Institutional Development, Organizational Capital and Misallocation

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A. Introduction

It is not until recent that macroeconomists have devoted effort toward understanding the role of institutions and organizations played in the process of economic development. This relatively thin but important literature includes:

- **Institutional development:**
  - classic: North (1990), Rogoff (1990)

- **Organizational capital:**
  - new wave:
    - *Atkeson-Kehoe (2005, 2007)*: theory and measurement


B. The Importance of Institutions and Organizations

- Institutional factors
  - affect laws and regulations under which households and firms function
  - shape the incentives individuals have for various decision-making

- Organizational structures
  - affect the operations of firms and government agencies
  - influence the efficiency of production and the effectiveness of public policy

• While Acemoglu-Johnson-Robinson (2005) provide convincing empirical evidence and informal arguments on the role of institutions played in the development of Western European Atlantic traders, a formal modeling framework has been absent.

• This paper makes crucial progress toward filling the gap by constructing a model to study how changes in political institutions can lead to subsequent changes in economic institutions.

1. The Model

• Total population $L$ within which there is a small elite $(E)$ group of size $M$ with the remaining as general citizen $(C)$.

• Preference: $\sum_{j=0}^{\infty} \beta^j \left( c_t^{e} + g_t^{h} \right)$, linear over private/public goods, $h \in \{E, C\}$.

• In each period, only 2 types of public goods are provided:
  - $g_{t+j} = e$ (elite type) $\Rightarrow$ $G_{t+j}^{E} = \gamma^{E} > 0$, $G_{t+j}^{C} = 0$
  - $g_{t+j} = c$ (citizen type) $\Rightarrow$ $G_{t+j}^{E} = 0$, $G_{t+j}^{C} = \gamma^{C} > 0$
● Ricardian technology: each citizen owns one unit of labor (supplied inelastically), capable of producing $A$ units of good

● Institutions: $\tau_t \in \{e, c\}$ (pro-elite or pro-citizen)
  ○ $\tau_t = c \Rightarrow w_c = A, R_c = 0$
  ○ $\tau_t = e \Rightarrow w_e = \lambda(1-\delta)A, R_e = (1-\lambda)(1-\delta)AL/M$
  
  where $\delta$ = inefficiency loss due to labor repression under e-institution

  ○ labor wage and elite rent differentials under the two institutions:
    - $\Delta w = w_c - w_e = [1-\lambda(1-\delta)]A > 0$
    - $\Delta R = R_e - R_c = (1-\lambda)(1-\delta)AL/M > 0$
    - since $L/M$ is very large, $\Delta R \gg \Delta w$

● Political regimes $s \in \{N, D\}$ (nondemocracy/monarchy or democracy)

● De facto political power depends on the investment in power-gaining:
  ○ elite: $P^E_t(s) = \phi^E(s) \sum_{i \in E} \theta^E_i(s)$

  ○ citizen: $P^C_t(s) = \phi^C(s) \sum_{i \in C} \theta^C_i(s) + \omega_i + \eta I(s_i = D)$, with

  - $\omega$ iid, drawn from a given distribution $F$ with support $(\omega, \infty)$, $\omega < 0$, and single-peaked density
  - $\eta$ measuring citizens’ de jure power in democracy

  ○ indicator of power $\pi \in \{e, c\}$: $\pi = e$ iff $P^E_t(s) \geq P^C_t(s)$, and $\pi = c$ otherwise
• **Timing of events:**
  - the group in power at $t$ decides $g_t \in \{e, c\}$
  - each elite $i \in E$ and each citizen $i \in C$ choose their investment in gaining power and $P^E_t$ is determined
  - $\omega$ is drawn from $F$ and $P^C_t$ is determined
  - if $\pi = e$, a representative elite chooses current institution and future regime $(\tau_t, s_{t+1})$; otherwise, a representative citizen chooses
  - given $\tau_t$, $R_t$ and $w_t$ are determined and consumption takes place

• **Symmetric Markov perfect equilibrium (MPE):**
  - equilibrium strategies are mappings from payoff-relevant states $s \in \{N, D\}$
  - all agents in the same group behave symmetrically

• **Symmetry implies:**
  - $P^E(\theta^i, \theta^E(s), \theta^C(s)|s) = \phi^E(s)((M - 1)\theta^E(s) + \theta^i)$
  - $P^C(\theta^i, \theta^E(s), \theta^C(s)|s) = \phi^C(s)L\theta^C(s) + \eta I(s = D) + \omega_t$
  - $pr(e \text{ in power}) = \frac{p(\theta^i, \theta^E(s), \theta^C(s)|s)}{F[\phi^E(s)((M - 1)\theta^E(s) + \theta^i) - \phi^C(s)L\theta^C(s) - \eta I(s = D)]}$

• **Backward induction within each stage implies the following best responses:**
  - $g(N) = e$, $g(D) = c$
  - $\tau(e) = e$, $\tau(c) = c$
  - $s'(e) = N$, $s'(c) = D$
Values under N (using one-step-ahead deviation principle a la Fudenberg-Tirole 1994):

