Organizational Equilibrium with Capital

Marco Bassetto, Zhen Huo, and José-Víctor Ríos-Rull

FRB of Chicago, Yale University, University of Pennsylvania, UCL, CAERP

Banque de France

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Question

- Time inconsistency is a pervasive issue
  - taxation, government debt, consumption-saving problem, monetary policy, ...

- Two Benchmarks:
  - Markov equilibrium
  - Sequential equilibrium/sustainable plan
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- Markov equilibrium:
  - Interesting comparative statics
  - Outcome determined by fundamentals
  - ... but can be largely improved upon
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- Markov equilibrium:
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  - Outcome determined by fundamentals
  - ... but can be largely improved upon

- Sequential equilibrium:
  - Can often attain very good outcomes (folk theorem)
  - Can also attain very bad outcomes (folk theorem again)
  - Relies on self-punishment as a threat
  - Weak predictions (big set of equilibria)
Our View

- Good institutions and social norms do not evolve overnight
- Collaboration across cohorts of decision makers builds slowly
- It probably also erodes slowly
- Look for equilibrium concept that captures this, and addresses shortcomings of Markov & Best Sequential Eq.
Organizational Equilibrium

- Reconsideration-Proof Equilibrium (Kocherlakota, 1996); Organizational Equilibrium (Prescott-Ríos-Rull, 2005)

- Based on renegotiation-proofness (Farrell and Maskin, 1989)

- Punisher does not suffer from punishing past misdeeds

- Retains meaningful comparative statics

- Improves on Markov Equilibrium
Organizational Equilibrium

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- Based on renegotiation-proofness (Farrell and Maskin, 1989)

- Punisher does not suffer from punishing past misdeeds

- Retains meaningful comparative statics

- Improves on Markov Equilibrium

- ... but does not deal with state variables (only repeated games, no dynamic games)

- This is where we come in
**Equilibrium Properties**

- **Compare with Markov equilibrium**
  - payoff only depends on state variables, like Markov equilibrium
  - action can depend on history, different from Markov equilibrium

- **Compare with sequential equilibrium**
  - no self-punishment
  - Refinement I: same continuation value on or off equilibrium path
  - Refinement II: no one wants to deviate and wait for a restart of the game

- **New issues with state variables**
  - how to induce stationary environment
  - Player preferences no longer purely forward-looking (new role for no-delaying condition)
Quantitative Findings

- Apply the equilibrium concept in
  - quasi-geometric discounting growth model
  - government taxation model

- Steady state
  - allocation is close to Ramsey outcome, much better than Markov equilibrium

- Transition
  - allocation starts similar to Markov, converges to similar to Ramsey
Related Literature

- **Markov equilibrium and GEE**

- **Sustainable plan**

- **Quasi-geometric discounting growth model**

- **Refinement of subgame perfect equilibrium**
Plan

1. An example: a growth model with quasi-geometric discounting
2. General definition and property
3. Application in government taxation problem
Part I: A Growth Model
The Environment

- Preferences: quasi-geometric discounting

\[ \Psi_t = u(c_t) + \delta \sum_{\tau=1}^{\infty} \beta^\tau u(c_{t+\tau}) \]

  - period utility function \( u(c) = \log c \)
  - \( \delta = 1 \) is the time-consistent case

- Technology

\[ f(k_t) = k_t^\alpha, \quad k_{t+1} = f(k_t) - c_t. \]
Benchmark I: Markov Perfect Equilibrium

- Take future $g(k)$ as given

$$\max_{k'} u[f(k) - k'] + \delta \beta \Omega(k'; g)$$

cont. value: $\Omega(k; g) = u[f(k) - g(k)] + \beta \Omega[g(k); g]$

- The Generalized Euler Equation (GEE)

$$u_c = \beta u'_c \left[ \delta f'_k + (1 - \delta) g'_k \right]$$

- The equilibrium features a constant saving rate

$$k' = \frac{\delta \alpha \beta}{1 - \alpha \beta + \delta \alpha \beta} k^\alpha = s^M k^\alpha$$
Benchmark II: Ramsey Allocation with Commitment

