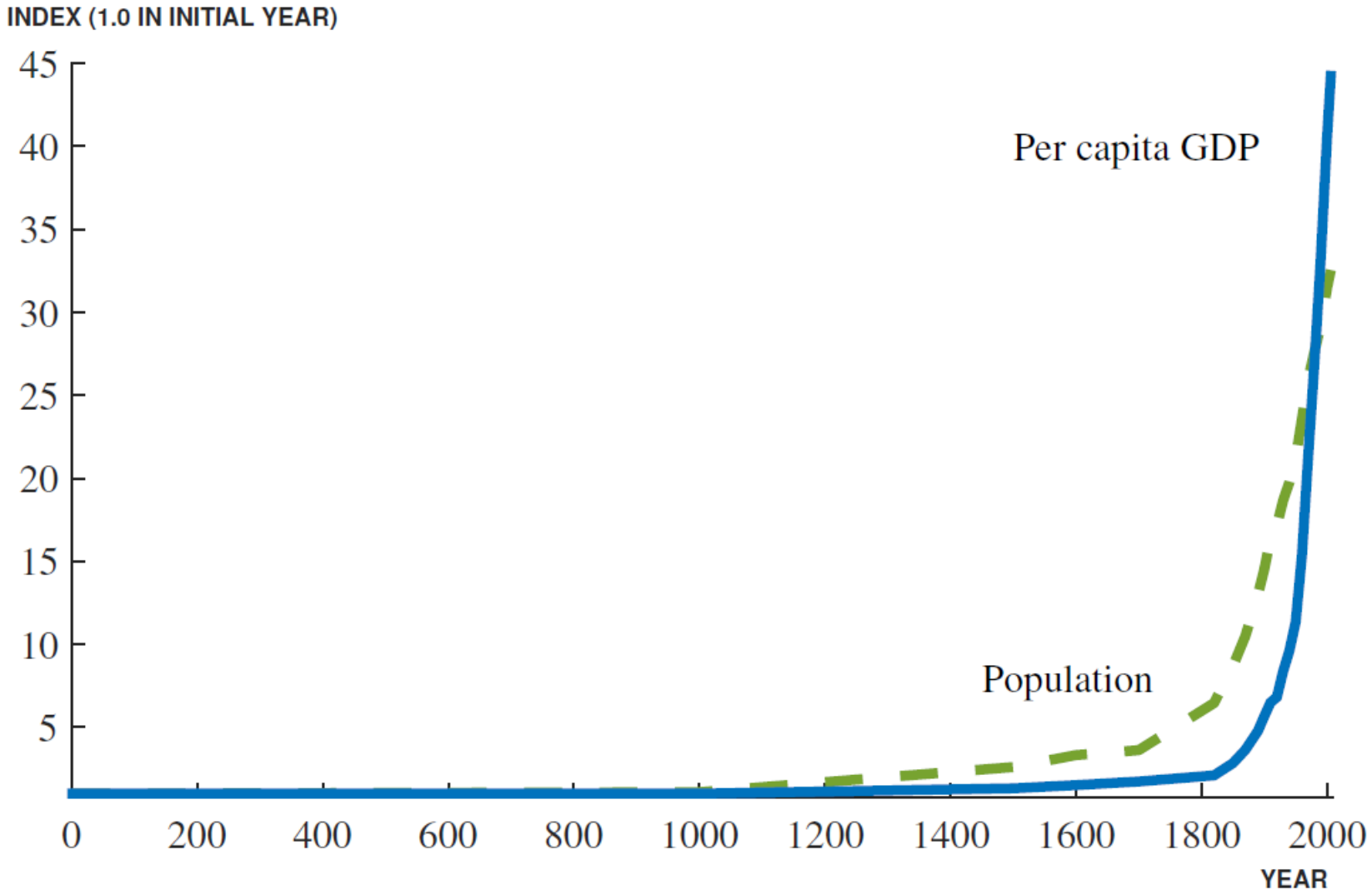
Major Issues in Growth and Development

Ping Wang
Department of Economics
Washington University in St. Louis

March 2024

- **What drives sustained growth and development especially since 1800:**

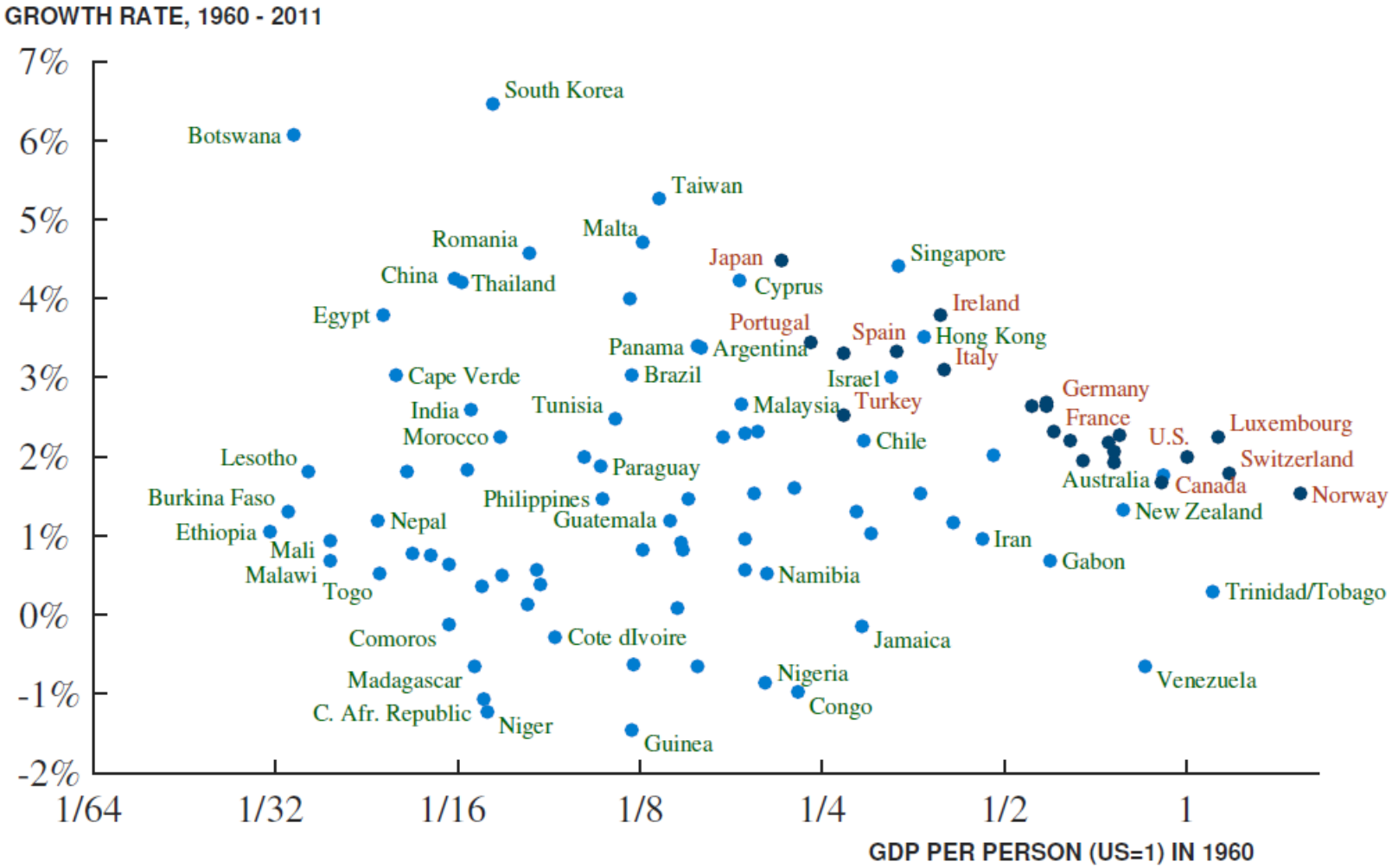


Very Long-Run Growth of the West (Jones 2015 using Maddison 2008)

