The Productivity of Nations

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Outline

- Development facts
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  - Disparity
  - Mobility
- Theory
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  - Neoclassical extension
  - Broad capital
  - Models of TFP
  - Sectoral composition
- Conclusions

Data

Duarte and Restuccia (2006)

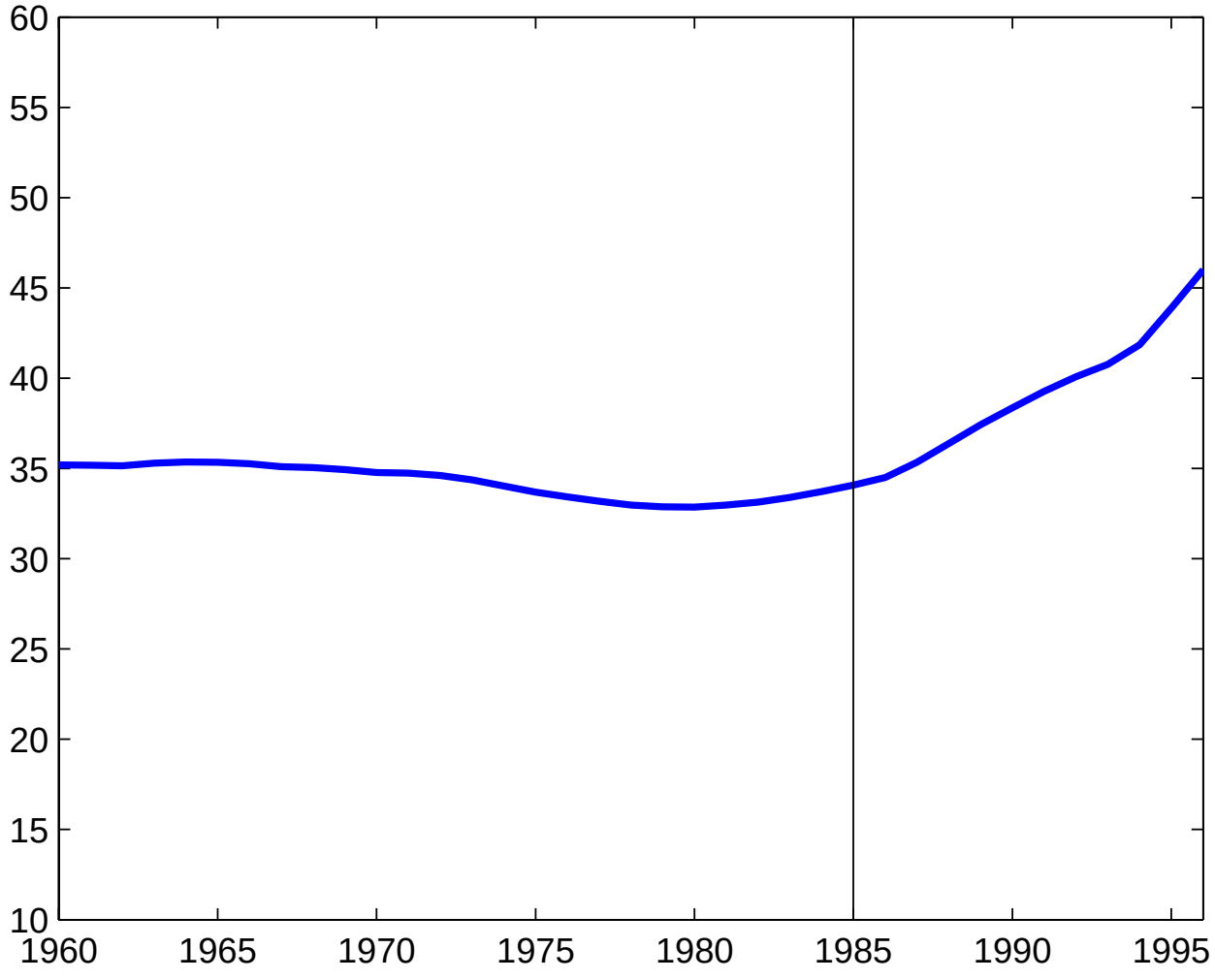
- Comparable measures of output across countries from Heston et al (2002)
- Two restrictions:
  - Data from 1960 to 1996
  - More than one million population in 1996
- Measure of labor productivity: GDP per worker
- Trended data
- Panel of 99 countries
- Data relative to the United States

