FEDERAL RESERVE BANK of ST. LOUIS

Conjectures on Learning in Krusell-Smith-Type Economies

James Bullard, Federal Reserve Bank of St. Louis

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Introduction

Nature of monetary policy

- Bill Poole, the previous St. Louis Fed president, paraphrased:
  - Beginning of FOMC term: "Macroeconomics is about steady states punctuated by shocks."
  - End of FOMC term: "Macroeconomics is about shocks punctuated by steady states."
- My argument illustrates the latter idea.

Large-scale heterogeneous-agent DSGE

- Increasing interest in large-scale heterogeneous-agent DSGE models.
  - Realistic degrees of inequality—approaching observed Gini coefficients.
  - Ideally, "Krusell-Smith" stochastic structure: aggregate risk plus idiosyncratic risk.
  - Can the equilibrium of such an economy be learned by agents not initially possessing rational expectations?

These remarks

- Sketch a heterogeneous-agent economy that has a known equilibrium that can be calculated by "pencil and paper" methods.
- Describe some of the features of the equilibrium.
- Outline a few considerations in a possible implementation of social learning.
- Conjecture that the learning process is likely to be especially slow in this environment.
- Draw out some possible policy implications.

The Classical Benchmarks Economy

Bullard-DiCecio (2021)

- A heterogeneous-agent life-cycle 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.
- Four policymaking authorities: (1) monetary, (2) fiscal, (3) labor and (4) education.
- Bullard and DiCecio (2021) describe a competitive equilibrium in which the four policymakers act in concert to attain the first-best allocation of resources defined in a social welfare theorem.

A note on life-cycle models

- 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.
- There is heterogeneity by age but also within cohorts.

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.
  - Households also draw a scaling factor ξ from a lognormal distribution as they enter the model: $\ln \xi \sim \mathcal{N}(\mu, \sigma^2)$.
  - The product of their scaling factor and their assigned productivity profile permanently determines their life-cycle productivity, that is, ξe.
  - Rationale: Huggett, Ventura and Yaron (AER, 2011).

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.
- There is a key friction in the credit market: non-state contingent nominal contracting.
- Under the proposed policy mix, the real rate of interest is equal to the stochastic growth rate of the economy.

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 to fund a government 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.

Characterizing the Equilibrium

The mass of life-cycle productivity

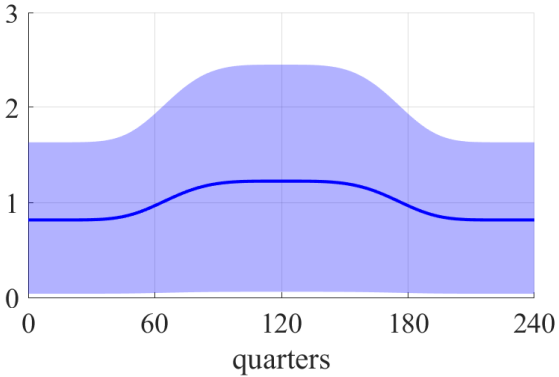

Figure: The mass of endowment profiles with the scaling factor drawn from a uniform distribution $U[0.05, 1.95]$. Drawing from a lognormal distribution is harder to visualize, but such a distribution would include arbitrarily rich and arbitrarily poor households. The endowment Gini is about 35%.

HOURS WORKED OVER THE LIFE CYCLE

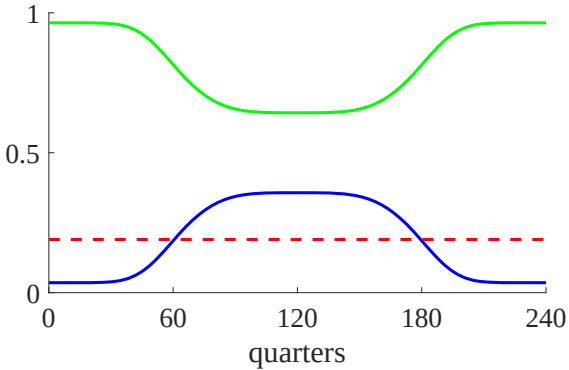

FIGURE: Cross section: Leisure decisions (green), labor supply decisions (blue) and fraction of work time in U.S. data, 19% (red). The labor/leisure choice depends on age only. High-income households plan to work the same hours as low-income households at each age. A certain percentage of the continuum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

Labor income mass

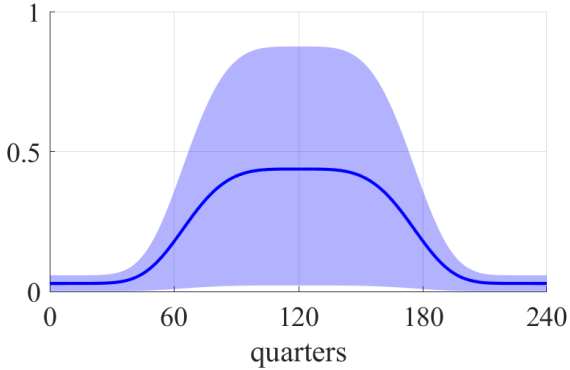

Figure: Cross section: Labor income profiles with unemployment insurance. Personal productivity peaks at the middle of the life cycle, and households work more at that time as well, making income even more concentrated in the peak earning years. The blue line depicts the limiting case with $\sigma_{\min}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