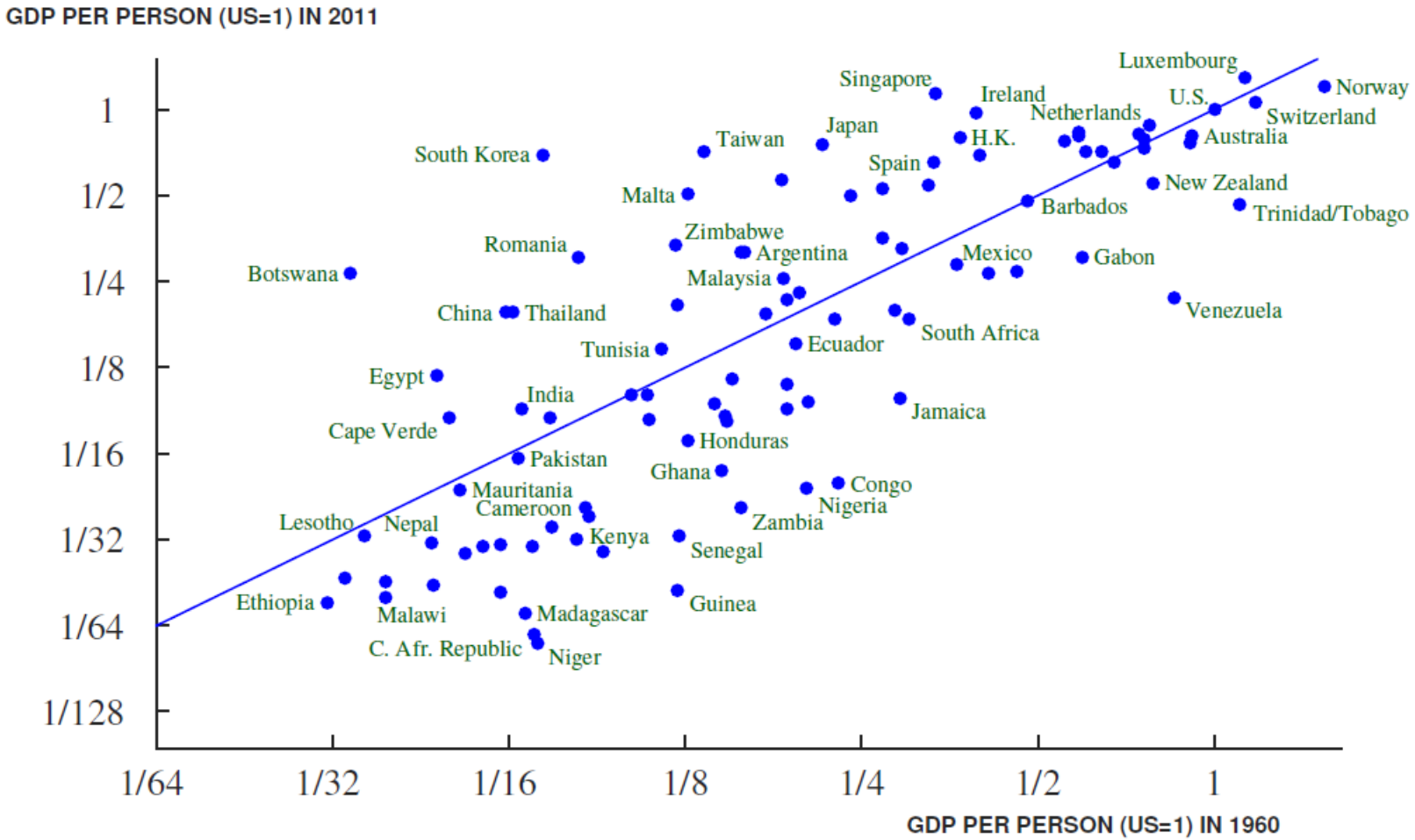
Year	GDP per person	Growth rate	Population (millions)	Growth rate
1	590	...	19	...
1000	420	-0.03	21	0.01
1500	780	0.12	50	0.17
1820	1,240	0.15	125	0.28
1900	3,350	1.24	280	1.01
2006	26,200	1.94	627	0.76

- **Why have many countries taken off but some remained stagnated?**

Nonconvergence of Poor Countries (Jones 2015; PWT 8.0)



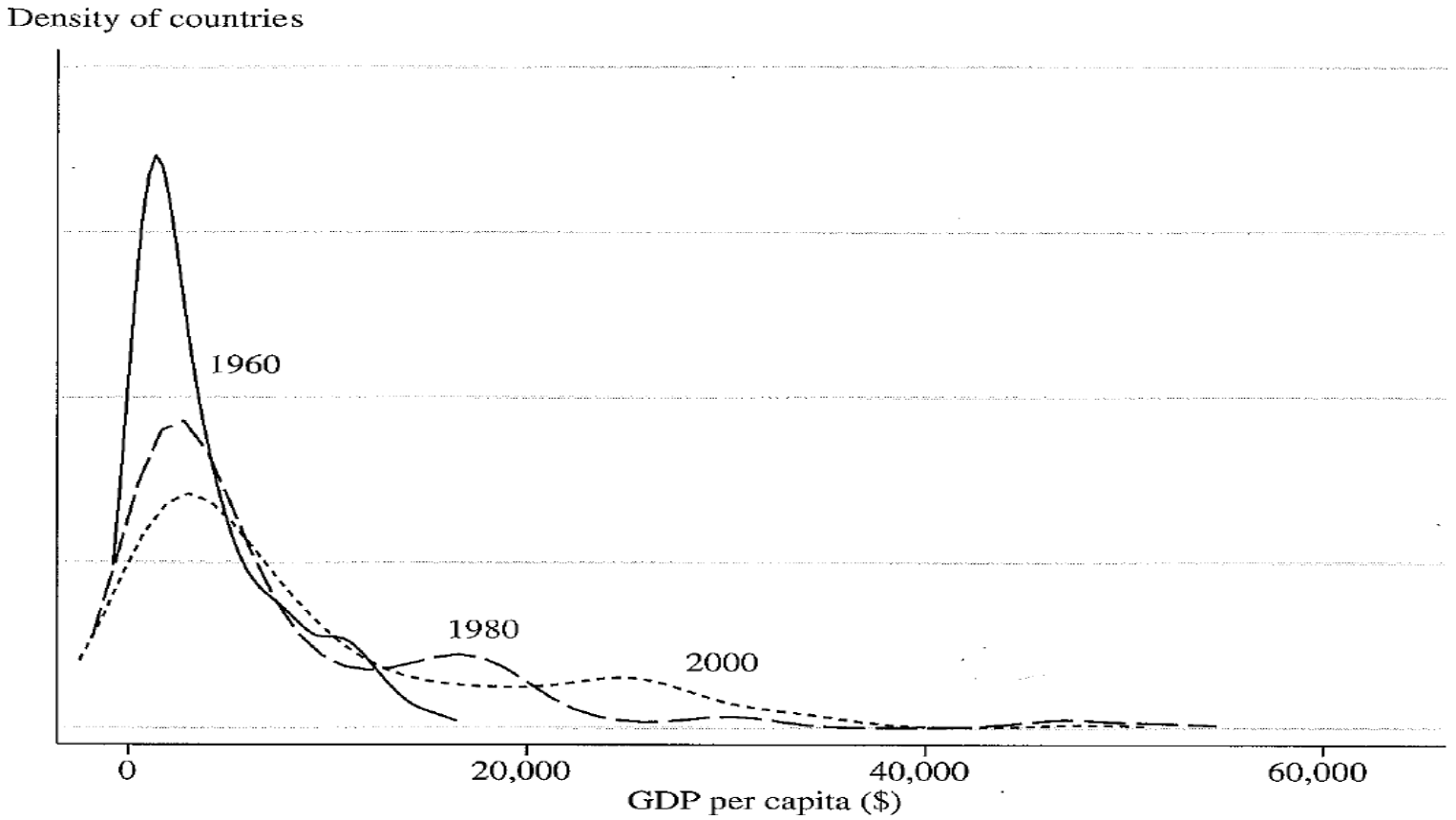
World Income Mobility (Jones 2015; PWT 8.0)