Disparity

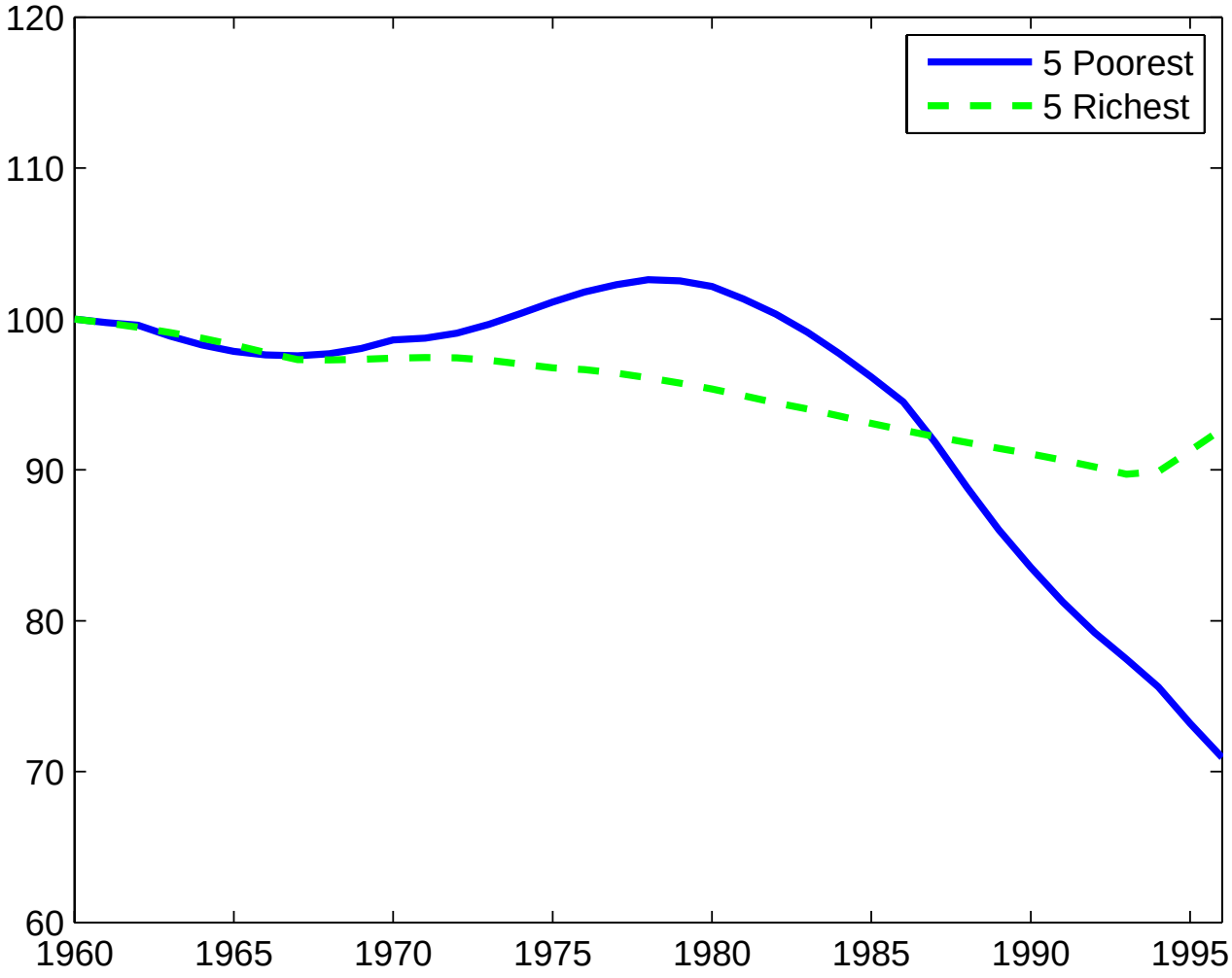
- *Large*
  In 1960, the average worker in the 5 richest countries is 35 times more productive than the average worker in the 5 poorest countries.

- *Increasing*
  By 1996, the 5 richest countries were 46 times more productive than the 5 poorest countries (stable until about 1985).

Output per Worker – Ratio of 5 Richest to 5 Poorest Countries



Relative Output per Worker – 5 Richest and 5 Poorest (1960=100)



Relative Output per Worker by Decile

	1960	1970	1980	1990	1996
			(%)		
D1	3.4	3.3	3.4	2.8	2.4
D2	6.0	5.8	5.5	4.6	3.7
D3	7.8	7.9	7.7	6.4	5.4
D4	11.0	10.6	12.2	11.4	10.6
D5	16.7	18.1	20.1	17.8	17.4
D6	21.2	22.8	27.8	25.1	23.9
D7	27.2	32.8	34.5	31.7	32.5
D8	38.6	44.1	50.2	48.0	51.0
D9	56.6	65.3	70.2	69.5	72.7
D10	89.6	89.7	88.3	85.2	86.0
Ratios:					
D10/D1	26.3	27.1	25.9	30.9	35.6
D9/D2	9.5	11.3	12.7	15.2	19.6