- **elite:**
  \[
  V^E(N|\theta^E,\theta^C) = \max_{\theta^i \geq 0} \{-\theta^i + \gamma^E + p(\theta^i, \theta^E(N), \theta^C(N)|N)[R_e + \beta V^E(N|\theta^E,\theta^C)] + [1 - p(\theta^i, \theta^E(N), \theta^C(N)|N)][R_c + \beta V^E(D|\theta^E,\theta^C)]\}
  \]

- **citizen:**
  \[
  V^C(N|\theta^E,\theta^C) = \max_{\theta^i \geq 0} \{-\theta^i + p_0(\theta^i, \theta^E(N), \theta^C(N)|N)[w_c + \beta V^C(N|\theta^E,\theta^C)] + [1 - p_0(\theta^i, \theta^E(N), \theta^C(N)|N)][w_c + \beta V^C(D|\theta^E,\theta^C)]\}
  \]

where \( p_0(\theta^i, \theta^E(s), \theta^C(s)|s) = F[\phi^E(s)M\theta^E(s) - \phi^C(s)((L - 1)\theta^C(s) + \theta^i) - \eta I(s = D)] \) is the conditional probability for \( e \) in power given all elite members choosing \( \theta^E \) and all other citizens choosing \( \theta^i \)

First-order conditions for power-spending \( \theta \) under N:

- **elite:**
  \[
  \phi^E(N) f[\phi^E(N)((M - 1)\theta^E(N) + \theta^i) - \phi^C(N)L\theta^C(N)] [\Delta R + \beta \Delta V^E] \leq 1
  \]

- **citizen:**
  \[
  \phi^C(N) f[\phi^E(N)M\theta^E(N) - \phi^C(N)((L - 1)\theta^C(N) + \theta^i)][\Delta w + \beta \Delta V^C] \leq 1
  \]

where \( \Delta V^E = V^E(N|\theta^E,\theta^C) - V^E(D|\theta^E,\theta^C) \) and \( \Delta V^C = V^C(D|\theta^E,\theta^C) - V^C(E|\theta^E,\theta^C) \) measure value differentials between two political regimes

Values under D and the associated first-order conditions:

- **elite:**
  \[
  V^E(D|\theta^E,\theta^C) = \max_{\theta^i \geq 0} \{-\theta^i + p(\theta^i, \theta^E(D), \theta^C(D)|D)[R_e + \beta V^E(N|\theta^E,\theta^C)] + [1 - p(\theta^i, \theta^E(D), \theta^C(D)|D)][R_c + \beta V^E(D|\theta^E,\theta^C)]\}
  \]

   \[\phi^E(D) f[\phi^E(D)((M - 1)\theta^E(D) + \theta^i) - \phi^C(D)\theta^C(D) - \eta] [\Delta R + \beta \Delta V^E] \leq 1\]

   (FOC)
citizen: \[ V^C(D|\theta^E, \theta^C) = \max_{\theta^i \geq 0} \{-\theta^i + \gamma^C + p_0(\theta^i, \theta^E(D), \theta^C(D)|D)[w_e + \beta V^C(N|\theta^E, \theta^C)] + [1 - p_0(\theta^i, \theta^E(D), \theta^C(D)|D)][w_e + \beta V^C(D|\theta^E, \theta^C)]\}, \]

\[ (FOC) \quad \phi^C(D)f[\phi^E(D)M\theta^E(D) - \phi^C(D)((L-1)\theta^C(D) + \theta^i) - \eta][\Delta w + \beta \Delta V^C] \leq 1 \]

2. Results

- **Power-gaining investment:** Any symmetric MPE involves:
  - \( \theta^C(N) = \theta^C(D) = 0 \): this is because the elite group has much larger gains from power than citizens (\( \Delta R >> \Delta w \)), implying two of the 4 FOCs hold for inequality
  - \( \{\theta^E(N), \theta^E(D)\} \) solve the remaining 2 FOCs:
    - \[ \phi^E(N)f[\phi^E(N)M\theta^E(N)] [\Delta R + \beta \Delta V^E] = 1 \]
    - \[ \phi^E(D)f[\phi^E(D)M\theta^E(D) - \eta] [\Delta R + \beta \Delta V^E] = 1 \]

- **Condition R:** The additional rent by elite from labor repression is sufficiently large such that \( \min \{\phi^E(N)f[0] \Delta R, \phi^E(D)f[-\eta] \Delta R\} > 1 \)

- **State Dependence:** Under Condition R, a symmetric MPE features:
  - Markov regime switch with the society fluctuating between \{N,e\} and \{D,c\}
  - with the regime probabilities \( p(N) > p(D) \) if \( \phi^E(N) > \phi^E(D) \)
  - with invariance \( p(N) = p(D) \) if \( \phi^E(N) = \phi^E(D) = \phi^E \)
• Condition I: \( \exists \bar{\theta}^E(N) > 0 \) s.t. \[ \phi^E(N)^f \left[ \phi^E(N) M \bar{\theta}^E(N) \right] \left( \frac{\Delta R + \beta \gamma^E - \beta \bar{\theta}^E(N)}{1 - \beta F \left[ \phi^E(N) M \bar{\theta}^E(N) \right]} \right) = 1 \] (interior power-gaining investment)

• Condition D: Democracy creates a substantial advantage in favor of citizens s.t. \( \eta > -\omega \)

