From Physical to Human Capital Accumulation: Inequality in the Process of Development

Oded Galor and Omer Moav
Objectives

A unified theory of inequality and economic development:

- Captures the changing role of inequality in the growth process
- Unifies the Classical and the Modern Paradigms
- Provides an intertemporal reconciliation between conflicting viewpoints about the effect of inequality on economic growth
- Generates novel testable predictions that may resolve empirical disputes about the relationship between inequality and growth
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The Classical Approach

Inequality is beneficial for growth

The marginal propensity to save increases with income

Inequality channels resources towards individuals whose marginal propensity to save is higher

\[ \Rightarrow \] increases aggregate savings & capital accumulation

\[ \Rightarrow \] enhances the development process
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The Credit Market Imperfections Approach:

Inequality is harmful for growth

CMI increases the cost of investment in human capital for less endowed individuals

Inequality increases the fraction of society for which investment in human capital is suboptimal

\[ \Rightarrow \]  reduces human capital accumulation

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A Unified Theory of Inequality and Development

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Places the dominating modern theories within a broader unified structure

Provides an intertemporal reconciliation between the Classical viewpoint and the Modern perspective
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Main Hypothesis

The replacement of physical capital accumulation by human capital accumulation as a prime engine of economic growth has changed the qualitative impact of inequality on the process of development.

Early stages of industrialization: physical capital accumulation is a main engine of growth ⇒ Inequality enhanced development by channeling resources towards individuals whose marginal propensity to save is higher.

Later stages of development: the return to human capital increases due to capital-skill complementarity and human capital became the prime engine of growth ⇒ Inequality, due to credit constraints, is harmful for growth.

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Central Argument

Fundamental asymmetry between:

- Human capital accumulation
- Physical capital accumulation
Central Argument

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Human Capital vs. Physical Capital Accumulation

Human capital is embodied in humans, leading to diminishing returns at the individual level. The accumulation of human capital would be larger if it were widely distributed among individuals in society.

Physical capital is not embodied in humans. Physical capital accumulation may benefit from the concentration of wealth among individuals whose marginal propensity to save is larger.
Human Capital vs. Physical Capital Accumulation

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Inequality and Growth
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A Unified Theory

Central Argument

Inequality and Physical and Human Capital Accumulation

Inequality is conducive for physical capital accumulation, as long as the marginal propensity to save rises with income.

Inequality is harmful for human capital accumulation, as long as credit constraints are binding.

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Inequality and Growth
Inequality and Physical and Human Capital Accumulation

- **Inequality** is conducive for **physical capital** accumulation, as long as the marginal propensity to save rises with income.
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Inequality and Growth in Different Stages of Development

Inequality stimulates economic growth in stages of development in which physical capital accumulation is the prime engine of growth.

Inequality is harmful for economic growth in stages of development in which human capital accumulation is the prime engine of economic growth and credit constraints are still binding.
Inequality and Growth in Different Stages of Development

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Early Stages of Industrialization

Labor (and thus human capital) is abundant and physical capital is scarce. The return to physical capital is higher than the return to human capital. Physical capital accumulation is the main engine of growth. 

$\Rightarrow$ Inequality is conducive for growth.
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⇒ Inequality is conducive for growth
Later Stages of Development

Physical capital accumulation complements human capital. The return to human capital increases sufficiently so as to induce human capital accumulation (Nelson and Phelps (1966), Shultz (1975), Foster and Rosenzweig (1996)).

Investment in human capital is sub-optimal due to CMI. The return to human capital is higher than on physical capital.

Human capital accumulation is the main engine of growth.

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Inequality and Growth
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⇒ Inequality is harmful for growth
Reconciliation: The Classical and Modern Approaches

A positive effect of inequality on growth underlined by the Classical Approach reflects early stages of industrialization when physical capital accumulation was the prime engine of growth.