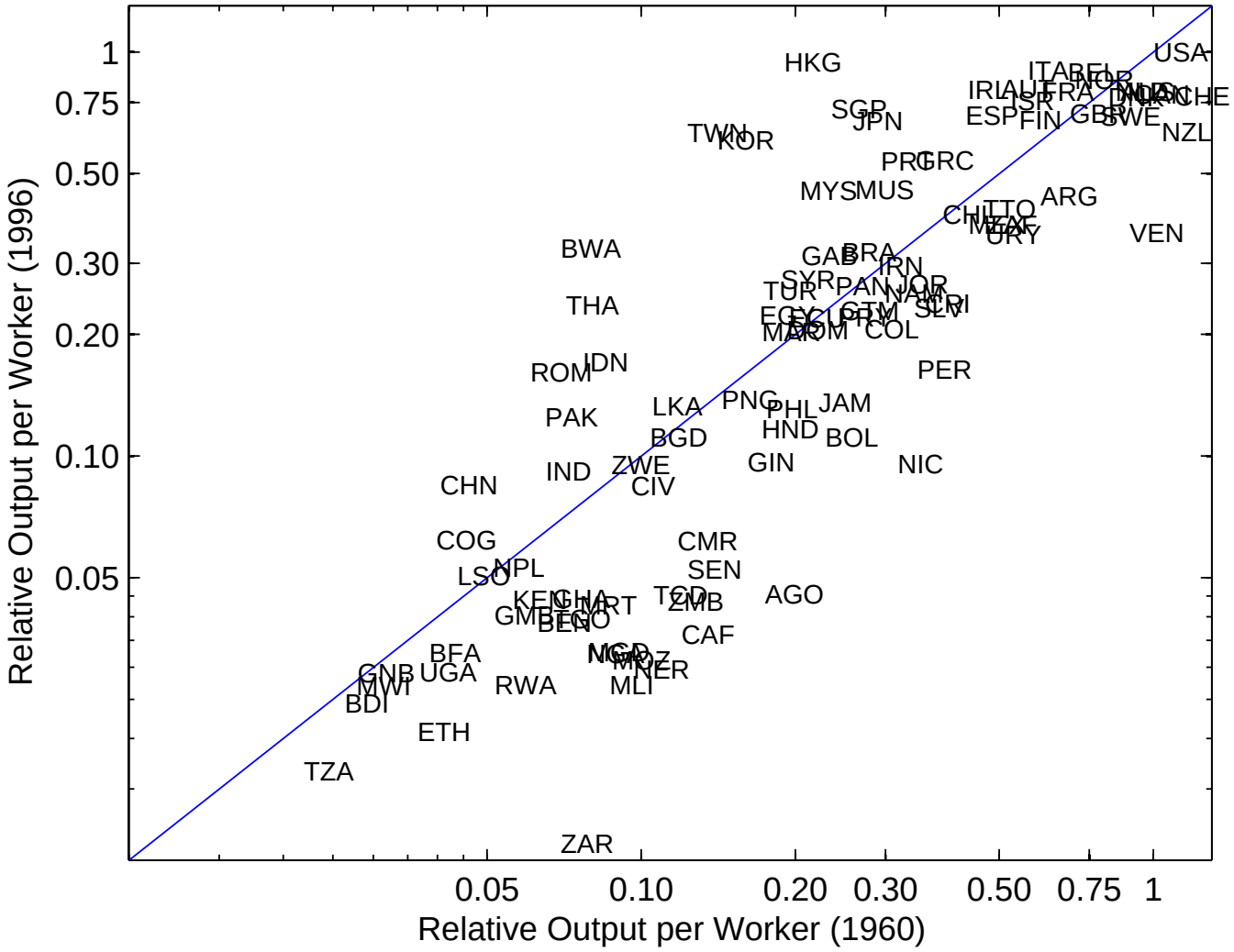
Relative Output per Worker by Region

	1960	1970	1980	1990	1996
Asia	0.14	0.18	0.23	0.28	0.34
Latin America	0.34	0.35	0.35	0.28	0.25
Africa	0.12	0.13	0.14	0.12	0.12
Western Europe	0.62	0.71	0.77	0.75	0.75
Canada	0.92	0.90	0.88	0.83	0.79
Oceania	0.68	0.65	0.60	0.54	0.52