Choose all future allocations at period 0

$$\max_{k_1} u[f(k_0) - k_1] + \delta\beta \Omega(k_1)$$

cont. value: $$\Omega(k) = \max_{k'} u[f(k) - k'] + \beta \Omega(k')$$

The sequence of saving rates is given by

$$s_t = \begin{cases} 
  s^M = \frac{\alpha \delta \beta}{1 - \alpha \beta + \delta \alpha \beta}, & t = 0 \\
  s^R = \alpha \beta, & t > 0 
\end{cases}$$

Steady state capital in Markov equilibrium is lower than Ramsey

$$s^M < s^R$$
Elements of Organization Equilibrium: Proposal

- A proposal is a sequence of saving rates \( \{s_0, s_1, s_2, \ldots \} \)

- Given an initial capital \( k_0 \), the proposal induces a sequence of capital

\[
\begin{align*}
k_1 &= s_0 k_0^\alpha \\
k_2 &= s_1 k_1^\alpha = k_0^{\alpha^2} s_1 s_0^\alpha \\
&\vdots \\
k_t &= k_0^{\alpha^t} \prod_{j=0}^{t-1} s_j^{\alpha^{t-j}-1}
\end{align*}
\]
Proposal and Value Function

- A proposal is a sequence of saving rates \( \{s_0, s_1, s_2, \ldots \} \)

- The lifetime utility for the agent who makes the proposal is

\[
U(k_0, s_0, s_1, \ldots) = \log[(1 - s_0)k_0^\alpha] + \delta \sum_{j=1}^{\infty} \beta^j \log[(1 - s_j)k_j^\alpha] = \frac{\alpha(1 - \alpha \beta + \delta \alpha \beta)}{1 - \alpha \beta} \log k_0 + \log(1 - s_0) + \delta \sum_{j=1}^{\infty} \beta^j \log\left[(1 - s_j)\prod_{\tau=0}^{j-1}s_\tau^{\alpha \tau - \tau}\right] \equiv \phi \log k_0 + V(s_0, s_1, \ldots)
\]
Separability

The lifetime utility for agent at period $t$ is

$$U(k_t, s_t, s_{t+1}, \ldots) = \phi \log k_t + V(s_t, s_{t+1}, \ldots)$$

- total payoff

- action payoff

There is a *Separability* property between capital and saving rates

- true for the initial proposer and all subsequent followers

- this property is crucial to our equilibrium concept

What type of proposals can be implemented?
Organizational Equilibrium

Definition

A sequence of saving rates \( \{s_\tau\}_{\tau=0}^{\infty} \) is organizationally admissible if

1. \( V(s_t, s_{t+1}, s_{t+2}, \ldots) \) is (weakly) increasing in \( t \)

2. The first agent has no incentive to delay the proposal.

\[ V(s_0, s_1, s_2, \ldots) \geq \max_s V(s, s_0, s_1, s_2, \ldots) \]

Within organizationally admissible sequences, a sequence that attains the maximum of \( V(s_0, s_1, s_2, \ldots) \) is an organizational equilibrium.
Remarks on Organizational Equilibrium

- OE is outcome of some SPE
  - SPE example: if someone deviates, next agent restarts from $s_0$

- SPE refinement criterion
  - same continuation value on and off equilibrium path (for $V$ component)
  - no one better off by deviating and counting on others to restart the game

- In equilibrium,
  \[
  U(k_t, s_t, s_{t+1}, \ldots) = \phi \log k_t + V(s_t, s_{t+1}, \ldots) = \phi \log k_t + V^*
  \]
  - total payoff only depends on capital, not a trigger with self-punishment
  - agents’ action depend on past actions, not a Markov equilibrium
Can the Ramsey Outcome be Implemented?

