Structural Transformation, Education and Growth

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Introduction

General Question:

- Do all countries go through the same process of Structural Transformation (ST)?
  - **Many recent papers:** Common features across most countries.
    - Focus in preferences and technology.
  - **This paper:** A crucial difference between countries with different growth/development success.
    - Focus in policies on human capital.

Introduction

- **Common (& commonly studied) facts of ST:**
  - Initially: Shift of labor from aggriculture (A) to manufacturing (M) and services (S).
    - This initial process leads to increased aggregate productivity.
    - Long standing puzzle: why poor countries allocate labor to A.
  - At a later stage: shift from M to S;
    - decline in overall share of M.
    - S end up dominating total VA and labor.
    - Overall income and growth performance of country driven by S.

Introduction

- **Lesser known: Wide differences in skill-intensity in S.**
  - *Success growth stories: S in high skill sectors.*
    - *Services:* designers, researchers, chefs, social workers, inv. bankers.
    - Innovation/adoption/skills in S: drive countries to grow.
    - Examples: Developed countries (late); South Korea.
  - *Not so successful stories: S in low skill sectors.*
    - *Services:* street vendors, handymen, domestic labor, and moneylenders
    - Low skill accumulation/innovation S: ceiling for growth.
    - Examples: Brazil; other Latin American after 1980s.

Introduction

Policies?

- **Trade/industrial policies:**
  - Usual story when comparing South East Asia vs. Latin America
  - Perhaps, but:
    - S are mostly non-tradeables.
    - 1980s onward: *Convergence* of policies & *divergence* of incomes.
- **Human Capital Policies:**
  - New workers:
    - If unskilled: low (measured) productivity growth in S.
    - If skilled: high (measured) productivity growth in S.
  - Can also look at implications for demographic change.

This Paper:

A Simple *Quantitative* Model:

- **Education and Fertility:** Quantity/Quality of Children.
  - Parents choose number & skills of children (as in Becker).
- **Structural Transformation:**
  - *Sectors and Skills:*
    - *Agriculture:* low skills only.
    - *Manufacturing:* high skills only.
    - *Services:* low and high skills.
  - *Exogenous sectoral productivities.*
  - *Non-homothetic preferences.*

This Paper:

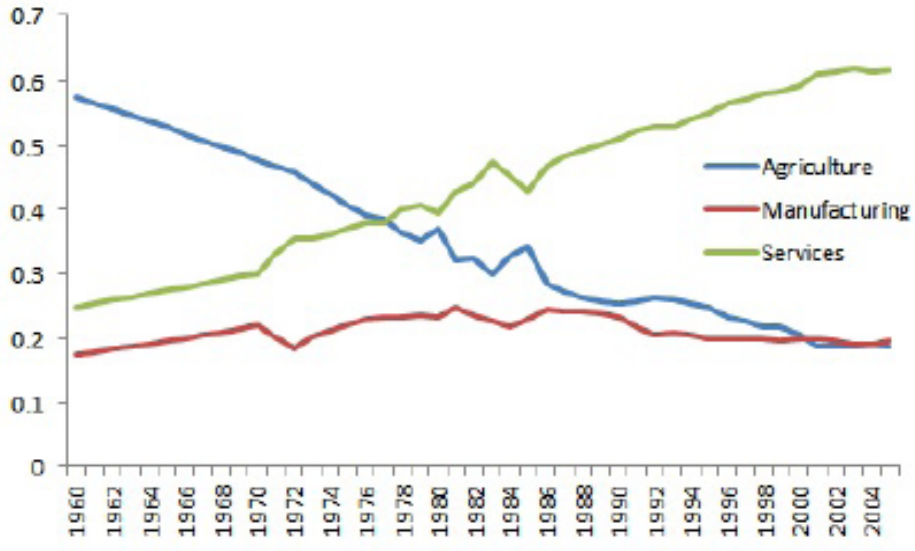
- **Education/Demographic Policies:**
  - *Two Policies:*
    - Child labor (allowed or not)
    - Schooling subsidies (funded with labor taxes).
  - *Redistribution with endogenous types.*
- **Calibration:**
  - *Two Countries: South Korea and Brazil, 1960-2005*
    - **Korea:** fast growth after 1980; Services: high producitivity/skills
    - **Brazil:** slow growth after 1980; Services: low producitivity/skills.
  - Model: education policies explain a big chunk of differences.