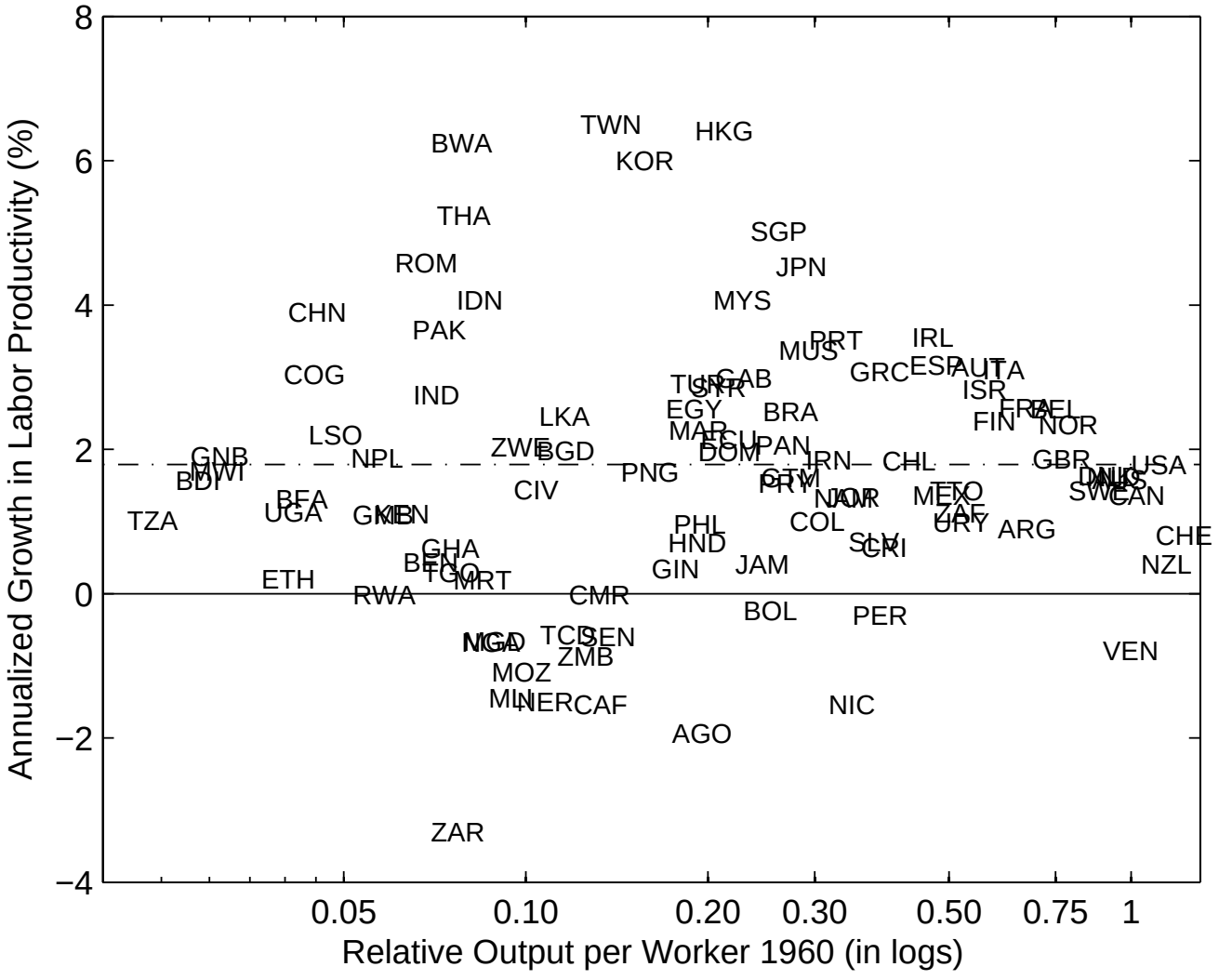
Mobility

- Substantial changes of individual countries in the distribution of labor productivity over time
- Many miracle and disaster experiences

Relative Output per Worker 1960 vs. 1996 (log scale)



Growth in Output per Worker (60−96)



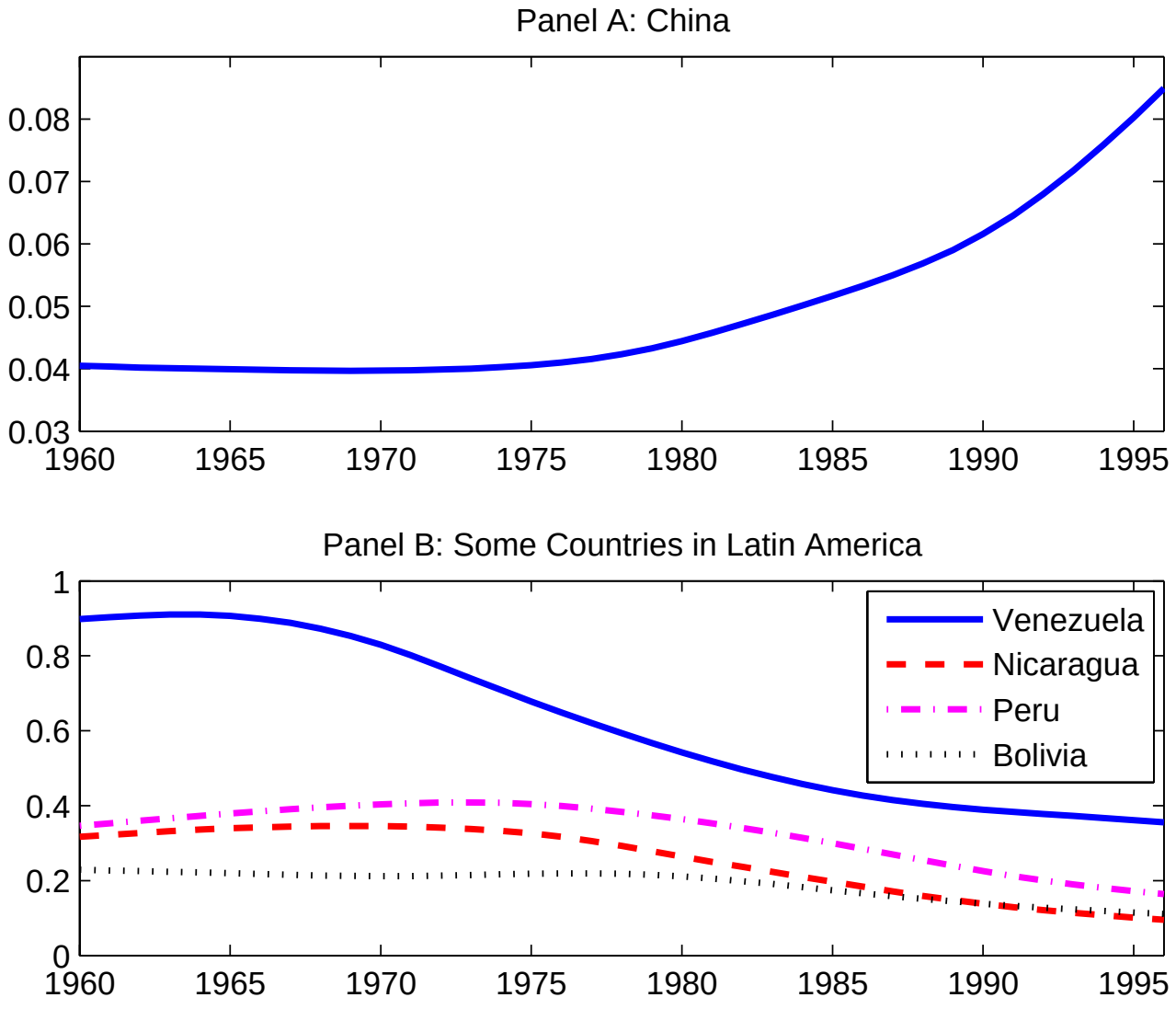
Miracle Experiences

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Botswana	5.59	1965	26	0.07	0.30
Taiwan	4.64	1960	36	0.12	0.63
Japan	4.56	1960	16	0.26	0.53
Hong Kong	4.54	1960	36	0.19	0.94
Greece	4.46	1960	15	0.34	0.66
Korea	4.20	1961	35	0.14	0.61
Singapore	4.10	1960	23	0.23	0.59
China	3.94	1978	18	0.04	0.08