- Imagine the initial agent with $k_0$ proposes $\{s^M, s^R, s^R, \ldots\}$, which implies

$$k_1 = s^M k_0^\alpha$$

- By following the proposal, the next agent's payoff is

$$U \left(k_1, s^R, s^R, s^R, \ldots\right) = \phi \log k_1 + V \left(s^R, s^R, s^R, \ldots\right)$$

- By copying the proposal, the next agent's payoff is

$$U \left(k_1, s^M, s^R, s^R, \ldots\right) = \phi \log k_1 + V \left(s^M, s^R, s^R, \ldots\right)$$

$$> \phi \log k_1 + V \left(s^R, s^R, s^R, \ldots\right)$$

- Copying is better than following, Ramsey outcome cannot be implemented
Can a Constant Saving Rate be Implemented?

- Suppose the initial agent proposes \( \{s, s, s\ldots\} \)

- By following the proposal, the payoff for agent in period \( t \) is

\[
U(k_t, s, s, \ldots) = \phi \log k_t + V(s, s, \ldots)
\]

where

\[
V(s, s, \ldots) \equiv \mathcal{H}(s) = \left(1 + \frac{\beta \delta}{1 - \beta}\right) \log(1 - s) + \frac{\delta \alpha \beta}{(1 - \alpha \beta)(1 - \beta)} \log(s)
\]

- To be followed, the constant saving rate has to be

\[
s^* = \arg\max \mathcal{H}(s)
\]
Optimal Constant Saving Rate

\[ H(s) \]

\[ s^M < s^* < s^R \]
Can \( \{ s^*, s^*, \ldots \} \) be Implemented?

- If the initial agent proposes \( \{ s^*, s^*, \ldots \} \), no one has incentive to copy

- But, she prefers to choose \( s^M \), and wait the next to propose \( \{ s^*, s^*, \ldots \} \)

\[
U \left( k_0, s^M, s^*, s^*, \ldots \right) = \phi \log k_0 + V \left( s^M, s^*, s^*, \ldots \right) \\
> \phi \log k_0 + V \left( s^*, s^*, s^*, \ldots \right)
\]

- Constant \( s^* \) proposal cannot be implemented, incentive to delay

- But, something else can be implemented, which converges to \( s^* \)
Construct the Organizational Equilibrium

- Look for a sequence of saving rates \( \{s_0, s_1, \ldots \} \)

- Every generation obtains the same \( \bar{V} \)

\[
V(s_t, s_{t+1}, \ldots) = V(s_{t+1}, s_{t+2}, \ldots) = \bar{V}
\]

which induces the following difference equation

\[
\beta(1 - \delta) \log(1 - s_{t+1}) = \frac{\delta \alpha \beta}{1 - \alpha \beta} \log s_t + \log(1 - s_t) - (1 - \beta)\bar{V}
\]

- We call this difference equation as the proposal function

\[
s_{t+1} = q(s_t; \bar{V})
\]

- The maximal \( \bar{V} \) and an initial \( s_0 \) are needed to determine \( \{s_\tau\}^{\infty}_{\tau=0} \)
Determine $V^*$

As $\bar{V}$ increases, the proposal function $q(s; \bar{V})$ moves upwards.

The highest $\bar{V} = V^*$ is achieved when $q(s; \bar{V})$ is tangent to the 45 degree line (at $s^*$).
Determine the Initial Saving Rate $s_0$

- The first agent should have no incentive to delay the proposal
  \[
  \max_s V(s, s_0, s_1, s_2, \ldots) = V(s^M, s_0, s_1, s_2, \ldots)
  \]

- $s_0$ has to be such that
  \[
  V^* = V(s_0, s_1, s_2, \ldots) \geq V(s^M, s_0, s_1, s_2, \ldots)
  \quad \rightarrow \quad s_0 \leq q^* (s^M)
  \]

- We select $s_0 = q^* (s^M)$, which yields the highest welfare for period $t + 1$
Proposition

