Optimal Macroeconomic Policies in a Heterogeneous World

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Introduction

Benchmark models

- The macroeconomics world has benefited from having simple benchmark models from which fruitful discussions can be launched.
- 1980s-1990s: real business cycle models—Prescott (*QR*, 1986).
- 2000s-present: New Keynesian models—Woodford (2003).
- Today, we want to be more granular in order to be able to discuss how macroeconomic policies impact different portions of the income distribution.
- But what would optimal macroeconomic policy look like in a heterogeneous world?

A benchmark model

- We study a simple (paper-and-pencil solution) benchmark DSGE heterogeneous-agent life-cycle model.
- The equilibrium features Gini coefficients approaching those in the U.S. data.
- The model is meant to be complementary to models in the HANK literature.
    - The subtext in this talk is that models in this class represent, broadly, the current and future direction of macroeconomics.
- The model features three aggregate shocks as well as permanent and temporary idiosyncratic risk.
- Macroeconomic policymakers in the model have tools to counter the frictions in the economy.
- A welfare theorem states the sense in which these policies can achieve an optimal allocation of resources.

MODEL-RECOMMENDED MACRO POLICIES

- The model equilibrium recommends the following “four horsemen” macroeconomic monetary-fiscal policy mix:
    - As in the NK model, the *monetary authority* should react to aggregate shocks each period and strive to achieve the “Wicksellian natural real rate of interest”; roughly, “easier” monetary policy in periods of low growth and “tighter” monetary policy in periods of high growth.
    - The *treasury authority* should issue nominal debt and roll it over at the current nominal interest rate in perpetuity.
    - The *labor market authority* should run an unemployment insurance program.
    - The *fiscal authority* should use a redistributive tax-transfer scheme to lower the consumption Gini coefficient.

A mapping to actual macro policies?

- These model-recommended macroeconomic policies seem to correspond, broadly speaking, to actual macroeconomic policies in place in many economies around the world today, including the U.S.
- By itself, this finding suggests that current observed macroeconomic policy is broadly on the right track in many countries.

A CALIBRATED CASE

- We consider a calibration of the model using U.S. data from 1995 to 2023.
    - We assume that actual observed U.S. macroeconomic policy during this period has essentially been an implementation of the optimal macroeconomic policies recommended by the model.
- We compare the calibrated model equilibrium to the data on six dimensions: (1) aggregate consumption growth correlations, (2) distributional consumption growth correlations, (3) Heckman-style labor supply, (4) marginal propensities to consume, (5) tax progressivity and Gini coefficients, and (6) nominal returns to asset holders.
- We argue that the fit to the data is generally good.
- This suggests that actual U.S. macro policy has been close to optimal during this period.
- The model fits less well during periods of very large shocks, such as the GFC or the onset of the pandemic.

Environment

ENVIRONMENT BASICS

- At each date t, a new continuum of households enters the economy, makes economic decisions over $T + 1 = 241$ dates, then exits the economy.
    - To fix ideas, think of $\approx 1m$ agents per quarterly cohort.
- This corresponds to an agent entering the economy as a decision-maker at age 20 and exiting as a decision-maker at age 80, inclusive of end points, and making economic decisions at a quarterly frequency.
- Results are perfectly general for the choice of T, with higher values corresponding to decision-making at more frequent intervals.
- We make enough assumptions to generate a paper-and-pencil equilibrium solution, and thus provide a simple benchmark model for heterogeneous-agent macroeconomies with aggregate shocks.

Assets

- There are three *nominally denominated* assets: privately issued debt, publicly issued debt and privately issued nominal claims to capital.
- We think of these as abstract representations of U.S. data counterparts: (1) mortgage-backed securities, (2) federally issued debt and (3) corporate debt, respectively.
- In the U.S. data, MBS net out, but federally issued debt and claims to capital are in positive net supply.
- We think of firms as being bond-financed and push physical capital into the background.

NOMINAL CONTRACTING

- The credit market friction is non-state contingent nominal contracting: All debt contracts are stated in nominal terms, with a stated nominal interest rate, and repayment is not state-contingent.
- The role of monetary policy is to adjust the price level each period in order to convert these nominal, non-state contingent contracts into real, state-contingent contracts.

