement error
  - For consumption, use martingale assumption and mean-reversion
  - For wages, use external estimates from Bound et al. (1994)

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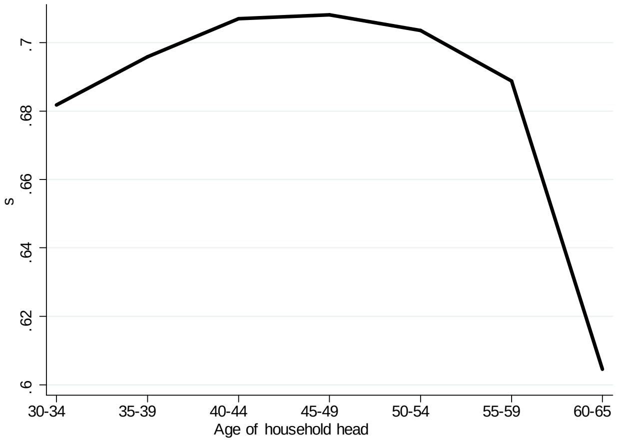
- Inference
  - Multi-step procedure
  - Block bootstrap standard errors

DISTRIBUTION OF s BY AGE

$$s_{i,t} \approx \frac{\text{Human Wealth}_{male,i,t}}{\text{Human Wealth}_{i,t}}:$$



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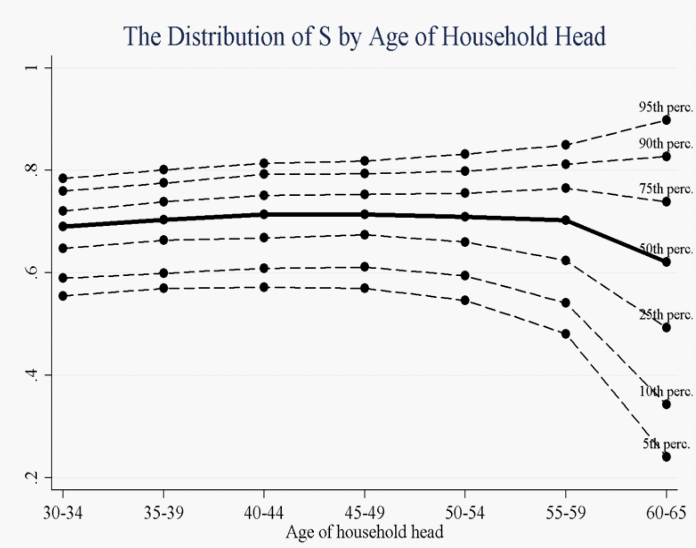

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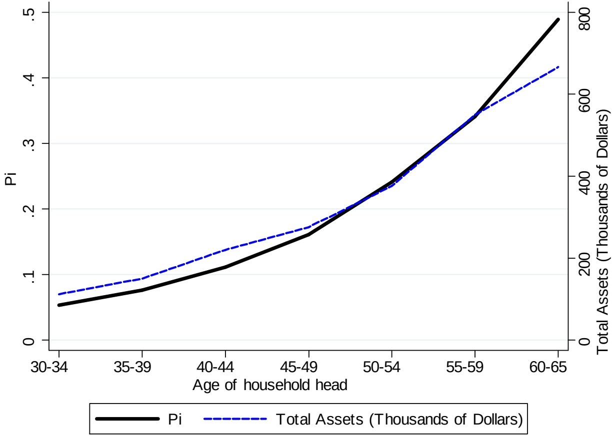

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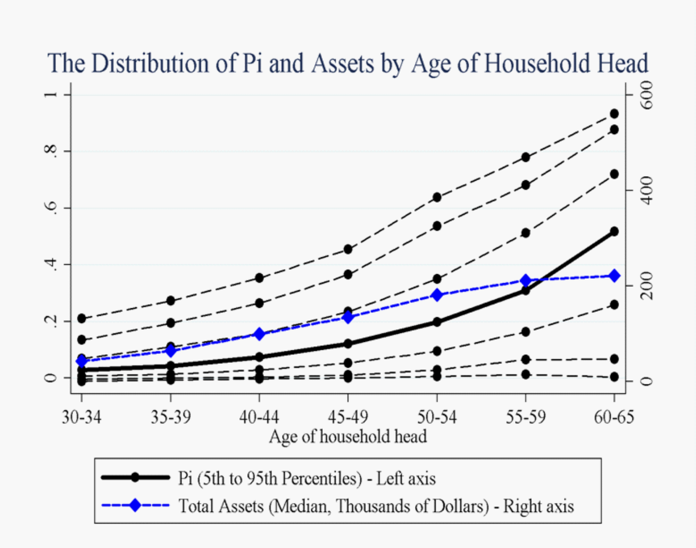
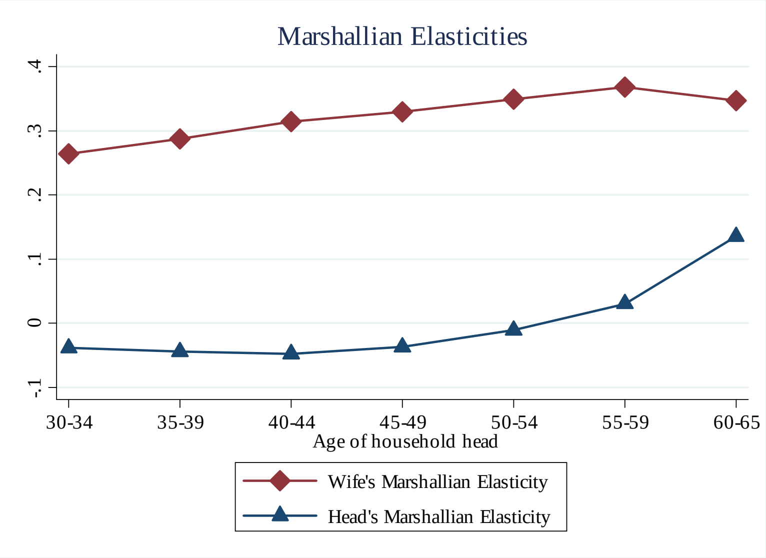


Results: With and Without Separability

	(1) Additive separ.	(2) Non-separab.	(3) Non-separab.
$E(\pi)$	0.181 (0.008)	0.181 (0.008)	0.181 (0.008)
β	0.741 (0.165)	-0.120 (0.198)	0
$\eta_{c,p}$	0.201 (0.077)	0.437 (0.124)	0.448 (0.126)
η_{h_1,w_1}	0.431 (0.097)	0.514 (0.150)	0.497 (0.150)
η_{h_2,w_2}	0.831 (0.133)	1.032 (0.265)	1.041 (0.275)
η_{c,w_1}	-.-	-0.141 (0.051)	-0.141 (0.053)
$\eta_{h_1,p}$	-.-	0.082 (0.030)	0.082 (0.031)
η_{c,w_2}	-.-	-0.138 (0.139)	-0.158 (0.121)
$\eta_{h_2,p}$	-.-	0.162 (0.166)	0.185 (0.145)
η_{h_1,w_2}	-.-	0.128 (0.052)	0.120 (0.064)
η_{h_2,w_1}	-.-	0.258 (0.103)	0.242 (0.119)

Marshallian Elasticities: By Age



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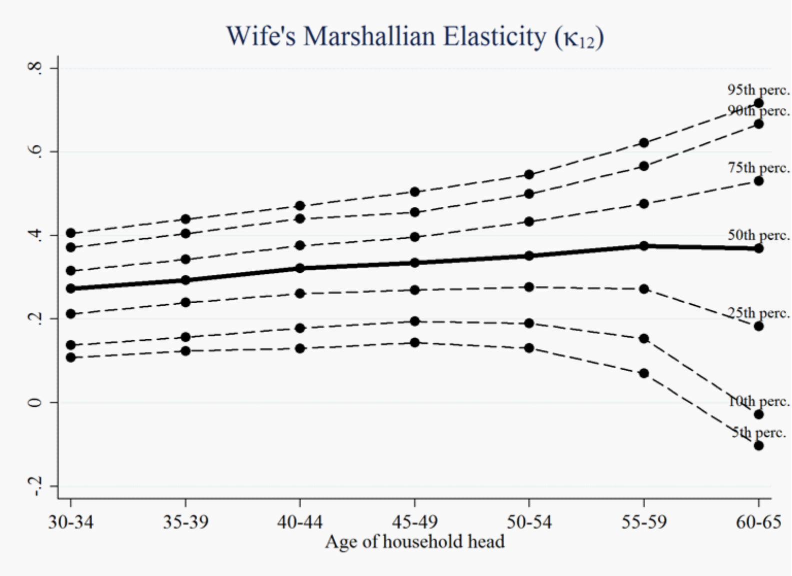

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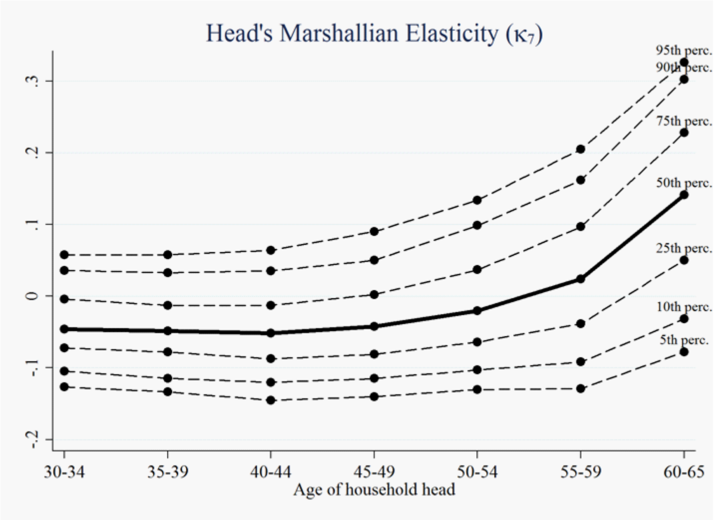
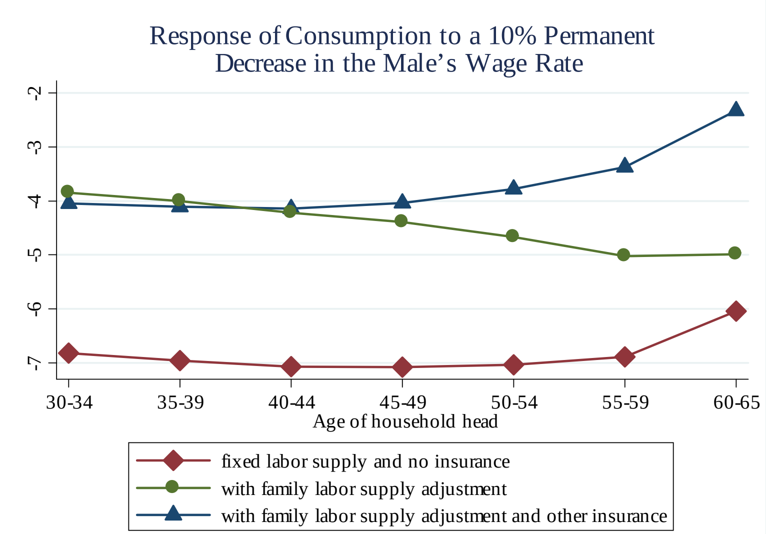


