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Classic Policy Benchmarks for Economies with Substantial Inequality

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Introduction

LARGE-SCALE HETEROGENEOUS-AGENT DSGE

- Increasing interest in large-scale heterogeneous-agent DSGE models.
  - Realistic degrees of inequality—approaching observed Gini coefficients.
  - What is the role of monetary policy in such a model?
  - Answer in this paper: The role of monetary policy is unchanged.

OUTLINE OF THE ARGUMENT

- We construct a heterogeneous-agent economy featuring:
  - Three aggregate shocks: (1) total factor productivity, (2) labor supply and (3) aggregate demand.
  - Both permanent and temporary idiosyncratic risk at the household level.
  - A simple and symmetric structure.
  - Income, wealth and consumption inequality on the same scale as in observed economies.
- We include four policymaking authorities: (1) monetary, (2) fiscal, (3) labor market and (4) education.
- We describe a competitive equilibrium in which the four policymakers act in concert to attain a first-best allocation of resources.

A CLASSIC VIEW

- The policymaker roles are "classic."
  - The monetary authority reacts to shocks each period in order to achieve the Wicksellian natural real rate of interest for the economy.
  - The fiscal authority raises revenue via a non-state contingent linear labor income tax on all households.
  - The labor market authority runs an unemployment insurance program.
  - The education authority minimizes the variance of beginning-of-life human capital endowments.
- *Hence, the main result is that classic policy prescriptions can achieve the first-best allocation of resources in this benchmark heterogeneous-agent economy.*
  - This result may be helpful in understanding more complicated economies that deviate from this benchmark.

SOME SURPRISING FINDINGS

- The proposed classic policies appear broadly similar to actual policies in place in many economies.
  - The monetary authority meets often and reacts to current developments.
  - Simple linear labor income taxes set for the long run can be used without distorting the labor supply; age-dependent taxation is unnecessary.
- The best policy combination drives the consumption Gini toward zero but leaves income and financial wealth Ginis substantially positive—suggesting that some observed income and financial wealth inequality is due to life-cycle effects alone.
- The model has a paper-and-pencil solution despite the three aggregate shocks and the idiosyncratic risk.

SOME RECENT LITERATURE

- Kaplan, Moll and Violante ("HANK," *AER*, 2018).
- Bhandari, Evans, Golosov and Sargent (*ECMA*, 2021, forthcoming). Ramsey meets HANK.
- Bullard and DiCecio (Working paper, St. Louis Fed, 2021).
- Bullard and Singh (*JMCB*, 2020). NGDP targeting in a simpler version.
- Azariadis, Bullard, Singh and Suda (*JEDC*, 2019). Effective lower bound.
- Heathcote, Storesletten and Violante (*JPubE*, 2020). Age-dependent taxation.
- Koenig (*IJCB*, 2013). NGDP targeting.
- Sheedy (*BPEA*, 2014). NGDP targeting.
- Huggett, Ventura and Yaron (*AER*, 2011). Idiosyncratic risk at the beginning of the life cycle.

Environment

LIFE-CYCLE MODELS

- We construct a general-equilibrium life-cycle economy with "symmetry assumptions" which could be relaxed in a computational exercise.
- Each period, a new continuum of households enters the economy, makes economic decisions over the next $T + 1 = 241$ periods ("quarterly"), then exits the economy.
- The symmetry assumptions:
  - All households have log preferences defined over consumption and leisure.
  - All households have a discount factor of unity.
  - All households are endowed with a personal productivity profile at the beginning of their life cycle which begins low, rises to a peak exactly in the middle of the life cycle, and then declines in a symmetric fashion.
  - The aggregate production technology is linear in the aggregate effective labor input. We allow variable utilization of the labor input.

PREFERENCES

- Households are uncertain about how much they may wish to consume in the future.
- For the agent entering the economy at date t, preferences are given by

$$V_t = \sum_{s=0}^{T} \eta \ln \tilde{c}_t (t+s) + (1-\eta) \ln \ell_t (t+s), \tag{1}$$

where $\tilde{c}_t (t+s) \equiv c_t (t+s) D (t+s)$ and the state of demand D is given by

$$D (t+1) = \delta (t, t+1) D (t), \tag{2}$$

where δ follows an $AR(1)$ process with mean unity.

- The preferences for other households are analogous and the demand shock is experienced by all households at each date.
- Following Bai, Ríos-Rull and Storesletten (manuscript, 2019), we allow the state of aggregate demand to influence productive activity in the economy.

PRODUCTION TECHNOLOGY

- The linear production technology is given by

$$Y(t) = Q(t) D(t) N(t) L(t), \tag{3}$$

where $L(t)$ is the aggregate effective labor input; $Q(t)$ is the state of technology which follows

$$Q(t+1) = \lambda(t, t+1) Q(t), \tag{4}$$

where λ follows an $AR(1)$ process with mean $\bar{\lambda} > 1$; $N(t)$ is the population index which follows

$$N(t+1) = \nu(t, t+1) N(t), \tag{5}$$

where ν follows an $AR(1)$ process with mean $\bar{\nu} > 1$.

- The population index is understood to measure the simultaneous increase or decrease in the size of all cohorts so as to maintain symmetry. It can be viewed as "immigration."

LIFE-CYCLE PRODUCTIVITY

- Each household is randomly assigned a personal productivity profile $e = \{e_0, e_1, ..., e_{240}\}$ when entering the model.
  - Profiles are symmetric—they begin low, rise and peak exactly in the middle of life, then decline symmetrically back to the low level.
  - Profiles are restricted to be consistent with interior solutions to all household problems—households will choose to work low hours but not zero.
  - Households also draw a scaling factor ξ from a lognormal distribution as they enter the model, i.e., $\ln(\xi) \sim \mathcal{N}(\mu, \sigma^2)$.
    - The product of their scaling factor and their assigned productivity profile permanently determines their life-cycle productivity, that is, ξe.
    - Accordingly, there will be arbitrarily rich and arbitrarily poor households in the economy.
  - For illustrative purposes, ξ is drawn from a uniform distribution $U[a, b]$ in the figures shown later.

RATIONALE FOR A PERMANENT LIFE-CYCLE PRODUCTIVITY ASSIGNMENT

- The assignment of productivity profiles is a stand-in for the human capital development that takes place before age 20 in actual economies, including schooling, parenting and any job experience.
- Huggett, Ventura and Yaron (*AER*, 2011) argue that differences in initial conditions (human capital at age 23) are more important than subsequent shocks in explaining lifetime income.

