Chapter 11: Consumption

Graduate Macroeconomics Slides

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Outline

- Introduction
- Consumption Under Autarky and Full Insurance
- Income Fluctuation & PIH
  - Precautionary Saving, Prudence & Buffer–Stock Behaviour
- Wealth Accumulation & Heterogeneous-Agent (HA) Models
- References

Why Study Consumption?

- **Welfare**: drives utility directly; stabilising C_t is a key policy goal.
- **Macro linkages**: growth, business cycles, inequality, asset pricing, taxation.
- **Rich micro data**: surveys (CEX, PSID) enable structural tests. (Deaton, 1992)

"Attempts by economists to understand the saving and consumption patterns of households have generated some of the best science in economics." (Deaton, 1992)

Two Benchmark Economies (Arrow-Debreu)

Autarky

$$c_{i,t}(\omega^t) = y_{i,t}(\omega^t) \quad \forall t,\ \omega^t \tag{11.1}$$

- No state-contingent trade $\Rightarrow$ idiosyncratic shocks *fully* pass through.
- Intertemporal Euler equation holds *within* household

$$u'(c_{i,t}) = \beta(1 + r_{i,t+1})\,\mathbb{E}_t\left[u'(c_{i,t+1})\right].$$

Complete Markets

$$\frac{u'(c_{i,t})}{u'(c_{j,t})} = \frac{\lambda_i}{\lambda_j}, \quad c_{i,t}(\omega^t) = \theta_i\, C_t(\omega^t), \tag{11.3 – 11.4}$$

$$\theta_i = \frac{(\lambda_i)^{-1/\sigma}}{\int_0^1 (\lambda_\ell)^{-1/\sigma}\, d\ell}.$$

- Household shares θ_i *time-invariant*.
- Aggregate shock Y_t only source of consumption volatility.
- State-price density $q_{t,t+1} = \beta\,\frac{u'(C_{t+1})}{u'(C_t)}$ identical across agents.

CRRA Utility: Algebra behind (11.3)–(11.4)

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}, \qquad u'(c) = c^{-\sigma}.$$

$$\frac{u'(c_{i,t})}{u'(c_{j,t})} = \left(\frac{c_{i,t}}{c_{j,t}}\right)^{-\sigma} = \frac{\lambda_i}{\lambda_j} \implies \frac{c_{i,t}}{c_{j,t}} = \left(\frac{\lambda_i}{\lambda_j}\right)^{-1/\sigma}.$$

$$C_t = \int_0^1 c_{i,t}\, di \implies c_{i,t} = \theta_i\, C_t \quad \text{with } \theta_i \text{ constant.}$$

Economic intuition

- θ_i summarizes *lifetime wealth* (via λ_i).
- Unanticipated *aggregate* shocks shift everybody proportionally.
- **PIH:** for $\sigma = 1$ ratio $c_{i,t}/C_t$ is fixed $\Rightarrow$ linear consumption path as in Hall (1978).

Risk Aversion Heterogeneity ($\sigma_1 \neq \sigma_2$)

FOCs $u_i'(c_{1,t}) = \lambda_1 q_t, \; u_2'(C_t - c_{1,t}) = \lambda_2 q_t \implies$

$$\lambda_2 c_{1,t}^{-\sigma_1} = \lambda_1 \left[Y_t - c_{1,t}\right]^{-\sigma_2}. \tag{11.5}$$

- Implicit function $c_{1,t} = g\big(Y_t\big)$ is *concave* when $\sigma_1 < \sigma_2$.(Muellbauer, 1994)
- Less-risk-averse agent absorbs larger slice of ΔY_t.
- Generates *counter-cyclical* consumption inequality .

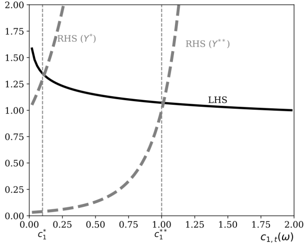

Figure 11.1: Plot of the left-hand-side (LHS) and right-hand-side (RHS) of equation (11.5).

