Macroeconomics 1

Lecture 1 - Introduction to Economic Growth

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Sciences Po

2022 Autumn

Practical Matters

- Lectures by Nicolas Coeurdacier (2 lectures), Diego De Sousa Rodrigues (8 lectures), Jean-Marc Robin and/or Pierre Cahuc (2 lectures)
- Lecture notes on moodle
- 12 two-hour sessions, Mondays 12:30-14:30
- office hour by appointment
  Send an email to set up a meeting
- Emails: diego.desousarodrigues@sciencespo.fr & nicolas.coeurdacier@sciencespo.fr

Practical Matters

- 12 two-hour tutorials, Tuesdays 12:30-14:30

  with Aymeric Ortmans (aymeric.ortmans@sciencespo.fr), starting next week
- you will have a problem set related to each lecture
- during the tutorials you will cover the problem sets (to be sent in advance to Aymeric), and other extra material
- you should also raise any questions you have related to the lectures or the problem sets
- you will also receive review questions for each lecture

Evaluation

- Grade from the tutorials based on assignments at home and in class (60%)
- Final exam, 2 hours (40%)

Roadmap

1. **Economic Growth**

   6 lectures with Nicolas Coeurdacier and Diego De Sousa Rodrigues

2. **Labor Markets**

   6 lectures with Diego De Sousa Rodrigues, Jean-Marc Robin and/or Pierre Cahuc

Economic Growth

- One of the most important questions in economics, especially in macro and development.

  Why are some countries much richer than others?

  Why are some countries growing faster than others?

- Empirical questions
  - What is driving income differences across countries?
  - What are the drivers of economic growth?

- Theoretical questions
  - Under which conditions should poor countries catch-up?
  - How should we model technological progress and innovation?

Economic growth

Roadmap

1. Introduction to Economic Growth
2. Solow Growth Model
3. Neoclassical Growth Model
4. Overlapping Generations
5. Endogenous Growth
6. Structural Change

Introduction to Economic Growth

Roadmap

1. Facts of Economic Growth
2. The Production Function
3. Development and Growth Accounting

Facts of Economic Growth

Gross Domestic Product

- GDP (Gross Domestic Product) is the most important variable in macroeconomics.
- GDP measures aggregate production/output = value added.
- GDP measures production, but also spending by economic agents as well as their income.
- GDP is a flow variable measured usually during a yearly or a quarterly period.
- GDP per capita indicates the level of development of a country. Massive variations across countries.