BASELINE LIFE-CYCLE PRODUCTIVITY

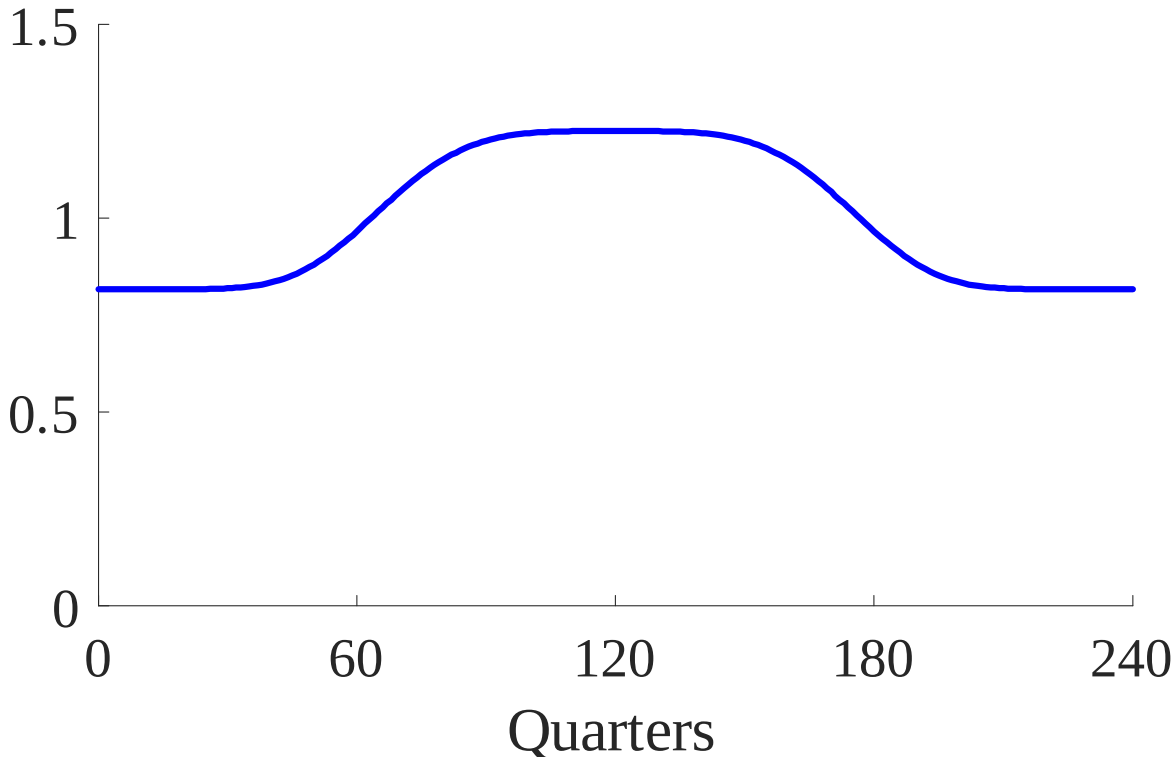

FIGURE: A baseline personal productivity endowment profile. The profile is symmetric and peaks in the middle period of the life cycle at a level about 50% greater than at the beginning or end. A full model would include a set of symmetric profiles with differing shapes.

THE MASS OF LIFE-CYCLE PRODUCTIVITY

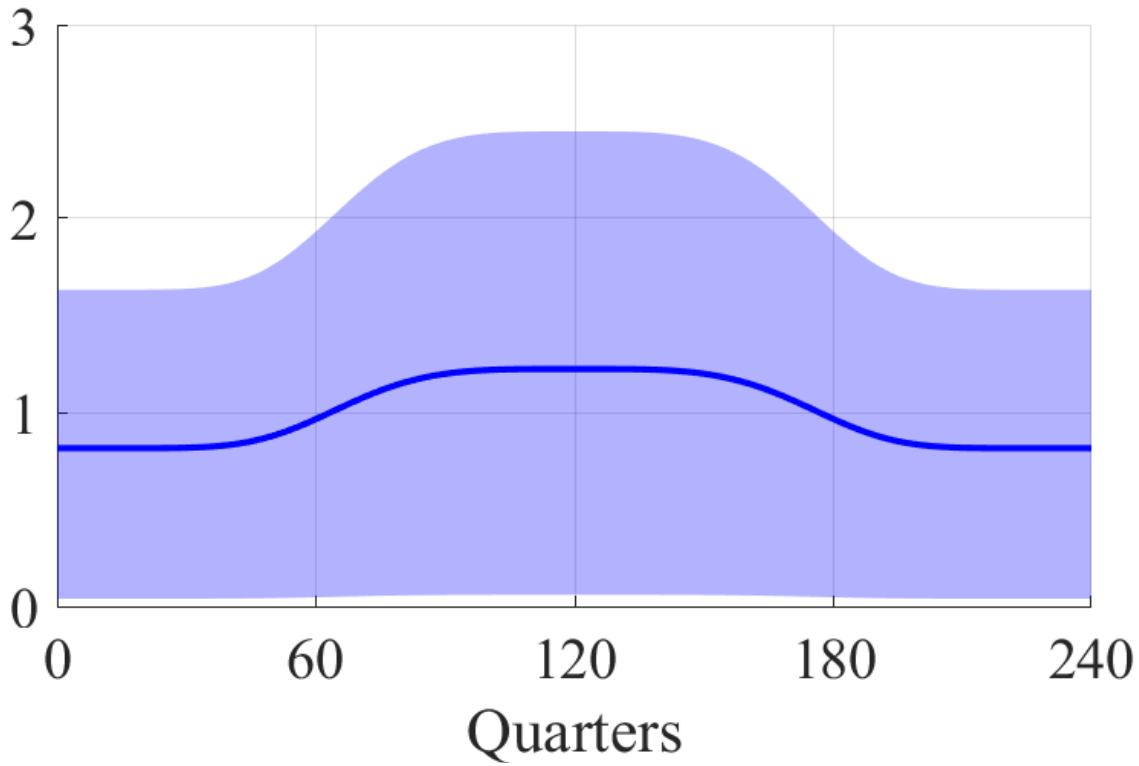

FIGURE: The mass of endowment profiles with the scaling factor drawn from a uniform distribution $U[0.05, 1.95]$. Drawing from a lognormal distribution is harder to visualize, but such a distribution would include arbitrarily rich and arbitrarily poor households.

ADDITIONAL IDIOSYNCRATIC RISK

- Households can earn income in a competitive economywide labor market by supplying hours along with the productivity they have available at that date.
- At the beginning of each period, each household may be randomly unemployed.
- The household earns no income from work on dates of unemployment.
- The unemployment probability is *i.i.d.* and uncorrelated with the aggregate shock.