A negative effect of inequality on growth underlined by the Modern Approach reflects later stages of development when human capital accumulation becomes a prime engine of growth, and credit constraints are still binding.
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The Basic Structure of the Model

- Overlapping-Generations economy
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- $t = 0, 1, 2, 3, ...$
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The Basic Structure of the Model

- Overlapping-Generations economy
- \( t = 0, 1, 2, 3, \ldots \)
- One good
- Two factors:
  - Physical capital (PC)
  - Human Capital (HC)
Output per-capita grows over time due to the accumulation of factors of production.
The Basic Structure of the Model

- Output per-capita grows over time due to the accumulation of factors of production.
- The stock of physical capital: Output produced in the preceding period net of consumption and HC investment.
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- Output per-capita grows over time due to the accumulation of factors of production.

- The stock of physical capital: Output produced in the preceding period net of consumption and HC investment.

- The level of HC: Outcome of education decisions, subject to borrowing constraint.
Production of Final Output

The output produced at time $t$:

$$Y_t = F(K_t, H_t) \equiv H_t f(k_t)$$
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$K_t$ - PC
Production of Final Output

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$K_t$ - PC

$H_t$ - HC (efficiency units)
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$K_t$ - PC

$H_t$ - HC (efficiency units)

$k_t \equiv K_t / H_t$
Factor Prices

Inverse demand for factors of production at time $t$

\[ r_t = f'(k_t) \equiv r(k_t) \]

\[ w_t = f(k_t) - f'(k_t)k_t \equiv w(k_t) \]
The Model

Individuals

Individuals have 1 parent and 1 child

Identical in:
Preferences
Innate abilities

Differ in:
Parental income
⇒ Inv't in HC

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Inequality and Growth
Individuals

- Continuum of measure 1
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Individuais of Generation $t$
Individuals of Generation $t$

- First period of life (Period $t$):
  - Human capital formation

Second period of life (Period $t+1$):
- Supply their efficiency units of labor
- Allocate income & inheritance between:
  - (a) Consumption
  - (b) Transfers to children
- Transfers are allocated to:
  - Finance of offspring's education
  - Saving for offspring's future wealth
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Individual i of Generation t: Wealth

Second period wealth:

\[ l_{t+1}^i = w_{t+1}h_{t+1}^i + x_{t+1}^i \]
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\[ w_{t+1} \text{ – wage} \]
Individual i of Generation t: Wealth

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- \( w_{t+1} \) — wage
- \( h_{t+1}^i \) — efficiency units of labor
Individual i of Generation t: Wealth

Second period wealth:

\[ l^i_{t+1} = w_{t+1} h^i_{t+1} + x^i_{t+1} \]

\( w_{t+1} \) – wage

\( h^i_{t+1} \) – efficiency units of labor

\( x^i_{t+1} \) – inheritance
Individual $i$ of Generation $t$: Budget Constraint

Second Period budget constraint:

$$c_{t+1}^i + b_{t+1}^i \leq l_{t+1}^i$$
Individual i of Generation t: Budget Constraint

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\[ c_{t+1}^i + b_{t+1}^i \leq l_{t+1}^i \]

\[ c_{t+1}^i \] — consumption
Individual i of Generation t: Budget Constraint

Second Period budget constraint:

\[ c^i_{t+1} + b^i_{t+1} \leq l^i_{t+1} \]

\[ c^i_{t+1} \] — consumption

\[ b^i_{t+1} \] — transfers to the offspring
Individual i of Generation t: Intergenerational Transfers

Transfer to offspring, $b_{t+1}^i$, is allocated between:

- Finance of offspring’s education - $e_{t+1}^i$
- Saving for offspring’s future wealth - $s_{t+1}^i$
Individual i of Generation t: Intergenerational Transfers

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Inheritance $x_{t+1}^i = s_{t+1}^i = R_{t+1} = (b_{t}^i - e_{t}^i) R_{t+1}$
Individual i of Generation t: Intergenerational Transfers

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Individual i of Generation t: Intergenerational Transfers

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- Finance of offspring’s education - $e_{t+1}^i$
- Saving for offspring’s future wealth
  \[ s_{t+1}^i = b_{t+1}^i - e_{t+1}^i \]
- Inheritance
  \[ x_{t+1}^i = s_t^i R_{t+1} = (b_t^i - e_t^i) R_{t+1} \]
Individual i of Generation t: Human capital formation

