Macroeconomic Policy during a Pandemic: The SRHANK Economy

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Motivation

- Strong Fiscal and Monetary Policy responses due to the Covid Crises.
  - IFE: direct fiscal transfers.
  - Pension funds withdrawals.
  - Monetary Policy: conventional and unconventional.
- Policies have impact on aggregate economic activity as well as on inequality.
- The distribution itself may be important for the effectiveness these of policies.
- We want to assess the impact of these policies on:
  - Aggregate economic activity
  - Inequality

Questions

- How effective were these policies in stabilizing output?
- What is the effect of these policies on the resulting inequality?
- How does the effectiveness of these policies depend on the ex-ante observed inequality?

Methodology

- Develop a model with heterogeneous agents capable of replicating
  - Income inequality. Match According to the Casen survey.
  - Wealth inequality. Wealth before pension funds withdrawals.
- Study the effect of policies:
  - Fiscal policy: increase in Fiscal transfers (as in IFE).
  - Monetary Policy: unconventional.
  - Pension funds withdrawals
- Study the transition dynamics starting from a steady state before the Covid shock.
- Use the model to simulate counterfactual scenarios in which a different policy mix is implemented.
  - Actual policy implemented.
  - No Policy.
  - Fiscal/Monetary/Pension at a time.

The Model: An Overview

- Heterogeneous Agents new Keynesian Model:
  - Heterogeneous income and wealth, as Huggett-Bewley-Aiyagari Framework.
  - Liquid and illiquid assets as in Kaplan et. al. (2018).
- Fiscal Policy:
  - Linear tax an lump sum transfer to replicate tax progressivity.
  - Increase in transfers to replicate IFE.
- Monetary Policy:
  - Conventional and unconventional Monetary Policy as in Wu and Zhang (2019).

Households

- **Life cycle:** Young and old stages. Young becomes old with probability λ_o and the old dies with probability ξ. Upon death, old is replaced by a young individual.
- **Heterogeneity:** Productivity z_t, liquid wealth b_t, and illiquid wealth a_t (pension funds).
- **Shocks**: Preference/Aggregate and Monetary shocks.

Households

- The young solves

$$
\begin{aligned}
\rho V_y(a,b,z_j) = \max_{c,l,b'} \; & u(c,l) + V_a'(a,b,z_j)(\kappa z_j wl + r^* a) \\
& + V_b'(a,b,z_j)((1-\tau)z_j wl + rb + T + \Pi(z) - c) \\
& \lambda_j(V_y(\cdot;z_{-j}) - V_y(\cdot;z_j)) \\
& \lambda^o(V_o(b) - V_y(\cdot;z_j))
\end{aligned}
$$

s.t.

$$
\begin{aligned}
c_t + \dot{b}_t &= r_t^b b_t + (1-\tau)w_t z_t l_t + \Pi_t + T_t \\
\dot{a}_t &= r^* a_t + \tau_a w_t z_t l_t \\
b_t &\geq 0
\end{aligned}
$$

Households

- The old solves

$$\rho V_0(a,b) = \max_{c,b'} u(c) + V_b'(a,b)(rb + T + (r^* + \xi)a - c)$$
$$+ \xi\Big[\lambda_{z_1} V_y(0,0,z_1) - V_o(a,b) + \lambda_{z_2} V_y(0,0,z_2) - V_o(a,b)\Big]$$

s.t.

$$c_t + \dot{b}_t = r_t^b b_t + (r^* + \xi)a_t + T_t$$
$$b_t \geq 0$$

Households

- **Kolmogorov Forward Equation**

$$
\begin{aligned}
\frac{\mathrm{d}g_t(a,b,z)}{\mathrm{d}t} = & -\partial_a\left(s^a(a,b,y)g(a,b,y)\right) - \partial_b\left(s^b(a,b,y)g(a,b,y)\right) \\
& -\lambda_j g_j(a,b,y) + \lambda_{-j} g_{-j}(a,b,z) \\
& -\lambda_o g(a,b,y) + \chi g_o(a,b)
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{\mathrm{d}g_{o,t}(a,b)}{\mathrm{d}t} = & -\partial_b\left(s_o^b(a,b)g_o(a,b)\right) \\
& +\lambda_o g(a,b,y) - \chi g_o(a,b)
\end{aligned}
$$