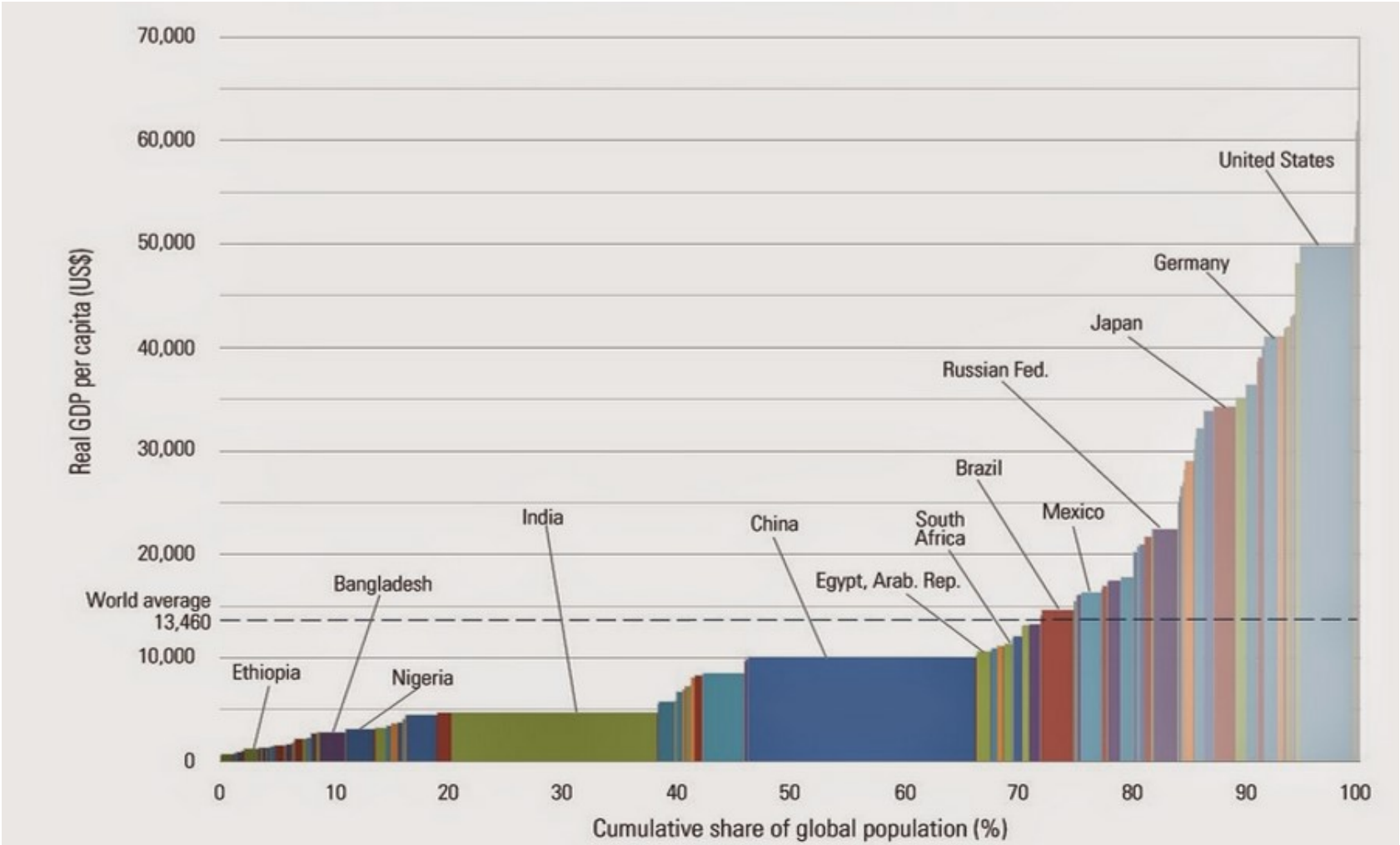

Figure: Real GDP per capita and shares of global population.

Source: : World Bank, 2011 Data.

GDP Growth

- Denote $y(t)$ the variable of interest (e.g. GDP or output per capita). Growth rate $g(t+1)$ between t and $t+1$,

$$y(t+1) = (1 + g(t+1)) \cdot y(t)$$

- if $y(t)$ grows at a constant rate,

$$\begin{aligned} & y(t+1) = (1+g) \cdot y(t) \\ \Rightarrow & \ln y(t+1) - \ln y(t) = ln(1+g) \approx g \\ \Rightarrow & \ln y(t) \approx tg + \ln y(0) \end{aligned}$$

$\rightarrow$ $\ln y(t)$ grows linearly and the slope of the log-transformed series gives the growth rate of the original series.