HOUSEHOLD CREDIT

- The overlapping-generations structure creates a large private credit market essential to good macroeconomic performance.
- The key asset is therefore *privately issued* household debt.
- As practical motivation, think of privately issued debt = "mortgage-backed securities."
  - U.S. household debt in the second quarter of 2021 was about $15 trillion, which was equal to about two-thirds of GDP.

NON-STATE CONTINGENT NOMINAL CONTRACTING

- There is a key friction in the credit market: non-state contingent nominal contracting.
- There are two aspects to this assumption.
  - The non-state contingent aspect means that real resources are misallocated via this friction.
  - The nominal aspect means that the monetary authority may be able to fix the distortion to the equilibrium through appropriate monetary policy.

ADDITIONAL ASSUMPTIONS

- There are no borrowing constraints.
  - See Azariadis et al. (*JEDC*, 2019) for a version with some households excluded from credit markets.
- There is stochastic labor force (= population) growth in this version.
- There is no default.
- Prices are flexible.
- Capital is fixed.
- We ignore the effective lower bound in this version; see Azariadis et al. (*JEDC*, 2019).
- All policies are set credibly for all time $t \in (-\infty, +\infty)$.

Four Policymakers

FOUR POLICYMAKING ENTITIES

- There are four policymaking entities.
  - The monetary authority can observe the three aggregate shocks at the beginning of date t and then set the price level $P(t)$.
  - The fiscal authority can set taxes on labor or capital income to raise an exogenously specified fraction of available real output.
  - The labor market authority observes household-specific unemployment shocks, sets taxes and provides household-specific transfers.
  - The education authority can control the initial dispersion of life-cycle productivity profiles by controlling the standard deviation of the scaling factor ξ up to some limit $\sigma_{\min} \geq 0$.

THE PROPOSED POLICY MIX

- The proposed policy mix is as follows:
  - The monetary policymaker follows an NGDP targeting rule similar to Koenig (*IJCB*, 2013) and Sheedy (*BPEA*, 2014).
  - The fiscal authority sets a linear tax on all labor income earned that is sufficient to meet its revenue requirement.
  - The labor market authority sets a linear tax on all labor income earned that is sufficient to provide appropriate transfers to unemployed households.
  - The education authority minimizes the dispersion of life-cycle productivity profiles by setting $\sigma = \sigma_{\min}$.

The Wicksellian natural real rate of interest

Theorem

Under the proposed policy mix, the real interest rate is exactly equal to the stochastic aggregate output growth rate at every date, and an equal-treatment social planner that discounts at this rate will conclude that this is a social optimum.

Corollary (Equity share contracting)

Any two households that share the same productivity profile consume the same amount at each date, and consumption growth is equalized for all households.

Corollary

Desired labor supply over the life cycle depends on the shape of the productivity profile alone.

Characterizing the Policies

CHARACTERIZING THE POLICIES

- We first describe how the monetary policy works.
- We then characterize the equilibrium in a series of schematic graphs representing the cross-sectional distribution of households at each date.
- In the graphs, we will show both the case where $\sigma_{\min} = 0$ and the case where $\sigma_{\min} > 0$.
  - We can interpret this latter case as one where the education policymaker cannot drive the variance of the scaling factor all the way to zero.

MONETARY POLICY

- The monetary policymaker controls the price level $P(t)$ directly and meets a price level targeting criterion given by

$$P(t) = \frac{R^n(t-1,t)}{\lambda(t-1,t)\,\nu(t-1,t)\,\delta(t-1,t)} P(t-1), \tag{6}$$

  where $R^n(t-1,t)$, the gross nominal interest rate, is equal to the expected gross rate of NGDP growth between dates $t-1$ and t.
- The NGDP targeting rule works because it provides a form of insurance for all households against current and future aggregate shocks.
  - There is a multiplicity of monetary policy rules that can be used to implement the price level targeting criterion. See Bullard and Singh (*JMCB*, 2020).
  - See Giannoni and Woodford (2005) on targeting criteria.

EFFECTS OF AN AGGREGATE SHOCK

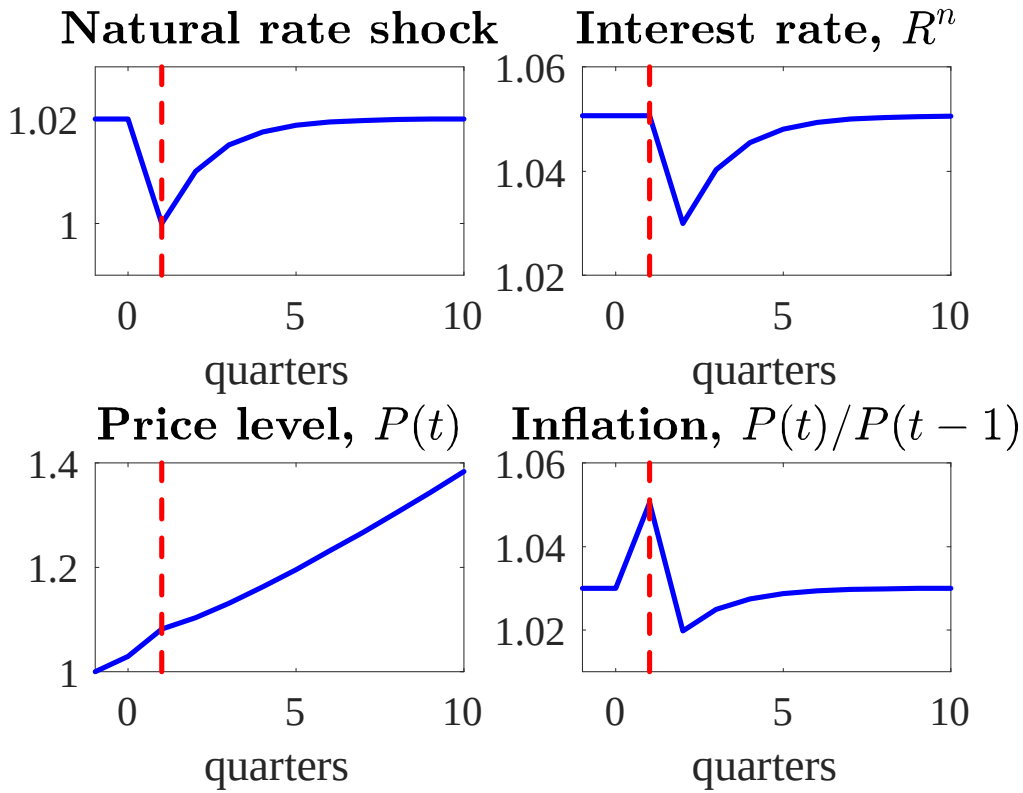

FIGURE: Monetary policy responds to a decrease in the natural rate, i.e., a decrease in λ, ν or δ, by increasing the inflation rate in the period of the shock. Subsequently, inflation converges to its long-run equilibrium value from below. The nominal interest rate drops in the period after the shock. The Phillips curve correlation is high in this model.