Final Good producer

- Representative firm produces in a competitive market with technology

$$Y_t = \left(\int_0^1 y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

- Demand for intermediate inputs is

$$y_{i,t}(p_{i,t}) = \left(\frac{p_{i,t}}{P_t} \right)^{-\varepsilon} Y_t$$

- Price index is given by $P_t = \left(\int_0^1 p_{i,t}^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}}$

Intermediate Goods producers

- There is continuum of monopolistically competitive firms producing with linear technology $y_{i,t} = n_{i,t}$.
- Firms face nominal rigidities à la Rotemberg (1982)
- Phillips curve :

$$\left(r^b - \frac{\dot{Y}}{Y}\right)\pi = \frac{1}{\theta}\left(1 - \varepsilon(1 - mc)\right) + \dot{\pi}$$

Fiscal Policy

- Government levies income tax and issues bonds to pay for exogenous government purchases and transfers.

- The government budget constraint is

$$G_t + T_t + \dot{B}_t = B_t r_t^b + + \int_S \tau_n z_t l_t d\mu(\mathcal{S})$$

where $\mu(\mathcal{S})$ is the distribution over individual states $\mathcal{S} = (z_t, a_t, b_t)$.

The Equilibrium

The equilibrium of this economy is the set of allocations, policy functions and value functions, distributions over individual states, and government policies such that:

1. Individuals and firms maximize.
2. Market clears (final goods, intermediate goods, labor market, bond market).
3. Distributions are consistent with policy functions and stochastic shocks.
4. Government budget constraint is satisfied.

Steady State

- Calibrate to match income and wealth distribution.
- Data:
  1. Income: Casen
  2. Wealth (pension funds): Subsecretaría de Protección Social , Encuesta Financiera de Hogares.

Solution Method

- **Solution Method**: finite difference method + upwind scheme to approximate value functions and distributions over a finite grid.

- Updating V^{n+1} given V^n requires solving a system of linear equations, which can be written in matrix form as:

$$\frac{1}{\Delta}\left(V^{n+1}-V^{n}\right)+\rho V^{n+1}=u^{n}+\left(\mathrm{A}^{n}+\Lambda\right)V^{n+1}+\Lambda^{o}V_{o}^{n+1}$$

and

$$\frac{1}{\Delta}\left(V_{o}^{n+1}-V_{o}^{n}\right)+\rho V_{o}^{n+1}=u_{o}^{n}+\left(\mathrm{A}_{o}^{n}\right)V_{o}^{n+1}+\Xi V^{n+1}$$

Here V^n, V^{n+1} and u^n are vectors of length $M \times I \times J$ and A^n and Λ are matrices of size $(M \times I \times J) \times (M \times I \times J)$.

Solution Method

- Stationary Kolmogorov Forward equation for the young :

$$
\begin{aligned}
0 = & -\partial_a \left(s^a(a,b,z)g(a,b,z)\right) - \partial_b \left(s^b(a,b,z)g(a,b,z)\right) \\
& - \lambda_j g_j(a,b,z) + \lambda_{-j} g_{-j}(a,b,z) \\
& - \lambda_o g(a,b,z) + \chi g_o(a,b)
\end{aligned}
$$

and for the old:

$$
0 = -\frac{d}{da}\left[s_j(a,b)g_o(a,b)\right] - \chi g_o(a) + \lambda_o g(a,b,z)
$$

Solution Method

- The whole system can be written as

$$B^n V^{n+1} = b^n$$

$$B_o^n V_o^{n+1} = b_o^n$$

$$A^t g + \chi g_o = 0$$

$$A_o^t g_o + \lambda_o g = 0$$

where $B^n \equiv (\frac{1}{\Delta} + \rho)\mathcal{I} - (A^n + \Lambda)$, $b^n \equiv u^n + \Lambda^o V_o + \frac{1}{\Delta} V^n$, $B_o^n \equiv (\frac{1}{\Delta} + \rho)\mathcal{I} - A_o^n$ and $b^n \equiv u_o^n + \frac{1}{\Delta} V_o^n + \Xi V^{n+1}$.