Related Literature

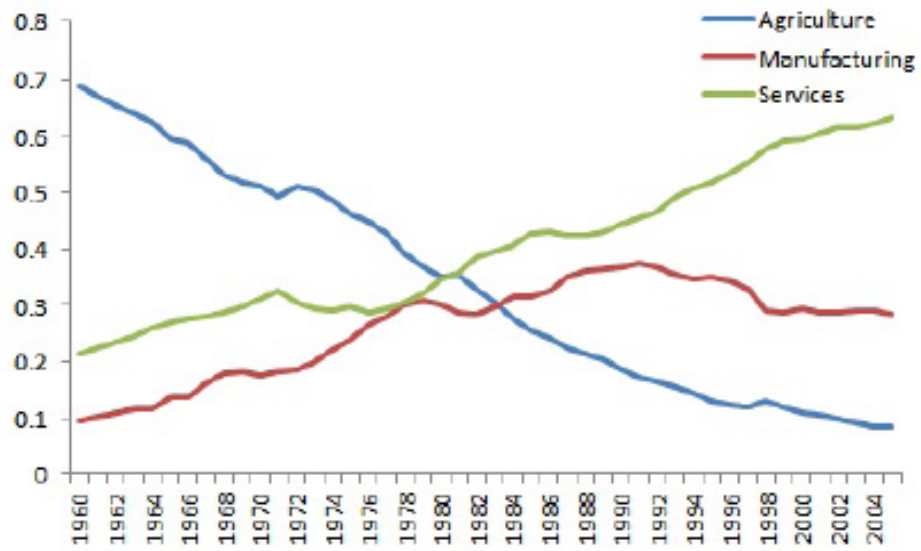
- **Structural transformation:**
  - Duarte and Restuccia (2010); Herrendorf, Rogerson and Valentinyi (2013), Ferreira and Silva (2014), McMillan and Rodrik (2011).
  - *Souh Korea:* Betts, Giri and Verma (2013), Kim and Topel (1995).

- **Demographic Transition and Human Capital:**
  - Fertility and Education: Becker (1960), Becker, Murphy, and Tamura (1990), De la Croix and Doepke (2013), Doepke (2004).
  - *DGE models:* Erosa, Koreshkova and Restuccia (2010); Restuccia and Vandenbroucke (2013).

