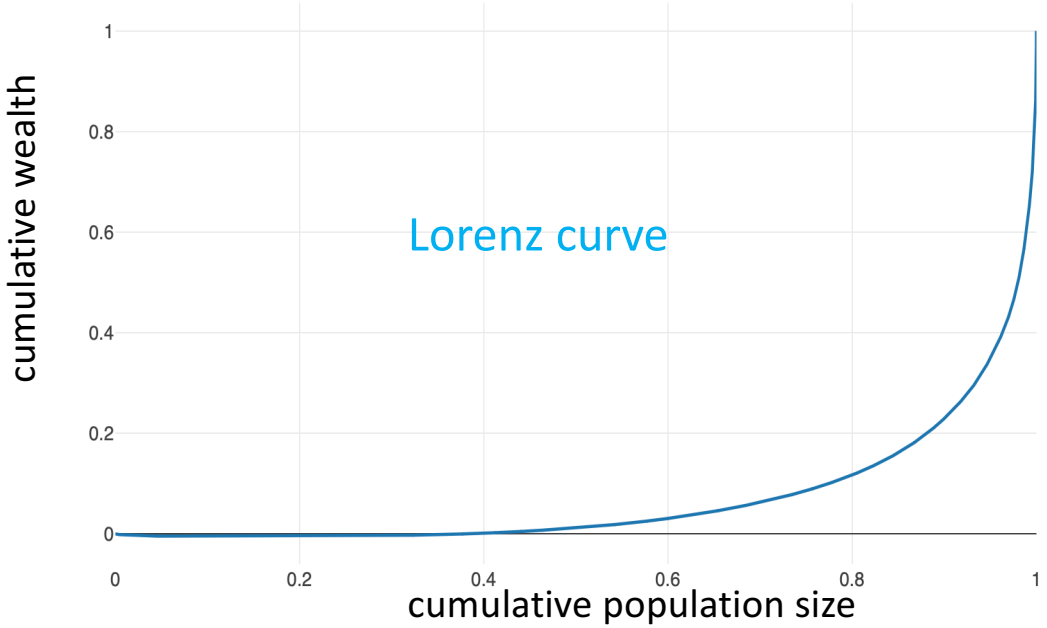
RL w/ hetero agents

https://github.com/shmister/inequality

The problem: top 1% owns 39% of the total wealth
bottom 40% no or negative wealth

**what are the causes of the wealth inequality?**



The problem: what are the causes of wealth inequality?

Many theories and non-verified opinions:

inheritance,
political/tax system,
access to better information…
individual characteristics

## Stanford marshmallow experiment

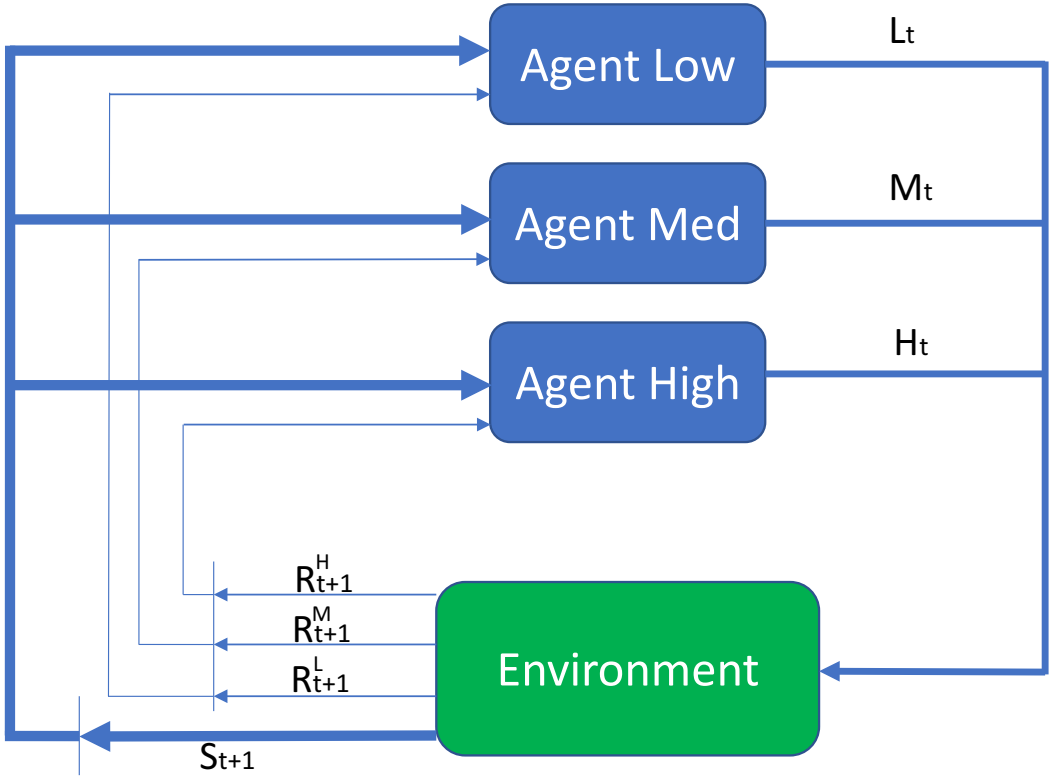
https://en.wikipedia.org/wiki/Stanford_marshmallow_experiment