LEISURE CHOICES AND TAX POLICY

- Given the monetary policy, the labor market authority sets a tax τ^u that is linear in labor earnings.
- The fiscal authority sets a tax τ^f that is also linear in labor earnings.
- The household i first-order condition for leisure can then be written as

$$\ell_{t,i}(t+s) = (1-\eta)\frac{\bar{e}_i}{e_{s,i}} = (1-\eta)\frac{\bar{e}}{e_s}, \ \forall i, \tag{7}$$

  where $\bar{e} = \frac{1}{T+1}\sum_{s=0}^{T} e_s$ and $\bar{e}_i = \frac{1}{T+1}\sum_{s=0}^{T} e_{s,i}$.
- The scaling factor ξ and the two taxes τ^u and τ^f are all linear in e and therefore cancel out in this expression—so taxing in this manner is nondistortionary.
- This result requires that all labor income is taxed at these rates for all time.

HOURS WORKED OVER THE LIFE CYCLE

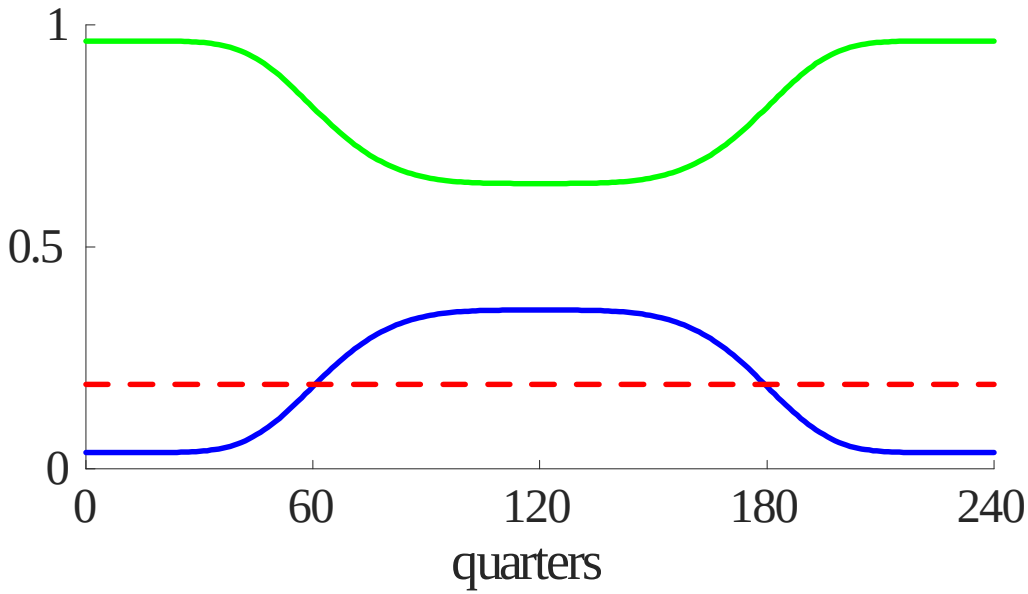

FIGURE: Cross section: Leisure decisions (green), labor supply decisions (blue) and fraction of work time in U.S. data, 19% (red). The labor/leisure choice depends on age only. High-income households plan to work the same hours as low-income households at each age. A certain percentage of the continuum of households in each cohort is unemployed but insured.

EDUCATION POLICY

- "Education policy" influences the productivity profile dispersion parameter σ.
- One could interpret this as an idealized insurance market that operates before households enter the economy at age 20.
- Limiting case: $\sigma_{\min} = 0$, all households receive the same profile.
- This would be a "perfectly equal" economy in that the talent distribution would collapse to just one life-cycle pattern.
  - This would drive the consumption Gini to zero.
  - However, the income and wealth Gini coefficients would remain close to observed values—these are driven mostly by the life-cycle structure.
- We will show both the idealized case $\sigma_{\min} = 0$ and cases where $\sigma_{\min} > 0$ in a later slide.

Characterizing the Equilibrium

LABOR INCOME

- Households want to work more when they are in their peak earning years in the middle of the life cycle.
- This creates substantial labor income inequality.