Disaster Experiences

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Dem. Rep. of Congo	−6.45	1971	25	0.06	0.01
Mauritania	−6.14	1977	19	0.14	0.04
Nicaragua	−5.51	1974	22	0.33	0.10
Mali	−5.06	1980	16	0.06	0.03
Mozambique	−5.03	1971	16	0.08	0.03
Angola	−4.82	1969	27	0.17	0.05
Peru	−4.48	1977	19	0.39	0.16
Nigeria	−3.99	1980	16	0.06	0.03
Central African Rep.	−3.94	1973	23	0.09	0.04
Bolivia	−3.93	1980	16	0.21	0.11
Zambia	−3.74	1976	20	0.09	0.04
Venezuela	−3.69	1968	21	0.87	0.40

Relative Output per Worker over Time



Solow Model

$$Y = AK^{\alpha}L^{1-\alpha} \qquad K' = (1-\delta)K + sY$$

$$\frac{Y}{L} = A^{\frac{1}{1-\alpha}}\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} \qquad \frac{K}{Y} = \frac{s}{\delta}$$

- As a theory of productivity differences (common A and δ)

$$\frac{(Y/L)_i}{(Y/L)_j} = \left(\frac{s_i}{s_j}\right)^{\frac{\alpha}{1-\alpha}}$$

	$(Y/L)_i/(Y/L)_j$	
s_i/s_j	$\alpha = 1/3$	$\alpha = 2/3$
4	2	16
6	2.5	36

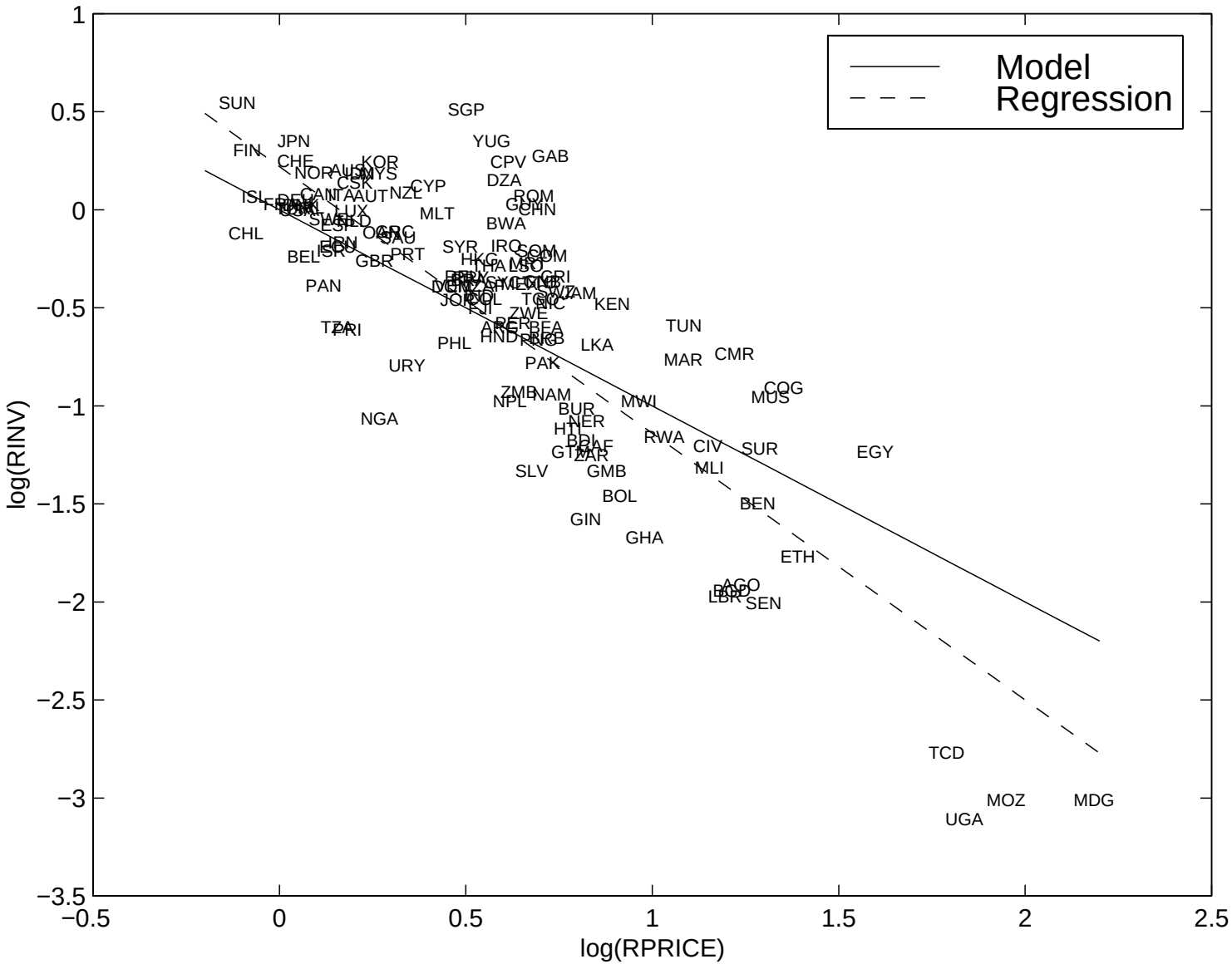
Neoclassical Extension

- Micro-foundation for s and their differences across countries
- Restuccia and Urrutia (2001)
  - Model with a tax on investment or relative productivity of investment goods

$$\frac{s_i}{s_j} = \frac{(I/Y)_i}{(I/Y)_j} = \left(\frac{(1+\theta_i)}{(1+\theta_j)}\right)^{-1}$$