wait longer

better life outcomes:
SAT scores,
educational attainment,
body mass index (BMI),
and other life measures

although the outcomes of the experiment are challenged now
intuitively, we know we are different

# Heterogeneity in discounting and appreciating rewards




$$U_L([s_0, s_1, s_2, \ldots]) = u_L(s_0) + \beta_L u_L(s_1) + \beta_L^2 u_L(s_2) + \ldots$$

$$U_M([s_0, s_1, s_2, \ldots]) = u_M(s_0) + \beta_M u_M(s_1) + \beta_M^2 u_M(s_2) + \ldots$$

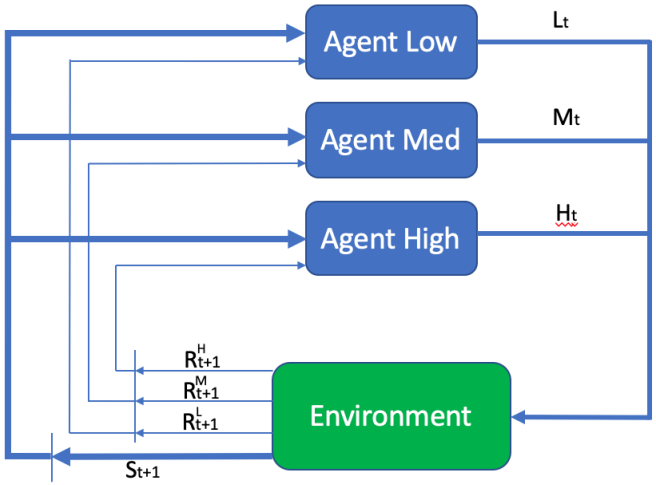
$$U_H([s_0, s_1, s_2, \ldots]) = u_H(s_0) + \beta_H u_H(s_1) + \beta_H^2 u_H(s_2) + \ldots$$

$u_H$, $u_L$ *and* $u_M$ are different
since the agents appreciate the rewards differently

**policy**

In this environment, agents receive reward (money) depending on employment (stochastic) and make a decision about the split
a) consume, i.e. immediate reward, b) invest to get future reward

# Heterogeneity in discounting and appreciating rewards

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$$\beta_L < \beta_M < \beta_H$$

$$u = u(\gamma), \text{ where } \gamma \text{ is sensitivity to risk}$$

$$\gamma_L < \gamma_M < \gamma_H$$

**Agents:**

three types (low, medium and high)
change their type stochastically with transition probabilities (MC)
each type has many agents

exploration: due to changing types, explore different paths
exploitation: due to big number of agents, exploit the same policy