Brazil and Korea: ST Similarities



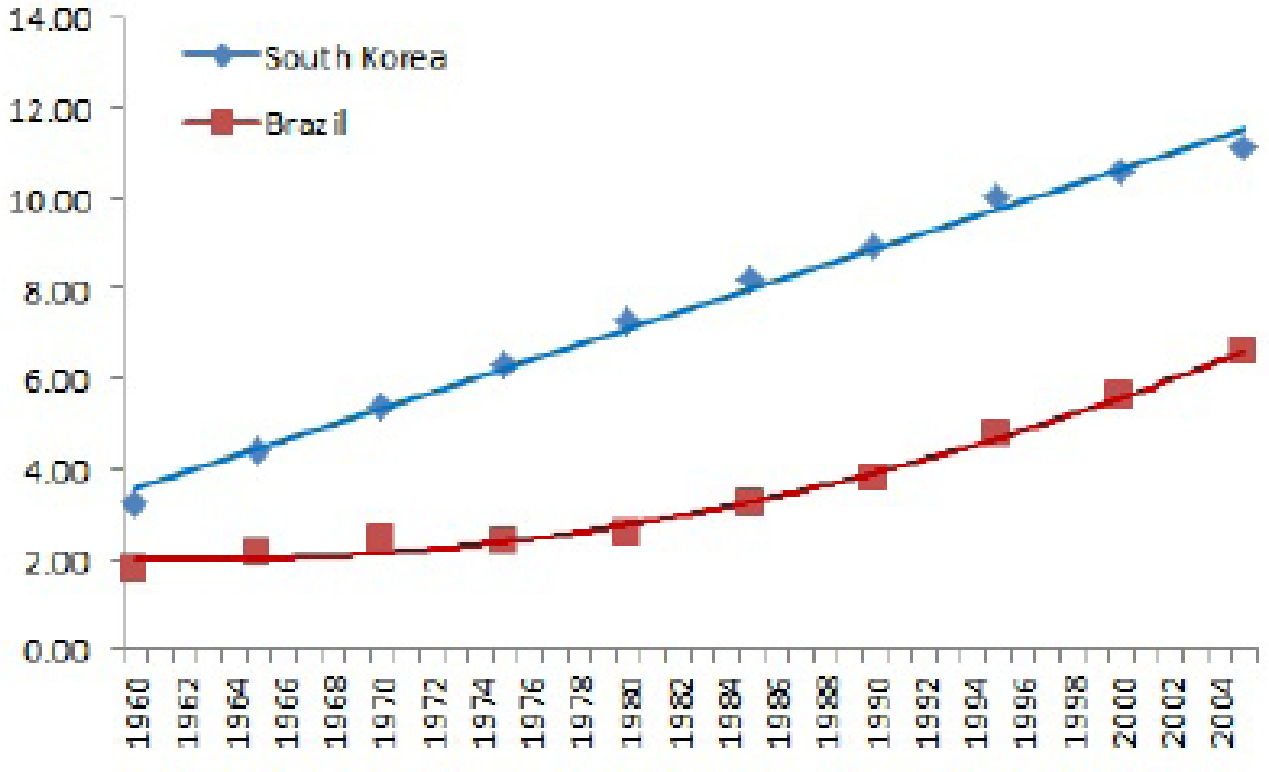
Brazil: Allocation of Labor



Korea: Allocation of Labor

Sectoral allocation of Labor

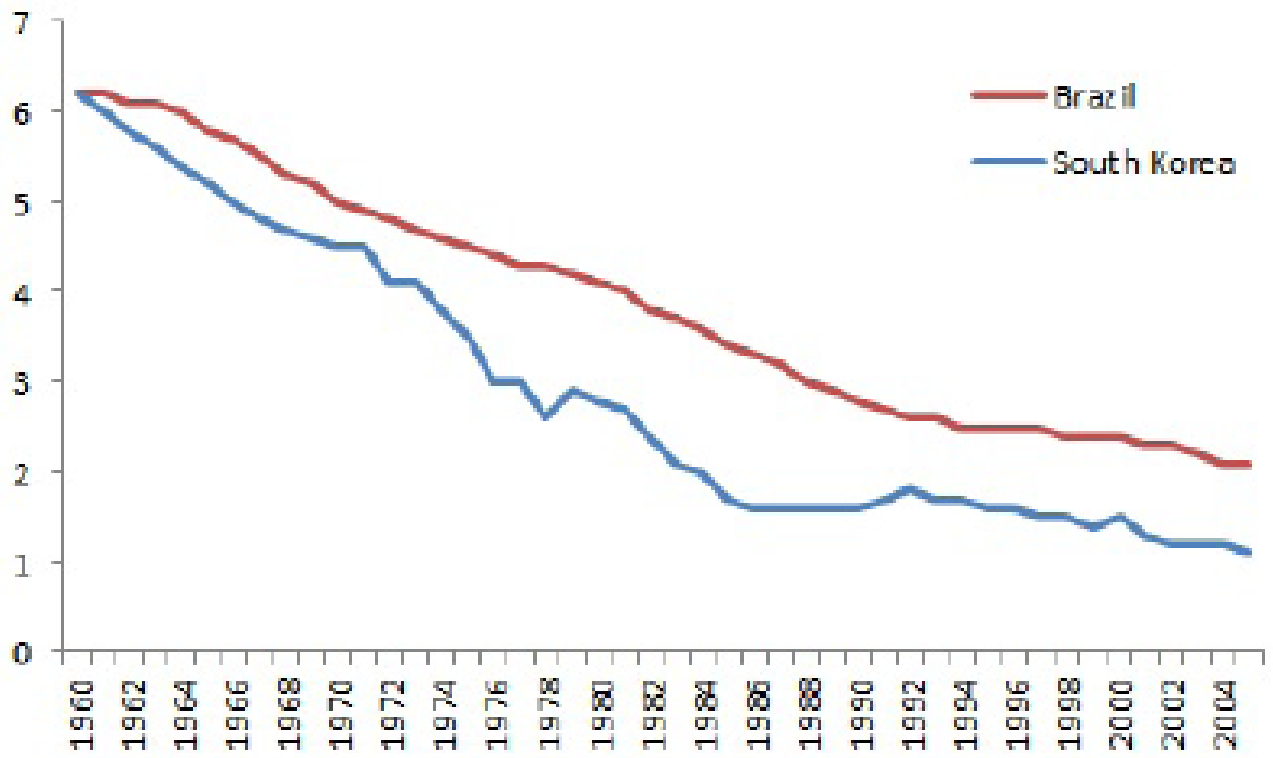
Brazil and Korea: Education Trends Differences