HOUSEHOLD TYPES

- Household types: “life cycle” (LC) and “hand-to-mouth” (HTM).
- The life-cycle households are assigned a hump-shaped productivity profile at the beginning of their life cycle. Accordingly, they need to use credit markets (hold assets) to smooth life-cycle consumption.
- The hand-to-mouth households are assigned a perfectly flat productivity profile as they enter the economy. Accordingly, they never need to use credit markets and instead consume their labor income each period.

Preferences

- Each household $i \in (0,1)$ entering the economy at date t has preferences (which are the same for both LC and HTM types)

$$U_{t,i} = \max_{\left\{\tilde{c}_{t,i}, \ell_{t,i}\right\}_{s=0}^{T}} E_t \sum_{s=0}^{T} \left[\eta \ln \tilde{c}_{t,i}\left(t+s\right) + \left(1-\eta\right) \ln \ell_{t,i}\left(t+s\right)\right].$$

- Households choose $\tilde{c}$, but we define $\tilde{c}_{t,i}\left(t+s\right) = D\left(t+s\right) c_{t,i}\left(t+s\right)$, where $D\left(t+s\right)$ is the "state of aggregate demand" at date $t+s$. The state of aggregate demand evolves as

$$D\left(t\right) = \delta(t-1,t) D\left(t-1\right),$$

  where $\delta(t-1,t)$ is the gross growth rate of demand, which follows an appropriate stochastic process that keeps $D(t) > 0 \; \forall t$.

- Households may decide to consume more or less at future dates depending on the state of aggregate demand at those dates.

Productivity profiles

- Agents entering the economy draw a scaling factor x from a lognormal distribution and receive a productivity profile that is a scaled version of a baseline profile, e_s :

$$e_{s,i} = x \cdot e_s.$$

- For LC agents, $e_s^{LC} = 1 + p_1 \exp\left[-\left(\frac{s-p_2}{p_3}\right)^4\right]$, and p_1, p_2 and p_3 are chosen to match calibration targets given on later slides.
- For HTM agents, $e_s^{HTM} = h\,(1/T)\sum_{s=0}^{T} e_s^{LC}$, where $h \in (0,1)$.
- Huggett, Ventura and Yaron (*AER*, 2011) argue that differences in initial conditions are more important than differences in shocks for lifetime earnings; therefore, we sometimes call the scaling factor the "HVY" shock.

Distortion in the scaling assignment

- The scaling draw x that each agent receives at the beginning of their life cycle is meant to be a proxy for unmodeled human capital development before age 20, including parenting, on-the-job experience and schooling.
- It can be characterized by the standard deviation of the lognormal distribution from which it is drawn, σ_{lc}.
- The full social optimum with only life-cycle agents would set $\sigma_{lc} = 0$.
- Since this value might be impractical, we will consider other values in the calibration section.

Idiosyncratic labor income risk

- All agents in the economy are subject to an *i.i.d.* unemployment shock each period which takes on a value of 0 with probability p or 1 with probability $1 - p$.
- Agents receiving a zero draw cannot earn labor income in that period.

TECHNOLOGY

- Aggregate real output $Y(t)$ is given by

$$Y(t) = [D(t)\, Q(t)\, N(t)]^{1-\alpha} K(t)^{\alpha} [L(t)]^{1-\alpha}, \tag{1}$$

  where $K(t)$ is the real value of the physical capital stock, $L(t)$ is the aggregate effective human capital supply (hours $\times$ productivity of various households), $Q(t)$ is a productivity index, $N(t)$ indexes the size of the labor force, and $D(t)$ is the state of aggregate demand.
- Q, N and D grow at stochastic gross rates λ, ν and δ, respectively.
- These assumptions mean that real output grows at the stochastic rate $\lambda\nu\delta$ each period.
  - The aggregate demand assumption is a simple version of Bai, Ríos-Rull and Storesletten (working paper, 2019).
  - Firms are bond-financed and issue debt each period according to

$$B^{c}(t+1) = R^{n}(t, t+1)\, B^{c}(t). \tag{2}$$

Nominal contracting and timing protocol

- Under the assumptions outlined, the contract nominal interest rate is given by

$$R^{n}(t, t+1)^{-1} = E_{t}\left[\frac{\tilde{c}_{t,i}(t)}{\tilde{c}_{t,i}(t+1)}\frac{P(t)}{P(t+1)}\right]. \qquad (3)$$