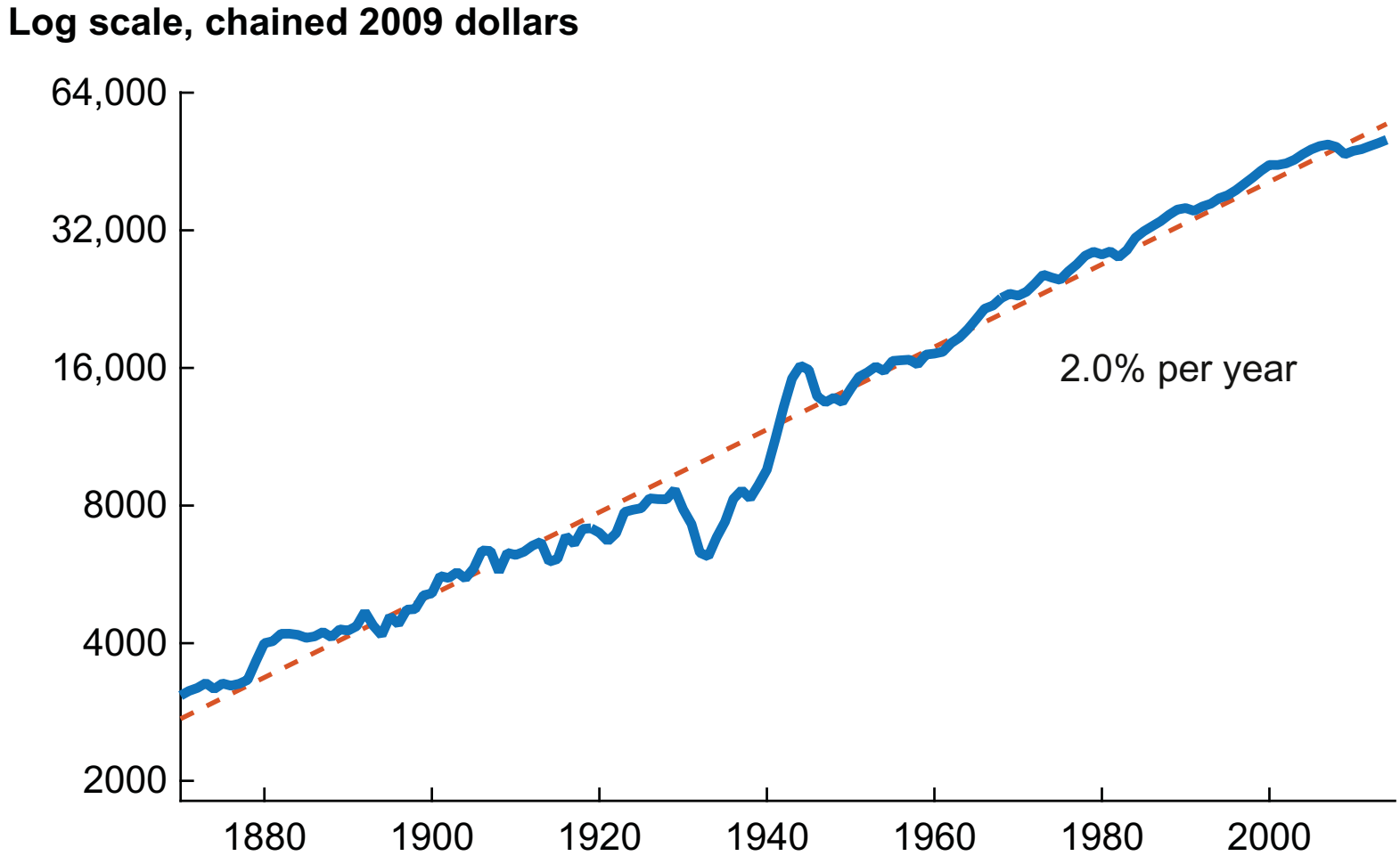

Figure: GDP per person in the United States.

Source: Jones (2016). Data for 1929-2014 are from the U.S. Bureau of Economic Analysis, NIPA table 7.1. Data before 1929 are spliced from Maddison, A. 2008.

Economic growth over the very long run

- Stagnation of standards of living until early 18th century.
- Economic growth kicks off with the Industrial Revolution in the 19th century.
- Small differences in income per capita across countries prior to 18th century. 'Great Divergence' thereafter.
- While the ratio of the poorest to the richest was less than 5 before 1700, it was about 10 after the Industrial Revolution in 1870 and above 100 nowadays.