**Environment:**

deterministic + stochastic to mimic recessions and expansions

**Solution (Autonomous Learning Laboratory slide):**

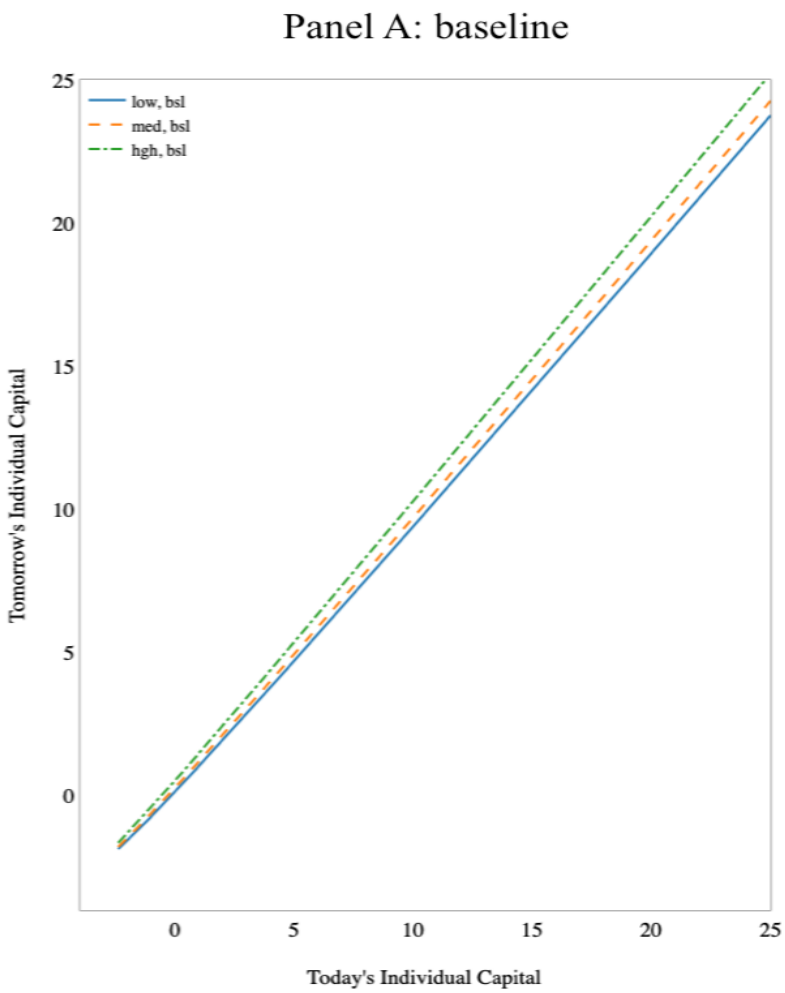
$$U_{i+1}^{\pi} \leftarrow R(s) + \gamma \sum_{s'} P(s' \mid s, \pi(s)) U_i^{\pi}(s')$$