- **What drives upward mobility in development miracles?**

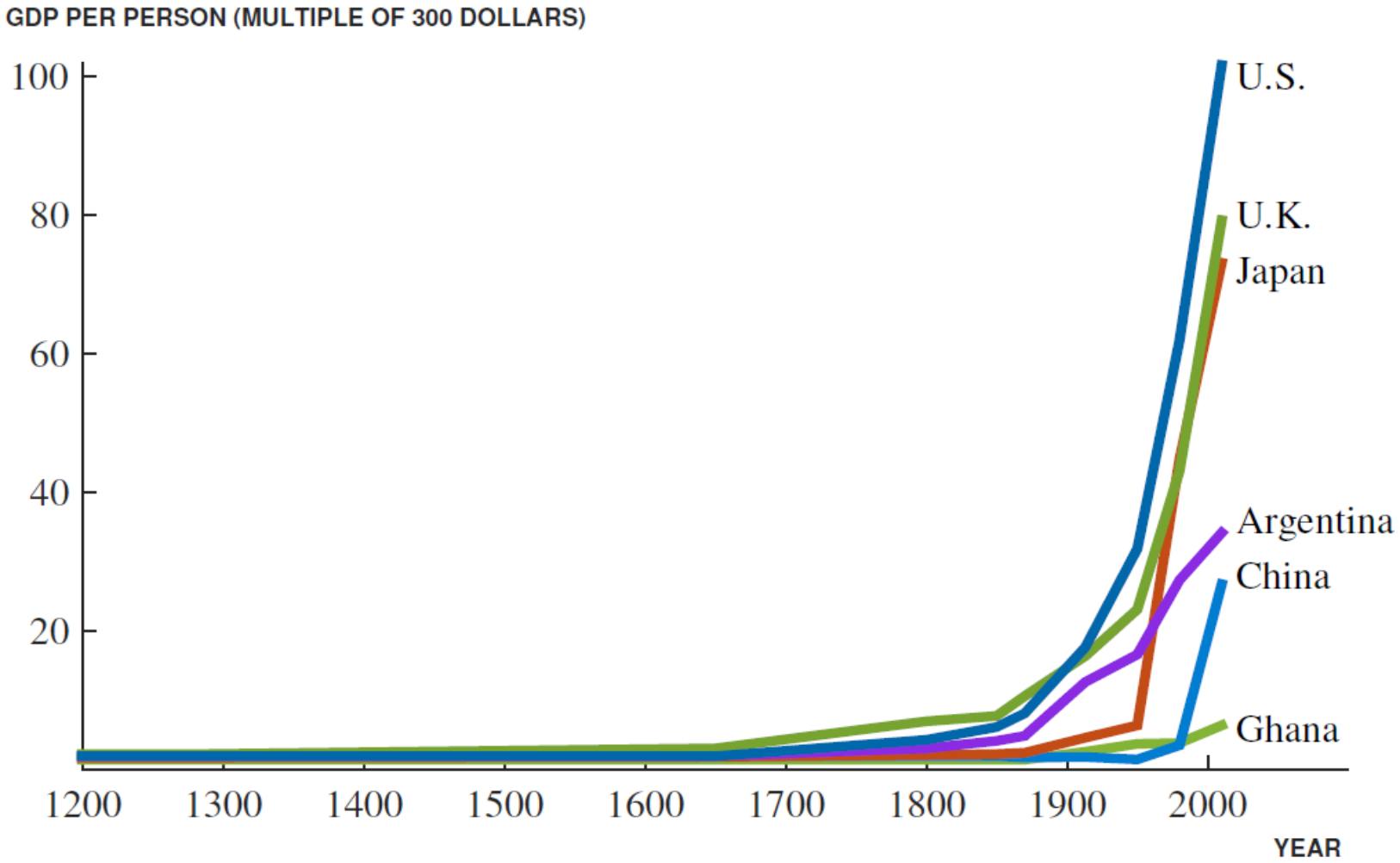
- **Why have cross-country income disparities (and TFP gaps) widened?**

Changes in World Income Distribution (Acemoglu 2009)



- **What drives widened world income disperities?**

Great Divergence (Jones 2015)



- **What leads to great divergence between poor economics and advanced/newly industrialized countries?**

- **Growth accounting:**
  - **TFP gap:** $$\frac{(Y/L)_i}{(Y/L)_{US}} = \frac{A_i}{A_{US}}\left[\frac{(K/L)_i}{(K/L)_{US}}\right]^{\alpha}\left[\frac{H_i}{H_{US}}\right]^{1-\alpha}$$
  - **It requires a TFP gap of 40-95 times which is viewed implausible particularly with technology adoption, spillovers and assimilation**

	GDP per worker, y	Capital/GDP $(K/Y)^{\alpha/(1-\alpha)}$	Human capital, h	TFP	Share due to TFP
U.S.	1.000	1.000	1.000	1.000	...
Hong Kong	0.854	1.086	0.833	0.944	48.9%
Singapore	0.845	1.105	0.764	1.001	45.8%
France	0.790	1.184	0.840	0.795	55.6%
Germany	0.740	1.078	0.918	0.748	57.0%
U.K.	0.733	1.015	0.780	0.925	46.1%
Japan	0.683	1.218	0.903	0.620	63.9%
South Korea	0.598	1.146	0.925	0.564	65.3%
Argentina	0.376	1.109	0.779	0.435	66.5%
Mexico	0.338	0.931	0.760	0.477	59.7%
Botswana	0.236	1.034	0.786	0.291	73.7%
South Africa	0.225	0.877	0.731	0.351	64.6%
Brazil	0.183	1.084	0.676	0.250	74.5%
Thailand	0.154	1.125	0.667	0.206	78.5%
China	0.136	1.137	0.713	0.168	82.9%
Indonesia	0.096	1.014	0.575	0.165	77.9%
India	0.096	0.827	0.533	0.217	67.0%
Kenya	0.037	0.819	0.618	0.073	87.3%
Malawi	0.021	1.107	0.507	0.038	93.6%
Average	0.212	0.979	0.705	0.307	63.8%