Notes: Parameter values: $\sigma_1 = 0.1, \sigma_2 = 5, \lambda_1 = \lambda_2 = 1$. Aggregate endowment rises from $Y^* = 1$ to $Y^{**} = 2$. Agent 1, who is less risk averse, absorbs most of the change

Testing Full Insurance Empirically

$$\Delta \log c_{i,t} = \beta_1 \Delta \log C_t + \beta_2 \Delta \log y_{i,t} + \varepsilon_{i,t}, \qquad \mathbb{E}[\varepsilon_{i,t}] = 0.$$

$$\text{Autarky: } (\beta_1, \beta_2) = (0, 1), \quad \text{Complete: } (\beta_1, \beta_2) = (1, 0).$$

Stylised findings

CES, PSID, HRS (Mace, 1991; Cochrane, 1991; Kaplan and Violante, 2022)

- $0 < \hat{\beta}_1 < 1, \;\; 0 < \hat{\beta}_2 < 1 \;\Rightarrow$ *partial insurance.*
- Cross-sectional heterogeneity in σ_i biases OLS (omitted variable $\Delta \log C_t$; Schulhofer-Wohl, 2011).

Two Modelling Paradigms for Partial Risk Sharing

1. **Endogenous Incomplete Markets (EIM)**
   - Limited commitment or private info $\rightarrow$ equilibrium asset menu sparse (Kehoe and Levine, 2001; Krueger and Perri, 2006).
   - Asset prices *and* admissible contracts respond to policy.
2. **Exogenous Incomplete Markets (XIM)**
   - Take bond + equity menu as given (Aiyagari, 1994).
   - Prices move, asset set fixed $\rightarrow$ tractable quantitative work.

Modeller's trade-off

Micro-foundation vs. tractability & data-fit. Recent DSGE–HANK models mix both elements (Kaplan and Violante, 2022).

Bond Economy: Household Problem

$$\max_{\{c_{i,t}, a_{i,t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_{i,t}^{1-\sigma}}{1-\sigma} \quad \text{s.t.} \quad a_{i,t+1} = (1+r)\left[y_{i,t} + a_{i,t} - c_{i,t}\right], \tag{11.11}$$

$$\lim_{t\to\infty} (1+r)^{-t} a_{i,t} \geq 0.$$

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Euler equation

$$c_{i,t}^{-\sigma} = \beta(1+r)\,\mathbb{E}_t\left[c_{i,t+1}^{-\sigma}\right] \quad \Longrightarrow \quad \underbrace{\sigma^2\,\text{Var}\left[\Delta c_{i,t}\right]}_{\text{prudence}} + \underbrace{\kappa\,\text{Borrow. Constraint}}_{\text{precaution}} = \text{excess consumptio}$$

Key insight

Self-insurance: agents accumulate buffer-stock wealth when borrowing is limited ((Carroll and Kimball, 1996) style precautionary saving).

- Extreme benchmarks *clarify* mechanisms; reality lies in-between.
- With CRRA and complete markets $\Rightarrow$ linear sharing rule θ_i.
- Heterogeneous $\sigma_i \;\Rightarrow$ counter-cyclical inequality.
- (β_1, β_2) regression is work-horse empirical test; rejects extremes.
- Choice of EIM vs. XIM depends on research question (policy vs. fit).

The Income–Fluctuation Problem

Household: $\{\, c_t, a_{t+1} \,\}_{t=0}^{\infty}$ solves

$$\max_{\{c_t\}} \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{1}$$

$$\text{s.t.} \quad a_{t+1} = (1+r)(y_t + a_t - c_t), \qquad \lim_{t\to\infty} (1+r)^{-t} a_t \geq 0. \tag{2}$$

- Partial–equilibrium; r exogenous and constant.
- Schechtman and Escudero (1977) coined *income–fluctuation problem*.
- Special cases link to Hall (1978) (quadratic/PIH) and Friedman (1957).

Deterministic Income Path

Assume y_t known at $t = 0$. FOC $\Rightarrow$

$$\frac{u'(c_t)}{\beta(1+r)u'(c_{t+1})} = 1. \tag{11.13}$$

CRRA $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ gives

$$\frac{c_{t+1}}{c_t} = [\beta(1+r)]^{\frac{1}{\sigma}}. \tag{11.14}$$

Intuition: higher β or $r \Rightarrow$ tilt consumption toward future; elasticity $1/\sigma$ governs strength.