The organizational equilibrium \( \{ s_\tau \}_{\tau=0}^{\infty} \) is given recursively by the proposal function \( q^* \)

\[
s_t = q^*(s_{t-1}) = 1 - \exp \left\{ \frac{-(1 - \beta)V^* + \frac{\delta\alpha\beta}{1 - \alpha\beta} \log s_{t-1} + \log(1 - s_{t-1})}{\beta(1 - \delta)} \right\}
\]

where the initial saving rate \( s_0 \), the steady state \( s^* \), and \( V^* \) are given by

\[
s_0 = q^* \left( s^M \right)
\]

\[
s^* = \frac{\delta\alpha\beta}{(1 - \beta + \delta\beta)(1 - \alpha\beta) + \delta\alpha\beta}
\]

\[
V^* = \frac{1 - \beta + \delta\beta}{1 - \beta} \log(1 - s^*) + \frac{\alpha\delta\beta}{(1 - \beta)(1 - \alpha\beta)} \log s^*
\]
The equilibrium starts from $s_0$, and monotonically converges to $s^*$. 
Remarks

1. To solve proposal function, no agent can treat herself specially, \( V_t = V_{t+1} \)

   Thank you for the idea, I will do it myself

2. To determine the initial saving rate, the agent starts from low saving rate

   Goodwill has to be built gradually

3. We will show how the outcome compared with the Markov and Ramsey

   We do much better than Markov equilibrium
Comparison: Steady State

- Organizational equilibrium is much better than the Markov equilibrium
Comparison: Allocation in Transition

- Organizational equilibrium: starts low, converges to being close to Ramsey
Comparison: Payoff in Transition

\[
U(k_t, s_t, s_{t+1}, \ldots) = \phi \log k_t + V(s_t, s_{t+1}, \ldots)
\]

- Total payoff
- Action payoff

- Organizational Equilibrium
- Ramsey and Sustainable Equilibrium
- Markov Equilibrium
Part II: Organizational Equilibrium for Weakly Separable Economies
**General Definition**

- An infinite sequence of decision makers is called to act
  - state $k \in K$
  - action $a \in A$
  - state evolves $k_{t+1} = F(k_t, a_t)$
  - preferences: $U(k_t, a_t, a_{t+1}, a_{t+2}, \ldots)$

**Assumption**

1. *At any point in time $t$, the set $A$ is independent of the state $k_t*"

2. $U$ *is weakly separable in $k$ and in $\{a_s\}_{s=0}^{\infty}$*

   $$U(k, a_0, a_1, a_2, \ldots) \equiv v(k, V(a_0, a_1, a_2, \ldots)).$$

   *and such that $v$ is strictly increasing in its second argument.*

3. $V$ *is weakly separable in $a_0$ and $\{a_s\}_{s=1}^{\infty}$*

   $$V(a_0, a_1, a_2, \ldots) \equiv \tilde{V}(a_0, \hat{V}(a_1, a_2, \ldots)),$$

   *with $\tilde{V}$ strictly increasing in its second argument.*
On the Choice of Actions

- Weak separability and state independence of $A$ depend on the specification of the action set.
- Example: hyperbolic discounting. If the choice is $c$, feasible actions depend on $k$.
- So, sometimes a problem may look nonseparable, but may become separable by rescaling actions appropriately.
Organizational Equilibrium

Definition

A sequence of actions \( \{a_t\}_{t=0}^{\infty} \) is organizationally admissible if

1. \( V(a_t, a_{t+1}, a_{t+2}, \ldots) \) is (weakly) increasing in \( t \)

2. The first agent has no incentive to delay the proposal.

\[
V(a_0, a_1, a_2, \ldots) \geq \max_{a \in A} V(a, a_0, a_1, a_2, \ldots)
\]

Within organizationally admissible sequences, the sequence that attains the maximum of \( V(a_0, a_1, a_2, \ldots) \) is an organizational equilibrium.
Organizational Equilibrium (OE) vs. Subgame-Perfect Equilibrium

1. OE is the equilibrium path of a sub-game perfect equilibrium

2. It can be implemented through various strategies. Examples:
   - restart from the beginning when someone deviates
   - use difference equation to make each player indifferent between deviating and following the equilibrium strategy (over a range)
OE vs. Reconsideration-Proof Equilibrium