• Nondemocracy as Absorbing State: Under Conditions I and P, there exists a symmetric MPE in which \( p(N) \in (0, 1) \) and \( p(D) = 0 \)

• Comparative Statics: Under Condition R with \( \phi^L(N) = \phi^L(D) = \phi^L \), a symmetric MPE features:
  ○ equilibrium power-gaining investments \( \{\theta^E(N), \theta^E(D)\} \) are increasing in \( \Delta R \), \( \beta \) and \( \eta \), and decreasing in \( M \)
  ○ the equilibrium probability for the elite to be in power is increasing in \( \Delta R \), \( \beta \), \( \eta \), and \( \phi^E \)
  ○ more patient (\( \beta \)) or greater de jure power advantage for citizens (\( \eta \)) causes the elite to have greater incentive to invest in power-gaining and raises the likelihood of labor repression institution

• Meeting the facts: \( M \) was sufficiently large while \( \eta \) was sufficiently low in UK and the Netherlands, thereby destroying the elite incentive to invest in its de facto power and leading to the eventual establishment of the democracy regime
D. Human Capital Institutions, Land Inequality and the Emergence of the Great Divergence: Galor-Moav-Vollrath (2009)

- The Great Divergence: the ratio of per capita real GDP between the richest and poorest regions increased from 3 in 1820 to 18 in 2001 (Maddison 2001)
- Main idea: link human capital promoting institutions (public schooling/child labor regulations) to the emergence of the Great Divergence

1. The Model

- Agriculture production (CRS in workers and land): \( y_t^A = F(X_t, L_t) \)
  - (raw) labor demand: \( w_t^A = F_L(X_t, L_t) \)
  - land demand: \( \rho_t = F_X(X_t, L_t) \)
- Manufacturing production (CRS in physical/human capital): \( y_t^M = K_t^\alpha H_t^{1-\alpha} = H_t k_t^\alpha \)
  - (effective) labor demand: \( w_t^M = (1-\alpha)k_t^\alpha \equiv w^M(k_t) \)
  - capital demand: \( R_t = \alpha k_t^{\alpha-1} \equiv R(k_t) \)
- Two-period lived OG with pop(generation) = 1 and household preference: \( u_t = (1-\beta) \log c_{t+1}^i + \beta \log b_{t+1}^i \) (i.e., an individual household values only 2\textsuperscript{nd}-period consumption and bequest to descendant)
• Bequest tax: at rate \( \tau_t \), to finance public education \( e_t \)
• Intergenerational human capital transmission: \( h_{t+1} = h(e_t) \), strictly increasing and strictly concave in \( e \), satisfying \( h(0) = 1 \) and Inada conditions
• Household budget constraint: \( c_{t+1}^i + b_{t+1}^i \leq I_{t+1}^i \), where \( I_{t+1}^i = w_{t+1}^i + b_{t+1}^i(1 - \tau_t)R_{t+1} + x_{t+1}^i \rho_{t+1} \)
• Household optimization:
  ○ consumption-bequest allocation: \( b_{t+1}^i = \beta I_{t+1}^i \)
  ○ indirect utility: \( v_t^i = \log I_{t+1}^i + \xi \equiv v(I_{t+1}^i) \), where \( \xi \equiv (1 - \beta) \log(1 - \beta) + \beta \log \beta \)

2. Equilibrium

• Aggregate output: \( y_t = y_t^A + y_t^M \)
• Aggregate bequest: \( B_t = \beta y_t \)
• Public education: \( e_t = \tau_t \beta y_t \)
• Equilibrium capital evolution:
  ○ physical capital: \( K_{t+1} = (1 - \tau_t) \beta y_t \)
  ○ human capital: \( H_{t+1} = \theta_{t+1} h(\tau_t \beta y_t) \), where \( \theta = \) manufacturing labor
• Equilibrium sectoral outputs:
  ○ agricultural sector: \( y_{t+1}^A = F(X, 1 - \theta_{t+1}) \equiv y^A(\theta_{t+1}; X) \)
  ○ manufacturing sector: \( y_{t+1}^M = [(1 - \tau_t) \beta y_t]^\alpha [\theta_{t+1} h(\tau_t \beta y_t)]^{1-\alpha} \equiv y^M(y_t, \tau_t, \theta_{t+1}) \)
- Equilibrium capital-effective labor ratio: 
  \[ k_{t+1} = \frac{(1 - \tau_t)\beta_y t}{\theta_{t+1} h(\tau_t\beta y_t)} \equiv k(y_t, \tau_t, \theta_{t+1}) \], which is strictly increasing in y and strictly decreasing in (\theta, \tau)

- Equilibrium labor allocation:
  - factor price equalization: 
    \[ w^A_{t+1} = h_{t+1} w^M_{t+1} \equiv w_{t+1} \]
  - MPL equalization: 
    \[ F_L(X, 1- \theta_{t+1}) = h(\tau_t\beta y_t)(1 - \alpha) \left( \frac{(1 - \tau_t)\beta y_t}{\theta_{t+1} h(\tau_t\beta y_t)} \right)^\alpha \], implying:
    - the RHS is:
      - strictly increasing/concave in y and strictly decreasing in \theta
      - strictly increasing/concave in \tau if \alpha < 1/2
    - the solution \( 1-L_{t+1} = \theta_{t+1} = \theta(y_t, \tau_t; X) \) is:
      - strictly increasing in y
      - strictly decreasing in (X, \tau)