- **What are the possible factors to narrow the TFP gap?**
  - **Measurement problem:**
    - **Capital barriers: Buera-Shin (2013)**
    - **Education quality: Schoellman (2012), Cubas-Ravikumar-Ventura (2014)**
  - **Missing inputs:**
    - **Intangible capital: ideas (Romer 1993) and organizational capital (Lucus 1978, Prescott-Visscher 1980)**
    - **Health: health capital (Acemoglu-Johnson 2007, Weil 2007, Y. Wang 2013), health barriers (Wang-Wang 2014) and health productivity (Ravikumar-Wang-Wang 2016)**
  - **Sectoral disparity:**
    - **Agricultural disparities (Colin et al 2012, Lagakos-Waugh 2013, Adamopoulos-Restuccia 2014, Lai 2014)**
    - **Service accounting and the cost disease (Baumol 1985, Young 2014, Liao 2014)**
  - **Country-specific technology assimilation (Wang-Wong-Yip 2016)**
  - **Endogenous technology choices:**
    - **Human capital technology choice (Hu-Kunieda-Nishimura-Wang 2022)**
    - **FDI technology choice (Hu-Kunieda-Nishimura-Wang 2023)**

The Schumpeterian Theory of Growth and Development

Ping Wang
Department of Economics
Washington University in St. Louis

March 2023

A. Introduction

Technological under-achievement is a major barrier to economic development. A more thorough study of technology advancement and its influence on output growth will enable us to understand not only the long-run determinants of sustained growth, but also the short-run costs of industrialization during the process of creative destruction.

Recent studies of R&D and technological choice consider imperfect market structures that permit rents for invention (Shell 1966):

- **Monopolistic Competition: Grossman-Helpman (1991), Romer (1990), Peng-Thisse-Wang (2003)**
- **Monopoly: Aghion-Howitt (1992), *Thesmar-Thoenig (2000),* Aghion (2002)**

However, in addition to R&D, technology transfer, including both imitation and adoption, may also play crucial roles, particularly in developing countries. Since the development stage matters, the distance-to-frontier is important as well, as discussed in Acemoglu-Aghion-Zilibotti (2006) and Wang (2014).

B. Causes of Technological Advancements

- **Innovation: Aghion-Howitt (1992), Grossman-Helpman (1991) and Stokey (1995) all focus on successful innovation from R&D as the main driving force for advancing technology**

- **Imitation: Rustichini-Schmitz (1991) emphasizes that imitation plays an important role particularly to less-developed countries – in their model, the optimal policy is to subsidize equally imitation and innovation**

- **Technology adoption: for countries with lower level of R&D, technology may be adopted rather than invented, but adoption may have barriers caused by:**
  1. **adoption inefficiency: Parente-Prescott (1994)**
  2. **incumbent blocks: Parente-Prescott (1999)**
  3. **match frictions: Chen-Mo-Wang (2002), Laing-Palivos-Wang (2002)**

- **Should we subsidize R&D and other technology-advancing activities? Boldrin-Levine (2004) provide strong arguments against such subsidies by stressing that competitive markets may work**

- **How would innovation-led creative destruction affect growth and welfare? In *Aghion-Akcigit-Deaton-Roulet (2016)*, a simple model is built and tested**

C. Organizational Choice: Thesmar-Thoenig (2002)

- March-Simon (1958)- organization theory
- Williamson (1975)- transaction cost
- Piore-Sable (1984), Chandler (1990)-firm organization trade-offs (efficiency vs. adaptability/ scale vs. scope)
- Becker-Murphy (1992)- coordination vs. division of labor
- Galor-Moar (2000)- skill, know-how and adaptability
- Aghion-Tirole (1994 QJE, 1997 JPE)- management of innovation, real vs. formal authority

(i) Key

a. Organization choice + Aghion-Howitt (1992)

b. Two forms of organization:

(1) mechanistic: high fixed cost, high SR productivity, low LR productivity

(2) organistic: no fixed cost, low SR productivity, high LR productivity

(ii)The model

a. Preference and Consumption Demand

$$U_t = \int_t^{\infty} \ln(C_s) e^{-\rho(s-t)} ds$$

$\Rightarrow$ **expenditure:** $\dot{E}_t / E_t = r_t - \rho = 0 \ (E_t \equiv 1 \ \forall \ t)$

consumption aggregator: $\ln(C_t) = \int_0^1 \ln(\gamma^{n(i)} c_t(i)) di$

where $n(i) =$ **# of innovations by *i* with size γ >1**

b. Sectoral demand: $x_t(i) = 1 / P_t(i)$ **(log preference)**

c. Research innovation: $\lambda = R / b$, ***b*= unit research labor requirement**

d. Sectoral production, unit cost and limiting pricing (Bertrand):

$$y = \mathrm{A} h^{\alpha} u^{1-\alpha}, \ uc_{\mathrm{t}} = \frac{1}{\mathrm{A}_t} \left(\frac{w_h}{\alpha}\right)^{\alpha} \left(\frac{w_u}{1-\alpha}\right)^{1-\alpha}, \ P_t = \gamma \cdot uc_{t-1}$$

e. Organizational choice

IRS: high fixed cost, high SR productivity $\overline{A}$, low LR productivity
CRS: low fixed cost, low SR productivity $\underline{A}$, high LR productivity

(1) new entrant's flow profit:

$$\pi_t = (P_t - uc_t)x_t = (\gamma \cdot uc_{t-1} - uc_t)x_t = 1 - A_{t-1} / (\gamma A_t)$$

(2) new entrant's expected value:

$$V(A) = \int_0^\infty \int_0^t \lambda e^{-\lambda\tau} \pi e^{-r\tau} d\tau dt - K(A) = \frac{\lambda\pi}{\lambda + r} - K(A) = \frac{\lambda}{\lambda + r}[1 - A_{t-1} / (\gamma A_t)] - K(A)$$

where $K(\overline{A}) = K$, $K(\underline{A}) = 0$

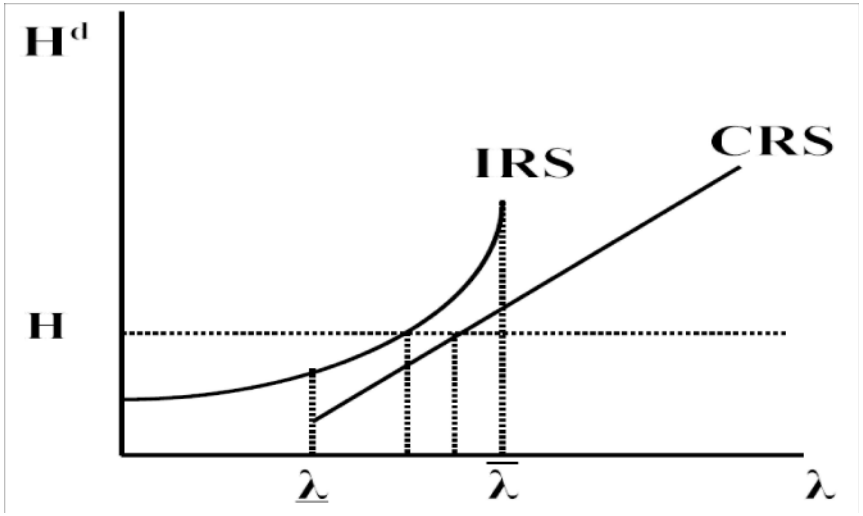
(what reported in the paper is the *ex post* value, which is irrelevant)