  - Differences in tax or productivity map into differences in the relative price of capital

Relative Prices and Investment Rates



Summary of findings:

- Large differences in the relative price of capital across countries (by a factor of 6 to 10 between poor and rich countries)
- Relative price of capital systematically related to I/Y and Y/L across countries
- A quantitative model with differences in the price of capital can account for a large portion of I/Y differences across countries but only for a small portion of Y/L differences

Broad Capital

- Mankiw, Romer, and Weil (1992)
- Bils and Klenow (2000) and Klenow and Rodriguez-Clare (1997)
- Manuelli and Seshadri (2005)
- Erosa, Koreshkova, and Restuccia (2006)

Erosa, Koreshkova, and Restuccia (2006)

- Use quantitative theory to measure the effects of total factor productivity (TFP) on:
  - Human capital (HC) and output per worker *across* countries
  - Inequality and mobility *within* a country
- Why theory? No good measure of HC across countries (quality) and no obvious variance decomposition (endogenous variables)
- Challenge:
  No direct evidence on the parameters of the HC technology and quantitative implications of the theory hinge on these parameters

- Key idea:
  Parameters of the HC technology are also important for inequality within a country.
- EKR proceed as follows:
  - Develop a model with heterogeneous agents.
  - Calibrate HC technology using U.S. data on earnings and schooling.
  - Quantify aggregate and distributional effects of differences in TFP across countries.

Model

- General-equilibrium heterogeneous-agents model
- People live 5 model periods
- Dynastic preferences
- Physical capital accumulation
- Human capital accumulation:
  - Investment in time (own and purchased) and goods
  - Idiosyncratic uncertainty on labor earnings (ability)
  - Public education (subsidies)

Human Capital Accumulation:

- Parents decide schooling time (s) and expenditures (e):

$$h' = z' \left(s^{\eta} e^{1-\eta} \right)^{\xi} \qquad \eta, \xi \in (0,1)$$

- A unit of schooling time is produced with
  - one unit of child's time and
  - $\bar{l}$ units of market human capital services
- Education is subsidized by p per unit of schooling time s
- Earnings (ability) transmission and life-cycle productivity

$$Pr(z' = z_i | z = z_j) = q_{ij}, \qquad (\psi_c, \psi_y, \psi_o)$$

Deterministic Income Maximization:

$$\max_{e,s,h} \left\{ w(1-s)h\psi_0 + wh\Psi - e - w\bar{l}s \right\} \qquad s.t.$$

$$h = z\left(s^{\eta}e^{1-\eta}\right)^{\xi} \qquad \text{and} \qquad \Psi = \sum_{i=1}^{3} \frac{\psi_i}{(1+r)^i}$$

FOC:

$$-wh\psi_0 + wh_s\left[(1-s)\psi_0 + \Psi\right] = w\bar{l}$$
$$wh_e\left[(1-s)\psi_0 + \Psi\right] = 1$$

where $h_s = \frac{h}{s}\eta\xi$ and $h_e = \frac{h}{e}(1-\eta)\xi$

Quantity and Quality of Schooling:

$$h\left\{-\psi_0+\frac{\eta\xi}{s}\left[(1-s)\psi_0+\Psi\right]\right\}=\bar{l}$$

- $\bar{l}=0$ implies no differences in schooling years (s) across individuals (z) and countries (w).

$$e=\left\{wz\left(1-\eta\right)\xi\left[(1-s)\psi_0+\Psi\right]s^{\eta\xi}\right\}^{\frac{1}{1-(1-\eta)\xi}}$$

- $\eta=1$ implies no differences in schooling quality (e) across individuals (z) and countries (w).

Expenditure Elasticity of HC and Inequality

- HC production function: $h = z\left(s^{\eta}e^{1-\eta}\right)^{\xi}$
- Let $\bar{l} = 0$, then $\frac{\partial log(s)}{\partial log(w)} = \frac{\partial log(s)}{\partial log(z)} = 0$
- Hence $\frac{\partial log(h)}{\partial log(w)} = \xi(1-\eta)\frac{\partial log(e)}{\partial log(w)} = \frac{(1-\eta)\xi}{1-(1-\eta)\xi}$
- Note that $\frac{y_i}{y_j} = 20$ is generated by:

wage ratio if $\frac{w_i}{w_j}$	exp. elast. of h $(1-\eta)\xi$	wage elast. of h (y) $\frac{(1-\eta)\xi}{1-(1-\eta)\xi}$
3.3	0.6	1.5 (2.5)
1.35	0.9	9 (10)

Calibration Strategy:

- Calibrate the benchmark economy (BE) to U.S. data
- Restrict HC parameters using:
  - Cross-sectional observations:
    - Distribution of schooling levels across the population
    - Earnings by schooling levels (Mincer return)
  - Share of goods in the total cost of education

Amplification Effect:

- Output per worker: $y = Ak^{\alpha}h^{1-\alpha}$
- Differences in TFP induce log-linear relationships:

$$\log(k) = c_k + \log(y)$$
$$\log(h) = c_h + \gamma \log(y)$$

- Hence,

$$y = c_y A^{\frac{1}{(1-\alpha)(1-\gamma)}}$$
$$\frac{y_i}{y_j} = \left(\frac{A_i}{A_j}\right)^{\frac{1}{(1-\alpha)(1-\gamma)}}$$

Amplification Effect (II):

$$\frac{y_i}{y_j} = \left(\frac{A_i}{A_j}\right)^{\frac{1}{(1-\alpha)(1-\gamma)}}$$

- TFP-elasticity of output per worker $\eta_{y,A} = \frac{1}{(1-\alpha)(1-\gamma)}$.
- Baseline calibration: $\alpha = 0.33$ and $\gamma = 0.46$. Hence $\eta_{y,A} = 2.77$.
- Implication:

TFP ratio generates $\frac{A_i}{A_j}$	output per worker ratio $\frac{y_i}{y_j}$
2	6.8
3	20.8

Human Capital Differences – Model vs. Mincer

Human Capital across Countries

Relative TFP	1	1/2	1/3
(1) Human Capital Ratio	1	0.45	0.25
(2) Mincer HC Ratio	1	0.69	0.51
Ratio (2) to (1)	1	1.5	2.0

We use education-level and economy specific Mincer returns.