Average years of schooling,

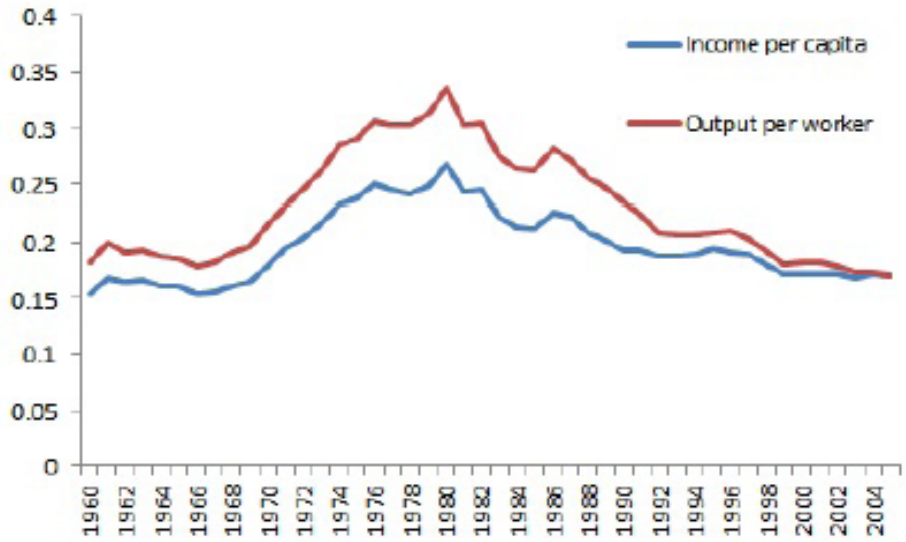
(economically active population)

Brazil and Korea: Fertility Differences

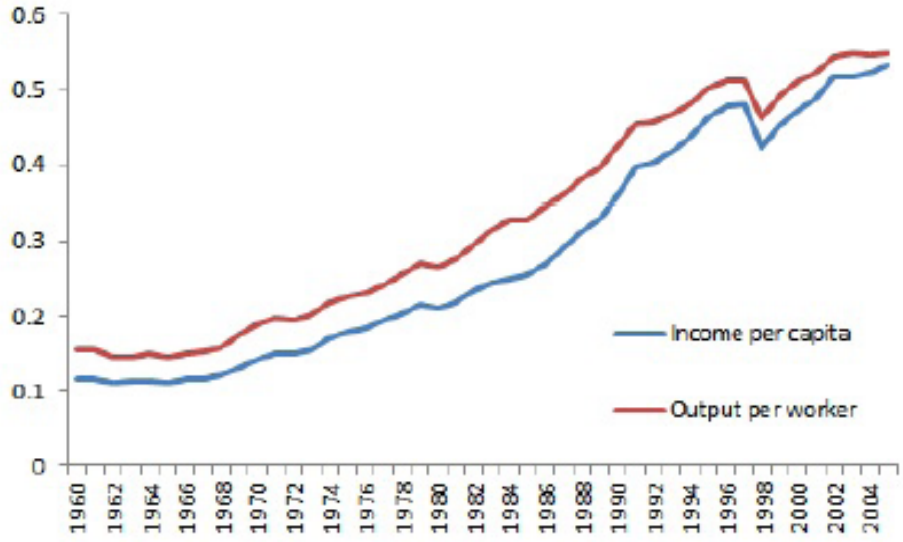


Total Fertility Rates

Brazil and Korea: Sharp Differences in Income



(a) Brazil



(b) South Korea

Output per worker and per person.