MPC out of Wealth

Iterate BC using (2) + (11.14):

$$c_t = \left(1 - R^{-1}(\beta R)^{\frac{1}{\sigma}}\right)\left[a_t + \sum_{j=0}^{\infty} R^{-j} y_{t+j}\right], \tag{11.15}$$

$$\boxed{\text{MPC} = 1 - R^{-1}(\beta R)^{\frac{1}{\sigma}}}. \tag{11.16}$$

Permanent Income Hypothesis (PIH)

Quadratic utility ($u(c) = b_1 c - \frac{b_2}{2} c^2$) and $\beta R = 1 \Rightarrow$

$$c_t = \mathbb{E}_t[c_{t+1}] \quad \Longrightarrow \quad \Delta c_t = \frac{r}{1+r}\left[\varpi_t - \mathbb{E}_{t-1}\varpi_t\right], \tag{11.22}$$

where $\varpi_t \equiv a_t + \sum_{j=0}^{\infty} R^{-j}\mathbb{E}_t y_{t+j}$.

- Consumption is a *martingale*; reacts only to news about total wealth.
- Certainty–equivalence: deterministic solution with y_{t+j} replaced by $\mathbb{E}_t y_{t+j}$ (Hall random-walk).

Permanent vs. Transitory Shocks

Income decomposition (Abowd and Card, 1989):

$$y_t = y_t^p + u_t, \qquad y_t^p = y_{t-1}^p + v_t, \quad u_t \perp v_t. \tag{11.25}$$

Insert into (11.22):

$$\boxed{\Delta c_t = \frac{r}{1+r} u_t + v_t.} \tag{11.27}$$

- Transitory shock u_t heavily discounted, coefficient $r/(1+r) \ll 1$.
- Permanent innovation v_t passes one-for-one into consumption.
- Empirical MPC out of transitory income $\approx r$; for permanent ≈ 1 (Campbell and Mankiw, 1989).

Borrowing Constraints

No-borrowing: $a_{t+1} \geq 0 \Rightarrow$ modified Euler

$$u'(c_t) \;\geq\; \beta R\,\mathbb{E}_t[u'(c_{t+1})], \tag{11.32}$$

inequality binds when $\lambda_t > 0$.

Consequences

- Timing of income now matters (hand-to-mouth vs. PIH).
- Marginal Propensity to Consume (MPC) jumps to ≈ 1 when constraint binds (Hall, 1988).

Natural borrowing limit:

$$a_{t+1} \;\geq\; -\frac{1+r}{r}\,y_{\min}.$$

Satisfies non- negativity of future consumption under worst-case $y_{\min}$.

Saving for the Rainy Day

Define saving $s_t = (r/(1+r))\, a_t + y_t - c_t$. Using (11.20) gives

$$s_t = -\sum_{j=1}^{\infty} \left(\frac{1}{1+r} \right)^j \mathbb{E}_t[\Delta y_{t+j}],$$

- Households save in anticipation of *expected* income declines (Campbell, 1987).
- Predicts pro-cyclical saving rates if income is mean-reverting.

Empirical Application: Inequality Dynamics

Blundell and Preston (1998) use PIH logic to decompose rise in UK inequality:

$$\Delta\,\mathrm{var}_k(c) = \Delta\,\mathrm{cov}_k(c, y) \simeq \mathrm{var}(v). \tag{11.28}$$

- Variance of permanent component v_t drove 1980s inequality surge.
- Complements cross-group evidence of Attanasio and Davis (1996).

Why Precautionary Saving?

- Definition: extra saving triggered by higher *uncertainty*, holding mean income fixed (Zeldes, 1989).
- Absent risk/constraints (quadratic u) $\Rightarrow$ consumption linear in total wealth ϖ_t (certainty equivalence) $\rightsquigarrow$ no precautionary motive.
- Two key forces generate $\partial s/\partial$uncertainty > 0:
  1. **Occasionally Binding Borrowing Constraints** $\Rightarrow$ value of wealth convex, consumption function concave.
  2. **Prudence** $\left(u'''(c) > 0\right)$ Kimball (1990) index of absolute prudence $P(c) = -u'''(c)u'(c)/[u''(c)]^2$.

Borrowing Limits $\rightsquigarrow$ Concave $c(a)$

Quadratic utility ($u'''=0$) but limit $a_{t+1} \geq -\bar{a}$ ($\beta R = 1$):

$$c_t = \min\left\{ y_t + a_t + \frac{\bar{a}}{R},\ \mathbb{E}_t c_{t+1} \right\}. \tag{11.33}$$

- At low wealth $a_t < a^*$ constraint binds $\Rightarrow c_t = y_t + a_t + \bar{a}/R$.
- At $a_t > a^*$ constraint slack; Euler equation holds.
- Consumption function linear $\left(\text{slope} = 1\right)$ for $a_t < a^*$, concave afterwards (Figure 11.2).