- Aggregate output-maximizing tax rate \( \tau^*_t \):
  - (FOC): 
    \[ \theta_{t+1} w^M (k_{t+1}) h'(\tau^*_t\beta y_t) = R(k_{t+1}) \], implying:
      - \( \tau^*_t = \tau^*(y_t) \)
      - \( \tau^*(y_t)y_t \) is strictly increasing in y
    - \( w(\rho) \) is strictly increasing (decreasing) in \tau for \( \tau \in (0, \tau^*_t) \)
    - \( \theta, y^M \) and \( (1-\tau)R \) are all strictly increasing in \tau for \( \tau \in (0, \tau^*_t) \)
    - \( \tau^*_t \) is optimal to individuals with low landownership \( x_i \)
3. Political Equilibrium

- Political mechanism: changes in the existing educational policy require the consent of all groups
- Landownership: suppose that a fraction \( \lambda \) of young individuals in period 0 are landlords, each owning an equal fraction \( 1/\lambda \) of the aggregate stock land \( X \) (i.e., per landlord land holding is \( X/\lambda \)) and being endowed with \( b_0^L \) units of output
- Key result: \( \exists \) a critical income \( \bar{y}_t = \bar{y}(b_t^L, \lambda; X) \) s.t. \( \forall y_t > \bar{y}_t, \tau_t^L = \tau_t^* \), with \( \bar{y} \) increasing in \( X \) and decreasing in \( \lambda \), satisfying:
  - \( \hat{y}(b_t^L, 1; X) = 0 \Rightarrow \) with no land inequality, human capital promoting institutions, \( \tau_t^L = \tau_t^* \), emerges at date 0
  - \( \lim_{\lambda \to 0} \hat{y}(b_t^L, \lambda; X) = \infty \) (extremely high land inequality results in \( \tau_t^L = 0 \))
- Process of development: a nation’s output per capita evolves according to:
  \[
  y_{t+1} = \begin{cases} 
  \psi^0(y_t) = (\beta y_t)^{\alpha} \theta_{t+1}^{1-\alpha} + F(X, 1 - \theta_{t+1}) & \text{for } \tau = 0; \\
  \psi^*(y_t) = [(1 - \tau_t^*) \beta y_t]^\alpha [\theta_{t+1} h(\tau_t^* \beta y_t)]^{1-\alpha} + F(X, 1 - \theta_{t+1}) & \text{for } \tau = \tau^*
  \end{cases}
  \]
  - \( \psi^*(y_t) > \psi^0(y_t) \) for \( y_t > 0 \) and both \( \psi^0 \) and \( \psi^1 \) are:
    - strictly increasing and strictly concave in \( y \) with \( \lim_{y_t \to \infty} dy^j(y_t)/dy_t = 0 \)
    - strictly increasing in \( X \)
  - economic growth is higher under human capital promoting institution
• Switch to the human capital promotion regime:

Main Finding: countries with higher land inequality will implement sooner human capital promoting institutions and experience higher economic growth.

Empirical test: historical evidence in the U.S. during the high school movement over 1880-1920 suggests that the Northeast and the Pacific regions had lower land inequality and higher high school graduation rates than the South region.

- Organizational capital is an important part of intangible capital
- Organizational capital can be tied to the life cycle of a plant:
  - variable profit of a plant of age $s$: $d_s = \max_i f_s(l) - w_l$
  - cost of the fixed factor: $w_m$
  - organization rent: $d_s - w_m$
  - free entry condition: $\sum_{s=0}^{N} \left( \frac{1}{1 + i} \right)^s (d_s - w_m) = 0$
  - cross-section aggregate organization rent: $\pi = \sum_{s=0}^{N} (d_s - w_m)$
  - if MPL rises with plant age (learning by doing), then older plants will be larger and hire more labor than younger ones
  - thus, organizational capital is summarized by the plant-specific productivity ($f_s$) as well as the age of the plant ($s$)
  - letting variable profit to grow at a constant rate $\gamma > 1$ (i.e., $d_s = \gamma^s d_0$), we can then use free entry condition to obtain:
  
  $$w_m = d_0 \frac{\sum_{s=0}^{N} \frac{\gamma}{1 + i}^s}{\sum_{s=0}^{N} \frac{1}{1 + i}^s}$$

  - thus, $\pi = d_0 (N + 1) \sum_{s=0}^{N} \gamma^s \omega_s$, where
  
  $$\omega_s = \frac{1}{N + 1} - \frac{\sum_{s=0}^{N} \frac{1}{1 + i}^s}{\sum_{s=0}^{N} \frac{1}{1 + i}^s}$$
1. The Basic Model