(3) entrant's organization decision (derived based on incorrect ex post value):

$$\mathrm{A}(\mathrm{A}_{-1},\lambda)=\begin{cases}\underline{\mathrm{A}} & \text{if } \lambda>\lambda_C\equiv\dfrac{(\overline{\mathrm{A}}-\underline{\mathrm{A}})A_{-1}}{\gamma K\overline{\mathrm{A}}\underline{\mathrm{A}}}-r \quad (CRS)\\ \overline{\mathrm{A}} & \text{if } \lambda<\lambda_C\equiv\dfrac{(\overline{\mathrm{A}}-\underline{\mathrm{A}})A_{-1}}{\gamma K\overline{\mathrm{A}}\underline{\mathrm{A}}}-r \quad (IRS)\end{cases}$$

$\lambda\uparrow$ $\Rightarrow$ **creative destruction (if direct effect small, which never holds true mathematically)**

$\Rightarrow$ **no incentive to pay fixed costs**



f. Equilibrium: Symmetric Steady-State Growth Path

(1) $w_n = \dfrac{\alpha}{\gamma h},\ w_u = \dfrac{1-\alpha}{\gamma u}, R = b\lambda, h + R = H$

(2) $v(\bullet, \lambda) = bw_h$ **(free entry)**

(3) $H^d = h + R = b\lambda + \dfrac{\alpha}{\gamma w_h}$ **(labor market)**

(4) $\dfrac{w_h}{w_u} = \dfrac{\alpha}{1-\alpha}\dfrac{u}{H - b\lambda} (\uparrow \text{in } \lambda)$

g. Equilibrium characterization

(1) **co-existence of IRS & CRS for** $\lambda \in (\underline{\lambda}, \overline{\lambda})$

(2) **multiplicity (interactions between R&D & OC)**

(3) equilibrium comparison

	IRS	CRS
H^d	high	low
λ	low	high
Y^s	high	low
w_h / w_u	low	high
efficiency	high in SR	high in LR

(4) market size↑=>R&D↑=>λ↑=>fixed cost unsustained
=> choice of CRS technology => scale ↓but scope ↑

h. An important organizational choice is automation. Acemoglu-Restrepo (2018, 2019) propose a task based framework to model such a choice and its consequences on productivity, (un)employment, and wages when the task content is endogenous as a result of organizational choice.

D. Creative Destruction and Individual Welfare: Aghion-Akcigit-Deaton-Roulet (2016)

(3) growth vs. happiness (subjective well-being)

(i) Key: a Shumpeterian model of growth and unemployment with job creation and destruction

(ii) The Model

a. Individuals: infinitely lived risk-neutral agents with a subjective discount rate ρ

b. Production:

(4) A single final good is produced by J intermediate goods, each employing one unit of labor:

$$\ln Y_t = \int_{j \in \mathcal{J}} \ln y_{jt}\, dj$$

where intermediate good j is produced by $y_{jt} = A_{jt} l_{jt}$ **with** $l_{jt} = 1$

(5) Unemployment: $u_t = 1 - J_t$

c. Innovation

(6) An innovator in sector j, who is a new entrant arriving at an exogenous Poisson rate x with vacancy creation cost cY, can improve the sectoral technology:

$$A_{jt} = \lambda A_{jt-1}$$

(7) The entry automatically makes the incumbent obsolete

d. Labor matching

(8) Matching function: $m(u_t, v_t) = u_t^{\alpha} v_t^{1-\alpha}$

(9) Job finding rate: $m(u_t, v_t)/u_t$

(10) Recruitment rate: $m(u_t, v_t)/v_t$

e. Sharing rule: workers get β fraction of firms' profit

f. Value functions

(11) Life satisfaction: $W_t = u_t U_t + (1 - u_t)E_t$

(12) Employed and unemployed value:

$$\rho E_t - \dot{E}_t = w_t + x(U_t - E_t)$$

$$\rho U_t - \dot{U}_t = b_t + (m(u_t, v_t)/u_t)(E_t - U_t)$$

(iii) Equilibrium

(13) Facing a unit elastic demand, each intermediate firm supplies: $y_{jt} = Y_t/p_{jt}$

(14) Intermediate firm profit: $\pi_{jt} = p_{jt}y_{jt} - w_{jt} = Y_t - w_{jt}$

(15) Equilibrium wage: $w_{jt} = w_t = \frac{\beta}{1+\beta}Y_t$ **, implying** $\pi_{jt} = \frac{1}{1+\beta}Y_t = \pi Y$

(16) Steady-state matching: $m(u, v) = (1 - u)x$ **and** ***u = v***

(17) Thus, $m = u = v$ and equilibrium unemployment becomes: $u = \frac{x}{1+x}$

(18) BGP: $g = m \ln\lambda$ **= (1-u) x ln λ =** $\frac{x}{1+x}\ln\lambda$

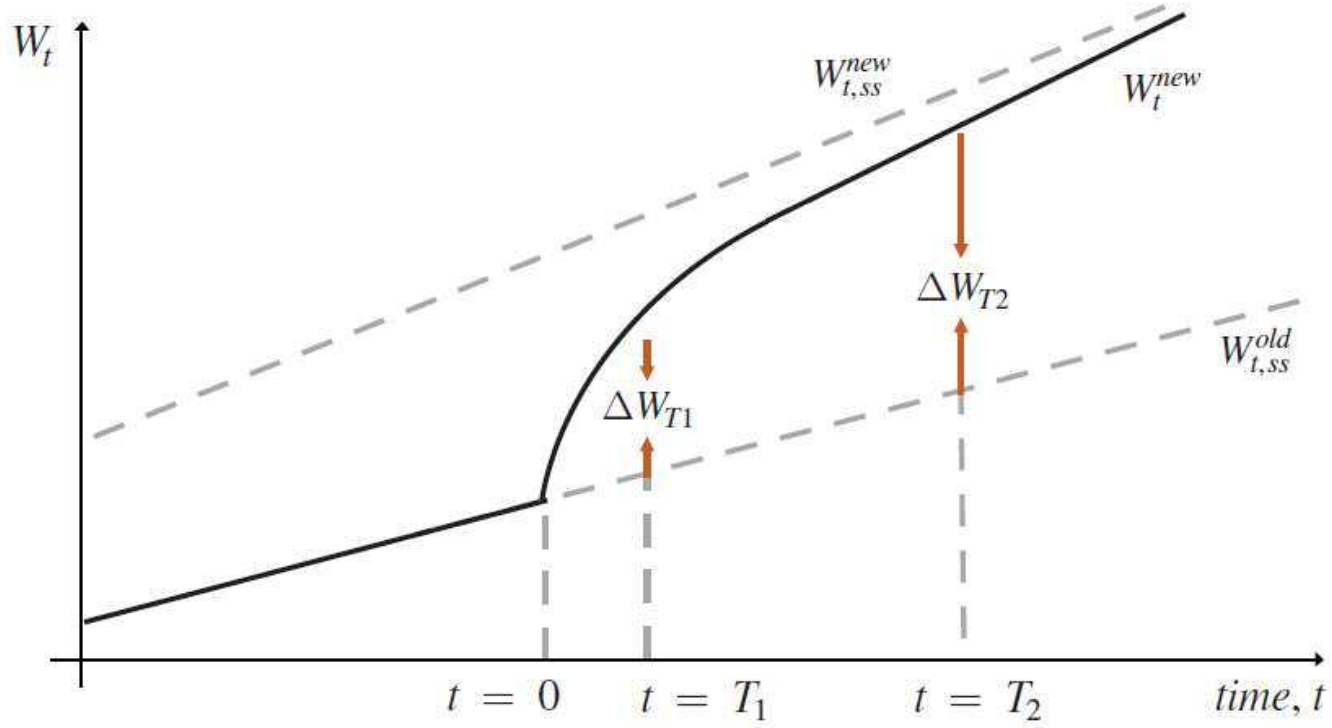
(19) Equilibrium individual welfare: $W = \frac{Y}{r-g}\left[\beta\pi - \frac{xB}{1+x}\right]$**, with** $B = \beta\pi - b$**, so**