Efficiency units of labor in period $t + 1$

$$h^i_{t+1} = h(e^i_t)$$
Individual i of Generation t: Human capital formation

Efficiency units of labor in period $t + 1$

$$h_{t+1}^i = h(e_t^i)$$

$e_t^i$ — expenditure on education
Individual i of Generation t: Human capital formation

\[ h(e_t) \]

\[ e_t \]

\[ h_{t+1} \]
Optimal Inv’t in Education of Member i of Generation t

In the absence of borrowing constraints:

$$e_t^i = \arg \max [w_{t+1} h(e_t^i) + (b_t^i - e_t^i) R_{t+1}]$$
Optimal Inv’t in Education of Member i of Generation t

In the absence of borrowing constraints:

\[ e_t^i = \arg \max \left[ w_{t+1} h(e_t^i) + (b_t^i - e_t^i) R_{t+1} \right] \]

\( e_t \) is unique and identical across members of generation \( t \).
Optimal Inv’t in Education of Member $i$ of Generation $t$

\[ e_t > 0 \quad \text{if} \quad w_{t+1} h'(e_t) = R_{t+1} \]
The Model

Individuals

Optimal Inv’t in Education of Member i of Generation t

\[ e_t = 0 \quad \text{if} \quad R_{t+1} > w_{t+1} h'(0) \]
Optimal Inv’t in Education of Member i of Generation t
Optimal Inv’t in Education of Member i of Generation t

\[ e_t = e(k_{t+1}) \left\{ \begin{array}{ll}
= 0 & \text{if } k_{t+1} \leq \tilde{k} \\
> 0 & \text{if } k_{t+1} > \tilde{k}
\end{array} \right. \]
Optimal Inv’t in Education of Member i of Generation t

\[ e_t = e(k_{t+1}) \begin{cases} 
= 0 & \text{if } k_{t+1} \leq \tilde{k} \\
> 0 & \text{if } k_{t+1} > \tilde{k} 
\end{cases} \]

where

\[ e'(k_{t+1}) > 0 \quad \text{if} \quad k_{t+1} > \tilde{k} \]
Borrowing Constraint of Member i of Generation t

Individuals cannot borrow to finance the education expenditure of their offspring:
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\[ e_t^i = \min[e(k_{t+1}), b_t^i] \]
Preferences and Transfers of Member $i$ of Generation $t$

- **Preferences:**

$$u_t^i = (1 - \beta) \log c_{t+1}^i + \beta \log (\bar{\theta} + b_{t+1}^i)$$
Preferences and Transfers of Member $i$ of Generation $t$

- **Preferences:**
  \[ u_t^i = (1 - \beta) \log c_{t+1}^i + \beta \log (\bar{\theta} + b_{t+1}^i) \]

- **Optimal transfer to offspring:**
  \[ b_{t+1}^i = b(l_{t+1}^i) \equiv \begin{cases} 
  \beta(l_{t+1}^i - \theta) & \text{if} \quad l_{t+1}^i \geq \theta \\
  0 & \text{if} \quad l_{t+1}^i \leq \theta 
\end{cases} \]

where $\theta \equiv \bar{\theta}(1 - \beta) / \beta$
Optimal transfer of a member \( i \) of generation \( t \)
Saving of Member $i$ of Generation $t$

\[ s^i_t = \begin{cases} 
    b^i_t & \text{if } k_{t+1} \leq \tilde{k} \\
    b^i_t - e^i_t & \text{if } k_{t+1} > \tilde{k}
\end{cases} \]
Saving of Member $i$ of Generation $t$

$$s^i_t = \begin{cases} 
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\end{cases}$$

Saving rate $s^i_{t+1} / l^i_{t+1}$ is increasing in $l^i_{t+1}$
The economy consists of two groups in period 0:
Initial Wealth Distribution

The economy consists of two groups in period 0:

- Capitalists (R)
  - Fraction $\lambda$ of all adult individuals

- Workers (P)
  - No ownership over the initial capital stock
Initial Wealth Distribution