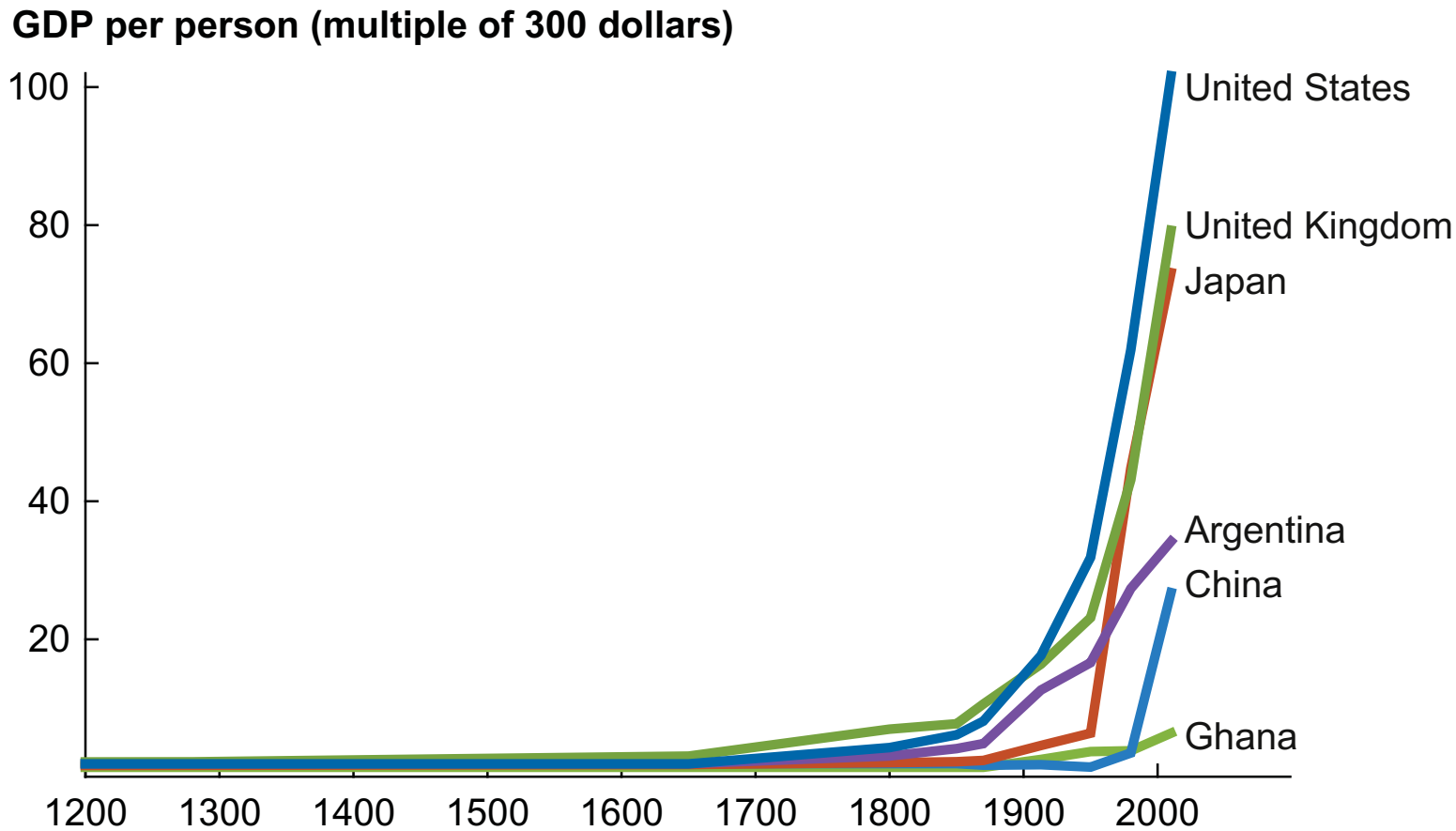

Figure: Economic growth over the very long run: the great divergence.

Source: Jones (2016). The graph shows GDP per person for various countries. The units are in multiples of 300 dollars and therefore correspond roughly to the ratio between a country's per capita income and the income in the poorest country in the world. Data from Bolt, J., van Zanden, J.L. 2014.