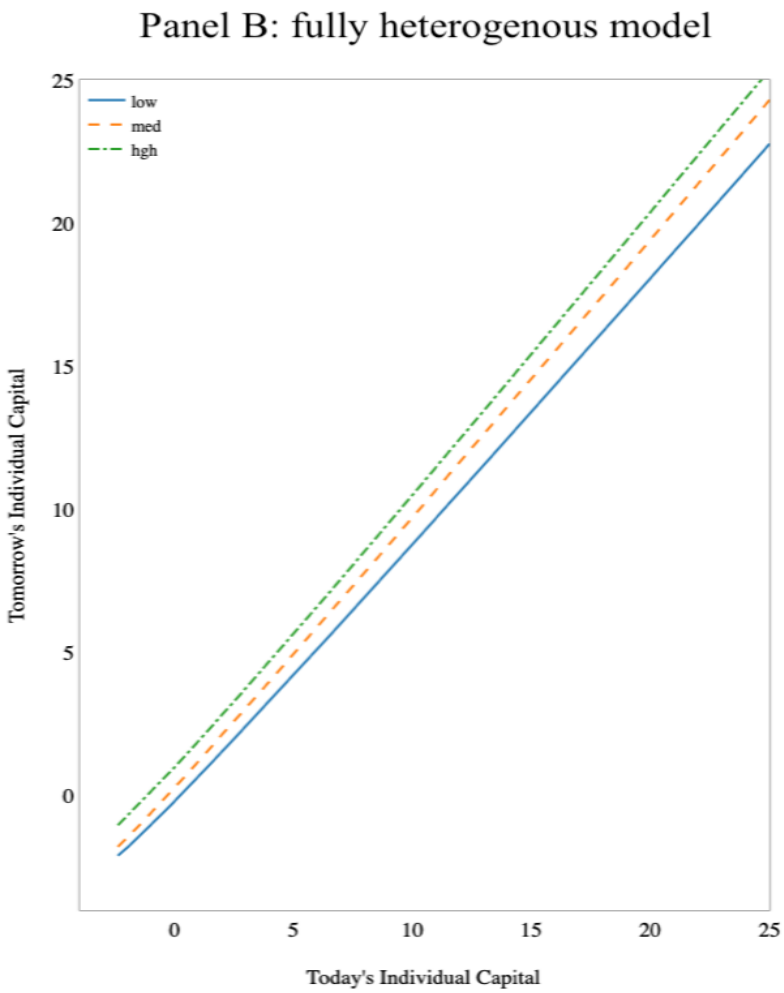
$$\pi_s^* = \arg\max_{\pi} U^{\pi}(s)$$

## Policy Iteration

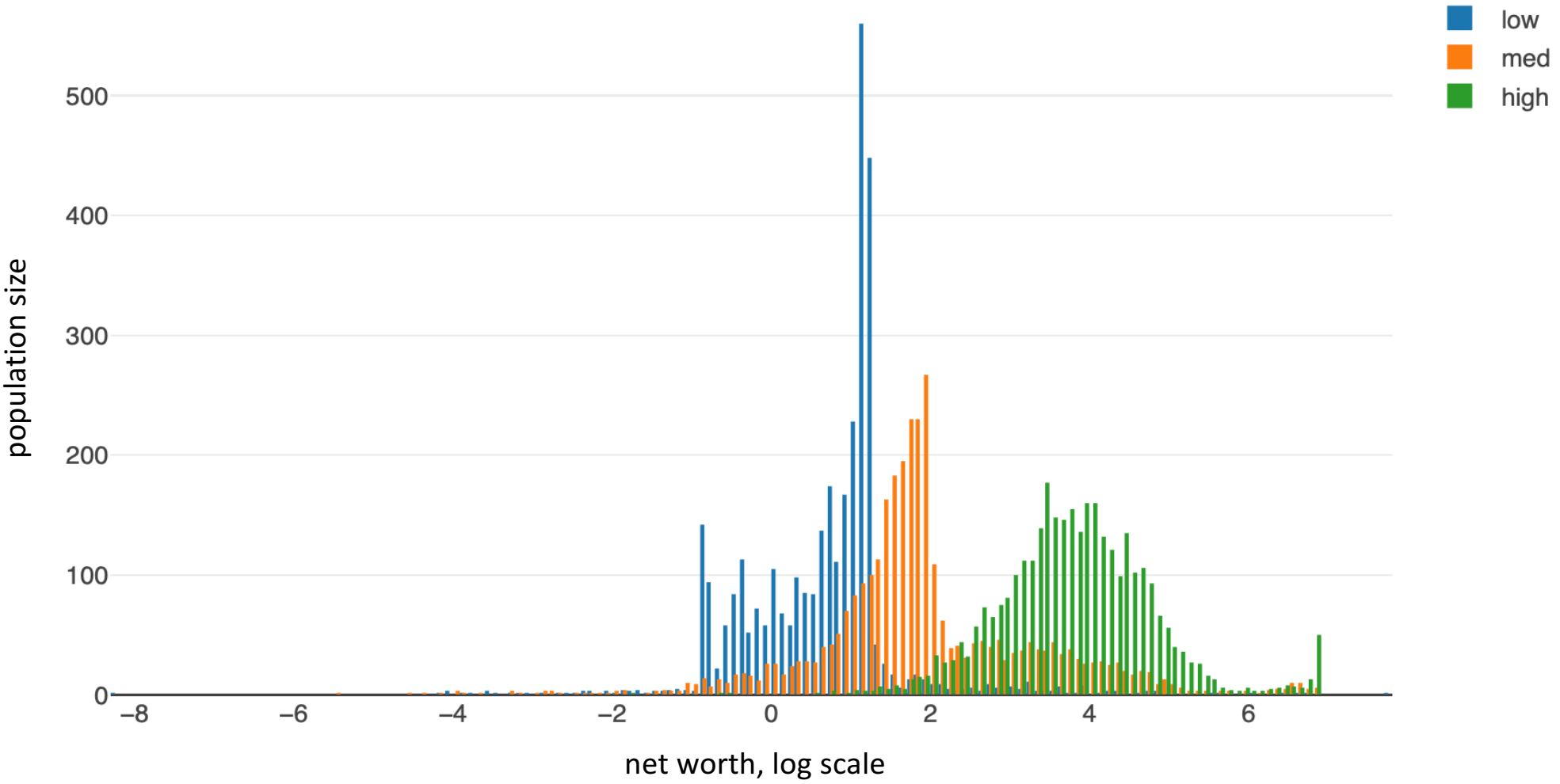
- Policy iteration interleaves two steps:
  - Policy evaluation: Given a policy, compute the utility of each state for that policy
  - Policy improvement: Calculate a new MEU policy
- Terminate when the policy doesn't change the utilities.
- Guaranteed to converge to an optimal policy

# Results: learned policies



# Results: wealth distribution



## Results: cumulative wealth distribution