- Preference: \( U = \sum_{t=0}^{\infty} \beta^{t} \log (c_{t}) \)
- Budget constraint: \( \sum_{t=0}^{\infty} p_{t} c_{t} \leq \sum_{t=0}^{\infty} p_{t}(w_{t} + w_{mt}) + k_{0} + a_{0} \)
- Production: \( y = zA^{1-\nu}F(k, l)^{\nu} \)
  - \( F \) is CRTS
  - \( z \) = aggregate technology
  - \( \nu \) = span of control parameter determining the return to scale (Lucas 1978)
  - Organization capital (A, s): a plant with organization capital (A, s) at t has stochastic organization capital (A\( \epsilon \), s+1) at t+1
  - Time-to-build: a plant built in t-1 can start operating in t
  - Frontier knowledge: productivity \( \tau_{t} \), adopted by all new plants, implying a new plant built in t-1 will have organization capital (\( \tau_{t}, 0 \)) at t
  - Plant optimization: \( \max_{k,l} z_{t}A^{1-\nu}F(k, l)^{\nu} - r_{t}k - w_{l}l - w_{mt} \)
    - variable profit: \( d_{t}(A) = z_{t}A^{1-\nu}F(k_{t}(A), l_{t}(A))^{\nu} - r_{t}k_{t}(A) - w_{l}l_{t}(A) \)
    - fixed cost of hiring a manager (one per plant, fixed supply): \( w_{m} \)
  - Bellman: \( V(A, s) = \max \left[ 0, d_{t}(A) - w_{mt} + \frac{p_{t+1}}{p_{t}} \int V_{t+1}(A\epsilon, s + 1)\pi_{s+1}(d\epsilon) \right] \)
Plant operating decision \( x(t, A, s) = 1 \) if operating, \( = 0 \) otherwise

Plant establishment decision, determined by the value of a new plan:
\[
V_t^0 = -w_m + \frac{p_{t+1}}{p_t} V_{t+1}(\tau_{t+1}, 0) \geq 0,
\]
which pins down the measure of managers \( \phi_t \)

Measure of operating plants: \( \lambda(A, s) = \int_0^A x(t, A, s) \mu_s(dA, s) \), with the distribution evolving as:
\[
\mu_{t+1}(A', s + 1) = \int_A \pi_{s+1} \left( \frac{A'}{A} \right) \lambda_A(dA, s)
\]

Factor market clearing:
\begin{enumerate}
\item capital:
\[
\sum_s \int_A k_t(A) \lambda_A(dA, s) = k_t
\]
\item labor:
\[
\sum_s \int_A l_t(A) \lambda_A(dA, s) = 1
\]
\item manager:
\[
\phi_t + \sum_s \int_A \lambda_A(dA, s) = 1
\]
\end{enumerate}

Goods market clearing:
\[
c_t + k_{t+1} = y_t + (1 - \delta)k_t \]
where aggregate output is given by
\[
y_t = z_t \sum_s \int_A A^{1-\sigma} F(k_t(A), l_t(A))^{\sigma} \lambda_A(dA, s)
\]

Plant size:
\[
n_t(A) = \left( \frac{A}{A_t} \right), \quad A_t = \sum_s \int_A A \lambda_A(dA, s) = \text{aggregate specific productivity}
\]

Equilibrium allocation:
\[
k_t(A) = n_t(A)k_t \quad \text{and} \quad l_t(A) = n_t(A)l_t
\]

Equilibrium output:
\[
y_t(A) = n_t(A)y_t = n_t(A)z_t A_t^{1-\sigma} F(k_t, l_t)^\sigma
\]

Equilibrium variable profit:
\[
d_t(A) = (1 - \nu)y_t(A) = (1 - \nu)n_t(A)y_t
\]
2. Generalization: Monopolistic Competition

- The competitive final good output: 
  \[ y_t = \left[ \sum_s \int_A f_y(A)^\theta \lambda_s(dA, s) \right]^{1/\theta} \]
  implying the demand schedule for intermediate goods:
  \[ y_t(A) = \left( \frac{p_t(A)}{p_t(A)} \right)^{-1/(1-\theta)} y_t \]
- Supply of intermediate goods: 
  \[ y_t(A) = z_t^{1/\theta} A_t^{(1-\gamma)/\theta} F(k_t(A), l_t(A)) \gamma \]
  with the powers adjusted to include the markup accrued from local monopoly power
- All other setups remain the same

3. Calibration Analysis

- Use standard macroeconomics and firm-distribution parameters and set the markup parameter to \( \theta = 0.9 \) and the span of control parameter to \( \gamma = 0.95 \)
- The rates of job turnovers can then be computed (based on the definition by Davis-Haltiwanger-Schuh 1996):

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
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<tbody>
<tr>
<td>Overall job creation rate</td>
<td>8.3</td>
<td>10.2</td>
</tr>
<tr>
<td>Overall job destruction rate</td>
<td>8.4</td>
<td>10.2</td>
</tr>
</tbody>
</table>

- Mean and standard deviation of shocks to \( \ln(n) \):
Firm age and average productivity

Measurement of organizational capital and growth accounting
  - physical capital income share: $\theta \gamma a = 19.9\%$
- labor income share: \( \theta \gamma (1-\alpha) = 65.1\% \)
- managerial and organization rent share: \( 1-\theta \gamma = 15\% \)
  - by using the expression for \( w_m \), managerial rent share is: 11.7%
  - organization rent share is: 3.3%
- Varying \( \nu = \theta \gamma \) by 5 percentage points, we obtain:

- Link organizational capital to productivity growth to explain establishment lifecycles and productivity slowdown of the 1970s and the 1980s based on changing patterns of technological adoption of fast-depreciating IT capital, whose share in equipment investment rose from 7% to 56%
- Average age of capital (equipment vs. structures)
  
  - average age of equipment capital *rose* over 1970-92
  - this, together with the fact of fast depreciation of the IT capital, implies that the adoption of new capital *decelerated* over the period
  - over the same period, Hobijn-Jovanovic (2001) find that young firms outperformed old ones
1. The Model

- Production of a plant of age $\tau$ and experience $a$: $y_t = \frac{\gamma_n^{\tau} \gamma_s^{1-\tau} \Omega(a) k_{t}^{\alpha_k} n_{t}^{\alpha_n}}{\gamma_s^{1/(1-\alpha_k)} \gamma_n^{1/(1-\alpha_n)}}$, where $\gamma_n$ and $\gamma_s$ measure general and plant-specific technologies, $\Omega(a)$ measures accumulated plant-level expertise, and $\alpha_k + \alpha_n < 1$
- Organizational capital: $\pi = \frac{\gamma_s^{\tau} \Omega(a)}{\gamma_s^{1/(1-\alpha_k)}} = \text{plant-specific component of productivity}$
- Updating cost from age $\tau$ to age $\nu$: $\kappa(\nu) = \frac{\kappa \gamma_s^{\tau-v} \gamma_s^{1/(1-\alpha_k)}}{\gamma_s^{1-(\nu-\tau)}}$
- Measure of plant follows a process $\mu_{t+1} = \Gamma(\mu_t)$, relying on entry/exit/updating
- Plant values:
  - growing factor on BGP: $\gamma_y = \frac{1}{\gamma_n} \frac{\gamma_s^{1/(1-\alpha_k)}}{\gamma_s^{1/(1-\alpha_n)}}$
  - plant value deflated by $\gamma_y$: $P(\tau, a, X_t) = \max_{k_t, n_t} \left\{ \frac{\gamma_s^{1-\tau} \Omega(a) k_{t}^{\alpha_k} n_{t}^{\alpha_n}}{\gamma_s^{1/(1-\alpha_k)} \gamma_n^{1/(1-\alpha_n)}} - k_t r(X_t) - n_t w(X_t) \right\}$
  - continuation value: $C(\tau, a, X_t) = \max_{0 \leq v} \left\{ W(\tau + 1, a + 1, \Gamma(X_t)), U(a, X_t) \right\}$
  - updating value: $U(a, X_t) = \max_{0 \leq v} \left\{ W(\nu, a + 1, \Gamma(X_t)) - \kappa \gamma_s^{\tau-v} p(\Gamma(X_t)) \right\}$
  - optimal updating rule: $\lambda(\tau, a, X_t) = \begin{cases} 1 & \text{if } U(a, X_t) \geq W(\tau + 1, a + 1, \Gamma(X_t)) \\ 0 & \text{otherwise.} \end{cases}$
  - value function: $W(\tau, a, X_t) = P(\tau, a, X_t) + \frac{\gamma_y}{1 + t} \lambda(\tau, a, X_t) C(\tau, a, X_t)$
- properties:
  - updating follows $(S,s)$-rule, with full updating once decided to do so
  - adoption lags decrease with age
2. Firm profit $\Pi$ will be redistributed to households (measure one)
Managerial supply: a household invests $e$ to generate $\varphi(e)$ managerial units paid at $p$
One manager per plant: managerial units $\varphi$ and new plant establishment investment ($q$) are homogeneous
Household optimization given state $X = (\mu, K)$:

$$\max \sum_{t=0}^{\infty} \beta^t \{ \ln c_t + \xi(\Xi - n_t) \}$$

s.t. $$c_t + I_t + p(X_t)q_t \leq \Pi(X_t) + r(X_t)K_t + \omega(X_t)(n_t - e_t) + p(X_t)\varphi(e_t)$$

$$K_{t+1} = I_t + (1 - \delta)K_t$$

2. Equilibrium and Productivity Slowdown

Stationary recursive competitive equilibrium with $\Gamma(\mu^*) = \mu^*$
Productivity slowdown due to an organizational shock:

- after $t^* = 1973$, learning accumulated before is no longer compatible with new technologies born since $t^*$
- plants established before $t^*$ must suffer by starting from the lowest rung of the learning ladder with:

$$U(a, X_t) = \max_{0 \leq v} \{ W(v, 0, \Gamma(X_t)) - \kappa_s^{-v}p(\Gamma(X_t)) \}$$
- Responses to the organizational shock:
  - given fixed prices,
    - slower updating: adoption lags increase for all plant types
    - faster turnovers (entry/exit): the ratio of values of the incumbent to the new entrant drops
    - age-biased updating: young plants update before older ones

3. Calibration Analysis

- Lifecycle dynamics:

<table>
<thead>
<tr>
<th>Statistic</th>
<th>US data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant growth (%)</td>
<td>35</td>
<td>30.5</td>
</tr>
<tr>
<td>Plant growth, young (%)</td>
<td>45</td>
<td>47.8</td>
</tr>
<tr>
<td>Relative size of the young (%)</td>
<td>77</td>
<td>67</td>
</tr>
<tr>
<td>New establishments (%)</td>
<td>9.2</td>
<td>8.6</td>
</tr>
<tr>
<td>5-year exit rate (%)</td>
<td>36</td>
<td>37</td>
</tr>
<tr>
<td>5-year exit rate, young plants (%)</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>Lumpy investments (%)</td>
<td>25</td>
<td>25.5</td>
</tr>
<tr>
<td>Lumpy investors (%)</td>
<td>8</td>
<td>7.5</td>
</tr>
<tr>
<td>Updating lag, years</td>
<td>5–8</td>
<td>7.5</td>
</tr>
<tr>
<td>Time to average learning</td>
<td>5–10</td>
<td>8</td>
</tr>
<tr>
<td>Average age of capital</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>
- Impulse responses to the organizational shock
  - output and productivity
plant dynamics and values
plant investment and age

- Cross-country differences in income and TFP are large and widened (see a nice survey in the North-Holland Handbook of Economic Growth by Caselli 2005
- Restuccia-Rogerson (2008) argue that misallocation of resources across firms can have large effects on aggregate TFP
- Lewis (2004, McKinsey Global Institute) argues that many institutions and policies can result in resource misallocation
- This paper ties all such bolts and nuts together

1. The Basic Model: Monopolistic Competition

- In addition to production efficiency differences as in Melitz (2003), firms also face different output and capital distortions
- A single final good is produced with a basket of industry goods, taking a Cobb-Douglas form: \( Y = \prod_{s=1}^{S} Y_{s}^{\theta_{s}} \), with \( \sum_{s=1}^{S} \theta_{s} = 1 \), where industry \( s \)'s output is a CES aggregate of \( M_{s} \) differentiated products: \( Y_{s} = \left( \sum_{i=1}^{M_{s}} Y_{si}^{\sigma_{i}} \right)^{\frac{\sigma}{\sigma-1}} \), with \( Y_{si} = A_{si} K_{si}^{\alpha_{s}} L_{si}^{1-\alpha_{s}} \).
Profit of firm $i$ in industry $s$ yields: 
$$\pi_{si} = (1 - \tau_{ysi})P_{si}Y_{si} - wL_{si} - (1 + \tau_{ksi})RK_{si}$$

- $\tau_{ysi}$ and $\tau_{ksi}$ measure output and capital distortions tied to economic institutions and policies
  - $\tau_{ysi}$ captures entry barriers, good market imperfections, income taxes, and/or transport costs
  - $\tau_{ksi}$ capture capital barriers, credit market imperfections, capital taxes and/or intermediation costs

- Profit maximization implies:
  - **MRTS = relative cost:** 
    $$\frac{K_{si}}{L_{si}} = \frac{\alpha_s}{1 - \alpha_s} \cdot \frac{w}{R} \cdot \frac{1}{(1 + \tau_{ksi})}$$
  - **competitive profit:** 
    $$P_{si} = \frac{\sigma}{\sigma - 1} \left( \frac{R}{\alpha_s} \right)^{\alpha_s} \left( \frac{w}{1 - \alpha_s} \right)^{1 - \alpha_s} \frac{1 + \tau_{ksi}}{A_{si} (1 - \tau_{ysi})}$$

- Induced demand for labor: 
  $$L_{si} \propto \frac{A_{si}^{\sigma - 1} (1 - \tau_{ysi})^\sigma}{(1 + \tau_{ksi})^\alpha_s (\sigma - 1)}$$

- Firm output: 
  $$Y_{si} \propto \frac{A_{si}^\sigma (1 - \tau_{ysi})^\sigma}{(1 + \tau_{ksi})^\alpha_s \sigma}$$

- Marginal revenue product of labor: 
  $$MRPL_{si} = (1 - \alpha_s) \frac{\sigma - 1}{\sigma} P_{si} Y_{si} = w \cdot \frac{L_{si}}{1 - \tau_{ysi}}$$

- Marginal revenue product of capital: 
  $$MRPK_{si} = \alpha_s \frac{\sigma - 1}{\sigma} P_{si} Y_{si} = R \cdot \frac{1 + \tau_{ksi}}{1 - \tau_{ysi}}$$

- Industry factor demand:
labor: \[ L_s = \sum_{i=1}^{M_s} L_{si} = L \frac{(1-\alpha_s) \theta_s / \text{MRPL}_s}{\sum_{s'=1}^{S} (1-\alpha_{s'}) \theta_{s'} / \text{MRPL}_{s'}} \], with \[ \text{MRPL}_s \propto \left( \sum_{s=1}^{M_s} \frac{1}{1 - \tau_{ysl}} \frac{P_{si} Y_{si}}{P_{s} Y_{s}} \right) \]

capital: \[ K_s = \sum_{i=1}^{S} K_{si} = K \frac{\alpha_s \theta_s / \text{MRPK}_s}{\sum_{s'=1}^{S} \alpha_{s'} \theta_{s'} / \text{MRPK}_{s'}} \], with \[ \text{MRPK}_s \propto \left( \sum_{s=1}^{M_s} \frac{1 + \tau_{ksi}}{1 - \tau_{ysi}} \frac{P_{si} Y_{si}}{P_{s} Y_{s}} \right) \]

aggregate factor demand: \[ L = \sum_{s=1}^{S} L_s \] and \[ K = \sum_{s=1}^{S} K_s \]