INSURANCE VIA LABOR SUPPLY (SHOCK TO MALE WAGES): BY AGE



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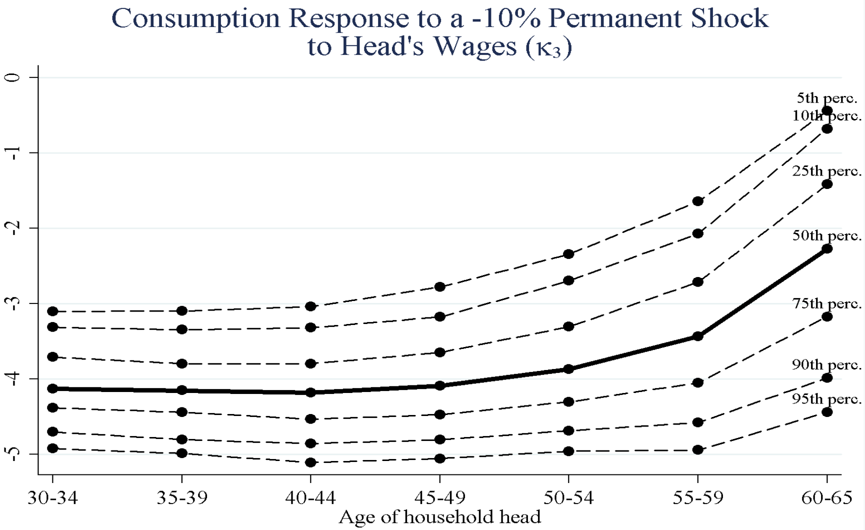

Some Misspecification Tests

Concavity and Advance Information

- **Concavity of preferences**. Use the fact that:

$$\begin{pmatrix} \eta_{cp}\frac{c}{p} & \eta_{cw_1}\frac{c}{w_1} & \eta_{cw_2}\frac{c}{w_2} \\ -\eta_{h_1p}\frac{h_1}{p} & -\eta_{h_1w_1}\frac{h_1}{w_1} & -\eta_{h_1w_2}\frac{h_1}{w_2} \\ -\eta_{h_2p}\frac{h_2}{p} & -\eta_{h_2w_1}\frac{h_2}{w_1} & -\eta_{h_2w_2}\frac{h_2}{w_2} \end{pmatrix} = \lambda \begin{pmatrix} \frac{d^2u}{dc^2} & \frac{d^2u}{dcdl_1} & \frac{d^2u}{dcdl_2} \\ \frac{d^2u}{dl_1dc} & \frac{d^2u}{dl_1^2} & \frac{d^2u}{dl_1dl_2} \\ \frac{d^2u}{dl_2dc} & \frac{d^2u}{dl_2dl_1} & \frac{d^2u}{dl_2^2} \end{pmatrix}^{-1}$$

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- Concavity is satisfied at average values of wages, hours, consumption.
- **Advance Information**. Consumption growth should be correlated with future wage growth (Cunha et al., 2008, and BPP 2008).
  - Test has p-value 13%

Results: Extensive Margin

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	Regression results		First stage F-stats	
	(1)	(2)	(1)	(2)
$\Delta EMP_t(Male)$	0.144 (0.369)		23.4	
$\Delta h_t(Male)$	-0.073 (0.175)	-0.013 (0.021)	26.3	135.5
$\Delta EMP_t(Female)$	0.356 (0.169)	0.362 (0.186)	98.4	91.2
$\Delta h_t(Female)$	-0.220 (0.100)	-0.171 (0.094)	86.5	77.7
Sample	All	EMP$_t$(Male)=1		
Instruments	2^{nd},4^{th} lags	2^{nd},4^{th} lags		

Note: Δx_t is defined as $(x_t - x_{t-1})$ / $[0.5\,(x_t + x_{t-1})]$

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  - Family labour supply
  - Informal contracts, gifts, etc.
- Showing the value, and possibilities for collecting, good panel data on consumption and assets.

And gathering up the results...

- Need to allow for non-stationarity over the life-cycle and over time
  - variances (of persistent shocks) display an U-shape over the (working) life-cycle,
  - note the spike in the variance of permanent shocks during the 80s and 90s recessions, Blundell & Preston (QJE, 1998).

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And gathering up the results...

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  - variances (of persistent shocks) display an U-shape over the (working) life-cycle,
  - note the spike in the variance of permanent shocks during the 80s and 90s recessions, Blundell & Preston (QJE, 1998).
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- Once family labor supply, assets and taxes/benefits are accounted for, there is little evidence for additional insurance
  - lots to be done to dig deeper into these, and other, mechanisms.
  - I want to close this lecture by considering the whole distribution of consumption and income - nonlinearities turn out to be key...

Part II: Extensions to a Nonlinear The Panel Data Framework

• Linearity of the income process simplifies identification and estimation. However, by construction it *rules out nonlinear transmission of shocks*.

• The aim in ABB (2015) is to take a different tack and to develop a new approach to modeling persistence in which the impact of past shocks on current earnings can be altered by the size and sign of new shocks.

⇒ this new framework allows for "*unusual*" *shocks to wipe out the memory of past shocks*.
⇒ the future persistence of a current shock depends on the future shocks.

• We show the presence of "unusual" shocks matches the data and has a key impact consumption and saving over the life cycle.

Methodology and data

• Nonlinear dynamic model with latent variables (the unobserved earnings components).

– Nonparametric identification builds on Hu and Schennach (08) and Wilhelm (12).

– Flexible parametric estimation that combines quantile modeling and linear expansions in bases of functions.

• Panel data on household earned income, consumption ($\approx$ 70% of expenditures of nondurables and services) and assets holdings from the new waves of PSID (1999-2009). Recently (2004) further improved.

– Avoids need to use food consumption or imputed consumption data.

– Compare with population panel (register) data from Norway, see Blundell, Graber and Mogstad (2014) - not quite finished constructing consumption data.

Nonlinear Persistence

• Consider a cohort of households, $i = 1, ..., N$, and denote age as t. Let y_{it} denote log-labor income, net of age dummies.

$$y_{it} = \eta_{it} + \varepsilon_{it}, \quad i = 1, ..., N, \quad t = 1, ..., T.$$

▷ η_{it} follows a general first-order Markov process (can be generalised).

• Denoting the τth conditional quantile of η_{it} given $\eta_{i,t-1}$ as $Q_t(\eta_{i,t-1}, \tau)$, we specify

$$\eta_{it} = Q_t(\eta_{i,t-1}, u_{it}), \qquad \text{where } (u_{it}|\eta_{i,t-1}, \eta_{i,t-2}, ...) \sim \mathit{Uniform}\,(0, 1).$$

▷ ε_{it} has zero mean, independent over time (at a 2-year frequency in the PSID).

▷ The conditional quantile functions $Q_t(\eta_{i,t-1}, u_{it})$ and the marginal distributions F_{ε_t} are age (t) specific.

A measure of persistence

- The model allows for nonlinear dynamics of income.

- To see this, consider the following measure of persistence

$$\rho_t(\eta_{i,t-1},\tau)=\frac{\partial Q_t(\eta_{i,t-1},\tau)}{\partial \eta}.$$

$\Rightarrow$ $\rho_t(\eta_{i,t-1},\tau)$ measures the persistence of $\eta_{i,t-1}$ when it is hit by a shock u_{it} that has rank τ.

– Allows a general form of conditional heteroscedasticity, skewness and kurtosis.

- In the "canonical model" $\eta_{it}=\eta_{i,t-1}+v_{it}$, with v_{it} independent over time and independent of past $\eta' s$,

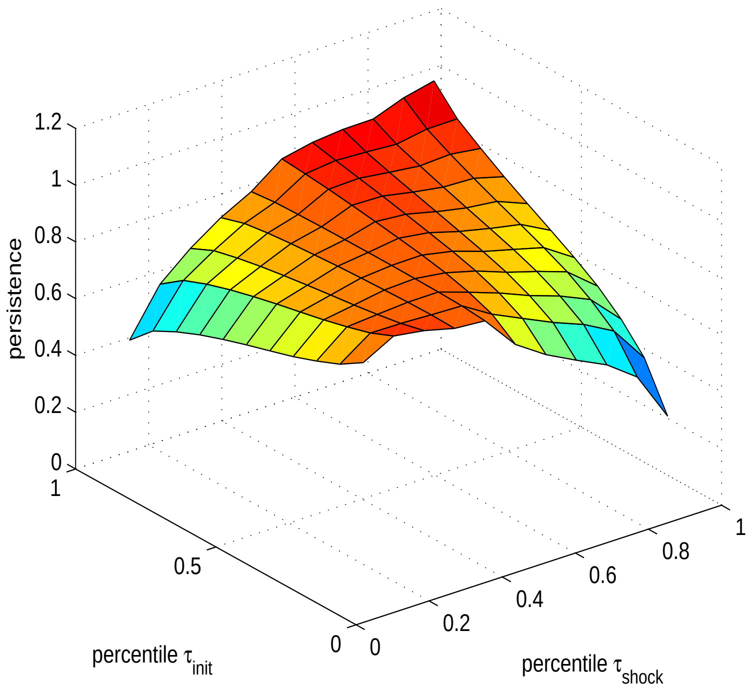
$$\eta_{it}=\eta_{i,t-1}+F_{v_t}^{-1}(u_{it}) \quad \Rightarrow \quad \rho_t(\eta_{i,t-1},\tau)=1 \text{ for all } (\eta_{i,t-1},\tau).$$

– But what's the evidence for such nonlinearities in persistence?

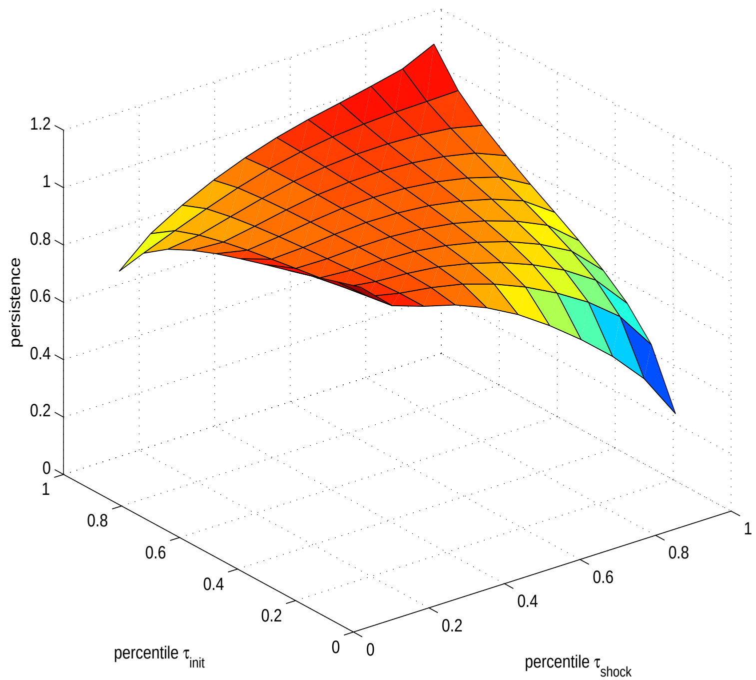
Some motivating evidence: Quantile autoregressions of log-earnings