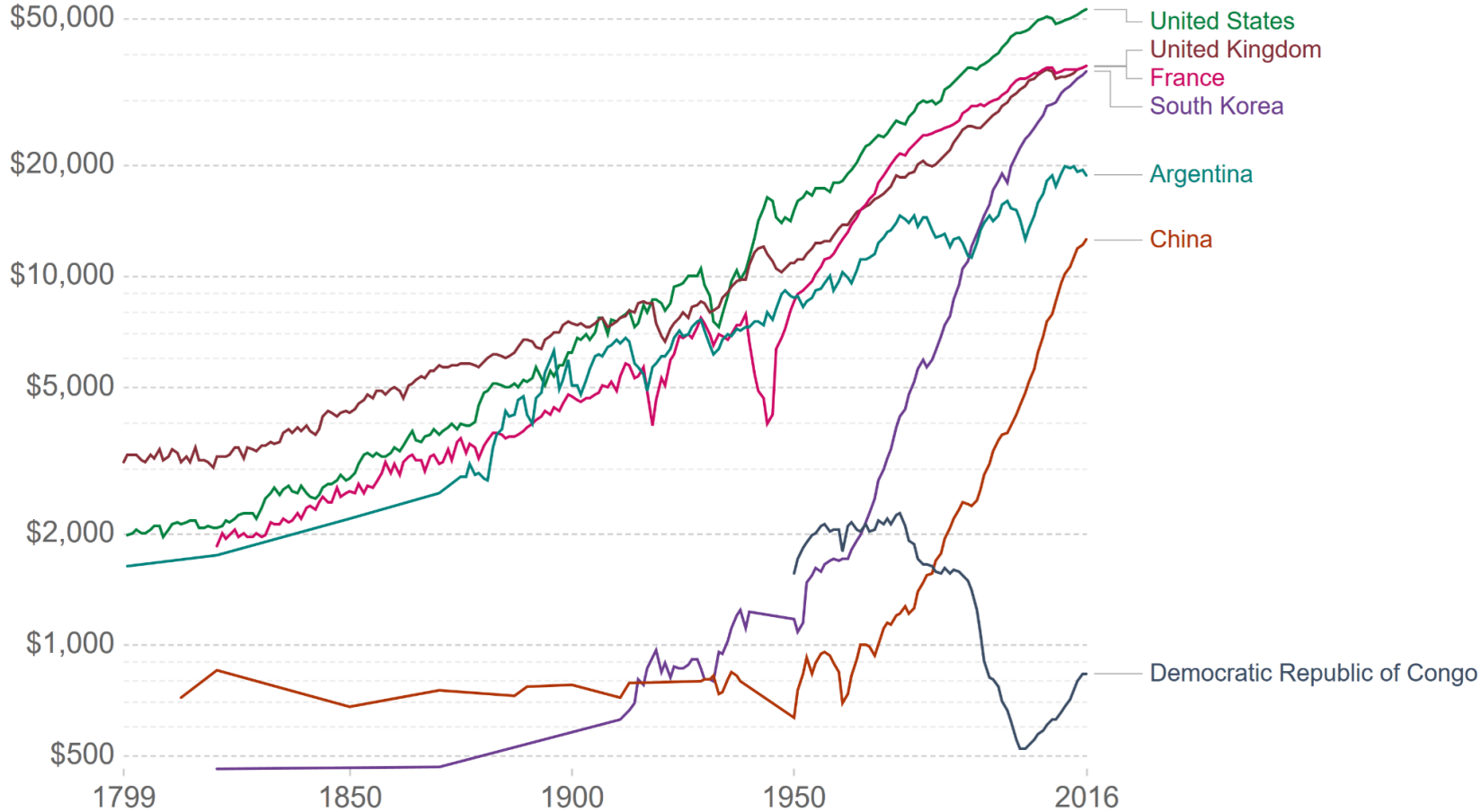

Figure: GDP per capita for selected countries (log-scale).

Source: Maddison.