LABOR INCOME MASS

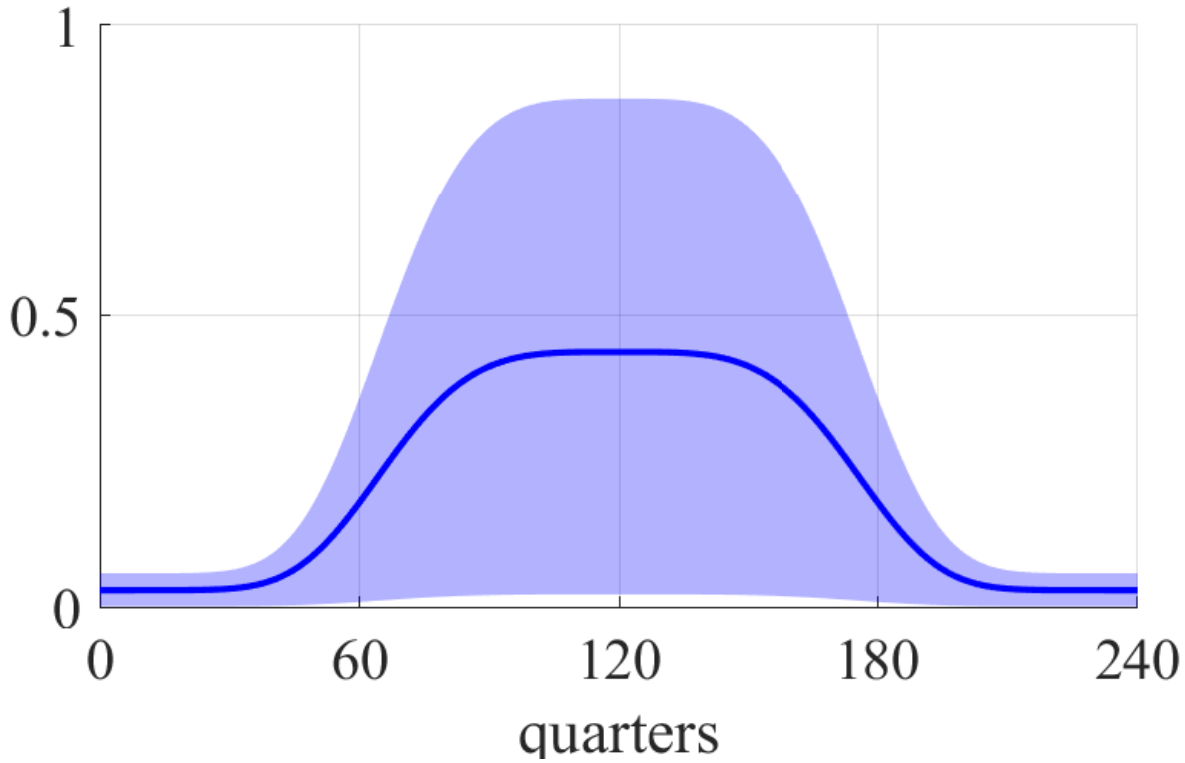

FIGURE: Cross section: Labor income profiles with unemployment insurance. Personal productivity peaks at the middle of the life cycle, and households work more at that time as well, making income even more concentrated in the peak earning years. The blue line depicts the limiting case with $\sigma_{\min} = 0$.

CONSUMPTION MASS

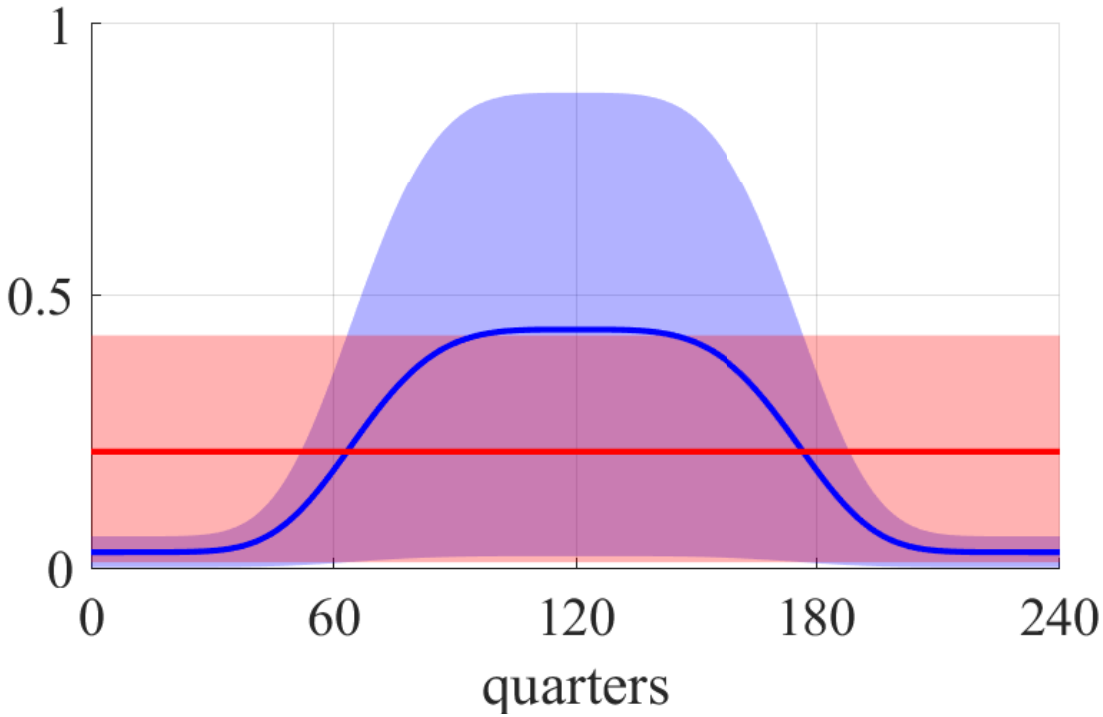

FIGURE: Cross section: Schematic consumption mass (red) and labor income mass (blue). Under optimal monetary policy, the private credit market reallocates uneven labor income into perfectly equal consumption along each productivity profile. The consumption Gini is 32%, by construction the same value as in U.S. data. The solid lines depict the limiting case with $\sigma_{\min} = 0$.

CONSUMPTION EVOLUTION

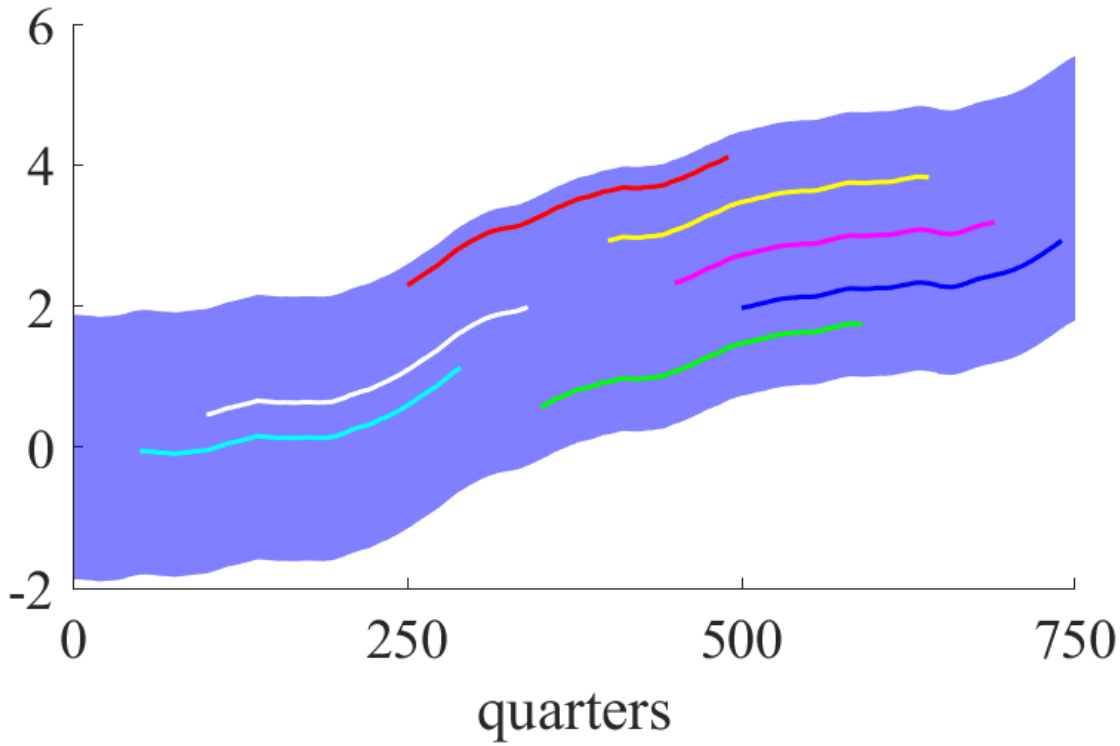

FIGURE: Time series: Evolution of the distribution of log consumption (shaded area) and examples of individual log consumption profiles (colored lines). Under optimal monetary policy, individual consumption profiles share the same stochastic trend as aggregate consumption.