The Model

- *Demographics:*
  - Two period lived OLG; $t = 0, 1, 2....$
  - Lifetime decisions:
    - 1st period: children: work or not; attend school or not.
    - 2nd period: adults: labor market; number and skill of children.
- *Preferences:*
  - Altruistic Parents: current utility and utility of offspring.
  - Non-homothetic preferences wrt to three goods:
- *Production Sectors and Skills:*
  - *Agriculture:* low skills only.
  - *Manufacturing:* high skills only.
  - *Services:* low and high skills.
- *Exogenous sectoral productivities.*
- *Exogenously given policies.*

The Model

- **Demographics:**Adult types:
  1. **Skilled (S)**, if they went to school.
  2. **Unskilled** (U), if they didn't.
     - Child labor $\Longrightarrow$ No school.
  - N_S: number of skilled adults.
  - N_U: number of unskilled adults.
- *Production Sectors and Skills:*
  - *Agriculture:* low skills only $Y_A = A_A L_{AU}$.
  - *Manufacturing:* high skills only $Y_M = A_M L_{MS}$..
  - *Services:* low and high skills $Y_{Se} = A_{Se}(L_{SeS})^{\alpha}(L_{SeU})^{1-\alpha}$.
- *Exogenous sectoral productivities:* $A_j' = (1+\gamma_j)A_j$.
- **State of the Economy:** $X \equiv \{A_A, A_I, A_{Se}, N_S, N_U\}$.

The Model

- **Production:** All sectors $j = A, M, Se$, are perfectly competitive:

$$\max_{l_{jS}, l_{jU}} \; p_j(X)\, Y_j(l_{jS}, l_{jS}) - w_S(X) l_{jS} - w_U(X) l_{jU},$$

  - Free entry + FOC:

$$w_U(X) = p_A(X) A_A = p_{Se}(X) A_{Se} (1-\alpha) \left[\frac{L_{SeS}(X)}{L_{SeU}(X)} \right]^{\alpha}$$

$$w_S(X) = p_M(X) A_M = p_{Se}(X) A_{Se} \alpha \left[\frac{L_{SeU}(X)}{L_{SeS}(X)} \right]^{1-\alpha}$$

  - and $L_{AS} = L_{MU} = 0$.

The Model

Households:

- **Preferences:** An adult's utility:

$$V(u, n_S, n_U) = U + \beta(n_S + n_U)^{-\varepsilon}[n_S V_S' + n_U V_U'],$$

where

$$\begin{aligned} U(c_A, c_M, c_{Se}) &= [v(c_A) + b\log(c_M) + (1-b)\log(c_{Se} + \bar{c}_{Se})]^{\sigma}, \\ v(c_A) &= \begin{cases} -\infty & \text{if} \quad c_A < \bar{c}_A \\ min\{c_A, \bar{c}_A\} & \text{if} \quad c_A \geq \bar{c}_A \end{cases}. \end{aligned}$$

here $\varepsilon > 0$ and $\sigma, b \in (0,1)$.

- **Time Allocation:** Work and raising children.
  - Raising a child: each child takes a fraction $\phi > 0$ of time.
    - If skilled child: addtional $\phi_S > 0$ of units of skilled (teacher's) time.
    - If unskilled: if allowed to work, $\phi_U < \phi$ units of unskilled labor.

The Model

- **Government Policies:** Schooling subsidies & child labor restrictions.
  - **Education subsidies:** The government subsidizes a fraction δ of the educational costs.
    - Financing: proportional income tax $\tau(X)$, s.t. budget balance.
    - $(\delta, \tau(X))$ is a regressive tax program (taxes paid even if unskilled).
  - **Child labor policies:** Limit on the number of hours a child can work.
    - Equivalent to reductions on returns of child labor to ϕ_U^g: $0 \leq \phi_U^g < \phi_U$.

Equilibrium

An adult of type $i \in \{S, U\}$:

$$V_i(X) = \max_{c_A, c_M, c_{Se}, n_U, n_S \geq 0} \left\{ U + \beta (n_S + n_U)^{-\varepsilon} [n_S V'_S + n_U V'_U] \right\},$$

subject to:

$$\begin{aligned} & \sum_{j \in \{A,M,Se\}} p_j c_j + \phi (1 - \tau(X)) w_i(X) (n_S + n_U) + (1 - \delta) \phi_S w_S(X) n_S \\ \leq \quad & (1 - \tau(X)) \left[w_i(X) + \phi_U^g w_U(X) n_U \right]. \end{aligned}$$

For each adult, the values V'_S and V'_U given by the law of motion of X'.

Equilibrium

- Let $\lambda_{i,,j}(X)$: fraction of adults type i who have children type j
- Let $n_{i,j}(X)$: number of children of type j that parents of type i have.