- Reconsideration-proof equilibria $\implies$ Value for all current and future players independent of past history
- OE: same property only for action payoff:

$$U(k, a_0, a_1, a_2, \ldots) \equiv v(k, V(a_0, a_1, a_2, \ldots)).$$

Future players affected by different state
- Without state variables, OE is the outcome of a reconsideration-proof equilibrium
OE vs. Reconsideration-Proof Equilibrium

- Reconsideration-proof equilibria \( \implies \) Value for all current and future players independent of past history
- OE: same property only for action payoff:

\[
U(k, a_0, a_1, a_2, \ldots) \equiv v(k, V(a_0, a_1, a_2, \ldots)).
\]

Future players affected by different state
- Without state variables, OE is the outcome of a reconsideration-proof equilibrium
- Rationale for renegotiation/reconsideration-proofness: reject threats that are Pareto-dominated ex post
- Similar spirit for no-delay condition:
  - If agents coordinate on Pareto-dominant equilibrium \( (s^*) \) right away...
  - … then they should do the same next period (independent of past history)...
  - \( \implies \) no discipline for first player
Existence and Properties

- Under separability and other weak conditions, OE exists

- Assume that continuation utility is recursive:

  \[ \hat{V}(a_1, a_2, \ldots) = W(a_1, \hat{V}(a_2, a_3, \ldots)) \]

Then:
- OE admits a recursive structure
  \[ a_{t+1} = q^*(a_t) \]
- Equilibrium converges to a steady state
A Class of Separable Economies

- Most economies do not satisfy separability condition

- Our strategy: approximate the original economy by separable ones

- First order approximation satisfies the separable property

\[
\Psi_t = u(k_t, a_t) + \delta \sum_{\tau=1}^{\infty} \beta^\tau u(k_{t+\tau}, a_{t+\tau})
\]

subject to

\[
\begin{align*}
    u(k_t, a_t) &= \Gamma_{10} + \Gamma_{11} h(k_t) + \Gamma_{12} m(a_t) \\
    h(k_{t+1}) &= \Gamma_{20} + \Gamma_{21} h(k_t) + \Gamma_{22} g(a_t)
\end{align*}
\]

- \(h(k), m(a), g(a)\) can be any monotonic functions
Example

- Original economy

\[ \Psi_t = \log(c_t) + \delta \sum_{\tau=1}^{\infty} \beta^\tau \log(c_{t+\tau}) \]

s.t. \[ c_t + i_t = k_t^\alpha \]

\[ k_{t+1} = (1 - d)k_t + i_t \]

- The approximated economy

\[ \Psi_t = \log(c_t) + \delta \sum_{\tau=1}^{\infty} \beta^\tau \log(c_{t+\tau}) \]

s.t. \[ c_t + i_t = k_t^\alpha \]

\[ k_{t+1} = (1 - d)k_t + i_t \]

- Let \( c_t = (1 - s)k_t^\alpha \), \( i_t = s k_t^\alpha \), the economy is separable between \( k \) and \( s \)
Part III: Government Taxation Problem
A Simple Version

- **Preference:** \[ \sum_{t=0}^{\infty} \beta^t [\gamma_c \log c_t + \gamma_g \log g_t] \]

- **Technology:** \[ f(k_t) = k_t^\alpha, \quad k_{t+1} = f(k_t) - c_t - g_t. \]

- **Consumers’ budget constraint:** \[ c_t + k_{t+1} = (1 - \tau_t) r_t k_t + \pi_t \]

- **Prices:** \[ r_t = f_k(k_t), \quad \pi_t = f(k_t) - r_t k_t \]

- **Government budget constraint:** \[ g_t = \tau_t r_t k_t \]
Difference from Previous Setup

- In the quasi-geometric discounting, only one player per period
- Here, gov’t + private sector
- Need to short-circuit competitive equilibrium component
Payoff

- Given an arbitrary $\{\tau_t\}_{t=0}^{\infty}$, Euler equation has to hold in equilibrium
  \[ u'(c_t) = \beta(1 - \tau_{t+1})f'(k_{t+1})u'(c_{t+1}) \]