- **Final sector:**
  - aggregate output: \[ Y = \prod_{s=1}^{S} \left( TFP_s \cdot K_s^{\alpha_s} \cdot L_s^{1-\alpha_s} \right) \]
  - cost minimization implies: \[ P_s Y_s = \theta_s P Y_s \], where \[ P = \prod_{s=1}^{S} \left( \frac{P_s}{\theta_s} \right) \]

- **Measurement of TFP:**
  - physical productivity of firm i in industry s: \[ TFPQ_{si} = A_{si} = \frac{Y_{si}}{K_s^{\alpha_s} (wL_s)^{1-\alpha_s}} \]
  - revenue productivity of firm i in industry s: \[ TFPR_{si} = P_{si} A_{si} = \frac{P_{si} Y_{si}}{K_s^{\alpha_s} (wL_s)^{1-\alpha_s}} \], or, \[ TFPR_{si} \propto (MRPK_{si})^{\alpha_s} (MRPL_{si})^{1-\alpha_s} \propto \frac{(1 + \tau_{ksi})^{\alpha_s}}{1 - \tau_{ysi}} \], which increases in both distortions, implying that those facing larger barriers are smaller than the optimal size and hence have higher marginal products (under diminishing returns)
industry TFP: 

$$ TFP_s = \left( \sum_{i=1}^{M_s} \left( A_{si} \cdot \frac{TFPR_{s}}{TFPR_{si}} \right)^{\sigma-1} \right)^{\frac{1}{\sigma-1}} $$

with $TFPR_s \propto (MRPK_s)^{\alpha_s} (MRPL_s)^{1-\alpha_s}

if TFPQ (A) and TFPR are jointly log-normally distributed, then:

$$ \log TFP_s = \frac{1}{\sigma-1} \log \left( \sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} \text{var}(\log TFPR_{si}), $$

that is, greater dispersion of marginal products worsens the extent of misallocation, thus lowering industry TFP.

2. Applications: China/India versus U.S.

- Calibration: based on the theory developed above, we can back out the two distortion measures as well as firm-level productivity:

  - capital distortion:
    $$ 1 + \tau_{K_{si}} = \frac{\alpha_s}{1-\alpha_s} \frac{wL_{si}}{RK_{si}} $$

  - output distortion:
    $$ 1 - \tau_{Y_{si}} = \sigma \frac{wL_{si}}{\sigma-1} \left(1 - \alpha_s\right) P_{si} Y_{si} $$

  - firm productivity:
    $$ A_{si} = \kappa_s \left( \frac{P_{si} Y_{si}}{K_{si}^\alpha L_{si}^{1-\alpha_s}} \right)^{\frac{1}{\sigma-1}}, $$

with $\kappa_s = w^{1-\alpha_s} \left( P_{si} Y_{si} \right)^{-\frac{1}{\sigma-1}} P_s$ set as one to infer $P_s$ from observed value $P_s Y_s$. 
Sources of TFPR variation within industries

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Age</th>
<th>Size</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>0.58</td>
<td>1.33</td>
<td>3.85</td>
</tr>
<tr>
<td>China</td>
<td>5.25</td>
<td>6.23</td>
<td>8.44</td>
</tr>
</tbody>
</table>

TFP gains from equalizing TFPR within industries
- China: 115.1% in 1998 86.8% in 2005
- India: 100.4% in 1987 127.5% in 1994
- U.S.: 36.1% in 1977 42.9% in 1997

TFP gains from equalizing TFPR relative to 1997 U.S. gains
- China: 50.5% in 1998 30.5% in 2005
- India: 40.2% in 1987 59.2% in 1994
- TFP by ownership in China and India

<table>
<thead>
<tr>
<th></th>
<th>TFP by ownership</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>-0.415 (0.023)</td>
<td>-0.144 (0.090)</td>
</tr>
<tr>
<td>Collective</td>
<td>0.114 (0.010)</td>
<td>0.047 (0.013)</td>
</tr>
<tr>
<td>Foreign</td>
<td>-0.129 (0.024)</td>
<td>0.228 (0.040)</td>
</tr>
<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State (Central)</td>
<td>-0.285 (0.082)</td>
<td>0.717 (0.295)</td>
</tr>
<tr>
<td>State (Local)</td>
<td>-0.081 (0.063)</td>
<td>0.425 (0.103)</td>
</tr>
<tr>
<td>Joint Public/Private</td>
<td>-0.162 (0.037)</td>
<td>0.671 (0.085)</td>
</tr>
</tbody>
</table>
China and India have lower TFPQ and higher TFPR than the U.S.:
China and India have overly concentrated plan size distribution than the efficient one.
- Experienced and larger firms in the U.S. have lower TFPR (less barriers)
  - in India, the results are opposite (need theory to explain)
  - in China, experienced and small firms have lower TFPR (need theory)