The economy consists of two groups in period 0:

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The economy consists of two groups in period 0:

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The economy consists of two groups in period 0:

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- **Workers (P)**
  - Fraction $1 - \lambda$ of all adult individuals
  - No ownership over the *initial* capital stock
Factor Accumulation

\[ K_{t+1} = \int_0^1 s_t \, di = \lambda (b_t^R - e_t^R) + (1 - \lambda)(b_t^P - e_t^P) \]

\[ = \quad K(b_t^R, b_t^P, k_{t+1}) \]

\[ H_{t+1} = \int_0^1 h_t^i \, di = \lambda h(e_t^R) + (1 - \lambda)h(e_t^P) \]

\[ = \quad H(b_t^R, b_t^P, k_{t+1}) \]
The Capital-Labor Ratio

\[ k_{t+1} = \frac{K_{t+1}}{H_{t+1}} = \frac{K(b_t^R, b_t^P, k_{t+1})}{H(b_t^R, b_t^P, k_{t+1})} \]

\[ \implies k_{t+1} = \kappa(b_t^R, b_t^P) \]
The Evolution of Transfers within group $i = R, P$

$$b^i_{t+1} = \max\{\beta[w_{t+1}h(e^i_t) + (b^i_t - e^i_t)R_{t+1} - \theta], 0\}$$
The Evolution of Transfers within group $i = R,P$

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$$\Rightarrow$$

$$b^i_{t+1} = \phi(b^i_t, k_{t+1})$$
The Evolution of Transfers within group $i = R,P$

\[ b_{t+1}^i = \max\{\beta[w_{t+1}h(e_t^i) + (b_t^i - e_t^i)R_{t+1} - \theta], 0\} \]

\[ \implies b_{t+1}^i = \phi(b_t^i, k_{t+1}) \]

There exists $\hat{k}$, a critical level of $k$ below which individuals who do not receive parental transfers (i.e., $b_t^i = e_t^i = 0$) do not transfer income to their offspring: $w(\hat{k}) = \theta$
The Evolution of Transfers within group $i = \text{R,P}$

\[
b^i_{t+1} = \max\{\beta[w_{t+1}h(e^i_t) + (b^i_t - e^i_t)R_{t+1} - \theta], 0\}
\]

\[\Rightarrow\]

\[
b^i_{t+1} = \phi(b^i_t, k_{t+1})
\]

There exists $\hat{k}$, a critical level of $k$ below which individuals who do not receive parental transfers (i.e., $b^i_t = e^i_t = 0$) do not transfer income to their offspring: $w(\hat{k}) = \theta$

\[
b^i_{t+1} = \phi(0, k_{t+1}) \begin{cases} 
= 0 & \text{if } k_{t+1} \leq \hat{k} \\
> 0 & \text{if } k_{t+1} > \hat{k}
\end{cases}
\]
The Evolution of Transfers within Group $i = R, P$

\[
 b^i_{t+1} = \phi(b^i_t, k_{t+1}) = \phi(b^i_t, \kappa(b^R_t, b^P_t)) = \psi^i(b^R_t, b^P_t)
\]
The dynamical system

\( \{ b_t^P, b_t^R \}_{t=0}^{\infty} \) such that:
The dynamical system

\[ \{ b^P_t, b^R_t \}_{t=0}^{\infty} \quad \text{such that:} \]

\[ b^{P}_{t+1} = \psi^P(b^R_t, b^P_t) \]

\[ b^{R}_{t+1} = \psi^R(b^R_t, b^P_t) \]
Regime I: PC Accumulation \((k \leq \tilde{k})\)
The Process of Development

- Regime I: PC Accumulation \((k \leq \tilde{k})\)
- Regime II: HC Accumulation \((k > \tilde{k})\)
The Process of Development

- Regime I: PC Accumulation ($k \leq \tilde{k}$)
- Regime II: HC Accumulation ($k > \tilde{k}$)
  - Stage I of Regime II ($\tilde{K} < K \leq \hat{K}$)
The Process of Development