$$\frac{\partial Q_{y_t|y_{t-1}}(y_{i,t-1},\tau)}{\partial y}$$

PSID data

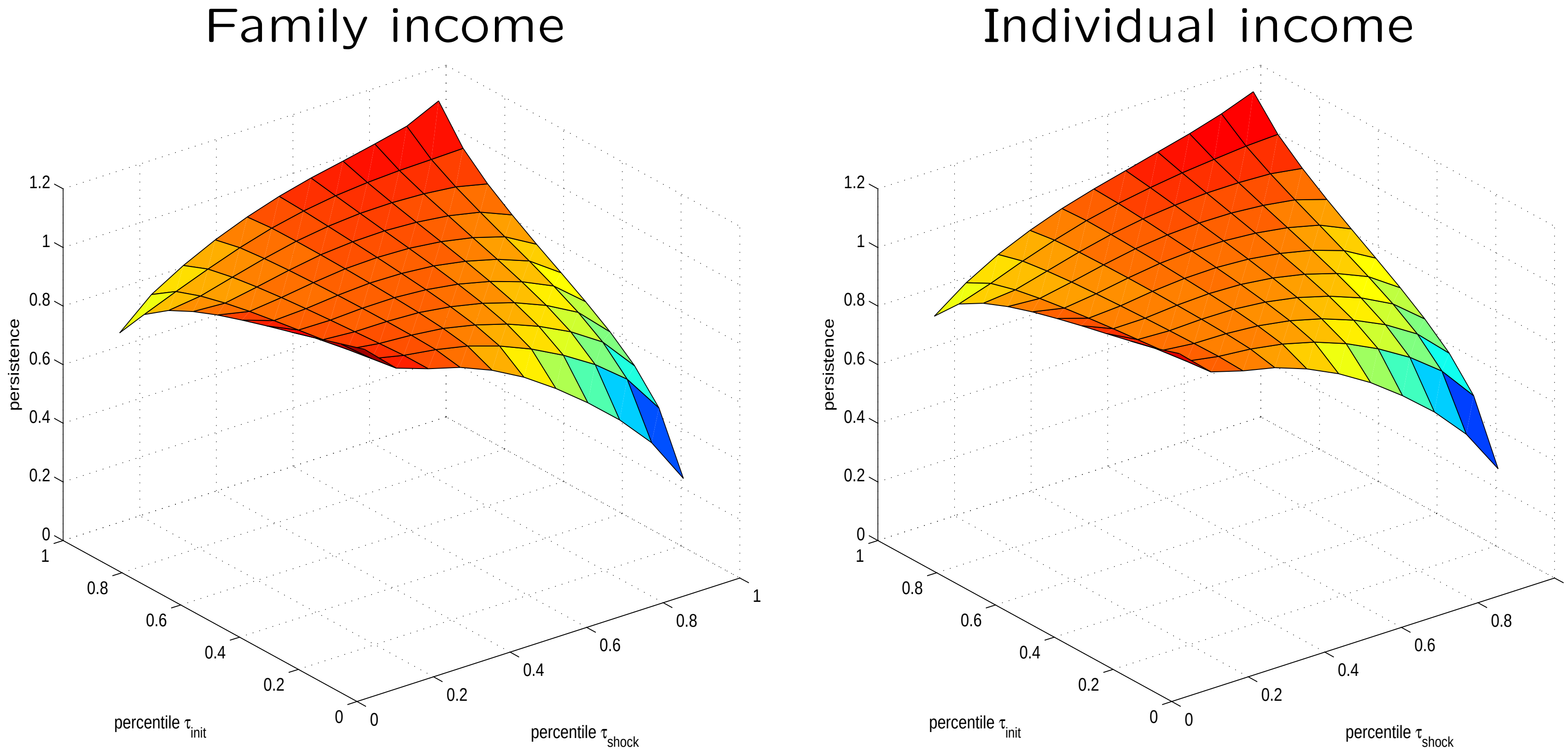


Norwegian administrative data



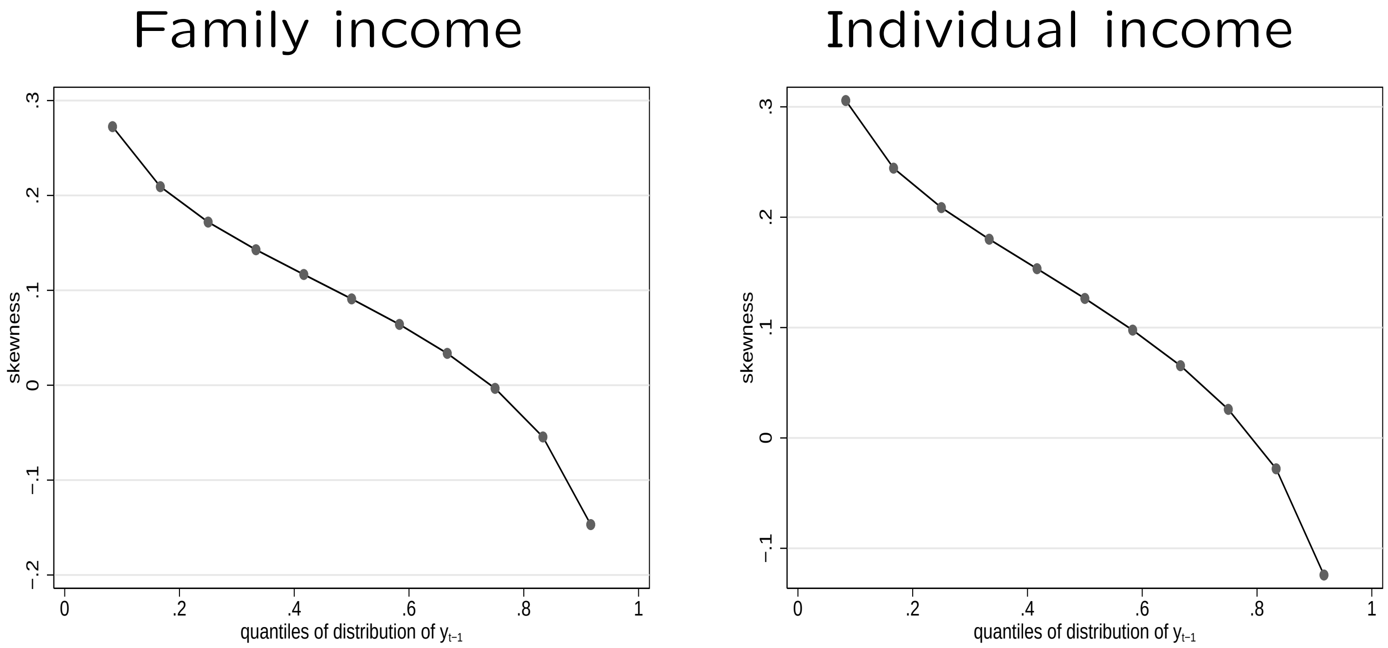
Note: Residuals of log pre-tax household labor earnings, Age 35-65 1999-2009 (US), Age 25-60 2005-2006 (Norway). Estimates of the average derivative of the conditional quantile function of y_{it} given $y_{i,t-1}$ with respect to $y_{i,t-1}$, using a grid of 11-quantiles and a 3rd degree Hermite polynomial.

Nonlinear earnings persistence, Norwegian administrative data



Note: Estimates of the average derivative of the conditional quantile function of y_{it} given $y_{i,t-1}$ with respect to $y_{i,t-1}$, evaluated at percentile τ_{shock} and at a value of $y_{i,t-1}$ that corresponds to the τ_{init} percentile of the distribution of $y_{i,t-1}$, using a grid of 11-quantiles and a 3rd degree Hermite polynomial. Age 25-60, years 2005-2006.

Conditional skewness, Norwegian administrative data



Note: Skewness measured as a nonparametric estimate of

$$\frac{Q_{y_t|y_{t-1}}(y_{i,t-1},.9)+Q_{y_t|y_{t-1}}(y_{i,t-1},.1)-2Q_{y_t|y_{t-1}}(y_{i,t-1},.5)}{Q_{y_t|y_{t-1}}(y_{i,t-1},.9)-Q_{y_t|y_{t-1}}(y_{i,t-1},.1)}.$$

Age 25-60, years 2005-2006.

Outline of the ABB paper

- Consumption simulations and model specification
- Identification
- Data and estimation strategy
- Empirical results

An Empirical Consumption Rule

• Let c_{it} and a_{it} denote log-consumption and log-assets (beginning of period) net of age dummies.

• Our empirical specification is based on

$$c_{it} = g_t \left(a_{it}, \eta_{it}, \varepsilon_{it}, \nu_{it} \right) \qquad t = 1, ..., T,$$

where ν_{it} are independent across periods, and g_t is a nonlinear, age-dependent function, monotone in ν_{it}.

– ν_{it} may be interpreted a taste shifter that increases marginal utility. We normalize its distribution to be standard uniform in each period.

• This consumption rule is consistent, in particular, with the standard life-cycle model of the previous slides. Can allow for individual unobserved heterogeneity and for advance information and habits.

Insurance coefficients

- With consumption specification given by

$$c_{it} = g_t\left(a_{it}, \eta_{it}, \varepsilon_{it}, \nu_{it}\right), \quad t = 1, ..., T,$$

consumption responses to η and ε are

$$\phi_t(a, \eta, \varepsilon) = \mathbb{E}\left[\frac{\partial g_t\left(a, \eta, \varepsilon, \nu\right)}{\partial \eta}\right], \quad \psi_t(a, \eta, \varepsilon) = \mathbb{E}\left[\frac{\partial g_t\left(a, \eta, \varepsilon, \nu\right)}{\partial \varepsilon}\right].$$

– $\phi_t(a, \eta, \varepsilon)$ and $\psi_t(a, \eta, \varepsilon)$ reflect the transmission of shocks to the persistent and transitory earnings components, respectively. That is the lack of insurance to shocks.

- The marginal effect of an earnings shock u on consumption is

$$\mathbb{E}\left[\left.\frac{\partial}{\partial u}\right|_{u=\tau} g_t\Big(a, Q_t(\eta, u), \varepsilon, \nu\Big)\right] = \phi_t\Big(a, Q_t(\eta, \tau), \varepsilon\Big)\frac{\partial Q_t(\eta, \tau)}{\partial u}.$$

Earnings: identification

• For $T = 3$, Wilhelm (2012) gives conditions under which the distribution of ε_{i2} is identified.

– In particular completeness of the *pdf*s of $(y_{i2}|y_{i1})$ and $(\eta_{i2}|y_{i1})$. This requires η_{i1} and η_{i2} to be dependent.

• We build on this result to establish identification of the earnings model.

• Apply the result to each of the three-year subpanels $t \in \{1, 2, 3\}$ to $t \in \{T-2, T-1, T\}$

$\Rightarrow$ The marginal distribution of ε_{it} are identified for $t \in \{2, 3, ..., T-1\}$.

$\Rightarrow$ By independence the joint distribution of $(\varepsilon_{i2}, \varepsilon_{i3}, ..., \varepsilon_{i,T-1})$ is identified.

$\Rightarrow$ By deconvolution the distribution of $(\eta_{i2}, \eta_{i3}, ..., \eta_{i,T-1})$ is identified.

• The distribution of ε_{i1}, η_{i1}, and ε_{iT}, η_{iT} are not identified in general.

Consumption: assumptions

- u_{it} and ε_{it} are independent of a_{i1} for $t \geq 1$, where $\eta_{it} = Q_t(\eta_{i,t-1}, u_{it})$.

- We let η_{i1} and a_{i1} be arbitrarily dependent.

– This is important, because asset accumulation upon entry in the sample may be correlated with past persistent shocks.

- Denoting $\eta_i^t = (\eta_{it}, \eta_{i,t-1}, ..., \eta_{i1})$, we assume (in this talk) that:

a_{it} is independent of $(\eta_i^{t-1}, a_i^{t-2}, \varepsilon_i^{t-2})$ given $(a_{i,t-1}, c_{i,t-1}, y_{i,t-1})$.