- Induce a sequence of saving rates such that
  \[
  \frac{s_t}{1 - s_t - \alpha \tau_t} = \frac{\alpha \beta (1 - \tau_{t+1})}{1 - s_{t+1} - \alpha \tau_{t+1}}
  \]

- From saving rate, get allocation

- Total payoff with initial capital $k$
  \[
  U(k, \tau_0, \tau_1, \tau_2, \ldots) = \frac{\alpha(1 + \gamma)}{1 - \alpha \beta} \log k + V(\tau_0, \tau_1, \tau_2, \ldots)
  \]

- Action payoff
  \[
  V(\{\tau_t\}_{t=0}^{\infty}) = \sum_{t=0}^{\infty} \beta^t \left\{ \log(1 - \alpha \tau_t - s_t) + \gamma \log \alpha \tau_t + \frac{\alpha \beta (1 + \gamma)}{1 - \alpha \beta} \log s_t \right\}
  \]
Organizational Equilibrium in Government Taxation Problem

**Definition**

A sequence of tax rates \( \{\tau_t\}_{t=0}^{\infty} \) is organizationally admissible if

\[ V(\tau_t, \tau_{t+1}, \tau_{t+2}, \ldots) \text{ is (weakly) increasing in } t \]

Within organizationally admissible sequences, any sequence that attains the maximum of \( V(\tau_0, \tau_1, \tau_2, \ldots) \) is an *organizational equilibrium*.
Organizational Equilibrium in Government Taxation Problem

Definition

A sequence of tax rates \( \{\tau_t\}_{t=0}^{\infty} \) is organizationally admissible if

- \( V(\tau_t, \tau_{t+1}, \tau_{t+2}, \ldots) \) is (weakly) increasing in \( t \)
- The implementability constraint is satisfied

Within organizationally admissible sequences, any sequence that attains the maximum of \( V(\tau_0, \tau_1, \tau_2, \ldots) \) is an organizational equilibrium.
**Organizational Equilibrium in Government Taxation Problem**

**Definition**

A sequence of tax rates \( \{\tau_t\}_{t=0}^{\infty} \) is organizationally admissible if

- \( V(\tau_t, \tau_{t+1}, \tau_{t+2}, \ldots) \) is (weakly) increasing in \( t \)
- The implementability constraint is satisfied
- Government has no incentive to delay the proposal.

\[
V(\tau_0, \tau_1, \tau_2, \ldots) \geq \max_{\tau} V(\tau, \tau_0, \tau_1, \tau_2, \ldots)
\]

Within organizationally admissible sequences, any sequence that attains the maximum of \( V(\tau_0, \tau_1, \tau_2, \ldots) \) is an *organizational equilibrium*. 
Proposal Function in Organizational Equilibrium

The equilibrium starts from $\tau_0$, and monotonically converges to $\tau^*$. 
Comparison: Payoff in Transition

$$U(k_t, \tau_t, \tau_{t+1}, \ldots) = \frac{\alpha(1 + \gamma)}{1 - \alpha\beta} \log k_t + V(\tau_t, \tau_{t+1}, \ldots)$$

**Total payoff**

**Action payoff**
A Quantitative Version

- Preference

\[ \sum_{t=0}^{\infty} \beta^t [\gamma_c \log c_t + \gamma_g \log g_t + \gamma_\ell \log (1 - \ell_t)] \]

Consumers' budget constraint

\[ c_t + k_{t+1} = (1 - \tau_\ell t - \tau_t)w_t \ell_t + (1 - \tau_k t - \tau_t)(r_t - \delta)k_t \]

Technology

\[ f(k_t) = k_t^{\alpha_t} \ell_t^{1-\alpha_t}, k_{t+1} = (1 - \delta)k_t + i_t \]

Government budget constraint

\[ g_t = \tau_k t (r_t - \delta)k_t + \tau_\ell t w_t \ell_t + \tau_t (w_t \ell_t + (r_t - \delta)k_t) \]
A Quantitative Version