- **Population law of motion:**

$$\begin{bmatrix} N_S' \\ N_U' \end{bmatrix} = \begin{bmatrix} \lambda_{S,S}(X)n_{S,S}(X) & \lambda_{U,S}(X)n_{U,S}(X) \\ \lambda_{S,U}(X)n_{S,U}(X) & \lambda_{U,U}(X)n_{U,U}(X) \end{bmatrix} \begin{bmatrix} N_S \\ N_U \end{bmatrix}.$$

Equilibrium

- **Total supply of skilled labor**:

$$\begin{aligned} L_S(X) &= \left[1-(\phi+\phi_S)\lambda_{S,S}(X)n_{S,S}(X)-\phi\lambda_{S,U}(X)n_{S,U}(X)\right]N_S \\ &\quad -\phi_S\lambda_{U,S}(X)n_{U,S}(X)N_U. \end{aligned}$$

- **Total supply of unskilled labor:**

$$\begin{aligned} L_U(X) &= \left[1-\phi\lambda_{U,S}(X)n_{U,S}(X)-\phi\lambda_{U,U}(X)n_{U,U}(X)\right]N_U \\ &\quad +\phi_U^g\left[\lambda_{S,U}(X)n_{S,U}(X)N_S+\lambda_{U,U}(X)n_{U,U}(X)N_U\right]. \end{aligned}$$

Equilibrium

- **Market-clearing labor markets:**
  - Skill workers: option to be unskilled:

$$w_S(X) \geq w_U(X).$$

  - Unskilled labor market clearing:

$$L_{MS}(X) + L_{SeS}(X) \leq L_S(X) \qquad (\text{with} = \text{if } w_S(X) > w_U(X)),$$

  - Skilled labor market clearing:

$$L_{AU}(X) + L_{SeU}(X) = L_U(X) + [L_S(X) - L_{MS}(X) - L_{SeS}(X)].$$

Some Simple Analytics

- Let the costs of each type of child for parents $i = U, S$:
  - Skilled child:
$$p_S^i = \phi w_i + \phi_S (1 - \delta) w_S;$$
  - Unskilled child:
$$p_U^i = \phi w_i - \phi_U^g w_U.$$

- An alternative way of formulating the problem: Adults chose
  - The total expenditure E on child rearing ($E = p_S + p_U$);
  - The fraction f that will be spent with skilled children

Some Simple Analytics

- **The intratemporal problem:** Given any w and E:

$$\begin{aligned} \bar{U}(w-E) &= \max_{c_j} \left[v(c_A) + b\log(c_M) + (1-b)\log(c_{Se}+\bar{c}_{Se}) \right]^{\sigma}, \\ \text{s.t.} &: \sum_{j\in\{A,M,Se\}} p_j c_j \leq w - E. \end{aligned}$$

- **The intertemporal problem:** Given w, choose $E \leq w$ and $f \in [0,1]$:

$$V_i = \max_{E,f} \left\{ \bar{U}(w_i - E) + \beta E^{1-\varepsilon} \left(\frac{f}{p_S^i} + \frac{(1-f)}{p_U^i} \right) \left[\frac{fV_S}{p_S^i} + \frac{(1-f)V_U}{p_U^i} \right] \right\}$$

Some Simple Analytics

- Assumed preferences: high-low skilled children are perfect substitutes.
  - indifference curves (n_S, n_U) are straight lines.

Proposition

For all $\{E, f\}$, that attains the maximum in (1), the solution is $f = 0$ or $f = 1$, i.e., the problem of adult has only corner solutions. So adults of each type choose only to have one type of child, that is, there are never both skilled and unskilled children within the same family.

- Only corner solutions: $f_i = 0$ or $f_i = 1$.
  - $n_{i,S}, n_{i,U}$ by comparing solutions with only one type of child.

Some Simple Analytics

Proposition

An adult is indifferent between both types of children if, and only if the costs and utilities of children satisfy the following condition:

$$\frac{V_S}{p_S^{1-\varepsilon}} = \frac{V_U}{p_U^{1-\varepsilon}} \tag{1}$$

If an adult is indifferent, the total expenditure on children does not depend on the type of child chosen.

Some Simple Analytics

- If $w_S > w_U$: skilled children relatively cheaper for skilled parents:

$$\frac{\phi w_S + \phi_S (1-\delta) w_S}{\phi w_S - \phi_U^g w_U} < \frac{\phi w_U + \phi_S (1-\delta) w_S}{\phi w_U - \phi_U^g w_U}.$$

- Parents of different skills cannot simulateneously be indifferent between the two types of children.