– Consistent with the accumulation rule in the standard life-cycle model with one single risk-less asset.

Extensions

• Consumption rule with *unobserved heterogeneity*:

$$c_{it} = g_t\left(a_{it}, \eta_{it}, \varepsilon_{it}, \xi_i, \nu_{it}\right).$$

• We assume that u_{it} and ε_{it}, for $t \geq 1$, are independent of (a_{i1}, ξ_i).

• The distribution of $(a_{i1}, \xi_i, \eta_{i1})$ is unrestricted.

• A combination of the above identification arguments and the main result of Hu and Schennach (08) identifies

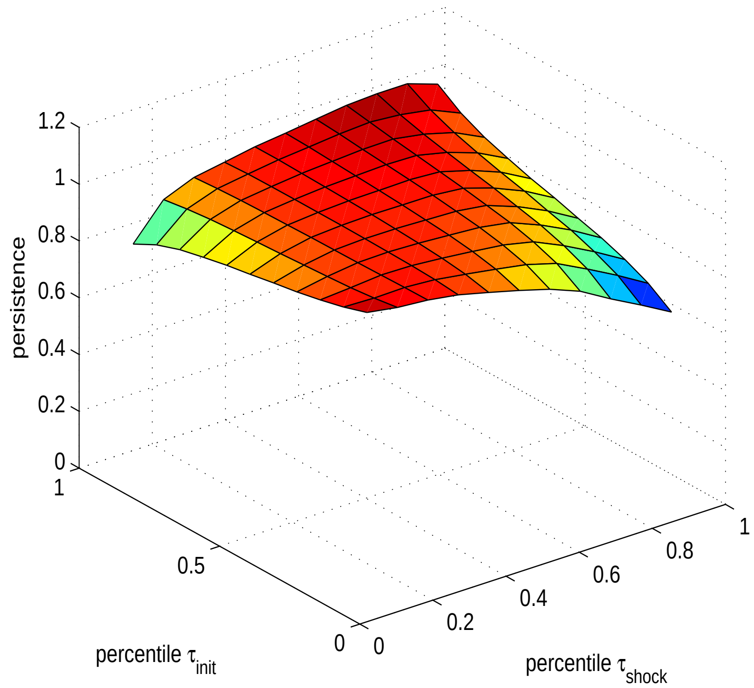
– The period-t consumption distribution $f(c_t | a_t, \eta_t, y_t, \xi)$.

– The distribution of initial conditions $f(\eta_1, \xi, a_1)$.

Empirical results

Nonlinear persistence of η_{it}

$$\rho_t(\eta_{i,t-1},\tau) = \frac{\partial Q_{\eta_t|\eta_{t-1}}(\eta_{i,t-1},\tau)}{\partial \eta}, \text{ nonlinear model}$$

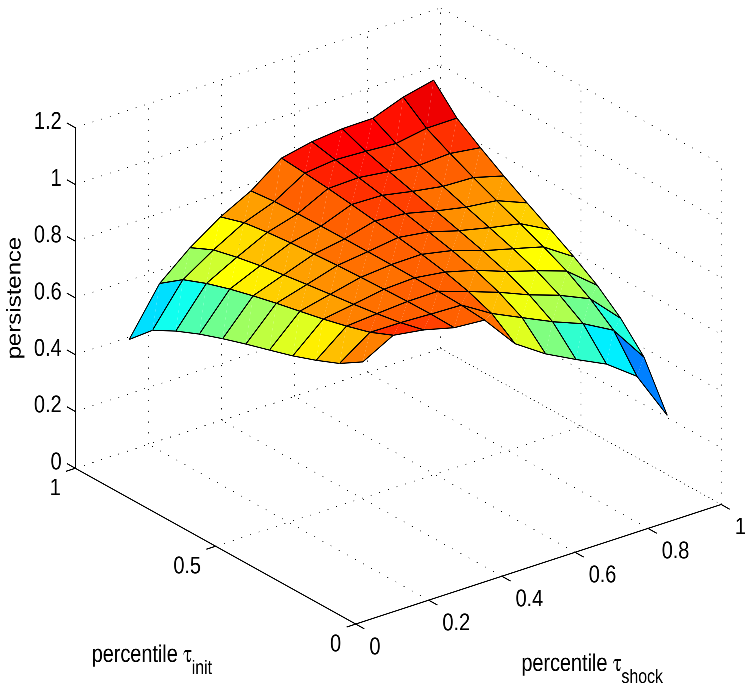


Note: Estimates of the average derivative of the conditional quantile function of η_{it} on $\eta_{i,t-1}$ with respect to $\eta_{i,t-1}$, evaluated at percentile τ_{shock} and at a value of $\eta_{i,t-1}$ that corresponds to the τ_{init} percentile of the distribution of $\eta_{i,t-1}$. Evaluated at mean age in the sample (47.5 years).

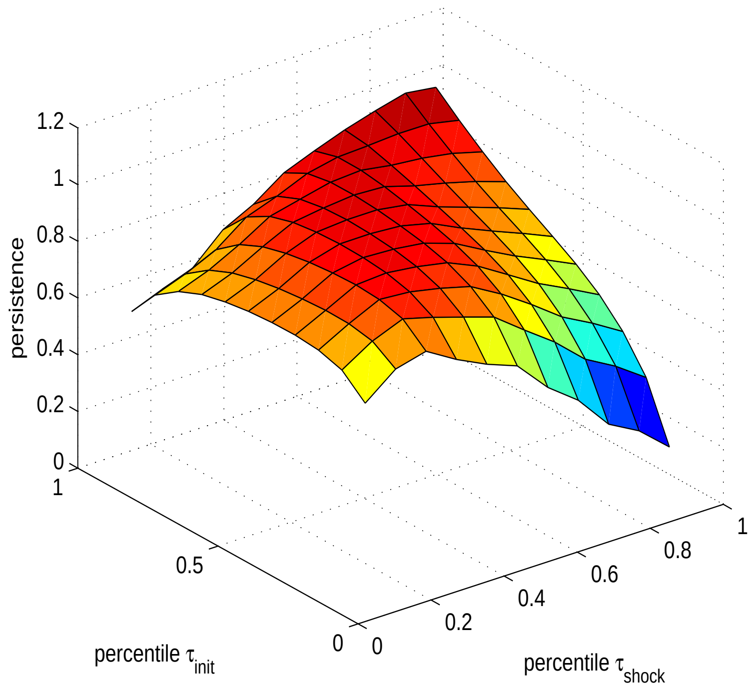
Nonlinear persistence of y_{it}

$$\frac{\partial Q_{y_t|y_{t-1}}(y_{i,t-1},\tau)}{\partial y}$$

PSID data



Nonlinear model

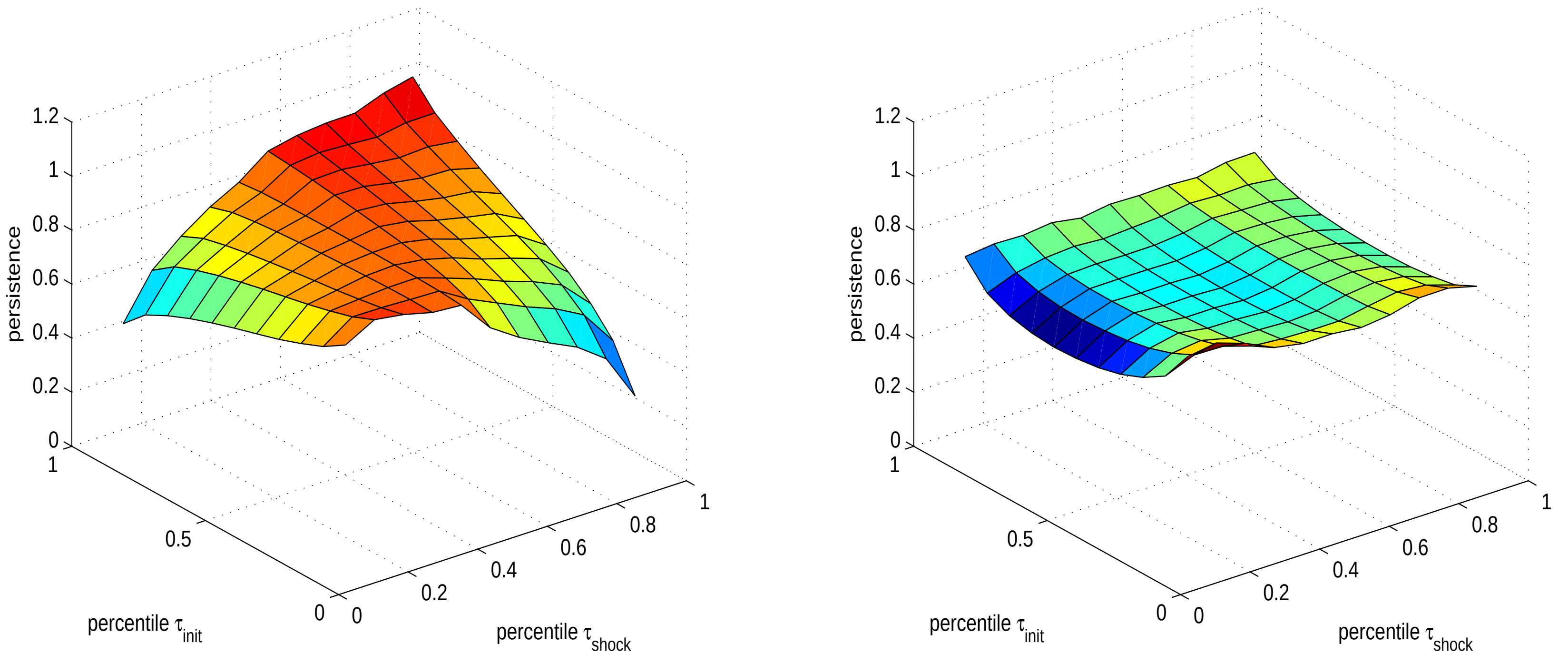


Note: Estimates of the average derivative of the conditional quantile function of y_{it} given $y_{i,t-1}$ with respect to $y_{i,t-1}$, evaluated at percentile τ_{shock} and at a value of $y_{i,t-1}$ that corresponds to the τ_{init} percentile of the distribution of $y_{i,t-1}$.

Nonlinear persistence of y_{it} (cont.)