NET ASSET HOLDING MASS

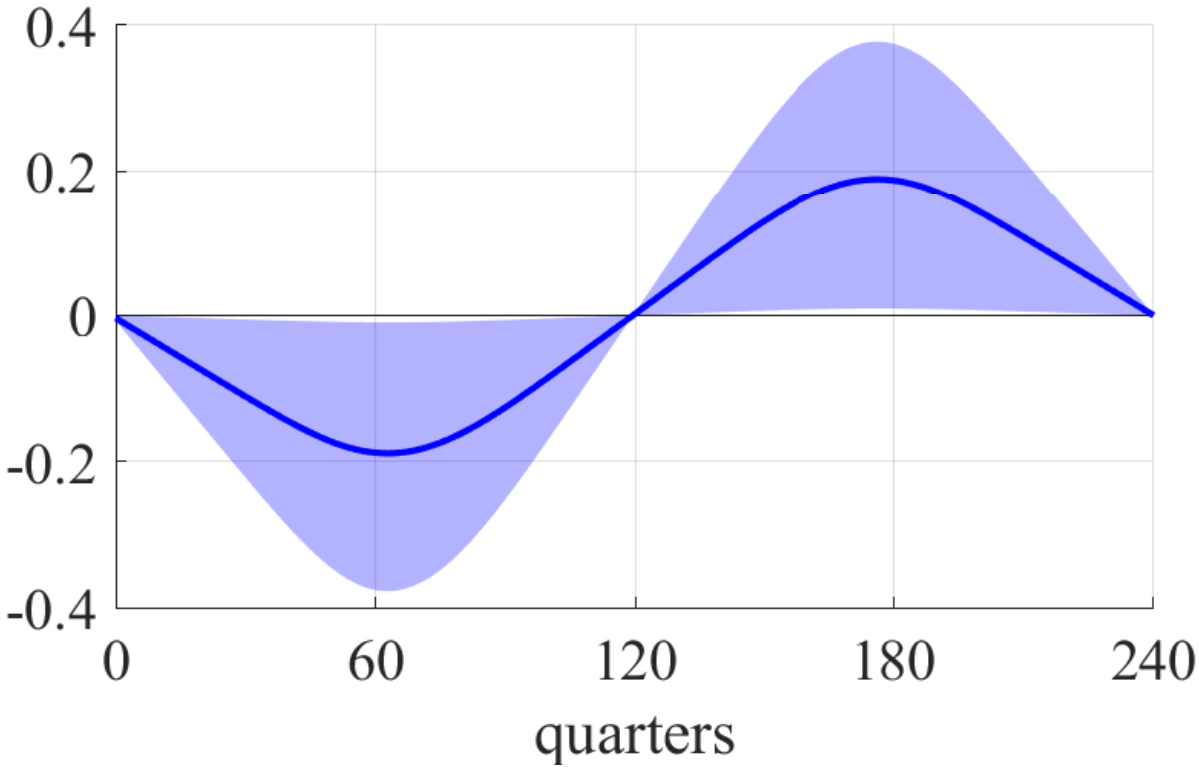

FIGURE: Cross section: Schematic net asset holding mass relative to GDP by cohort. Borrowing, the negative values to the left, peaks at stage 60 of the life cycle (age ~35), while positive assets peak at stage 180 of life (age ~65). The financial wealth Gini is 72.4%, similar to values calculated in U.S. data. The blue line depicts the limiting case with $\sigma_{\min} = 0$.

THREE NOTIONS OF INCOME

- Three notions of income:
  - Pretax labor income, Y_1.
  - Pretax labor income plus non-negative capital income, Y_2.
  - The non-negative component of total income, Y_3.
- Gini coefficients of income distributions: $G_{Y_1} = 55.7\%$, $G_{Y_2} = 51.1\%$, $G_{Y_3} = 59.0\%$.

LABOR INCOME + NON-NEGATIVE CAPITAL INCOME

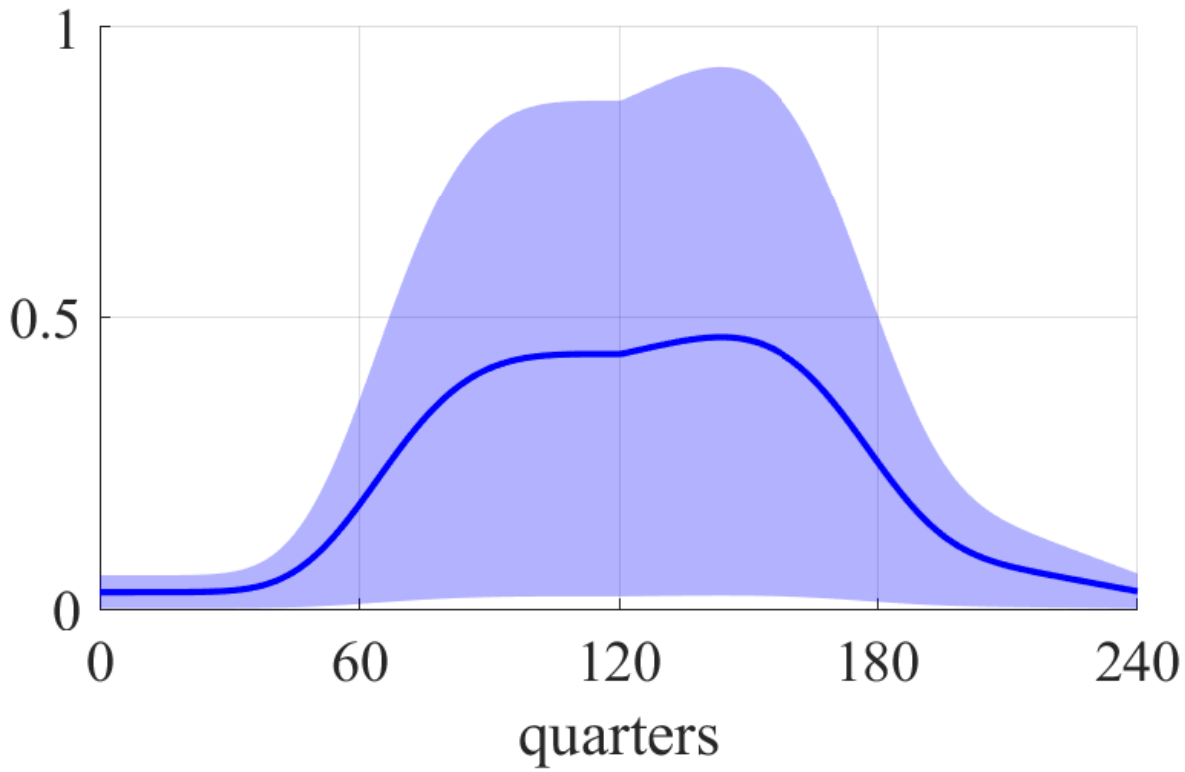

FIGURE: Cross section: Profiles of labor income and non-negative capital income. The blue line depicts the limiting case with $\sigma_{\min} = 0$.