Preliminar Results - Steady state

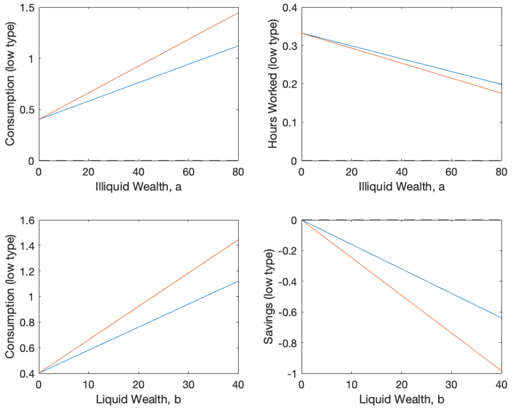

Figure: Consumption, Savings and Hours Worked - low type

Preliminar Results - Steady state

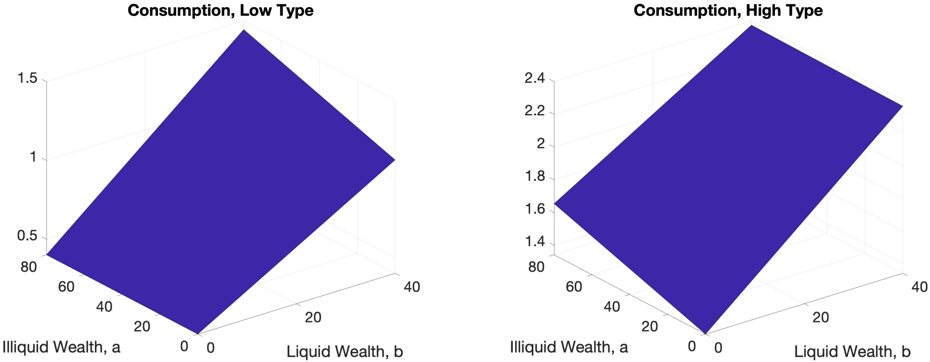

Figure: Consumption for the young

Preliminar Results - Steady state

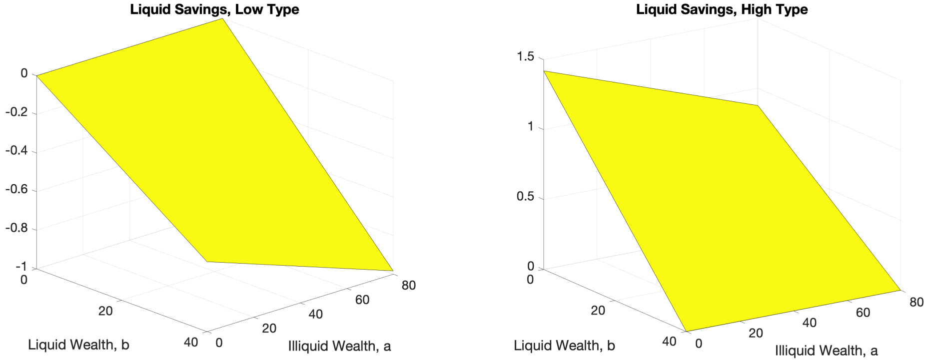

Figure: Liquid Savings for the young

Preliminar Results - Steady state

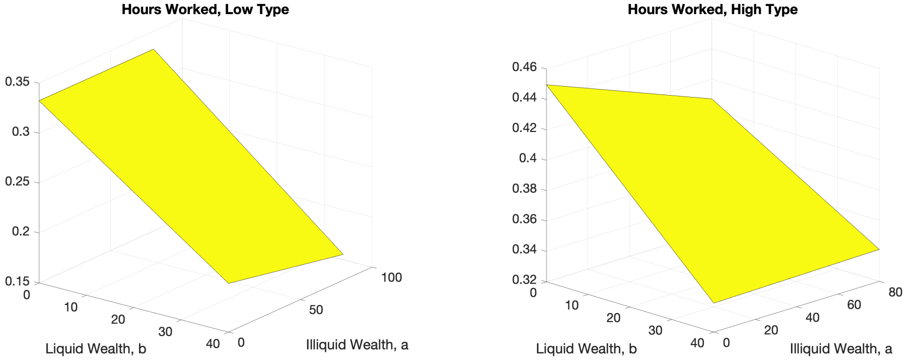

Figure: Hours Worked for the young

Preliminar Results - Steady state

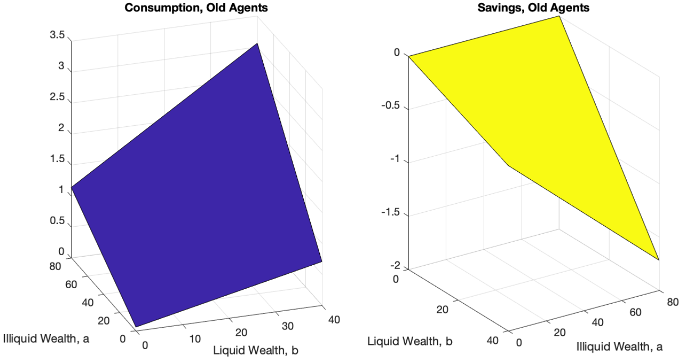

Figure: Consumption and Savings for the old

Preliminar Results - Steady state

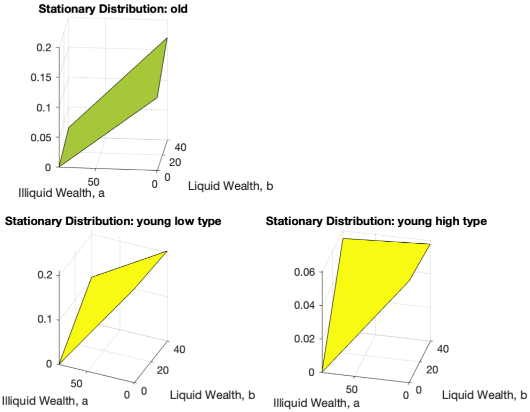

Figure: Stationary Distributions

Expansions

- We want to expand the model in three different dimensions:
    1. Introduce a SOE framework.
    2. Introduce Aggregate shocks.
    3. Introduce Unconventional MP.

Expansions

1. SOE Framework:

- The government budget constraint becomes

$$G_t + T_t + \dot{B}_t + \frac{\dot{B}_t^*}{\mathcal{E}_t} = B_t r_t^b + \frac{B_t^* r_t^*}{\mathcal{E}_t} + \int_S \tau_n z_t l_t d\mu(\mathcal{S})$$

An uncovered interest rate parity condition holds

$$r_t^b = r_t^* + \frac{\dot{\mathcal{E}}_t}{\mathcal{E}_t}$$

- The pension fund drift for the young becomes $\dot{a}_t = r^* a_t + \tau_a w_t z_t l_t / \mathcal{E}_t$.
- The budget constraint for the old becomes $c_t + \dot{b}_t = r_t^b b_t + (r^* + \lambda_o) a_t \mathcal{E}_t + T_t$

Expansions

2. Aggregate Shocks:

- Period-by-period preferences are given by $u(c_t, n_t; X_t, \psi_t) = X_t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \psi_t \frac{n^{1+\phi}}{1+\phi} \right)$ where X_t and ψ_t are aggregate shocks.
  Agents solve

$$\max \mathbb{E}_0 \int_0^\infty e^{-\rho t} u(c_t, n_t) dt$$

  subject to the budget constraint.

Expansions

3. Unconventional Monetary Policy:

- The return on bonds is the relevant interest rate households face rather than the fed funds rate .

- Define

$$rp_t \equiv r_t^B - r_t$$

where the policy rate r_t follows the Taylor rule during normal times. We refer to the wedge between the two rates rp_t as the risk premium.

- Assume rp_t is a decreasing function of the total purchase of bonds by the central bank b^{CB}:

$$rp_t'\left(b_t^{CB}\right) < 0$$

Expansions

3. Unconventional Monetary Policy:

- The linear model implies:

$$rp_t \left(b_t^{CB} \right) = rp - \varsigma \left(b_t^{CB} - b^{CB} \right)$$

  where $\varsigma > 0$. During normal times, $b_t^{CB} = b^{CB}$, and $rp_t \left(b^{CB} \right) = rp$, i.e assume a constant risk premium during normal times.

- When the ZLB binds $r_t = 0$, the central bank implements QE to increase its bond holdings b_t^{CB} in order to provide further stimulus.

Expansions

3. Unconventional Montetary Policy:

- Monetary policy enters the IS curve through the return on the bond:

$$r_t^B = r_t + rp - \varsigma \left(b_t^{CB} - b^{CB} \right)$$

- During normal times, $b_t^{CB} = b^{CB}$, $r_t^B = r_t + rp$, and monetary policy operates through the usual Taylor rule on r_t, which is equal to the shadow rate s_t.
- At the ZLB, the policy rate no longer moves, $r_t = 0$, and the overall effect of monetary policy is $r_t^B = rp - \varsigma \left(b_t^{CB} - b^{CB} \right)$.
- Then

$$r_t^B = s_t + rp$$

captures both the conventional monetary policy during normal times and unconventional policy at the ZLB.

Final Remarks

- To do - following steps:
  - Document empirical facts that we want t match and find data sources (calibrate the model).
  - Study the transition dynamics under different policy scenarios:
    1. No policy at all.
    2. Fiscal and Monetary Policy.
    3. Only Fiscal, only Monetary.