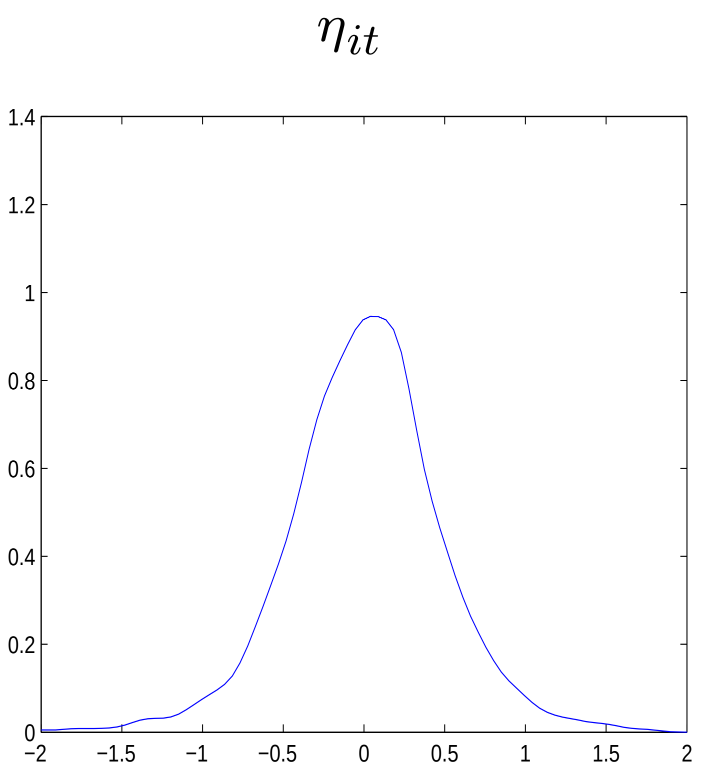
$$\frac{\partial Q_{y_t|y_{t-1}}(y_{i,t-1},\tau)}{\partial y}$$

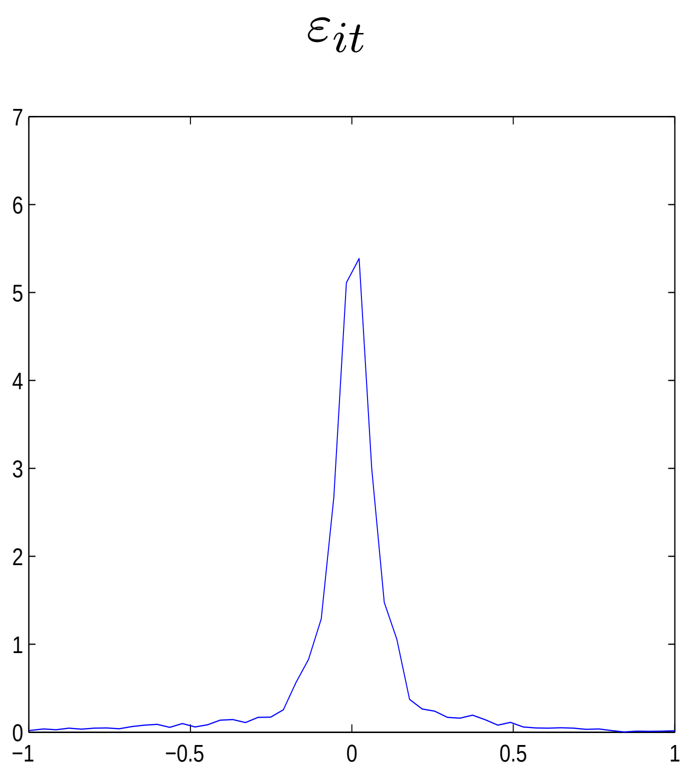
PSID data | Canonical model



Note: Estimates of the average derivative of the conditional quantile function of y_{it} given $y_{i,t-1}$ with respect to $y_{i,t-1}$, evaluated at percentile τ_{shock} and at a value of $y_{i,t-1}$ that corresponds to the τ_{init} percentile of the distribution of $y_{i,t-1}$.

Densities of persistent and transitory earnings components

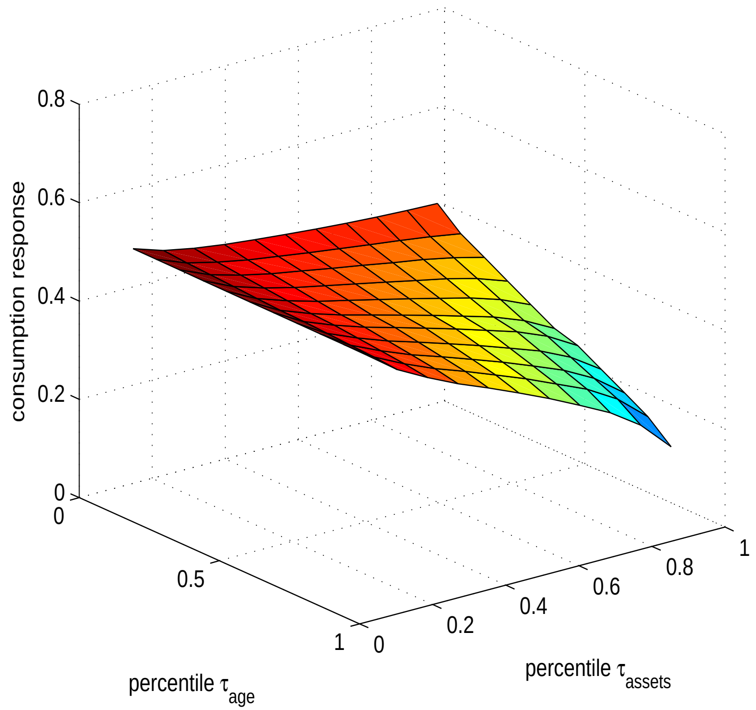




Note: Nonparametric kernel estimates of densities based on simulated data according to the nonlinear model.

Consumption response to η_{it}, by assets and age

$$\overline{\phi}_t(a) = \mathbb{E}\left[\frac{\partial g_t(a,\eta_{it},\varepsilon_{it},\nu_{it})}{\partial \eta}\right], \text{ nonlinear model}$$

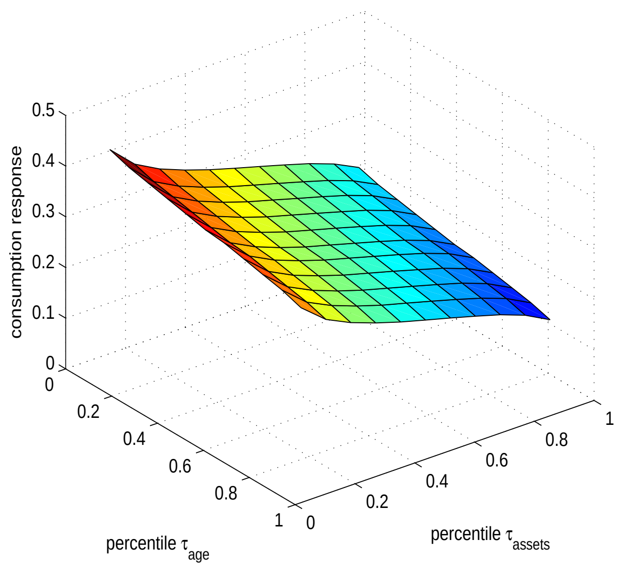


Note: Estimates of the average consumption response $\overline{\phi}_t(a)$ to variations in η_{it}, evaluated at τ_{assets} and τ_{age}.

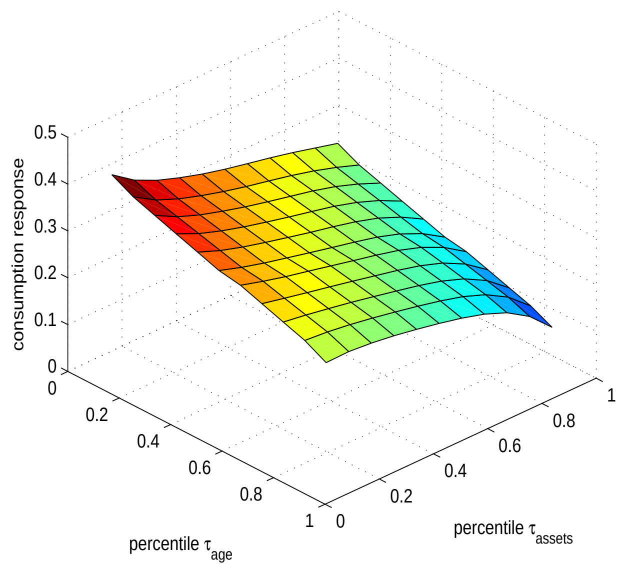
Consumption responses to y_{it}, by assets and age

$$\mathbb{E}\left[\left.\frac{\partial}{\partial y}\right|_{y_{it}}\mathbb{E}\left(c_{it}|a_{it}=a,y_{it}=y,age_{it}=age\right)\right]$$

PSID data



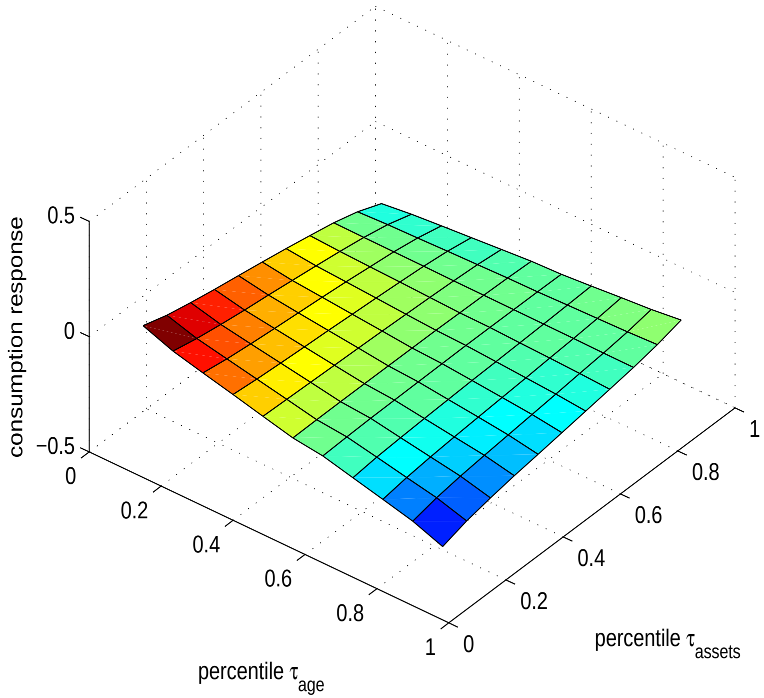
Nonlinear model



Note: Estimates of the average derivative of the conditional mean of c_{it} given y_{it}, a_{it} and age_{it} with respect to y_{it}, evaluated at values of a_{it} and age_{it} that corresponds to their τ_{assets} and τ_{age} percentiles, and averaged over the values of y_{it}.

Consumption response to ε_{it}, by assets and age

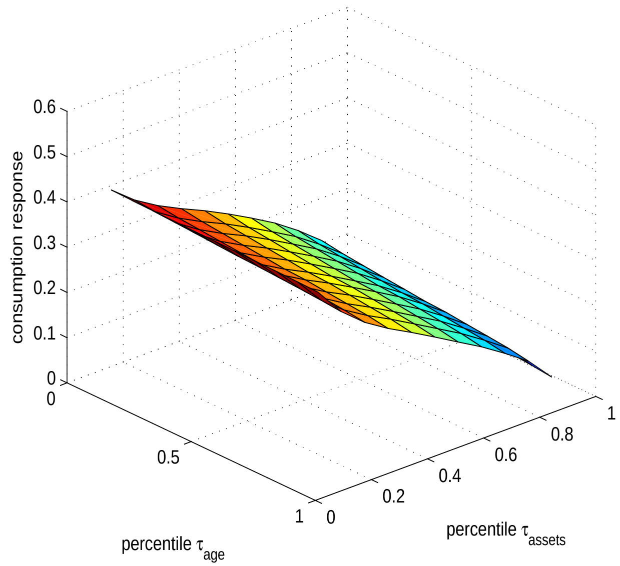
$$\overline{\psi}_t(a) = \mathbb{E}\left[\frac{\partial g_t(a,\eta_{it},\varepsilon_{it},\nu_{it})}{\partial \varepsilon}\right], \text{ nonlinear model}$$



Note: Estimates of the average consumption response $\overline{\psi}_t(a)$ to variations in ε_{it}, evaluated at τ_{assets} and τ_{age}.