- **Preference**
  \[
  \sum_{t=0}^{\infty} \beta^t [\gamma_c \log c_t + \gamma_g \log g_t + \gamma_\ell \log (1 - \ell_t)]
  \]

- **Consumers’ budget constraint**
  \[
  c_t + k_{t+1} = k_t + (1 - \tau_\ell - \tau_t)w_t\ell_t + (1 - \tau_k - \tau_t)(r_t - \delta)k_t
  \]
A Quantitative Version

- **Preference**
  \[ \sum_{t=0}^{\infty} \beta^t [\gamma_c \log c_t + \gamma_g \log g_t + \gamma_\ell \log (1 - \ell_t)] \]

- **Consumers’ budget constraint**
  \[ c_t + k_{t+1} = k_t + (1 - \tau_\ell - \tau_t)w_t \ell_t + (1 - \tau_k - \tau_t)(r_t - \delta)k_t \]

- **Technology**
  \[ f(k_t) = k_t^\alpha \ell_t^{1-\alpha}, \quad k_{t+1} = (1 - \delta)k_t + i_t \]
A Quantitative Version

- Preference
  \[ \sum_{t=0}^{\infty} \beta^t [\gamma_c \log c_t + \gamma_g \log g_t + \gamma_\ell \log(1 - \ell_t)] \]

- Consumers’ budget constraint
  \[ c_t + k_{t+1} = k_t + (1 - \tau_\ell - \tau_t) w_t \ell_t + (1 - \tau_k - \tau_t)(r_t - \delta) k_t \]

- Technology
  \[ f(k_t) = k_t^\alpha \ell_t^{1-\alpha}, \quad k_{t+1} = (1 - \delta) k_t + i_t \]

- Government budget constraint
  \[ g_t = \tau_k^k (r_t - \delta) k_t + \tau_\ell w_t \ell_t + \tau_t (w_t \ell_t + (r_t - \delta) k_t) \]
## Labor Income Tax

<table>
<thead>
<tr>
<th>Aggregate statistics</th>
<th>Labor income tax</th>
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<td>Organization</td>
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<td>0.172</td>
</tr>
<tr>
<td>$c/g$</td>
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<td>3.240</td>
<td>3.662</td>
<td>3.435</td>
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<tr>
<td>$\ell$</td>
<td>0.320</td>
<td>0.253</td>
<td>0.254</td>
<td>0.253</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.281</td>
<td>0.256</td>
<td>0.269</td>
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</table>

Parameter: $\alpha = 0.36$, $\beta = 0.96$, $\delta = 0.08$, $\gamma_g = 0.09$, $\gamma_c = 0.27$, $\gamma_{\ell} = 0.64$
### Capital Income Tax

<table>
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<tr>
<th>Aggregate statistics</th>
<th>Capital income tax</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pareto</td>
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<tr>
<td>$y$</td>
<td>1.000</td>
</tr>
<tr>
<td>$k/y$</td>
<td>2.959</td>
</tr>
<tr>
<td>$c/y$</td>
<td>0.583</td>
</tr>
<tr>
<td>$g/y$</td>
<td>0.180</td>
</tr>
<tr>
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</tbody>
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## Total Income Tax

<table>
<thead>
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<th>Aggregate statistics</th>
<th>Total income tax</th>
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<tr>
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<td>Pareto</td>
</tr>
<tr>
<td>$y$</td>
<td>1.000</td>
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<tr>
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<tr>
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<tr>
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</tr>
<tr>
<td>$\tau$</td>
<td>0.236</td>
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</tbody>
</table>

Parameter: $\alpha = 0.36$, $\beta = 0.96$, $\delta = 0.08$, $\gamma_g = 0.09$, $\gamma_c = 0.27$, $\gamma_\ell = 0.64$
Propose organizational equilibrium for economy with state variables
Conclusion

- Propose organizational equilibrium for economy with state variables

- Three properties
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Bassetto, Huo, Ríos-Rull

Organizational Equilibrium
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- Future agenda:
  - Idea can be used to generalize renegotiation-proofness in games with multiple players
    Further analysis of approximation options