- **Regime I**: PC Accumulation \((k \leq \tilde{k})\)
- **Regime II**: HC Accumulation \((k > \tilde{k})\)
  - Stage I of Regime II \((\tilde{K} < K \leq \hat{K})\)
  - Stage II of Regime II \((\hat{K} < K < K^*)\)
The Process of Development

- **Regime I:** PC Accumulation \((k \leq \tilde{k})\)
- **Regime II:** HC Accumulation \((k > \tilde{k})\)
  - Stage I of Regime II \((\tilde{K} < K \leq \hat{K})\)
  - Stage II of Regime II \((\hat{K} < K < K^*)\)
  - Stage III of Regime II \((K > K^*)\)
Regime I: Physical Capital Accumulation

Early stages of development \((k \leq \tilde{k})\)
Regime I: Physical Capital Accumulation

Early stages of development \((k \leq \tilde{k})\)

- \(K\) is the main engine of growth: \(\rho^{HC} < \rho^K\)
Regime I: Physical Capital Accumulation

Early stages of development \((k \leq \tilde{k})\)

- \(K\) is the main engine of growth: \(\rho^{HC} < \rho^K\)
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- Transfers within Group \(R\) ↑
- Wages ↑
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Early stages of development \((k \leq \tilde{k})\)

- \(K\) is the main engine of growth: \(\rho^{HC} < \rho^K\)
- No investment in education
- No Transfers within Group \(P\)
- Transfers within Group \(R\) ↑
- Wages ↑
- Income inequality ↑
Inequality and Development

The Process of Development

The Conditional Dynamical System: Regime I

\[ \phi(b_i^t; k) \]

Poverty Trap

Group \( P \)

Group \( R \)

\[ b_{i+1} \]

Galor-Moav

Inequality and Growth
Regime I: Effect of Inequality

Inequality enhances the process development
Regime I: Effect of Inequality

Inequality enhances the process development

- A transfer of wealth from Group R to P $\Rightarrow$
Regime I: Effect of Inequality

Inequality enhances the process development

- A transfer of wealth from Group R to P $\Rightarrow$
  - Aggregate consumption $\uparrow$
Regime I: Effect of Inequality

Inequality enhances the process development

- A transfer of wealth from Group R to P $\implies$
  - Aggregate consumption $\uparrow$
  - Aggregate intergenerational transfers $\downarrow$
Regime I: Effect of Inequality

Inequality enhances the process development

- A transfer of wealth from Group R to P \(\Rightarrow\)
  - Aggregate consumption \(\uparrow\)
  - Aggregate intergenerational transfers \(\downarrow\)
  - Rate of capital accumulation \(\downarrow\)
Regime II: Human Capital Accumulation

Mature stages of development: \((k > \tilde{k})\)
Regime II: Human Capital Accumulation

Mature stages of development: \((k > \tilde{k})\)

- HC is the engine of growth: \(\rho_{HC} \geq \rho^K\)
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \((\tilde{K} < K \leq \hat{K})\)
Stage I of Regime II: HC Accumulation by group $R$

Stage I of Regime II ($\tilde{K} < K \leq \hat{K}$)

- Members of group $P$
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \((\hat{K} < K \leq \hat{K})\)

- Members of group \(P\)
  - No intergenerational transfers
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \((\tilde{K} < K \leq \hat{K})\)

- Members of group \(P\)
  - No intergenerational transfers
  - No investment in education
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \((\tilde{K} < K \leq \hat{K})\)

- Members of group \(P\)
  - No intergenerational transfers
  - No investment in education

- Members of group \(R\)
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \( (\tilde{K} < K \leq \hat{K}) \)

- Members of group \( P \)
  - No intergenerational transfers
  - No investment in education

- Members of group \( R \)
  - Transfers ↑
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II ($\tilde{K} < K \leq \hat{K}$)

- Members of group $P$
  - No intergenerational transfers
  - No investment in education

- Members of group $R$
  - Transfers $\uparrow$
  - Expenditure on education $\uparrow$
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II ($\tilde{K} < K \leq \hat{K}$)

- Members of group $P$
  - No intergenerational transfers
  - No investment in education