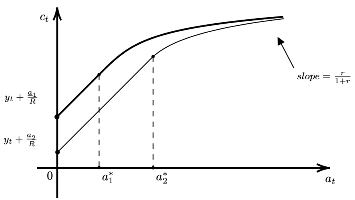

Figure 11.2: Decision rule for consumption in the presence of a borrowing constraint $\underline{a}$ as a function of wealth a_t, for a given realization of income y_t.

Notes: The function is linear, with slope equal to 1, until a^*, after which it becomes concave. For large enough wealth, its slope converges to $\frac{r}{1+r}$. The two lines correspond to different values of the borrowing limit.

Implication: MPC bracketed by 1 and $r/(1+r)$; tighter credit $\uparrow$ MPC, stronger precautionary saving (Hall, 1988).

Prudence: the $u'''(c) > 0$ Channel

Two–period problem (no constraint) (Leland, 1968; Sandmo, 1970):

$$u'(y_0 - a_1) = \beta R\,\mathbb{E}_0\big[u'(Ra_1 + y_1)\big]. \tag{11.35}$$

Mean–preserving spread in y_1 raises RHS (convex in a_1) $\Rightarrow a_1^{**} > a_1^{*}$.

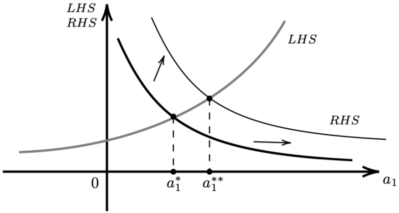

Figure 11.3: Left hand side (LHS) and right hand side (RHS) of the Euler equation (11.35).

Notes: It shows that when a mean-preserving spread in future income occurs, the RHS shifts outward and the optimal amount of saving in period zero a_1 increases.

Analytic Decomposition (Blanchard and Mankiw, 1988)

Second–order expansion delivers

$$\mathbb{E}_t\left(\frac{c_{t+1}-c_t}{c_t}\right) \simeq \underbrace{EIS(c_t)\,(r-\rho)}_{\text{intertemporal smoothing}} + \frac{1}{2}P(c_t)\,\mathbb{E}_t\Big[\Big(\frac{c_{t+1}-c_t}{c_t}\Big)^2\Big]. \qquad (11.36)$$

- Risk enters via prudence term $P(c_t) = -u'''(c_t)c_t/u''(c_t)$.
- For CRRA ($u(c) = c^{1-\sigma}/(1-\sigma)$): $P(c) = \sigma(\sigma+1)$.

Buffer–Stock Behaviour & Stable Target $x^\star$

Carroll–Hall–Zeldes model with CRRA σ, income (y_t^p, u_t) and $R > 1$ but $\rho < R$:

$$\mathbb{E}_t \Delta \log c_{t+1} \simeq \frac{1}{\sigma}(r - \rho) + \frac{\sigma + 1}{2} \text{var}_t(\Delta \log c_{t+1}). \tag{11.41}$$

Normalise state by cash–in–hand $x_t \equiv a_t + y_t^p$.

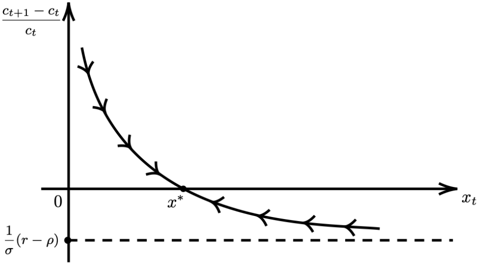

Figure 11.4: Consumption dynamics in the buffer-stock model as a function of cash-in-hand x.

Notes:There exists an optimal target level of cash in hand x toward which the household wants to move.

- Unique stable target $x^\star$, *buffer stock*; wealth reverts to $x^\star$ (arrows in figure).
- For $x < x^\star$: precautionary motive dominates $\Rightarrow$ save $\uparrow$.
- Provides microfoundation for heterogeneous-agent DSGE models (Carroll, 2001).