- The timing protocol is: (1) nature assigns new entrant productivity profiles and also draws idiosyncratic and aggregate shocks; (2) the treasury authority issues nominal debt; (3) the monetary authority sets the price level; (4) households choose date t consumption, hours worked and net asset holding, and all other activities take place.
- Households will be able to make date t decisions without reference to future uncertainty in the paper-and-pencil solution.

Policymakers

The treasury authority

- The fully credible nominal debt issuance process is given by

$$B^{g}(t) = R^{n}(t-1,t)\, B^{g}(t-1), \tag{4}$$

  where $B^{g}(t)$ is the total level of nominal debt and $B^{g}(0) > 0$.
- The treasury authority is issuing enough new debt to maintain the level of assets in the economy at the appropriate level.

The labor market authority

- The labor market authority runs an unemployment insurance program that uses a linear labor earnings tax to raise revenue sufficient to exactly cover payments to unemployed workers.
- Unemployed workers receive the same after-tax income that they would if they were not unemployed.
    - Note: Linear labor income tax factors $(1-\tau)\,e_s$, with τ set for all periods s in a household's life cycle, will not distort labor supply in this model.

The monetary authority

- The monetary authority controls the price level directly and implements a targeting criterion

$$P(t) = \frac{R^n(t-1,t)}{\delta(t-1,t)\,\lambda(t-1,t)\,\nu(t-1,t)} P(t-1). \qquad (5)$$

- This targeting criterion calls for countercyclical price level movements relative to the expectation embodied in the contract rate $R^n(t-1,t)$.
  - See Koenig (*IJCB*, 2013) and Sheedy (*BPEA*, 2014) on NGDP targeting.

The fiscal authority

- The fiscal authority taxes high-income life-cycle individuals within a cohort and transfers to low-income life-cycle individuals within the same cohort.
- The tax-transfer scheme is nondistortionary with respect to labor supply.
- The term $(1-\tau_i)\, x_i e_s$ in labor income is replaced with $x_j e_s$ by setting $(1-\tau_i) = \left(x_j / x_i\right)$, where x_j is the draw in a lognormal distribution with standard deviation $\sigma_{lc}' \leq \sigma_{lc}$ corresponding to the x_i draw from the lognormal distribution with standard deviation σ_{lc}.
- This is as if nature had drawn the original x_i from a distribution with lower variance.
- This will reduce the consumption Gini, but it will also affect other Gini coefficients.

Competitive equilibrium and social welfare

- Solution: Guess and verify that there is a competitive equilibrium in which the real rate of interest is always equal to the stochastic rate of real output growth.
    - The "Wicksellian natural real rate of interest" for this economy.
- A social planner would conclude that the allocation of resources is a social optimum provided (i) the planner places equal weight on all households for all time, (ii) the planner discounts backward and forward in time at the stochastic real rate of interest, and (iii) the planner cannot alter the distribution of productivity profiles.
- Limiting case: If there are no HTM agents and $\sigma_{lc} = 0$, then all agents receive exactly the same utility over their lifetime modulo the real interest rate adjustment.
- Question: Does the model equilibrium match data with respect to consumption growth and leisure?