- Members of group $R$
  - Transfers $\uparrow$
  - Expenditure on education $\uparrow$

- Wages $\uparrow$
Stage I of Regime II: HC Accumulation by group R

Stage I of Regime II \( (\tilde{K} < K \leq \hat{K}) \)

- Members of group \( P \)
  - No intergenerational transfers
  - No investment in education

- Members of group \( R \)
  - Transfers ↑
  - Expenditure on education ↑

- Wages ↑

- Income inequality ↑
The Conditional Dynamical System: Stage I of Regime II
Stage II of Regime II: HC Accumulation by the Poor

Stage II of Regime II ($\hat{K} < K < K^*$)
Stage II of Regime II: HC Accumulation by the Poor

Stage II of Regime II ($\hat{K} < K < K^*$)

- Members of group $P$ (credit constrained): $\rho^{HC} > \rho^K$
Stage II of Regime II (\( \hat{K} < K < K^* \))

- Members of group \( P \) (credit constrained): \( \rho^{HC} > \rho^K \)
  - Start to transfers
Stage II of Regime II: HC Accumulation by the Poor

Stage II of Regime II ($\hat{K} < K < K^*$)

- Members of group $P$ (credit constrained): $\rho^{HC} > \rho^K$
  - Start to transfers
  - Start to acquire education
Stage II of Regime II: HC Accumulation by the Poor

Stage II of Regime II ($\hat{K} < K < K^*$)

- Members of group $P$ (credit constrained): $\rho^{HC} > \rho^K$
  - Start to transfers
  - Start to acquire education

- Members of group $R$ (not credit constrained): $\rho^{HC} = \rho^K$
Stage II of Regime II (\( \hat{K} < K < K^* \))

- Members of group \( P \) (credit constrained): \( \rho^{HC} > \rho^K \)
  - Start to transfers
  - Start to acquire education

- Members of group \( R \) (not credit constrained): \( \rho^{HC} = \rho^K \)
  - Invest optimally in human and physical capital
Conditional Dynamical System: Stage II-III of Regime II
Stage II of Regime II: Effect of Inequality

- More equality is beneficial for the process development
Stage II of Regime II: Effect of Inequality

- More equality is beneficial for the process development
  - A transfer of wealth from group $R$ to group $P$ allows (due to credit constraint) a more efficient allocation of aggregate investment between HC and PC
Stage III of Regime II: Credit Constraints are not Binding

- All individuals are not credit constrained: $R^{HC} = R^K$
Stage III of Regime II: Credit Constraints are not Binding

- All individuals are not credit constrained: $R^{HC} = R^K$
- Inequality has no effect on the process of development
The changing Role of Inequality in the Development Process

Regime I

\[ \rho^K > \rho^H \]

K only engine

Inequality (+)

Regime II

\[ \rho^K \leq \rho^H \]

HC main engine

Inequality (-)
Effect of Inequality in Regime II

<table>
<thead>
<tr>
<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho^K &lt; \rho^H_P$</td>
<td>$\rho^K &lt; \rho^H_P$</td>
<td>$\rho^K = \rho^H$</td>
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<tr>
<td>$\rho^K = \rho^H_R$</td>
<td>$\rho^K = \rho^H_R$</td>
<td></td>
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<tr>
<td>2 engines</td>
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<td></td>
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</tbody>
</table>
Testable Implications

The effect on inequality depends on the country's level of income. Inequality is beneficial for poor economies and harmful for rich ones.

The Unified Approach

The effect of inequality on growth depends on the relative return to human and physical capital. The higher is the relative return to human capital the more harmful is inequality for economic growth.
Testable Implications

The CMI approach

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Implications for DC and LDCs

The replacement of physical capital accumulation by human capital accumulation as a prime engine of economic growth has changed the impact of inequality on the process of development. Inequality stimulates economic growth in stages of development in which physical capital accumulation is the prime engine of growth. Inequality is harmful for economic growth in stages of development in which human capital accumulation is the prime engine of growth. Int’l capital inflow to LDCs and the adoption of skilled-biased technologies may place economies directly in the second stage in which inequality is harmful.
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References

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