$$W = \frac{Y}{r-g}[ub + (1-u)\beta\pi]$$

(iv) Characterization

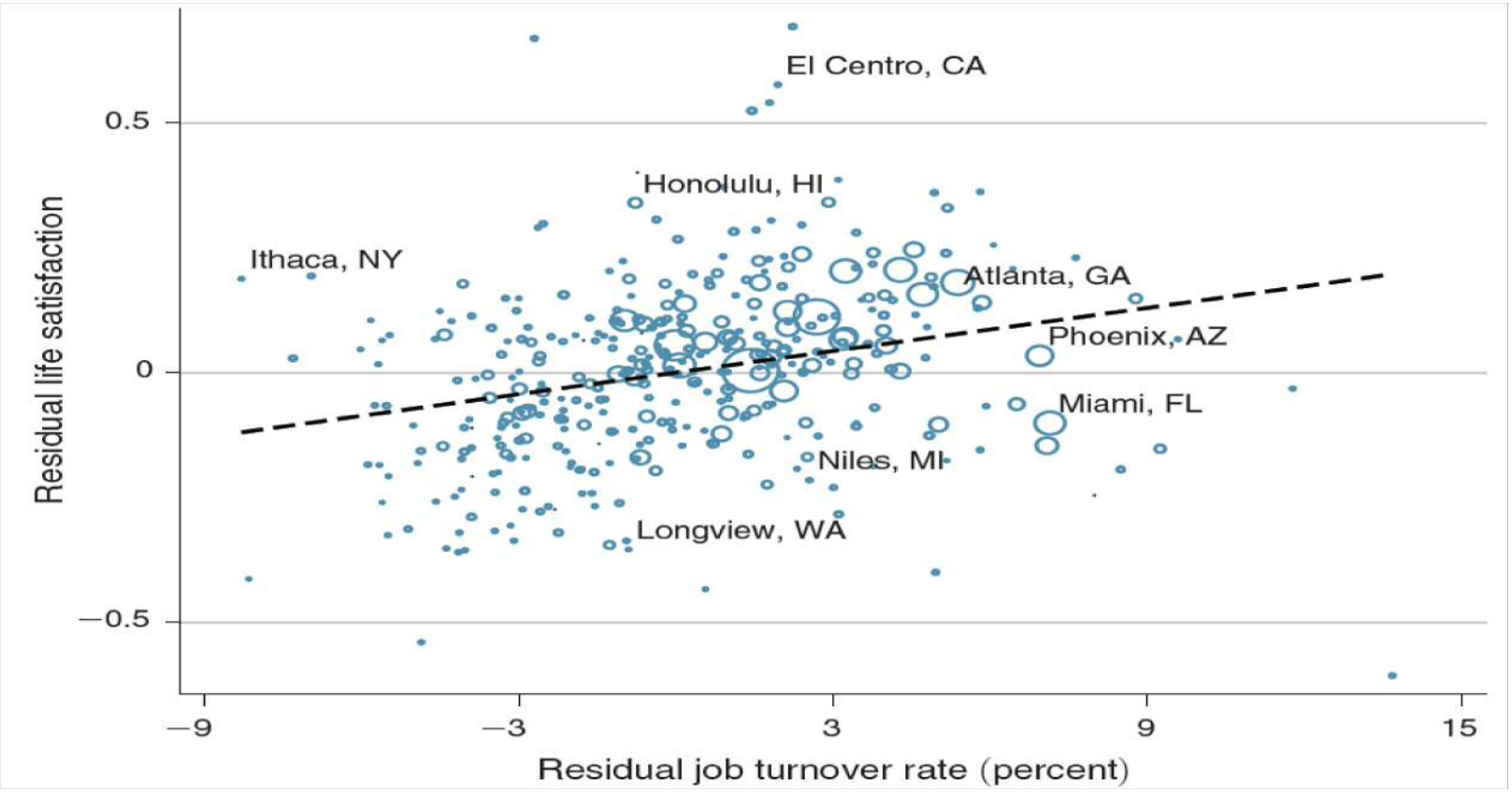
- **Higher x (creative destruction or job turnover) =>**
  - **higher g**
  - **higher u**
  - **two effects on W:**
    - **unemployment effect (assuming $b < \beta\pi$): negative**
    - **growth effect: positive**
    - **the positive growth effect dominates when b is sufficiently large**

- **Subjective well-being during transition**



(v) Empirical analysis: application to the U.S.

- **Use Gallup Healthways Well-Being Index (WBI), after controlling time fixed effects and typical demographics**



On Big Push Theory

Ping Wang
Department of Economics
Washington University in St. Louis

March 2023

A. The Basic Idea

Rosenstein and Rodan (1943, 1961) argue that "coordinated investment" is the basis of the concept of the big push. When many sectors have simultaneously adopted increasing returns technologies, they would all create income as well as demand for goods in other forward and backward linked sectors. Such income creation and demand enhancement would then enlarge the market, leading to industrialization.