Consumption response to η_{it}, by assets and age, household heterogeneity

$$\overline{\phi}_t(a) = \mathbb{E}\left[\frac{\partial g_t(a,\eta_{it},\varepsilon_{it},\xi_i,\nu_{it})}{\partial \eta}\right], \text{ nonlinear model}$$



Note: Estimates of the average consumption response $\overline{\phi}_t(a)$ to variations in η_{it}, evaluated at τ_{assets} and τ_{age}.

Model's simulation

• Simulate life-cycle earnings and consumption after a shock to the persistent earnings component (at age 37).

• We report the difference between:

– Households that are hit by a "bad" shock ($\tau_{shock} = .10$) or by a "good" shock ($\tau_{shock} = .90$).

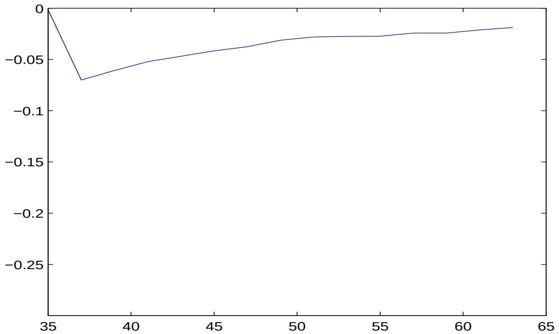
– Households that are hit by a median shock $\tau = .5$.

• Age-specific averages across 100,000 simulations. At age 35 all households have the same persistent component (percentile τ_{init}).

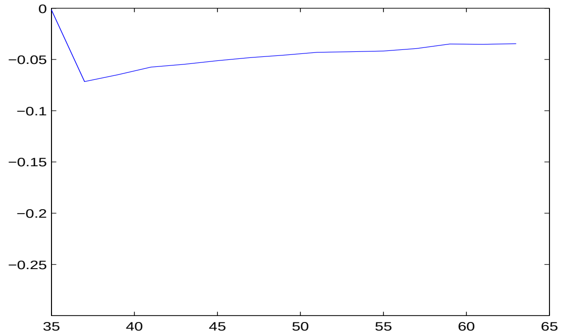
Impulse responses, earnings

Bad shock: $\tau_{shock} = .1$

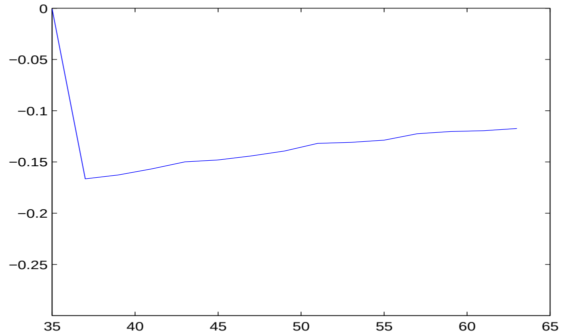
$\tau_{init} = .1$



$\tau_{init} = .5$



$\tau_{init} = .9$



Good shock: $\tau_{shock} = .9$

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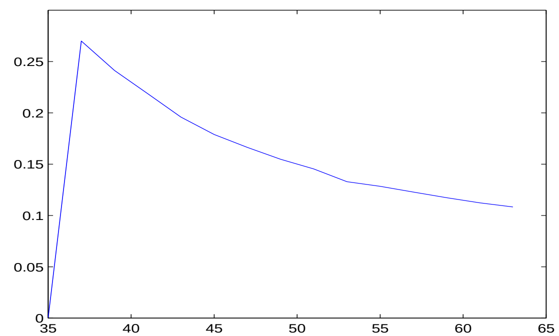
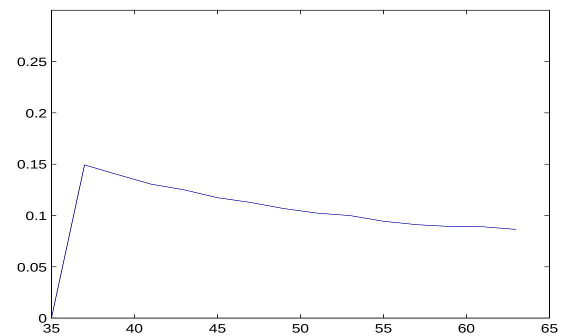
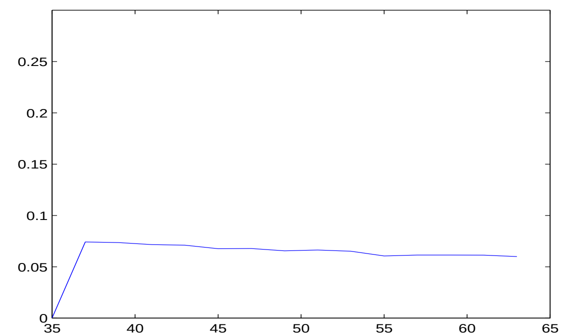


$\tau_{init} = .5$



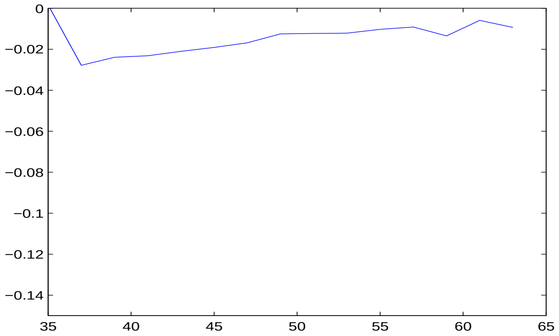
$\tau_{init} = .9$



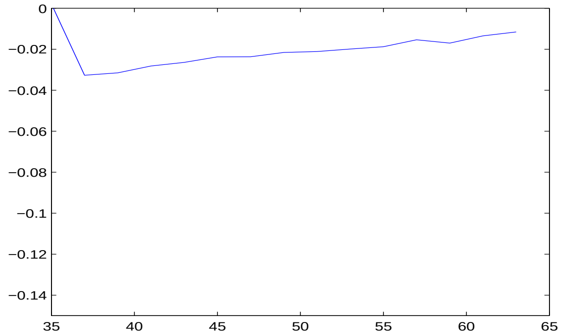
Impulse responses, consumption

Bad shock: $\tau_{shock} = .1$

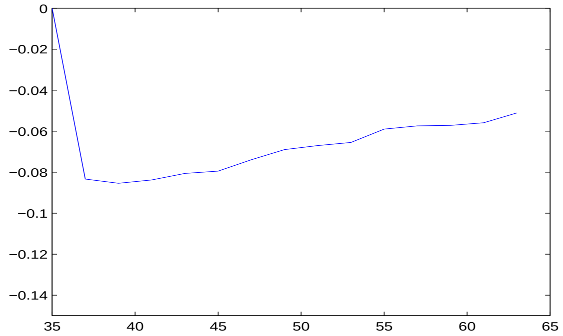
$\tau_{init} = .1$



$\tau_{init} = .5$

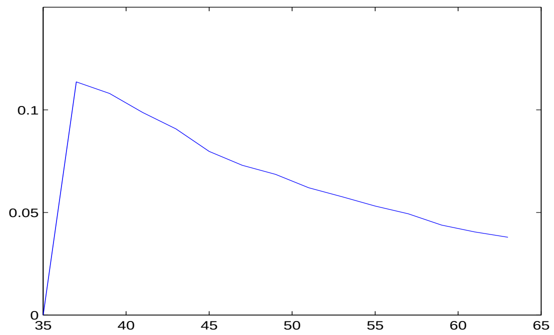


$\tau_{init} = .9$

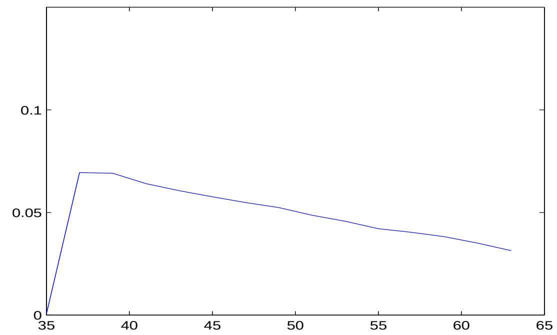


Good shock: $\tau_{shock} = .9$

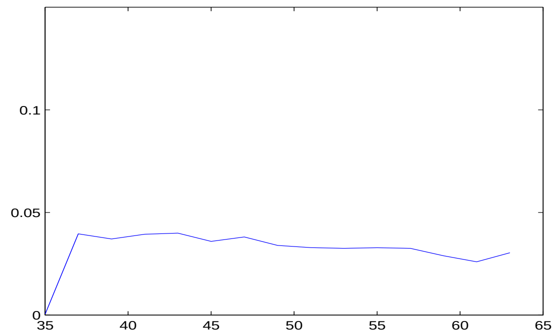
$\tau_{init} = .1$



$\tau_{init} = .5$



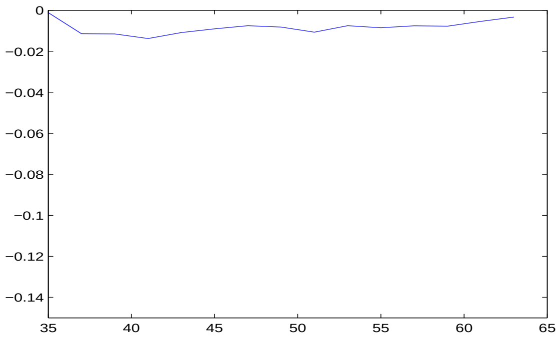
$\tau_{init} = .9$



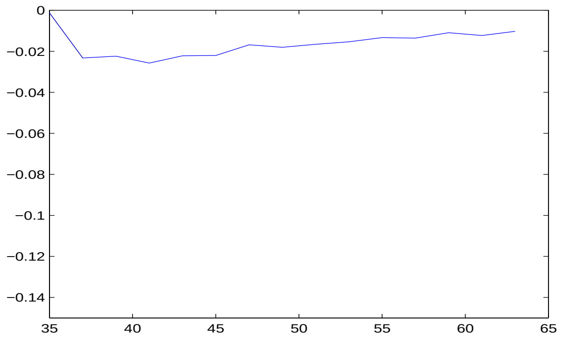
Impulse responses, consumption, household heterogeneity

Bad shock: $\tau_{shock} = .1$

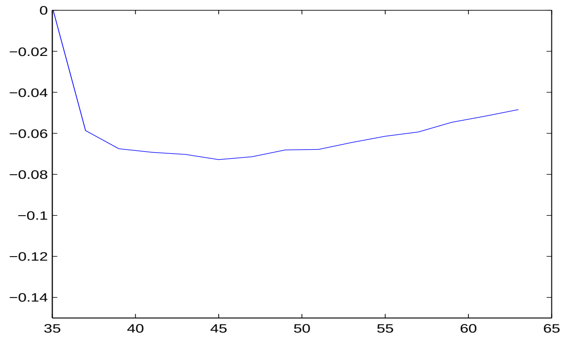
$\tau_{init} = .1$



$\tau_{init} = .5$



$\tau_{init} = .9$



Good shock: $\tau_{shock} = .9$

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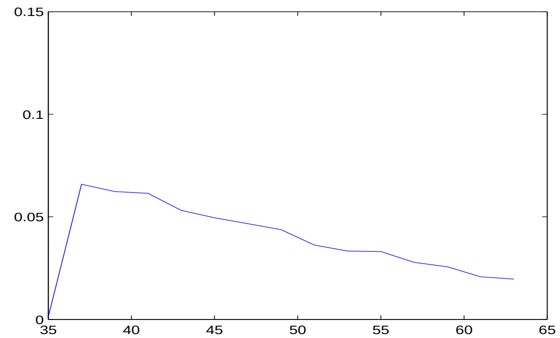