- In our calibration: equilibrium with intergenerational upward mobility.
  - High-skilled parents: only high-skilled children.
  - Low-skilled parents: indifferent between the two types of children.

Calibration

- **Preferences:**.

Parameter	Value	Target/Source
β	0.132	Doepke (2004)
σ	0.5	"
ε	0.5	"
b	0.15	Herrendorf et al. (2011)
$\bar{c}_A$	by country/year	share labor in agriculture
$\bar{c}_{Se}$	by country/year	match $C_{Se} = Y_{Se}$

Calibration

- **Technology, Production, Education:**

Parameter	Value		Target/Source
	Korea	Brazil	
α	0.40		PNAD
ϕ	0.155		Doepke(2004)
ϕ_S	0.04		"
δ	0.5	0.0	"
$\phi^g_{U,60-82}$	0.07	0.069	"
$\phi^g_{U,83-05}$	0	0.069	"

- *Sectoral productivity paths:* set as in Duarte and Restuccia (2010).
- Skilled labor *defined* as *"some secondary education"* (otherwise too few in 1960).

Results

- Growth rates:
  - *Calibrated model:* large gaps in the Korea vs. Brazil growth rates.

Growth: Output per worker	**Brazil**	**Korea**
PWT: $\frac{avg.\ 83-05}{avg.\ 60-82}$	18%	210%
Model:	36%	232%

Results: Allocation of workers across sectors

- **Initial:** 1960-1982; **Final:** 1983-2005

Variable	Brazil				Korea			
	Initial		Final		Initial		Final	
	Data	Model	Data	Model	Data	Model	Data	Model
N_S	0.10	0.31	0.27	0.35	0.29	0.49	0.70	0.74
L_{AU}/L_U	0.64	0.63	0.35	0.36	0.65	0.65	0.27	0.28
L_{MS}/L_S	0.74	0.77	0.67	0.67	0.81	0.82	0.74	0.69
L_{SeU}/L_U	0.36	0.37	0.65	0.64	0.35	0.35	0.73	0.72
L_{SeS}/L_S	0.26	0.23	0.33	0.34	0.19	0.18	0.26	0.31

- Overall: model matches share of skilled labor in Korea and Brazil for both periods.
  - Overestimates skilled workers (b.c.only skilled labor in M)

Results: Demographic Transitions

Total Fertility rate	Brazil		Korea	
	Data	Model	Data	Model
1982	3.8	2.3	2.4	2.2
2005	2.1	2.1	1.1	1.2

- Model close to the data in Korea.
  - Underestimates initial fertility in Brazil.

Counterfactuals: Education Policies and Growth

Brazil	Growth	**Korea**	Growth
Benchmark	36%	Benchmark	232%
Brazil: Korean policies	57%	Korea: Brazilian policies	112%

- Korea with Brazilian policies: **growth less than half.**
- Brazil with Korean polices: **growth 60% more.**

Counterfactual Policies: Fertility & Labor Allocation

Variable	Brazil				Korea			
	Benchmark		Korean Policies		Benchmark		Brazilian Policies	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
TFR	2.3	2.1	2.5	1.2	2.2	1.2	2.1	1.9
N_S	0.31	0.35	0.38	0.60	0.49	0.74	0.37	0.42
L_{AU}/L_U	0.63	0.36	0.73	0.57	0.65	0.28	0.62	0.13
L_{MS}/L_S	0.77	0.67	0.80	0.65	0.82	0.69	0.81	0.66
L_{SeU}/L_U	0.37	0.64	0.27	0.43	0.35	0.72	0.38	0.87
L_{SeS}/L_S	0.23	0.34	0.20	0.35	0.18	0.31	0.19	0.34

Counterfactual Policies: Fertility & Labor Allocation

- **Brazil with Korean policies:**
  - Fertility rate first increases and then decreases.
  - Large increase (70%) in skilled workers in second period.

- **Korea with Brazilian policies:**
  - Fertility rate would remain high (1.9 instead of 1.2).
  - Skilled workers would decreases by almost 50%.

Concluding Remarks

- We incorporate fertility and education decisions to a structural transformation model.
- Calibrated the model to Korea and Brazil.
  - Model matches growth paths, fertility and labor allocation across skills and sectors.
- We use the model to understand impact of education policies.
  - Model helps explain the differences between Korea and Brazil.
  - Education subsidies and restrictions on child labor: help explain Koreans growth, human capital accumulation and structural transformation.