B. A Simple Illustrative Model: Murphy-Shleifer-Vishny (1989)

- **Main contribution: to formalize the demand spillovers**
- **Preference: log-linear over a continuum of goods x_i: $U = \int_0^1 \ln(x_i)di$**
- **Production:**
  - **traditional technology (m sectors): constant returns – each unit of labor produces one unit of output (cottage production, zero profit)**
  - **modern technology (n sectors): increasing returns – upon paying a fixed amount of labor input F, the monopolist in each sector turns each additional unit of labor into α unit of output**

- **Profit of each increasing returns sector: by taking labor as numeraire (wage = 1), $\pi = \left(\frac{a-1}{a}\right)y - F = \mu y - F$, where μ is the markup**
- **Aggregate profit: $\Pi = n(\mu y - F)$**
- **Budget constraint: D = y = Π + L, which can be combined with the profit function to yield, $y = \left(\frac{1}{1-\mu n}\right)(L - Fn)$**
  - **$L - Fn$ is total labor used in production (rather than fixed cost investment in the modern sector technology)**
  - **$\frac{1}{1-\mu n}$ is the multiplier, increasing in n and exceeding one due to increasing returns**
- **Demand spillovers: the more firms are in the modern sector (n higher), the larger is the multiplier and the higher is the aggregate demand (D higher) – when goods are normal, higher income and aggregate demand will raise demand for goods in all sectors, which will in turn make additional traditional firms switch to the modern sector**
- **To have enough mass n in the modern sector requires a big push.**

C. Development of Big Push Theory

- **Azariadis-Drazen (1990): presence of human capital threshold due to ad hoc interaction complementarity**
- **Matsuyama (1991): increasing returns in labor and the big push**
- **Laing-Palivos-Wang (1995): matching externality between workers and firms and dynamic threshold**
- **Redding (1996): presence of human capital threshold due to worker-entrepreneur interaction complementarity**
- **Ciccone-Matsuyama (1996): setup costs and the big push**
- **Becsi-Wang-Wynne (1999): big push or big crash**
- **Ghiglino-Sorger (2002): wealth heterogeneity and poverty trap**

D. Equilibrium Threshold: Redding (1996)

- The idea of "threshold externality" was originated in Azariadis-Drazen (1990):
  - accumulation of human capital depends on exogenous threshold ($\underline{v}$): $h_{t,t+1} = (1+\gamma(v_t)v_t^{\theta})h_{t,t}$, $\theta \in (0,1)$, $\gamma = \gamma_H$ if $v_t \geq \underline{v}$ and $\gamma = \gamma_L$ if $v_t < \underline{v}$
  - problem: ad hoc, lacking deep structure mechanism

1. The Model

- Workers
  - 2-pd lived
  - undertaking education (fraction of time = v) and being self-employed when young to yield an output $A(1-v)h_{t,t}$
  - working with an entrepreneur when old to receive a share β of output
  - utility: $u(c_{t,t}, c_{t,t+1}) = c_{t,t} + \frac{1}{1+\rho} c_{t,t+1}$
  - human capital evolution: $h_{t,t+1} = (1+\gamma(v)v^{\theta})h_{t,t}$, with $h_{t,t} = 1$

- **Entrepreneurs**
  - **match with old workers**
  - **determine a probability μ to invest in R&D that incurs a sunk cost of αA when young and yields an output of $\lambda A(1+\gamma(v)v^{\theta})$ when old, $\lambda > 1$**
  - **with probability 1-μ, simply produce an output of $A(1+\gamma(v)v^{\theta})$**

2. Optimization

- **Workers**
  - **optimization problem:** $\max_{v} (1-v)A + \frac{1}{1+\rho}\beta[\mu\lambda+(1-\mu)]A(1+\gamma(v)v^{\theta})$
  - **first-order condition:**

$$v = \left\{\frac{\beta\theta\gamma(v)}{1+\rho}[1+(\lambda-1)\mu)]\right\}^{\frac{1}{1-\theta}}$$ **, which is increasing in μ**

- **Entrepreneurs**
  - **optimization problem:** $\max_{\mu} -\mu\alpha A + \frac{1}{1+\rho}(1-\beta)[\mu\lambda+(1-\mu)]A(1+\gamma(v)v^{\theta}$
  - **this binary discrete choice implies:**

$$\mu = 1 \text{ if } \alpha < \frac{(1-\beta)(\lambda-1)(1+\gamma(v)v^{\theta})}{1+\rho}$$ **and μ = 0 o.w., so μ increases in v**

3. Equilibrium

- **Strategic complementarity and equilibrium threshold: the mutual positive dependence between ν and μ => strategic complementarity between workers and entrepreneurs**
- **Equilibrium features 3 regimes:**
  - $\alpha > \alpha_H \equiv \frac{(1-\beta)(\lambda-1)}{1+\rho}\left[1+\gamma_H\left(\frac{\lambda\beta\theta\gamma}{1+\rho}\right)^{\frac{\theta}{1-\theta}}\right]$:

    => low-growth trap with $\mu = 0$ & $\nu = \left(\frac{\beta\theta\gamma}{1+\rho}\right)^{\frac{1}{1-\theta}}$
  - $\alpha < \alpha_L \equiv \frac{(1-\beta)(\lambda-1)}{1+\rho}\left[1+\gamma_L\left(\frac{\beta\theta\gamma}{1+\rho}\right)^{\frac{\theta}{1-\theta}}\right]$

    => high-growth path with $\mu = 1$ & $\nu = \left(\frac{\lambda\beta\theta\gamma}{1+\rho}\right)^{\frac{1}{1-\theta}}$
  - $\alpha \in [\alpha_L, \alpha_H]$ => multiple equilibria (indeterminacy)

- **Diagrammatic analysis: to facilitate this, let us rewrite workers' and firms optimizing conditions**

  - **workers' Optimization:**
    - $\mathbf{MC_v = A}$ **(foregone marginal benefit from current production)**
    - $\mathbf{MB_v} = \left(\frac{1}{1+\rho}\right)\beta[1+(\lambda-1)\mu]\mathbf{A}\alpha\gamma(\mathbf{v})\mathbf{v}^{\alpha-1}$

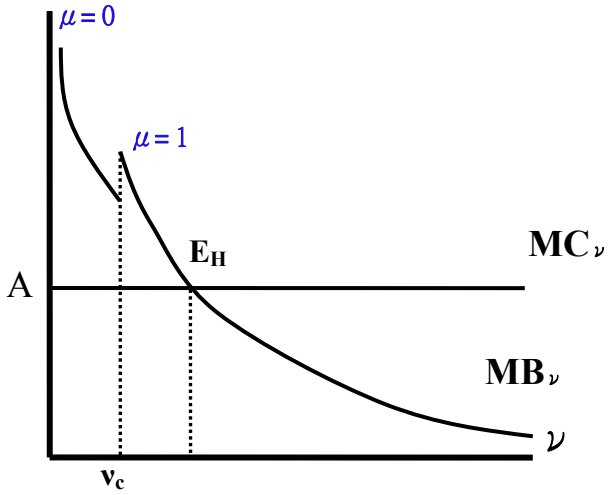
  - **entrepreneurs:** $\Pi(\mu) = -\mu\phi\mathbf{A} + \left(\frac{1}{1+\rho}\right)(1-\beta)[\mu\lambda+(1-\mu)]\mathbf{A}(1+\gamma(\mathbf{v})\mathbf{v}^{\alpha})\mathbf{h}$
    - **value difference:**