Decision rules for consumption, leisure and assets

- Life-cycle agents:

$$\tilde{c}_{t-s,i}(t) = \eta(1-\tau_i)(1-\tau^u)w(t)x_i\bar{e},$$

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

$$\frac{a_{t-s,i}(t)}{P(t)} = (1-\tau_i)(1-\tau^u)w(t)x_i\sum_{j=0}^{s}(e_j-\bar{e}).$$

- Hand-to-mouth agents (assuming no dispersion):

$$\tilde{c}^{htm}_{t-s,i}(t) = \eta e^{htm},$$

$$\ell^{htm}_{t-s,i}(t) = (1-\eta),$$

$$\frac{a^{htm}_{t-s,i}(t)}{P(t)} = 0.$$

Calibration

Mapping to the data

- Adjust the cohort size based on data from the U.S. Census Bureau.
- Set the baseline hump-shaped life-cycle productivity profile such that households endogenously choose to work the hours worked by age in the U.S. data.
- Choose η to match the average time devoted to market work across the economy.
- Set the fraction of HTM households (who do not hold assets) to the share of unbanked U.S. households, 4.5% in 2021 according to the FDIC.
- Choose the within-cohort standard deviation of productivity scaling for life-cycle households, σ_{lc}, to match the Gini coefficient for financial wealth in the U.S. data.
- Set the redistributional tax initially to zero; then set it to match the Gini coefficient for consumption in the U.S. data.

THE MASS OF LIFE-CYCLE PRODUCTIVITY

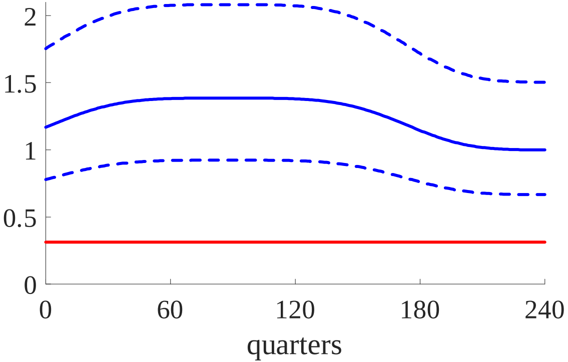

FIGURE: The mass of endowment profiles: life-cycle agents (blue) and hand-to-mouth agents for $h = 0.25$ (red). The dashed lines denote the 25$^{\text{th}}$ and the 75$^{\text{th}}$ percentiles of the lognormal endowment scaling distributions.

Hours worked by age

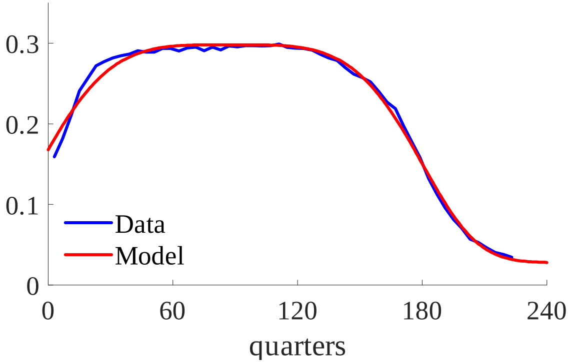

FIGURE: Hours worked by age for life-cycle households: U.S. data (blue) and calibrated model (red).

Model Fit to U.S. Data

AGGREGATE CONSUMPTION GROWTH

- The model is characterized by explicit stochastic growth—no detrending.
- The model equilibrium under the optimal monetary-fiscal policy mix states that real output growth will be perfectly correlated with real aggregate consumption growth, and their nominal counterparts will be similarly correlated.
- In the data, it is not clear what the real-world counterpart is to "output" since the model does not have an international sector or other important dimensions (e.g., inventories and a "large" government sector).
- Accordingly, we consider a variety of output measures.
- Bottom line: The correlations are close to one.

AGGREGATE CONSUMPTION GROWTH

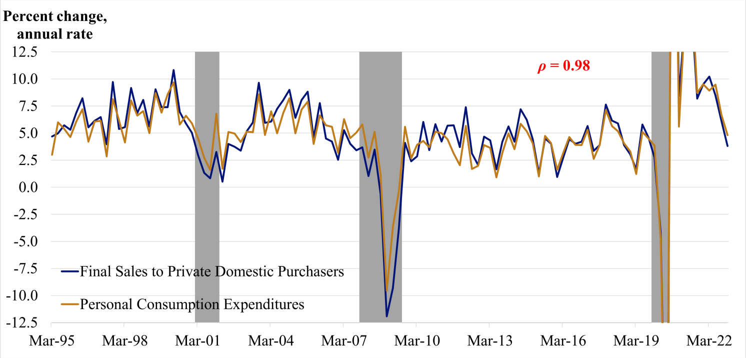

FIGURE: The model equilibrium under the optimal policy mix suggests that the nominal output growth rate and the nominal aggregate consumption growth rate should be equal. This chart shows one measure of nominal output growth and one measure of nominal consumption growth, and the raw correlation is 0.98.