Consumption mass

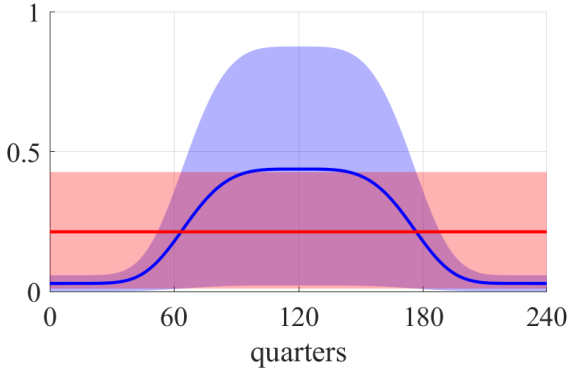

Figure: Cross section: Schematic consumption mass (red) and labor income mass (blue). Under optimal monetary policy, the private credit market reallocates uneven labor income into perfectly equal consumption along each productivity profile. The consumption Gini is 32%, calibrated to the U.S. data value.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

NET ASSET HOLDING MASS

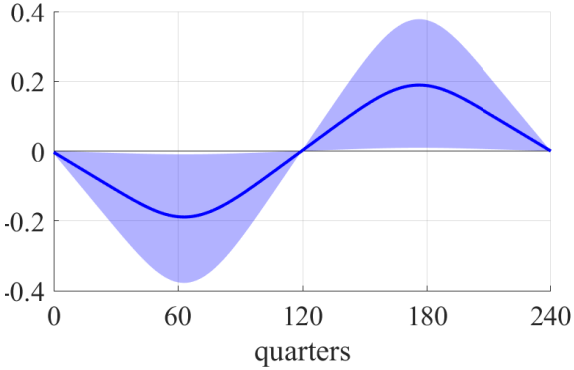

FIGURE: Cross section: Schematic net asset holding mass relative to GDP by cohort. Borrowing, the negative values to the left, peaks at stage 60 of the life cycle (age ˜35), while positive assets peak at stage 180 of life (age ˜65). The financial wealth Gini is 72.4%, similar to values calculated in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

YOUNGER AND OLDER AGENTS HAVE HIGH MPC

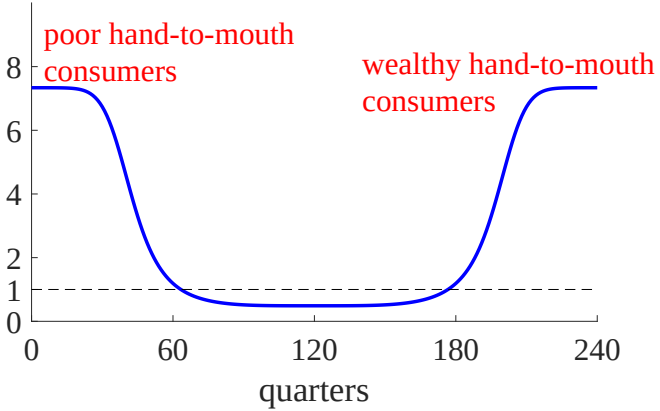

FIGURE: Cross section: Marginal propensity to consume out of labor income by cohort. Notice that the MPC does not depend on the endowment scaling factor, ξ.

Social Learning

LEISURE CHOICES

- Given the proposed policies, the household i first-order condition for leisure can be written as

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

  for all i where $\bar{e}_i = \frac{1}{T+1}\sum_{s=0}^{T} e_{s,i}$.
- A typical social learning implementation would allow leisure choices to initially deviate from these values for all households.
- This would mean aggregate labor supply and output would initially deviate from equilibrium values.

CONSUMPTION CHOICES

- Given the proposed policies, the household i first-order condition for consumption is linear in the contemporaneous value of the real wage and can be written as

$$c_{t,i}(t+s) = \eta(1-\tau^u)\left(1-\tau^f\right)\bar{e}_i w(t+s) \tag{2}$$

  for all i, where $\bar{e}_i = \frac{1}{T+1}\sum_{s=0}^{T} e_{s,i}$.
- A typical social learning implementation would allow consumption choices to initially deviate from these values for all households.
- This would mean the net asset holding distribution and the real interest rate would initially deviate from equilibrium values.

Fitness

- We can think of an individual household in the social learning environment as choosing a pair (c, ℓ) at each date.
- The consumption choice could be constrained to be a simple linear function of the wage at that date.
- The leisure choice could be constrained to be a simple linear function of the ratio of total productivity to current productivity at that date.
- Fitness is conceptually difficult—households would have to conjecture that if they used their existing linear rules over their remaining life, they would attain higher utility than using an alternative rule.
- Alternative rules could be evaluated by households via crossover and mutation operators.

Convergence

- The life-cycle nature of this economy means that if any cohort or member of a cohort makes choices inconsistent with the long-run equilibrium at any date, then, in principle, one has to wait for that cohort or individual to exit the economy in order to attain convergence.
- In addition, under social learning, the households have to learn the correct decision rules (in this formulation), which itself takes (perhaps considerable) time.
- In principle, this means more members of cohorts making more choices inconsistent with the long-run equilibrium for longer.
- Conjecture: Learning in a Krusell-Smith environment would be "slow," where slow is appropriately defined.

Policy

Policy choices

- The classical benchmarks economy has clearly delineated policies for the four policymakers.
- The monetary policymaker would likely be the most affected by the slow learning process I have described.
- In particular, real interest rates (which are supposed to equal the real output growth rate) could be disturbed for long periods of time as the social learning process plays out.
- Other important quantities, such as Gini coefficients for consumption, income and financial wealth, would also be disturbed.
- One might want to develop policies that would speed up the social learning process.

Conclusions

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- 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.
- These classic benchmarks may be useful in understanding the effects of macroeconomic policy for models in this class going forward.
- These remarks have emphasized, however, that with social learning an economy of this type is more likely on a transition path at any point in time than actually at the rational expectations equilibrium.
- Whether the classic combination of policies could be altered to account for this is an open question.