- Schooling quality causes Mincer returns to underestimate human capital differences across countries by a large margin.

Are Schooling-Quality Differences in Our Theory Reasonable?

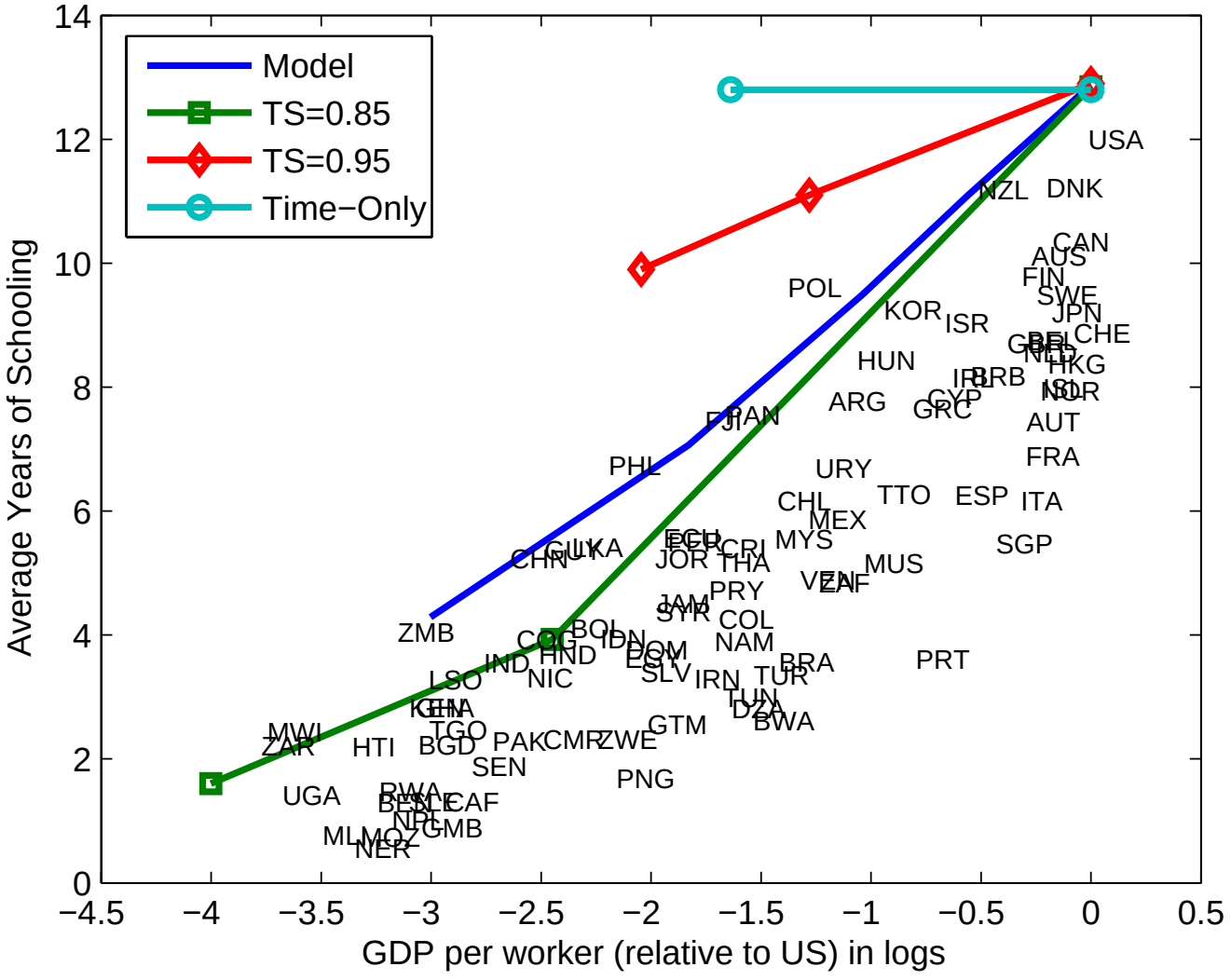
- Borjas (1987): On average, for a given schooling level, the wage of an immigrant worker in the U.S. is 0.12% higher if the worker comes from a country with a 1% higher per capita income.