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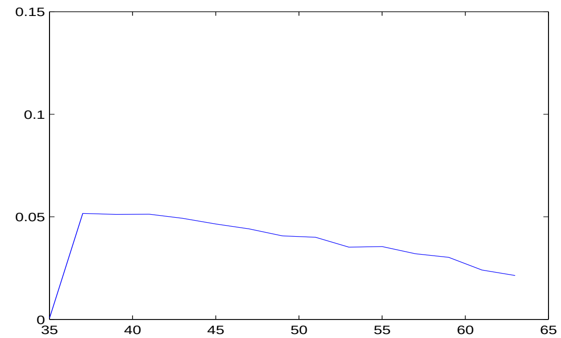
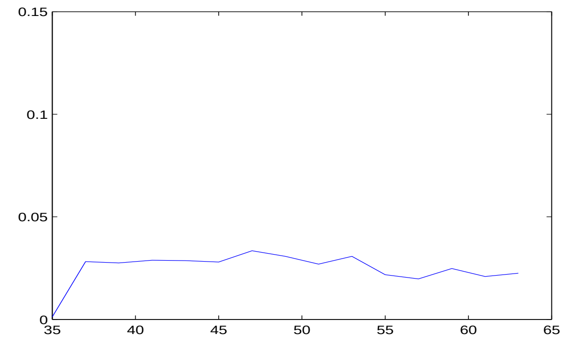


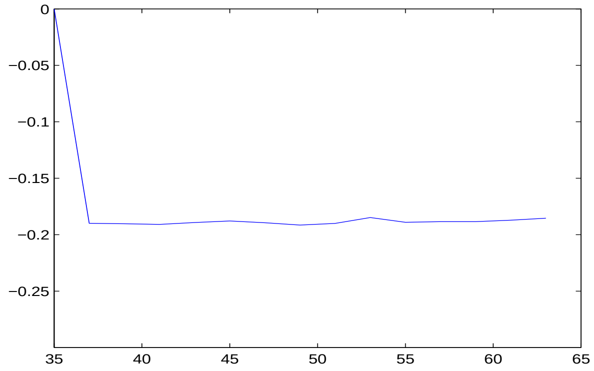
$\tau_{init} = .9$



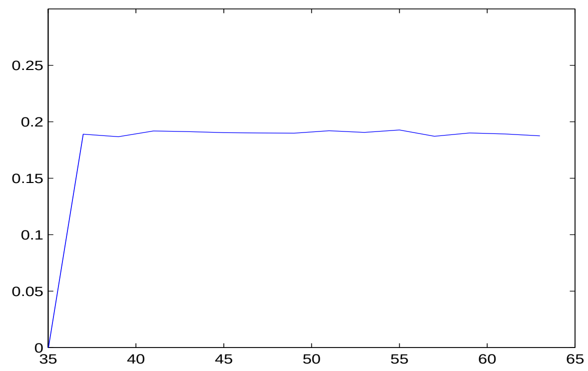
Impulse responses, canonical model

Earnings

$\tau_{shock} = .1$

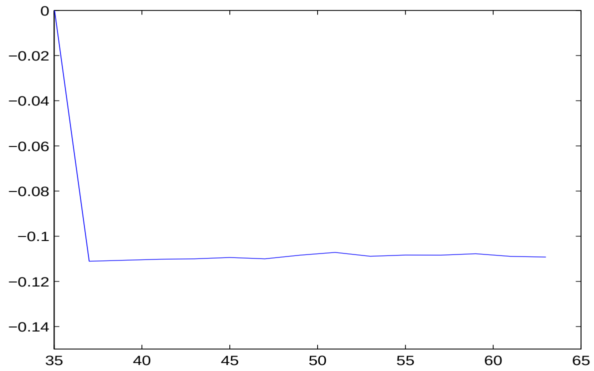


$\tau_{shock} = .9$

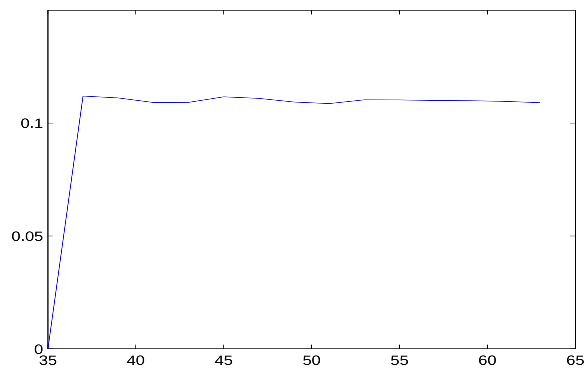


Consumption

$\tau_{shock} = .1$



$\tau_{shock} = .9$



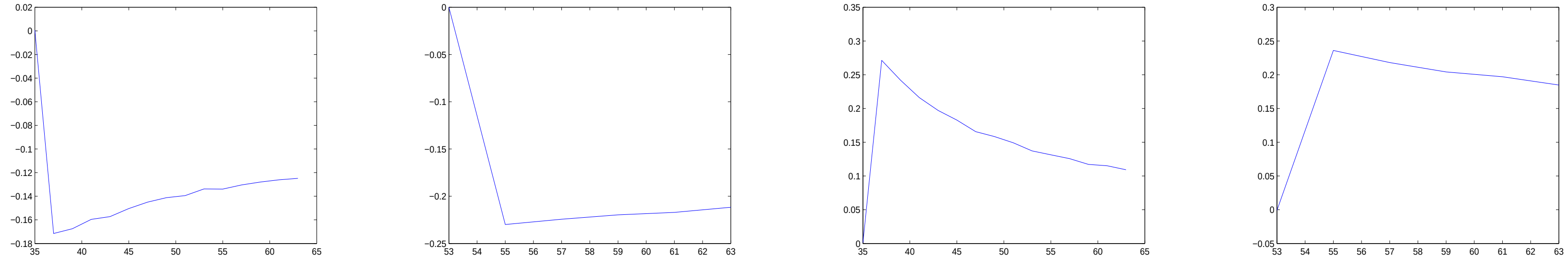
Note: Canonical earnings model and linear consumption rule.

Impulse responses, by age and initial assets

Earnings

$\tau_{init} = .9,\ \tau_{shock} = .1$ — Young, Old

$\tau_{init} = .1,\ \tau_{shock} = .9$ — Young, Old



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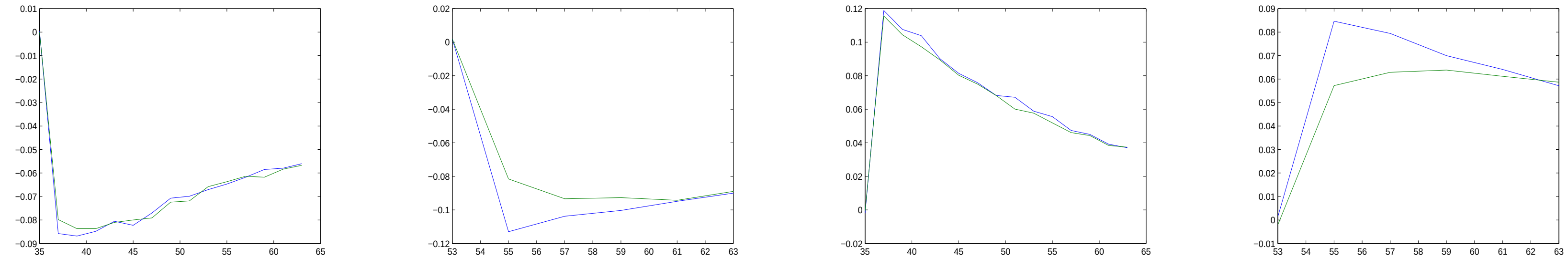

Note: Initial assets at age 35 (for "young" households) or 53 (for "old" households) are at percentile .10 (blue curves) and .90 (green curves).

Conclusion

• In the second part of the lecture, I have drawn on the paper with Manuel Arellano and Stephane Bonhomme to develop a nonlinear framework for modeling persistence that sheds new light on the nonlinear transmission of income shocks and the nature of consumption insurance.

– A Markovian permanent-transitory model of household income, which reveals asymmetric persistence of unusual shocks in the PSID.
– An age-dependent nonlinear consumption rule that is a function of assets, permanent income and transitory income.

• We provide conditions under which the model is nonparametrically identified.

⇒ We explained how a simulation-based sequential QR method is feasible and can be used to estimate this model.

• This framework leads to new empirical measures of the degree of partial insurance.

⇒ Next step: generalize our nonlinear model to allow for other states or choices, such as evolution of household size and intensive/extensive margins of labor supply.

Additional Slides

Descriptive Statistics for Consumption

PSID Consumption

	1998	2000	2002	2004	2006	2008
Consumption	27,290	31,973	35,277	41,555	45,863	44,006
Nondurable Consumption	6,859	7,827	7,827	8,873	9,889	9,246
Food (at home)	5,471	5,785	5,911	6,272	6,588	6,635
Gasoline	1,387	2,041	1,916	2,601	3,301	2,611
Services	21,319	25,150	28,419	33,755	36,949	35,575
Food (out)	2,029	2,279	2,382	2,582	2,693	2,492
Health Insurance	1,056	1,268	1,461	1,750	1,916	2,188
Health Services	902	1,134	1,334	1,447	1,615	1,844
Utilities	2,282	2,651	2,702	4,655	5,038	5,600
Transportation	3,122	3,758	4,474	3,797	3,970	3,759
Education	1,946	2,283	2,390	2,557	2,728	2,584
Child Care	601	653	660	689	648	783
Home Insurance	430	480	552	629	717	729
Rent (or rent equivalent)	8,950	10,645	12,464	15,650	17,623	15,595
Observarions	1,872	1,951	1,984	2,011	2,115	2,221

Notes: PSID data from 1999-2009 PSID waves. PSID means are given for the main sample of estimation: married couples with working males aged 30 to 65. SEO sample excluded. PSID rent is imputed as 6% of reported house value for homeowners. Missing values in consumption and assets sub-categories were treated as zeros.

Nonseparability and Measurement Errors

$$\begin{pmatrix} \Delta w_{i,1,t} \\ \Delta w_{i,2,t} \\ \Delta c_{i,t} \\ \Delta y_{i,1,t} \\ \Delta y_{i,2,t} \end{pmatrix} \simeq \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ \kappa_{c,u_1} & \kappa_{c,u_2} & \kappa_{c,v_1} & \kappa_{c,v_2} \\ \kappa_{y_1,u_1} & \kappa_{y_1,u_2} & \kappa_{y_1,v_1} & \kappa_{y_1,v_2} \\ \kappa_{y_2,u_1} & \kappa_{y_2,u_2} & \kappa_{y_2,v_1} & \kappa_{y_2,v_2} \end{pmatrix} \begin{pmatrix} \Delta u_{i,1,t} \\ \Delta u_{i,2,t} \\ v_{i,1,t} \\ v_{i,2,t} \end{pmatrix} + \begin{matrix} \Delta\xi^{w}_{i,1,t} \\ \Delta\xi^{w}_{i,2,t} \\ \Delta\xi^{c}_{i,t} \\ \Delta\xi^{y}_{i,1,t} \\ \Delta\xi^{y}_{i,2,t} \end{matrix}$$

- where $\zeta^{w}_{i,j,t}$, $\zeta^{c}_{i,t}$ and $\zeta^{y}_{i,j,t}$ are measurement errors in log wages of earner j, log consumption, and log earnings of earner j.