NON-NEGATIVE TOTAL INCOME

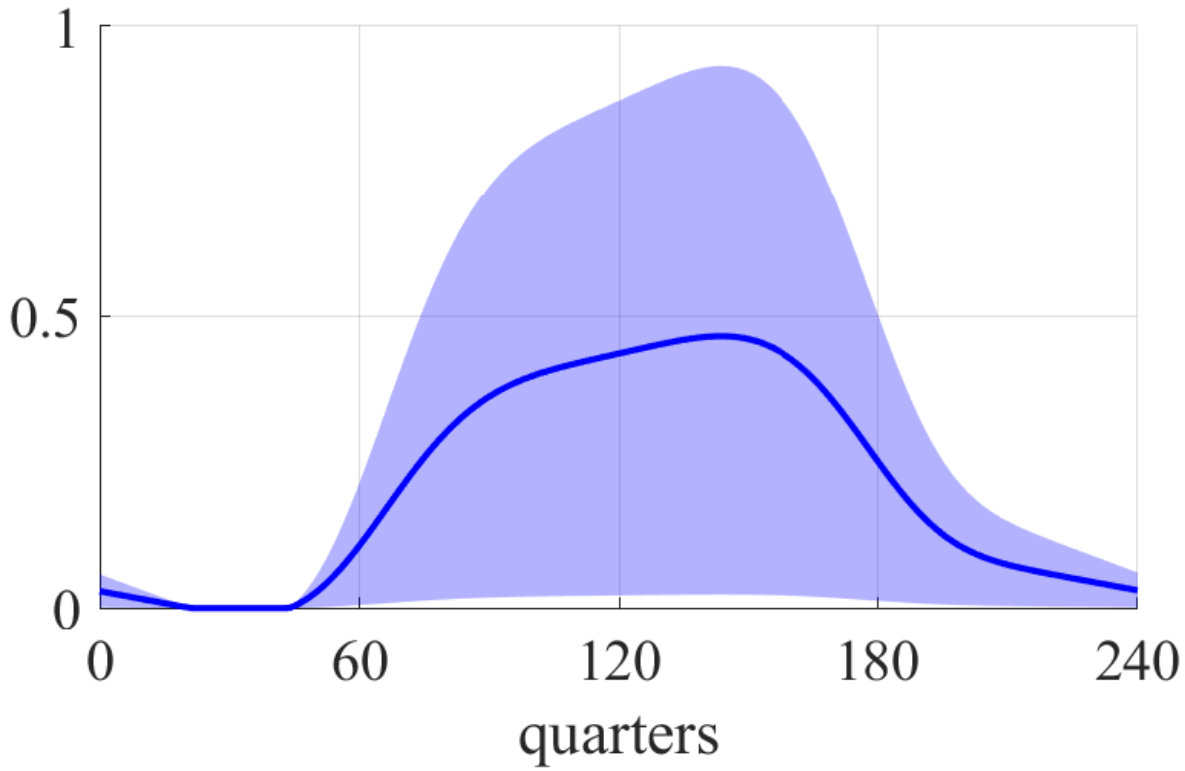

FIGURE: Cross section: Profiles of non-negative total income. The blue line depicts the limiting case with $\sigma_{\min} = 0$.

MARGINAL PROPENSITY TO CONSUME

- Consumption is linear in the real wage

$$c_{t,i}(t+s) = \eta\xi\bar{e}\left(1-\tau^{f}\right)\left(1-\tau^{u}\right)w(t+s).$$

- Labor income is linear in the real wage

$$\Upsilon_{1;t,i}(t+s) = \xi e_s\left[1-\ell_t(t+s)\right]\left(1-\tau^{f}\right)\left(1-\tau^{u}\right)w(t+s).$$

- Hence, the MPC can be calculated as follows:

$$\begin{aligned} MPC &= \frac{dc/dw}{d\Upsilon_1/dw} = \frac{\eta\bar{e}\xi\left(1-\tau^{f}\right)\left(1-\tau^{u}\right)}{e_s\xi\left[1-(1-\eta)\frac{\bar{e}}{e_s}\right]\left(1-\tau^{f}\right)\left(1-\tau^{u}\right)} = \\ &= \frac{\eta\bar{e}}{e_s-(1-\eta)\bar{e}}. \end{aligned}$$