Earnings and HC

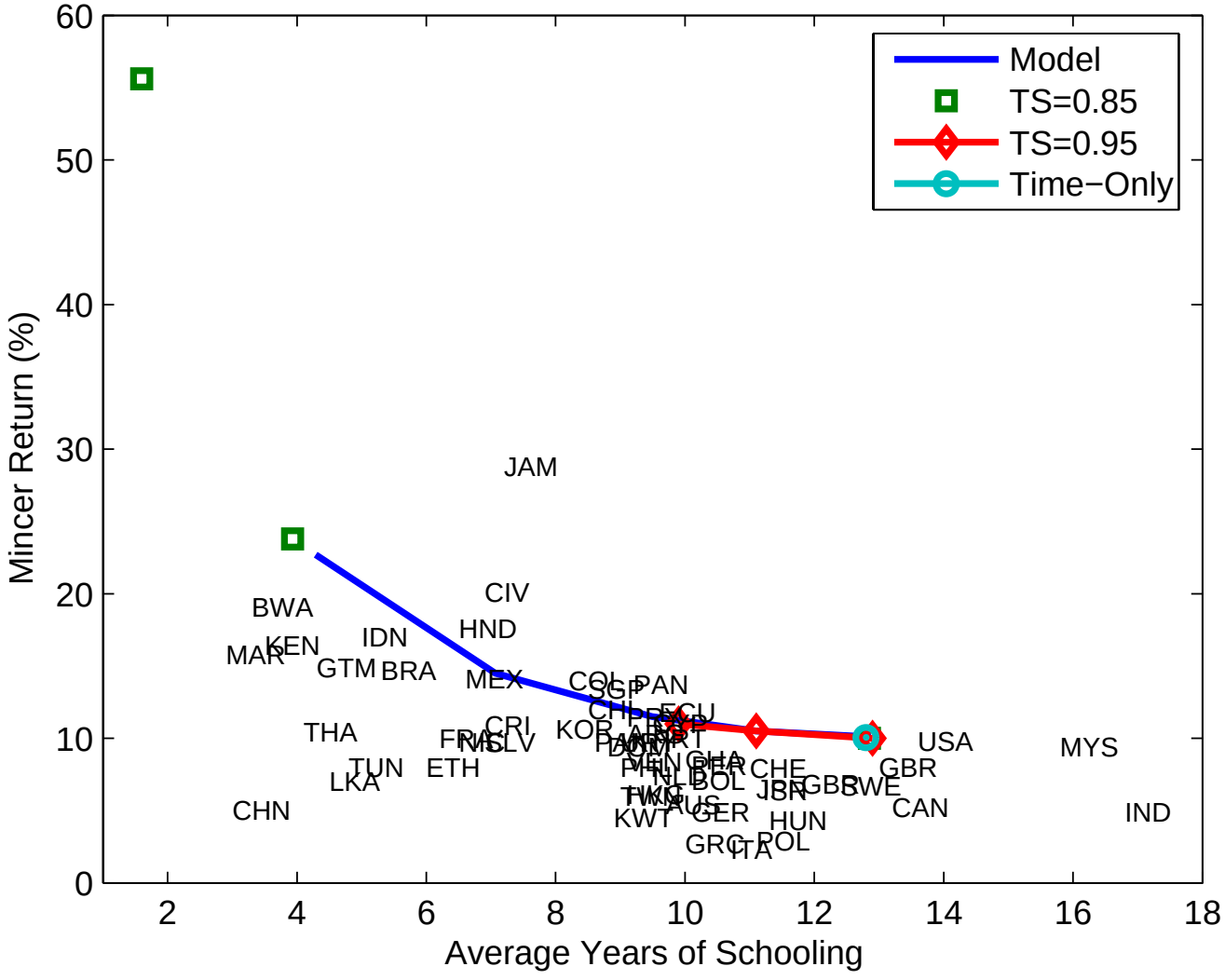
(Relative TFP 1 vs. 1/3)

	Earnings	Wages	Quality HC	Elasticity
Primary	10.6	5.2	2.0	0.23
Secondary	7.4	5.2	1.4	0.11
Some college	7.1	5.2	1.4	0.11

Schooling and Income – Data vs. Model



Schooling and Mincer Returns – Data vs. Model



Theories of TFP

- Prescott (1998)
- Parente and Prescott (1999)
- Restuccia and Rogerson (2003)

Restuccia and Rogerson (2003)

- Importance of allocation of factors across productive uses (micro evidence)
- Theory:
  - Representative consumer – heterogeneous producers
  - Production unit is a plant – decreasing returns to scale at the plant level
  - Plants differ in their total factor productivity (constant over time)
  - Fixed entry cost and productivity drawn from $H(s)$
- Calibration: range of s and $H(s)$
- Misallocation: Policies that affect prices of individual producers (idiosyncratic distortions)

Quantitative effects on measured TFP:

- Amplification effect of aggregate policies (10 percent)
- Quantitative effect cost of entry (10 percent)
- Idiosyncratic distortions (6 to 20 percent – uncorrelated and 27 to 45 percent – correlated)

Discussion of results following similar framework:

- Guner, Ventura, and Yi (2005)
- Hsieh and Klenow (2006)
- Haltiwanger et al (2006)

Importance of Sectoral Structure

- Agriculture – richest vs. poorest countries
  Gollin, Parente and Rogerson (2002) and Restuccia, Yang, and Zhu (2005)
- Services – not so poor countries
  Duarte and Restuccia (2006)

Restuccia, Yang, and Zhu (2005)

- 90% of employment in agriculture in poor countries while only 5% in rich countries
- This matters for aggregate productivity since poor countries are relatively unproductive at agriculture relative to rich countries
  Using FAO data RYZ calculate that labor productivity differences are a factor of 70 in agriculture between rich and poor countries and 5 in non-agriculture

Duarte and Restuccia (2006)

- Role of the structural transformation in aggregate productivity of countries over time
- Labor productivity differences are large in agriculture and services and small in industry
- Accounts for recent slowdown in economies such as Japan, Korea, and some European countries

Conclusions

- Some progress in understanding productivity differences across countries by restricting models to data
- Recent advances in studying time paths of individual countries
- Lots of open questions...