WAGE PARAMETERS BY ASSETS AND AGE

			(1)	(2)	(3)	(4)	(5)
Sample			All	1^{st} asset tercile	$2^{nd,}$ 3^{rd} asset terciles	age<40	age>=40
Males	Trans.	σ^2_{u1}	0.033	0.03	0.042	0.042	0.028
			(0.007)	(0.009)	(0.009)	(0.013)	(0.008)
	Perm.	σ^2_{v1}	0.035	0.027	0.039	0.025	0.039
			(0.005)	(0.006)	(0.007)	(0.009)	(0.007)
Females	Trans.	σ^2_{u2}	0.012	0.023	0.011	0.02	0.01
			(0.005)	(0.009)	(0.007)	(0.015)	(0.005)
	Perm.	σ^2_{v2}	0.046	0.036	0.05	0.053	0.042
			(0.004)	(0.007)	(0.006)	(0.013)	(0.005)
Correlations of Shocks	Trans.	$\sigma_{u1,u2}$	0.202	-0.264	0.39	0.459	0.115
			(0.159)	(0.181)	(0.197)	(0.28)	(0.201)
	Perm.	$\sigma_{v1,v2}$	0.153	0.366	0.096	0.041	0.162
			(0.06)	(0.142)	(0.066)	(0.174)	(0.063)
Observations			8,191	2,626	5,565	2,172	6,019

Non-linear Taxes

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- implications for underlying structural preference parameters
- e.g.

$$\widetilde{\eta}_{h_j,w_j} = \frac{\eta_{h_j,w_j}(1-\mu)}{1+\mu\eta_{h_j,w_j}} (\text{with } \widetilde{\eta}_{h_j,w_j} \leq \eta_{h_j,w_j} \text{ for } 0 \leq \mu \leq 1)$$

Inference

- Multi-step estimation procedure:
  - Regress $c_{i,t}, y_{i,j,t}, w_{i,j,t}$ on observable characteristics, and construct the residuals $\Delta c_{i,t}, \Delta y_{i,j,t}$ and $\Delta w_{i,j,t}$
  - Estimate the wage parameters using the conditional second order moments for $\Delta w_{i,1,t}$ and $\Delta w_{i,2,t}$
  - Estimate $\pi_{i,t}$ and $s_{i,t}$ using asset and (current and projected) earnings data
  - Estimate preference parameters using restrictions on the joint behavior of $\Delta c_{i,t}, \Delta y_{i,j,t}$ and $\Delta w_{i,j,t}$
- GMM with standard errors corrected by the block bootstrap.

Removing Additive Separability: Theory

- Approximating the first order conditions (intensive margin):

$$
\begin{aligned}
\Delta c_{i,t} \quad \simeq \quad & \left(\eta_{c,w_1} + \eta_{c,w_2} - \eta_{c,p}\right) \Delta \ln \lambda_{i,t} \\
& + \eta_{c,w_1} \Delta w_{i,1t+1} + \eta_{c,w_2} \Delta w_{i,2t+1}
\end{aligned}
$$

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- Moments

$$\begin{pmatrix} \Delta c_{i,t} \\ \Delta y_{i,1,t} \\ \Delta y_{i,2,t} \end{pmatrix} \simeq \begin{pmatrix} \kappa_{i,c,u_1} & \kappa_{i,c,u_2} & \kappa_{i,c,v_1} & \kappa_{i,c,v_2} \\ \kappa_{i,y_1,u_1} & \kappa_{i,y_1,u_2} & \kappa_{i,y_1,v_1} & \kappa_{i,y_1,v_2} \\ \kappa_{i,y_2,u_1} & \kappa_{i,y_2,u_2} & \kappa_{i,y_2,v_1} & \kappa_{i,y_2,v_2} \end{pmatrix} \begin{pmatrix} \Delta u_{i,1,t} \\ \Delta u_{i,2,t} \\ v_{i,1,t} \\ v_{i,2,t} \end{pmatrix}$$

where (for $j = 1, 2$)

$$\kappa_{i,c,u_j} = \eta_{c,w_j}; \;\; \kappa_{i,y_j,u_j} = 1 + \eta_{h_j,w_j}; \;\; \kappa_{i,y_j,u_{-j}} = \eta_{h_j,w_{-j}}$$

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- Individual i of age a in time period t, has log income $y_{i,a}(\equiv \ln Y_{i,a,t})$

$$y_{i,a} = \boldsymbol{X}_{i,a}^T \varphi_a + \alpha_i + \beta_i p_a + v_{i,a} + \varepsilon_{i,a}$$

  where $\beta_i p_a$ is an individual-specific trend, allow non-zero covariance between α and β.

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- Allow variances (or factor loadings) of $v_{i,a}$ and $\varepsilon_{i,a}$ to vary with age/time for each birth cohort and education group.

Idiosyncratic Trends

- The idiosyncratic trend term $p_t\beta_i$ could take a number of forms. Two alternatives are worth highlighting:
  - (a) deterministic idiosyncratic trend:

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- Alternatively, stochastic trends (b) are most likely to occur during periods of technical change when skill prices are changing across the unobserved ability distribution. Formally, this is a calender time effect.

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4. Piecewise-Linear Specification:

$$\boldsymbol{p}_a = \begin{cases} \kappa_1 a + 35\,(1-\kappa_1) & \text{if } a \leq 35 \\ a & \text{otherwise} \\ \kappa_2 a + 52\,(1-\kappa_2) & \text{if } a \geq 52 \end{cases}$$

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   with knots at age 35 and age 52.
5. Polynomials up to degree 4.

Covariance structure

- Suppose we observe individual i at age $a = 1, ..., T$, we then have $T - 1$ equations $\Delta^{\rho} y_{ia}$ $(\equiv y_{i,a} - \rho y_{i,a-1})$. In vector form
$$\Delta^{\rho} \boldsymbol{y}_i = ((1-\rho)\,\boldsymbol{\iota}, \Delta^{\rho} \boldsymbol{p}_a) \begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} + \boldsymbol{u}_i + \Delta^{\rho} \boldsymbol{\varepsilon}_i.$$

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- The Variance-Covariance matrix in general has the form: $\mathrm{Var}(\Delta^\rho \boldsymbol{y}_i) = \boldsymbol{\Omega} + \boldsymbol{W}$ where $\mathbf{W} =$

$$\begin{pmatrix} \sigma_2^2 + \omega_2^2 + \rho^2\omega_1^2 & -\rho\omega_2^2 & 0 & 0 \\ -\rho\omega_2^2 & \sigma_3^2 + \omega_3^2 + \rho^2\omega_2^2 & -\rho\omega_3^2 & 0 \\ 0 & -\rho\omega_3^2 & \ddots & -\rho\omega_{T-1}^2 \\ 0 & 0 & -\rho\omega_{T-1}^2 & \sigma_T^2 + \omega_T^2 + \rho^2\omega_{T-1}^2 \end{pmatrix}$$

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- For the linear heterogeneous profiles case:

$$\boldsymbol{\Omega} = \left[(1-\rho)\, \boldsymbol{\iota}, \boldsymbol{\xi}_0 \right] \begin{pmatrix} \sigma_\alpha^2 & \rho_{\alpha\beta}\sigma_\alpha\sigma_\beta \\ \rho_{\alpha\beta}\sigma_\alpha\sigma_\beta & \sigma_\beta^2 \end{pmatrix} \left[(1-\rho)\, \boldsymbol{\iota}, \boldsymbol{\xi}_0 \right]^T.$$

Loading Factor Matrix: Estimates

Response to	Separable case			Non-separable case		
	Consump.	Husband's earnings	Wife's earnings	Consump.	Husband's earnings	Wife's earnings
	(1)	(2)	(3)	(4)	(5)	(6)
v_1	0.13 (0.060)	1.15 (0.067)	−0.54 (0.206)	0.38 (0.057)	0.98 (0.131)	−0.81 (0.180)
v_2	0.07 (0.040)	−0.16 (0.057)	1.53 (0.101)	0.21 (0.037)	−0.23 (0.048)	1.32 (0.087)
Δu_1	0	1.43 (0.097)	0	−0.14 (0.051)	1.51 (0.150)	0.26 (0.103)
Δu_2	0	0	1.83 (0.133)	−0.14 (0.139)	0.13 (0.051)	2.03 (0.265)

Approximation of the Euler equation (1)

- From $\lambda_{i,t} = \frac{1+\delta}{1+r}\mathbb{E}_t\lambda_{i,t+1}$, use a second order Taylor approximation (with $r = \delta$) to yield:

$$\Delta \ln \lambda_{i,t+1} \approx \omega_t + \varepsilon_{i,t+1}$$

- where

$$\begin{aligned} \omega_t &= -\frac{1}{2}\mathbb{E}_t \left(\Delta \ln \lambda_{i,t+1}\right)^2 \\ \varepsilon_{i,t+1} &= \Delta \ln \lambda_{i,t+1} - \mathbb{E}_t \left(\Delta \ln \lambda_{i,t+1}\right) \end{aligned}$$

- Then use the fact that

$$\begin{aligned} \Delta \ln U_{C_{i,t+1}} &= \Delta \ln \lambda_{i,t+1} \\ \Delta \ln U_{H_{i,j,t+1}} &= -\Delta \ln \lambda_{i,t+1} - \Delta \ln W_{i,j,t+1} \end{aligned}$$

Approximation of the Euler equation (2)

- Consider now Taylor expansion of $U_{C_{i,t+1}} (= \lambda_{i,t+1})$:

$$\begin{aligned} U_{C_{i,t+1}} &\approx U_{C_{i,t}} + (C_{i,t+1} - C_{i,t})\, U_{C_{i,t}C_{i,t}} \\ \frac{U_{C_{i,t+1}} - U_{C_{i,t}}}{U_{C_{i,t}}} &\approx \left(\frac{C_{i,t+1} - C_{i,t}}{C_{i,t}}\right) \frac{U_{C_{i,t}C_{i,t}} C_{i,t}}{U_{C_{i,t}}} \\ \Delta \ln U_{C_{i,t+1}} &\approx -\frac{1}{\eta_{c,p}} \Delta \ln C_{i,t+1} \end{aligned}$$

- and therefore, from

$$\Delta \ln \lambda_{i,t+1} \approx \omega_{t+1} + \varepsilon_{i,t+1}$$

- get

$$\Delta \ln C_{i,t+1} = -\eta_{c,p} \left(\omega_{t+1} + \varepsilon_{i,t+1}\right)$$

Approximation of the life time budget constraint

- Use the fact that

$$\mathbb{E}_I\left[\ln\sum_{i=0}^{T-t}X_{t+i}\right] = \ln\sum_{i=0}^{T-t}\exp\mathbb{E}_{t-1}\ln X_{t+i} + \sum_{i=0}^{T-t}\frac{\exp\mathbb{E}_{t-1}\ln X_{t+i}}{\sum_{j=0}^{T-t}\exp\mathbb{E}_{t-1}\ln X_{t+j}}\left(\mathbb{E}_I-\mathbb{E}_{t-1}\right)\ln X_{t+i} + O\left(\mathbb{E}_I\left\|\xi_t^T\right\|^2\right)$$

for $X = C, WH$ and appropriate choice of $\mathbb{E}_I$.

- Goal: obtain a mapping from wage innovations to innovations in consumption (marginal utility of wealth)