YOUNG AND OLD AGENTS HAVE HIGH MPC

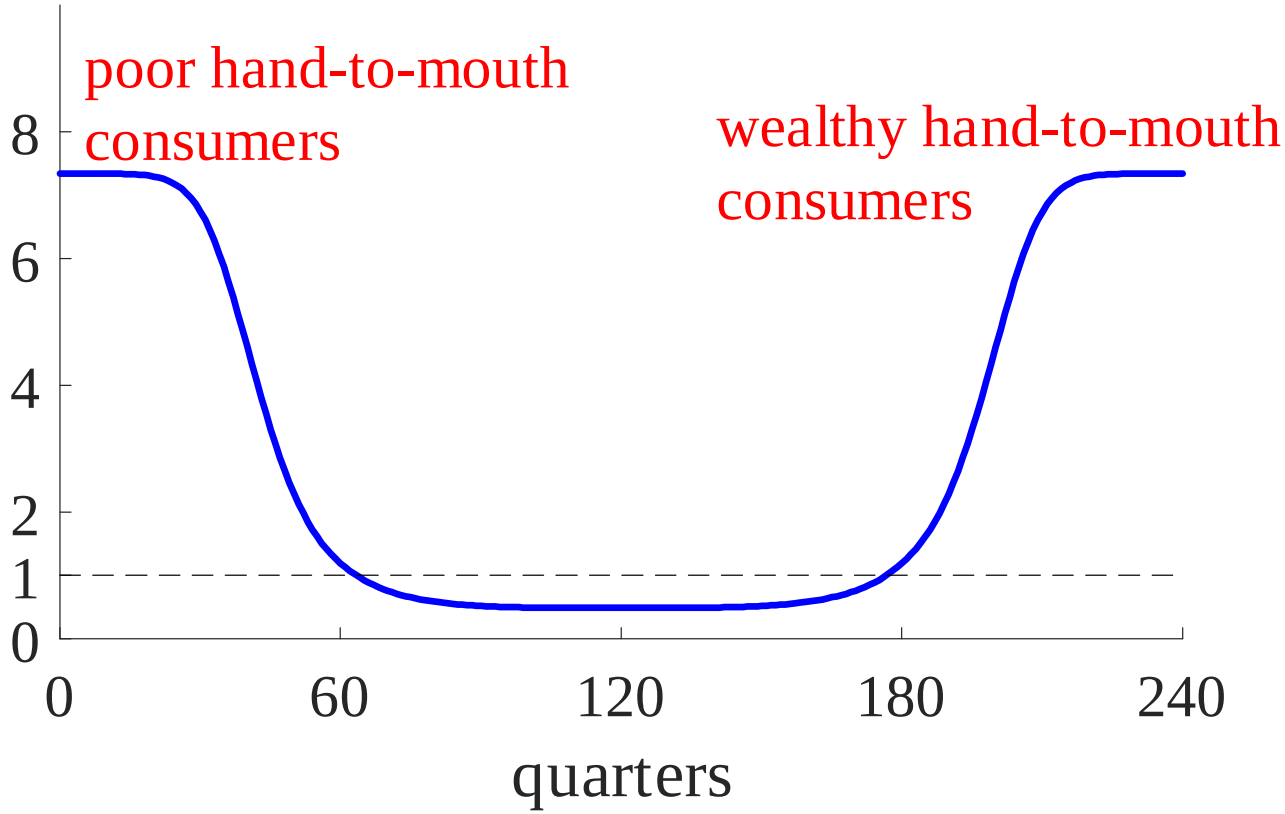

FIGURE: Cross section: Marginal propensity to consume out of labor income by cohort. Notice that the MPC does not depend on the endowment scaling factor, ξ.

Inequality

DATA ON INEQUALITY IN THE U.S.

- Consumption (Heathcote, Perri and Violante, *RED*, 2010): $G_{C,\text{U.S.}} = 32\%$.
- Income (CBO, 2016): pre-taxes/transfers $G_{Y,\text{U.S.}} = 51\%$; post-taxes/transfers $G_{Y,\text{U.S.}} = 43\%$.
- Financial wealth (Davies, Sandström, Shorrocks and Wolff, *EJ*, 2011): $G_{W,\text{U.S.}} = 80\%$.

GINI COEFFICIENTS

	Wealth		**Income**		**Consumption**
	W	Y_1	Y_2	Y_3	C
U.S. data	80%		51%		32%
Model	72.4%	55.7%	51.1%	59.0%	32%

TABLE: Gini coefficients in the U.S. data and in the model with lognormal productivity.

PRODUCTIVITY DISPERSION AND GINI COEFFICIENTS

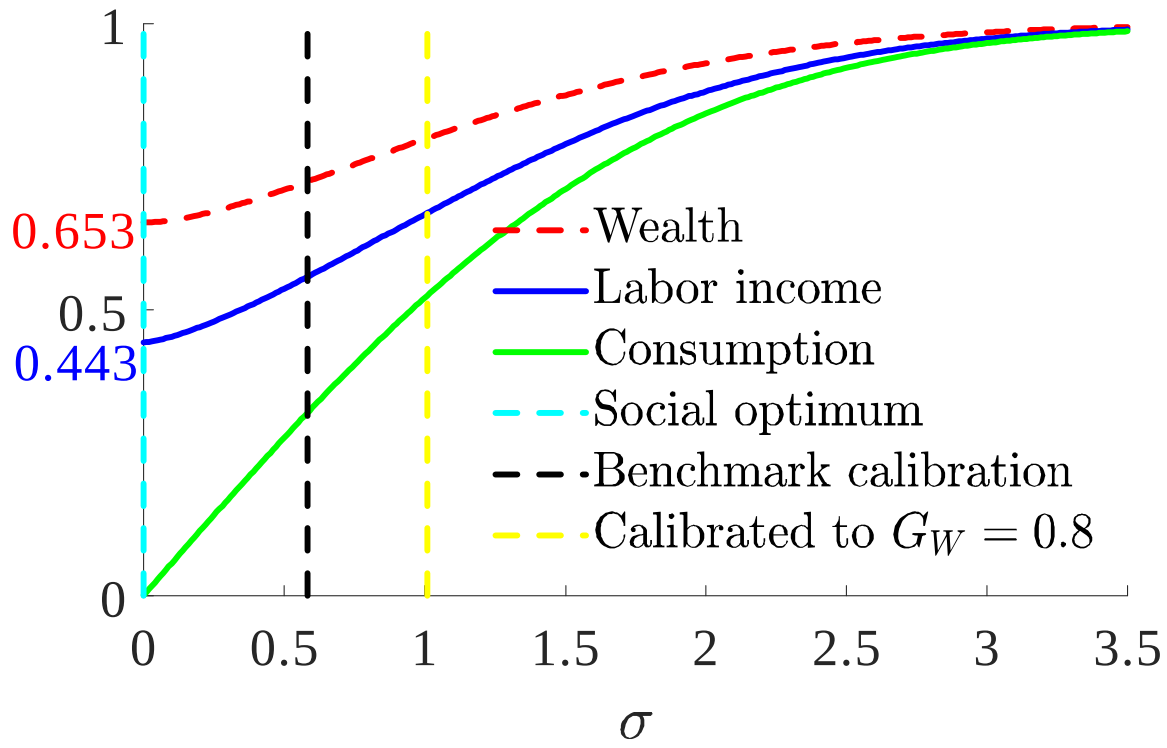

FIGURE: As the dispersion of productivity profiles, σ, increases, the Gini coefficients increase. The ordering $G_W > G_Y > G_C$ is preserved. The case where $\sigma_{\min} = 0$ has $G_C = 0$, but $G_W = 65.3\%$ and $G_Y = 44.3\%$. The model can match any single Gini with a sufficiently large choice of σ.

Conclusions

CONCLUSIONS

- A classic combination of policies can deliver a first-best allocation of resources in this environment even with substantial inequality in income, wealth and consumption.
  - A monetary policymaker provides period-by-period insurance against aggregate shocks.
  - This enables nondistortionary linear labor income taxes to fund government expenditures as well as an unemployment insurance program.
  - Education policy can drive the consumption Gini toward zero but would leave income and wealth Ginis at positive levels.
- These classic benchmarks may be useful in understanding the effects of macroeconomic policy for models in this class going forward.