Comparative Statics of $c(a)$ (Numerical)

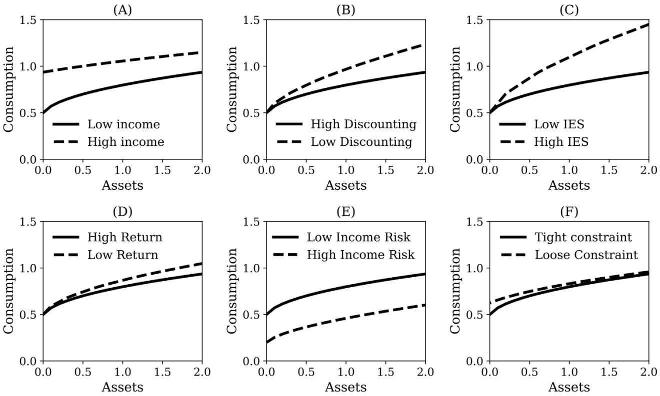

Figure 11.5: Comparative statics of the optimal consumption function with respect to various parameters in the income fluctuations problem.

- **(A)** Low income $\downarrow$ $c(a)$; same slope when unconstrained.
- **(B)** High impatience $(\beta \downarrow) \Rightarrow$ consume more, MPC $\uparrow$.
- **(C)** Lower IES $(\sigma \uparrow) \Rightarrow$ weaker smoothing, $c(a) \downarrow$.
- **(D)** Higher r raises future returns $\Rightarrow$ consume less.
- **(E)** More income risk boosts precautionary motive $\Rightarrow$ consume less.
- **(F)** Tight credit limit shifts a^* right, MPC rises for wider range of a.

Key Lessons on Precautionary Saving

1. Borrowing constraints and prudence both induce concavity of $c(a)$, raising the MPC for low/medium wealth.
2. *Precautionary* vs. *intertemporal-substitution* motives enter Euler via $P(c)$ and $EIS(c)$ (11.36).
3. Buffer-stock model predicts stable wealth target $x^{\star}$ and describes empirical wealth distributions.
4. Tight credit or higher risk can rationalise “excess sensitivity” of c_t to lagged income (Zeldes, 1989; Campbell and Mankiw, 1989).

Upper Bounds on Wealth: Why Do We Need Them?

- Saving motives: **intertemporal** ($\beta R \gtrless 1$) & **precautionary** (> 0).
- If $\beta R \geq 1$ *and* risk aversion low $\Rightarrow$ assets can explode $\rightsquigarrow$ non-compact state space $\Rightarrow$ no stationary equilibrium (Schechtman and Escudero, 1977; Clarida, 1987; Huggett, 1997).

Sufficient condition (stochastic income, CRRA utility, no growth):

$$\boxed{\beta R < 1}$$

Idea of proof: iterate Euler equation under a *worst-case* income realisation $\bar{y}$:

$$u_c(c(x)) = \beta R\, \mathbb{E}[u_c(c(x'))] \leq \beta R\, u_c(c(\bar{x}'))$$

HA Incomplete-Market Framework

Household dynamic programme (endowment economy; ad-hoc debt limit $a \geq -\bar{a}$):

$$V(a,y) = \max_{c,a'} \; u(c) + \beta \sum_{y' \in Y} \pi(y'|y)\, V(a',y') \quad \text{s.t.} \;\; c + a' = Ra + y, \;\; a' \geq -\bar{a}. \tag{11.47}$$

Stationary Competitive Equilibrium (SCE)

Find $\{r^\star, V, c(\cdot), a'(\cdot), \lambda^\star\}$ such that

1. Household policies solve (11.47) at rate $r^\star$.
2. *Asset market clears*: $\int a'(a,y)\, d\lambda^\star = 0$.
3. *Goods market clears*: $\int c(a,y)\, d\lambda^\star = \sum_i y_i \Pi^\star(y_i)$.
4. *Cross-section invariant*: $\lambda^\star$ fixed point of $\lambda_{n+1}(A \times Y) = \int Q((a,y), A \times Y)\, d\lambda_n$ with Q in (11.48)–(11.49).

Existence: follows from $\beta R < 1$ (asset bound) plus standard contraction arguments (Huggett 1993). Uniqueness harder – monotonicity of aggregate saving $A(r)$ in r not guaranteed unless risk aversion $\sigma < 1$ (Achdou et al., 2022).

Equilibrium Interest Rate & the Risk-Free Rate Puzzle

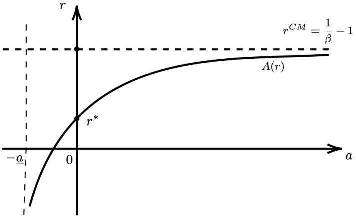

Figure 11.6: Equilibrium of the endowment economy where assets are in zero net supply.