Consumption growth across households

- The model also predicts that under the optimal monetary-fiscal policy mix, consumption growth rates for all households—rich and poor, relatively young and relatively old—will be equalized.
- To address this, we consider weekly data from January 2020 to March 2023 on credit card expenditure by zip code, with median income in the various zip codes distinguishing between rich and poor.
- The spending growth week-by-week in the lowest income quartile of zip codes is highly correlated with spending growth week-by-week in the highest income quartile, consistent with the model equilibrium.

Consumption growth across households

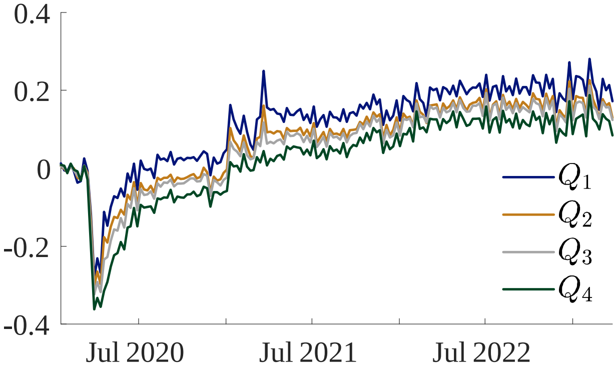

FIGURE: Credit card spending by income group, weekly, January 2020 to March 2023. The model equilibrium predicts that nominal spending growth rates across society should be equalized. The correlation in consumption growth between the groups is indeed very high, as predicted by the model.

Consumption growth across households

Correlations in growth rates

Household zip code income distribution

	Q_1	Q_2	Q_3	Q_4
Q_1	1.000	0.980	0.957	0.901
Q_2	–	1.000	0.984	0.940
Q_3	–	–	1.000	0.972
Q_4	–	–	–	1.000

Table: Correlation in consumption growth rates across the household zip code income distribution, January 2020 to March 2023, as measured by credit card expenditure indexed to the home address of the credit card. The correlations between the richest and poorest quartiles are high, close to the model prediction of 1.0.

Carneiro-Heckman-type labor supply

- Carneiro and Heckman (discussion paper, 2003, p. 67): "Estimated intertemporal labor supply elasticities are small, and welfare effects from labor supply adjustment are negligible."
    - See also Ljungqvist and Sargent (unpublished manuscript, 2014).
- In the present model, hours worked for all households is given by, for $s = 0, ..., T$,

$$1 - \ell_{t-s,i}(t) = 1 - (1-\eta)\frac{\bar{e}}{e_s} = 1 - \ell_{t-s}(t) \ \forall i. \qquad (6)$$

- This does not depend on real wages or other income, providing *prima facie* evidence that the model will match the micro-labor evidence.

Marginal propensities to consume

- Hand-to-mouth implies that agents consume only out of labor income each period and do not use asset markets.
- In the model equilibrium, life-cycle agents will sometimes consume only out of labor income, in particular when they are asset-poor and again when they are asset-rich.
- There will be a wide variety of MPCs in this economy, as in the U.S. data.
- The MPCs *per se* are not the key input into the success of the optimal monetary-fiscal policy mix.

MARGINAL PROPENSITIES TO CONSUME

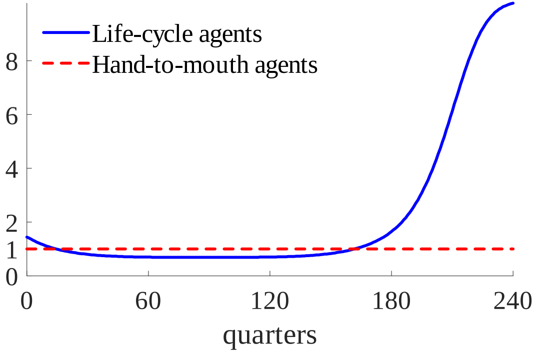

FIGURE: A cross-section diagram of marginal propensities to consume out of labor earnings at each date in the model equilibrium. Relatively young (asset poor) and older (asset rich) life-cycle agents have an MPC larger than one. The MPC of life-cycle agents during the middle of life is 0.69.