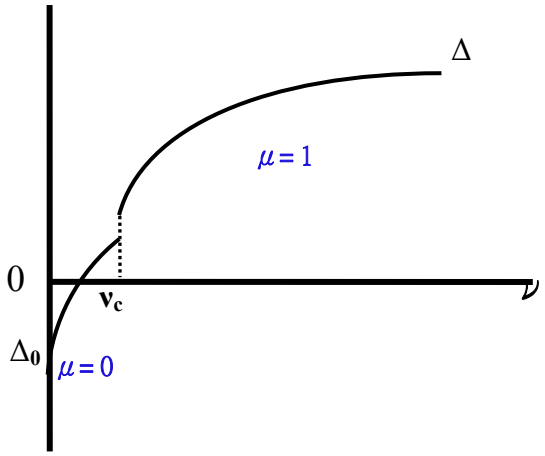
      $$\Delta(\mathbf{v}) = \Pi(1) - \Pi(0) = \left(\frac{1}{1+\rho}\right)(1-\beta)(\lambda-1)\mathbf{A}(1+\gamma(\mathbf{v})\mathbf{v}^{\alpha}) - \phi\mathbf{A},$$

      which is increasing in v with $\Delta(0) = \left(\frac{1}{1+\rho}\right)(1-\beta)(\lambda-1)\mathbf{A} - \phi\mathbf{A} = \Delta_0$
    - **discrete choice with μ = 1 or 0 if Δ(v) > or < 0**

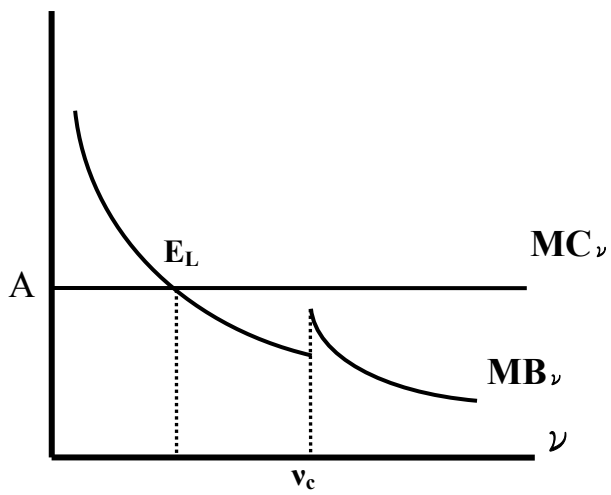
  - **equilibrium: high, low or multiple equilibria**

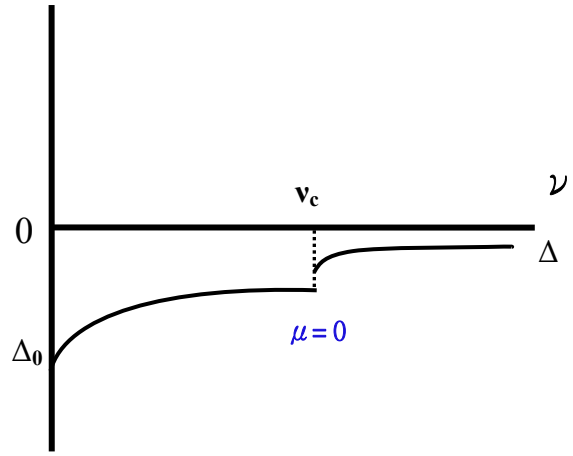
(i) High Equilibrium



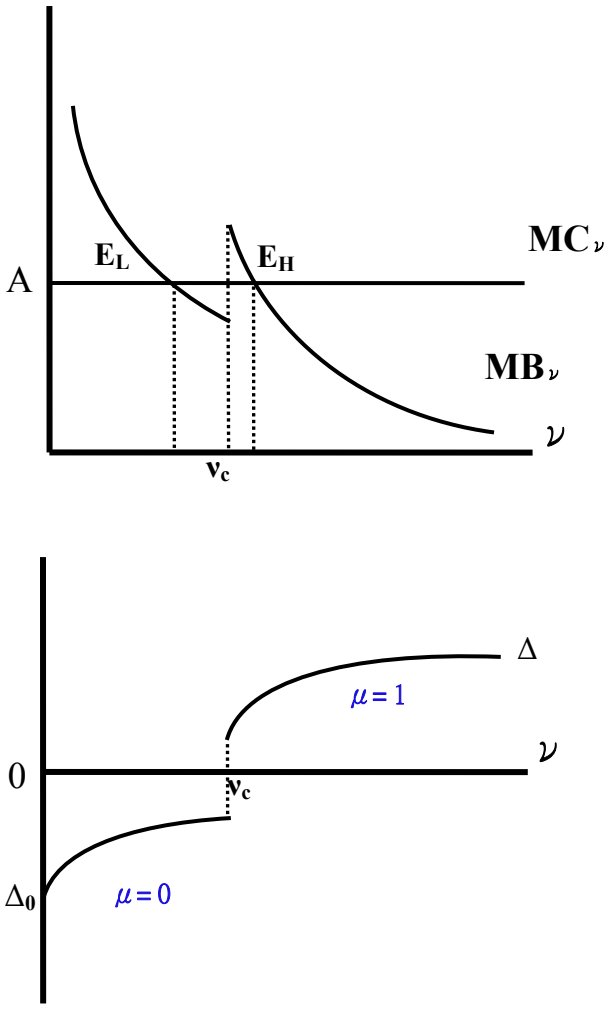


(ii) Low Equilibrium





(iii) Multiple Equilibria



- **Main findings:**
  - **Coordinated worker investment in education and entrepreneur investment in R&D can generate a big push over the required threshold v_c, giving a high-human capital and high-output equilibrium with**
    $$y' = \lambda A(1 + \gamma_H v_H^{\alpha})$$
  - **lacking such coordination (coordination failure), the equilibrium features low-human capital and low-output with** $y' = A(1 + \gamma_L v_L^{\alpha})$
  - **expectations are crucial:**
    - **if workers expect entrepreneurs to invest in R&D ($\mu = 1$), they exert $v_H > v_c$**
    - **if entrepreneurs expect workers to exert $v_H > v_c$, they invest $\mu = 1$**

D. Problems with Big Push Theory

- **History or expectations (Krugman 1991, Matsuyama 1991):**
  - **initial conditions relative to the threshold matter (histories): but Lucas (1993) forcefully argues countries with similar initial conditions may end up with divergent development paths**
  - **self-fulfilling prophecies matter (expectations): address this, the recent literature relies on dynamic indeterminacy**
    - **IRS economy:**
      - ◊ **one-sector setup: Benhabib-Farmer (1994): labor externality + elastic labor supply**
      - ◊ **two-sector setup:**
        - ➢ **Boldrin-Rustichini (1994): generalized Uzawa**
        - ➢ **Benhabib-Perli (1994): generalized Lucas**
        - ➢ **Xie (1994): Lucasian economy**
    - **CRS economy:**
      - ◊ **Bond-Wang-Yip (1996): general 2-sector with distorting taxes**
      - ◊ **Benhabib-Meng-Nishimura (2000), Mino (2001), Mino-Nishimura-Shimomura-Wang (2003): sector-specific externalities**

- **How big is a big push:**
  - **Laing, Palivos and Wang (1995): with job matching interactions and on the job learning, it may only require a small shift to move out of a low-growth trap to reach a high-growth equilibrium**
  - **Becsi, Wang and Wynne (1999): with market participation externality, a small shift can turn a big push into a big crash**

- **General issue: the big push literature focuses too much on techniques rather than economics, leaving the underlying mechanism of big push largely unspecified:**
  - **how to implement a policy to lift over the threshold when histories matters**
  - **how to affect people's self-fulfilling prophecies when expectations matter**