Notes:$A(r)$ denotes aggregate asset holdings of the household sector as a function of the interest rate in the incomplete-market model. r^{CM} denotes the complete markets equilibrium real rate, and also the infinitely elastic demand for assets in the complete market model. r^* is the equilibrium real rate in the model with incomplete markets.

- Incomplete markets $\Rightarrow A(r)$ upward-sloping (blue).
- *Precautionary demand* shifts $A(r)$ right/down, lowering $r^\star$ below complete-markets $r^{\text{CM}} = 1/\beta - 1$.
- Helps reconcile low observed risk-free rate (Huggett, 1993).

Government Bonds in Positive Net Supply

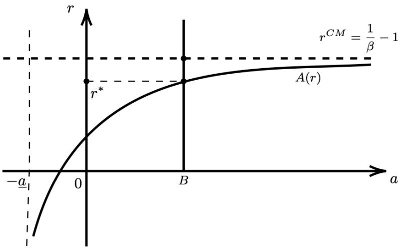

Figure 11.7: Equilibrium of the endowment economy where assets are in fixed positive supply.

Notes:$A(r)$ denotes aggregate asset holdings of the household sector as a function of the interest rate in the incomplete-market model. r^{CM} denotes the complete markets equilibrium real rate, and r^* the equilibrium real rate in the model with incomplete markets.

$$rB = T, \qquad c + a' = Ra + y - T. \tag{11.50}$$

More liquidity $\Rightarrow$ equilibrium moves toward r^{CM}; optimal debt trades off insurance vs. crowd-out (Aiyagari and McGrattan, 1998).

Production Economy à la Aiyagari (1994)

$$c + a' = Ra + wy, \qquad F_K(K,L) = r + \delta, \;\; F_L(K,L) = w.$$

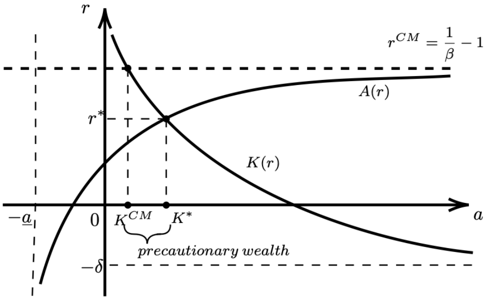

Figure 11.8: Equilibrium of the production economy.

Notes: $A(r)$ denotes aggregate asset holdings of the household sector as a function of the interest rate in the incomplete-market model. r^{CM} and K^{CM} denote, respectively, the complete markets equilibrium real rate and capital stock. r^* and K^* are their incomplete markets counterparts. The difference between K^* and K^{CM} is the equilibrium amount of precautionary wealth.

- Firms' demand $K(r)$ downward-sloping (red) intersects household supply $A(r)$ (blue).
- Gap $K^{\star} - K^{CM}$ measures *precautionary capital*.

Quantitative Insights: Aiyagari (1994)

Calibration to US micro earnings data:

- Precautionary motive ↑ aggregate saving by 3–10 pp.
- Generates realistic equity premium + low risk-free rate.
- Wealth distribution more skewed than income; still too little top concentration.

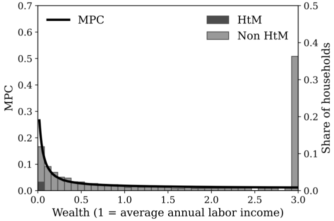

Figure 11.9: MPC, i.e. the slope of the consumption decision rule (curve), as a function of wealth jointly with the distribution of wealth (bars).

Notes: The dark bar near zero represents the share of constrained (or hand-to-mouth, HtM) households in the calibrated model. This figure is reproduced from Kaplan and Violante (2022).

"Hand-to-mouth" ($a \approx 0$) agents carry high MPC $\simeq 1 \rightsquigarrow$ heterogeneous policy effects.

Bounds, Existence & Policy Takeaways

1. **Bounded asset space** ensured by $(\beta R < 1)$ & DARA $\Rightarrow$ SCE exists.
2. Incomplete markets solve *risk-free rate puzzle* but leave wealth highly unequal.
3. Government debt and production reshape $A(r)$, altering $r^{\star}$, precautionary wealth and MPCs.
4. HA-DSGE models (HANK) build on these mechanics for fiscal/monetary analysis (Kaplan and Violante, 2018; see Chapter 21).

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Thank you!

Questions or comments?

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