Tax progressivity and Gini coefficients

	Model 1	Model 2	U.S. data
σ_{lc}	1.42	0.52	–
$A/(4Y)$	3.79	3.79	4.52
G_W	0.78	0.55	0.78
G_Y	0.71	0.41	0.63
G_C	0.69	0.32	0.32

TABLE: Gini coefficients in the model equilibrium with no progressive taxation (Model 1) and sufficient within-cohort scaling variance to match the wealth Gini in the U.S. data, and with progressive taxation (Model 2), which lowers the within-cohort scaling variance sufficiently to match the observed consumption Gini in the U.S. data.

Tax progressivity and Gini coefficients

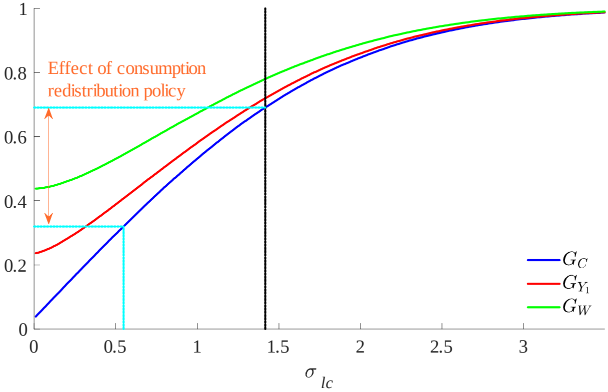

FIGURE: The consumption, income and financial wealth Gini coefficients in the model equilibrium for values of $\sigma_{lc} \geq 0$. The progressive tax is lowering the consumption Gini from 0.69 to 0.32, matching the U.S. data, but missing other Ginis.

Nominal returns to asset holding

- The model equilibrium states that nominal consumption growth will be equal to the nominal rate of return on asset holding.
- There are three assets in the model (MBS, federal government debt and corporate debt), but these assets are not further differentiated.
- We consider the seven-year high-quality corporate bond as a measure of the return to capital.
- The equilibrium condition is met on this metric, except during periods of extreme market turmoil.

NOMINAL RETURNS

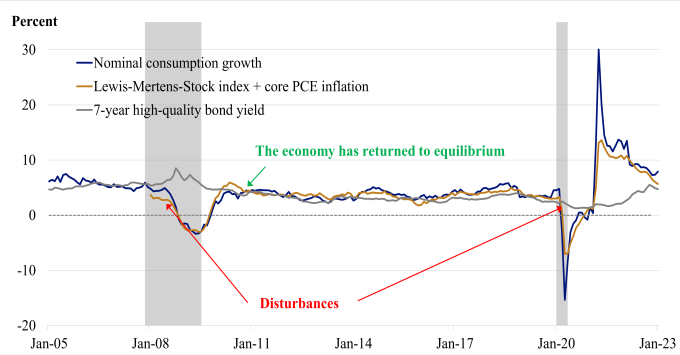

FIGURE: The model with optimal policy predicts the gray line will coincide with nominal consumption growth and nominal GDP growth. This prediction broadly holds in the figure outside of the two large disturbances.

Conclusions

A BENCHMARK MODEL

- We studied a benchmark DSGE model with "massive" heterogeneity.
- The model recommends a set of macroeconomic policies which, if jointly implemented, can achieve a first-best allocation of resources.
- The recommended macroeconomic policies resemble those in place in the U.S. and other countries in recent decades.
- The calibration to U.S. data suggests that the model equilibrium assuming the optimal monetary-fiscal macroeconomic policies are in place fits the data relatively well, except for periods of exceptionally high volatility.
- The recommended macroeconomic policies seem unlikely to substitute for one another—all policies have to be working together simultaneously.