Economic growth post World War II

- Large differences in income per capita post WWII.
- Some countries catching-up with economic leaders (e.g. Japan and East Asia) but stagnation in many countries (e.g. Sub-Saharan Africa).
- Differences in income per capita very persistent. Post WWII growth cannot explain alone cross-country income differences.
- **Do countries converge in terms of GDP per capita?**

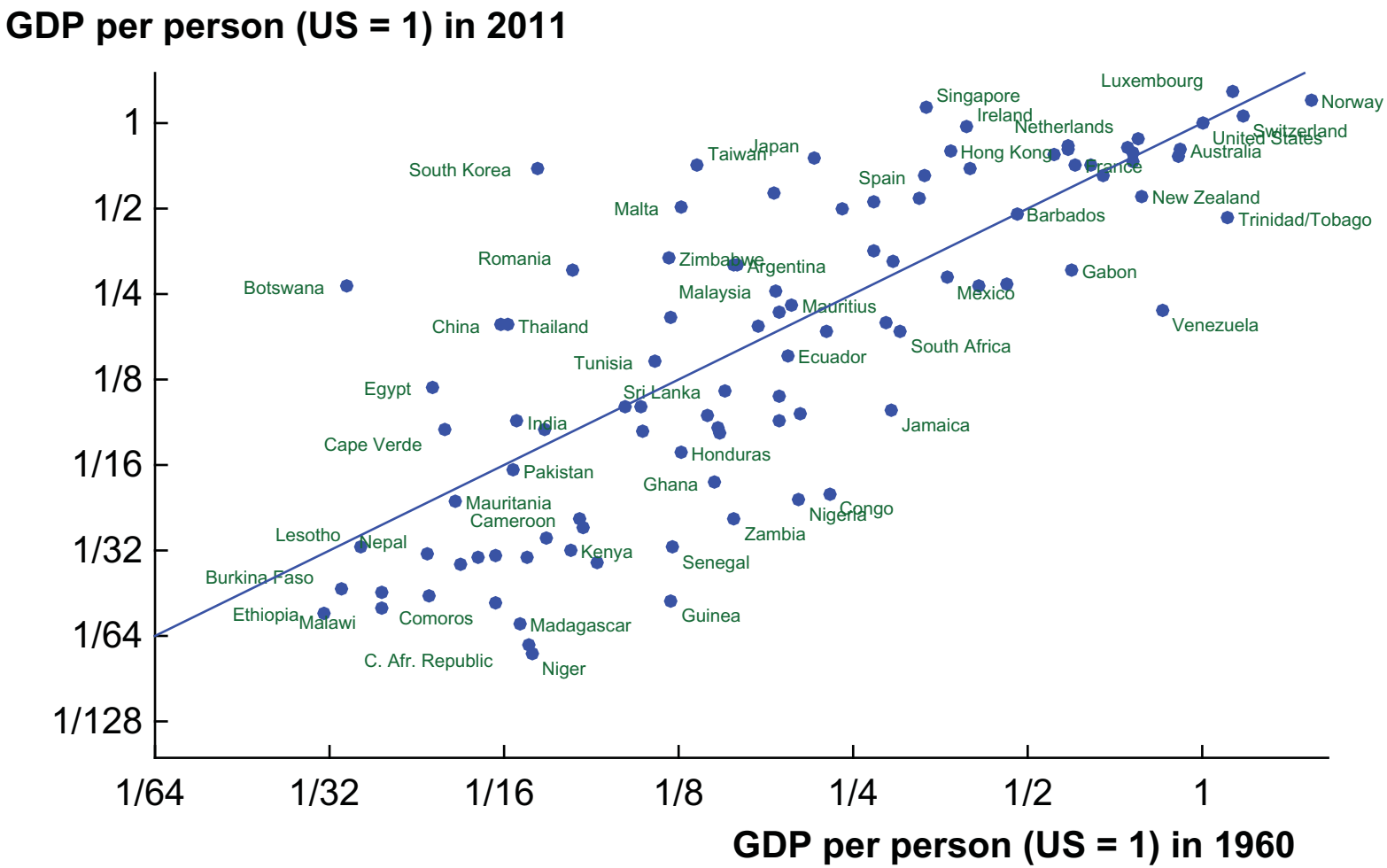

Figure: GDP per person, 1960 and 2011.

Source: Jones (2016) using The Penn World Tables 8.0.

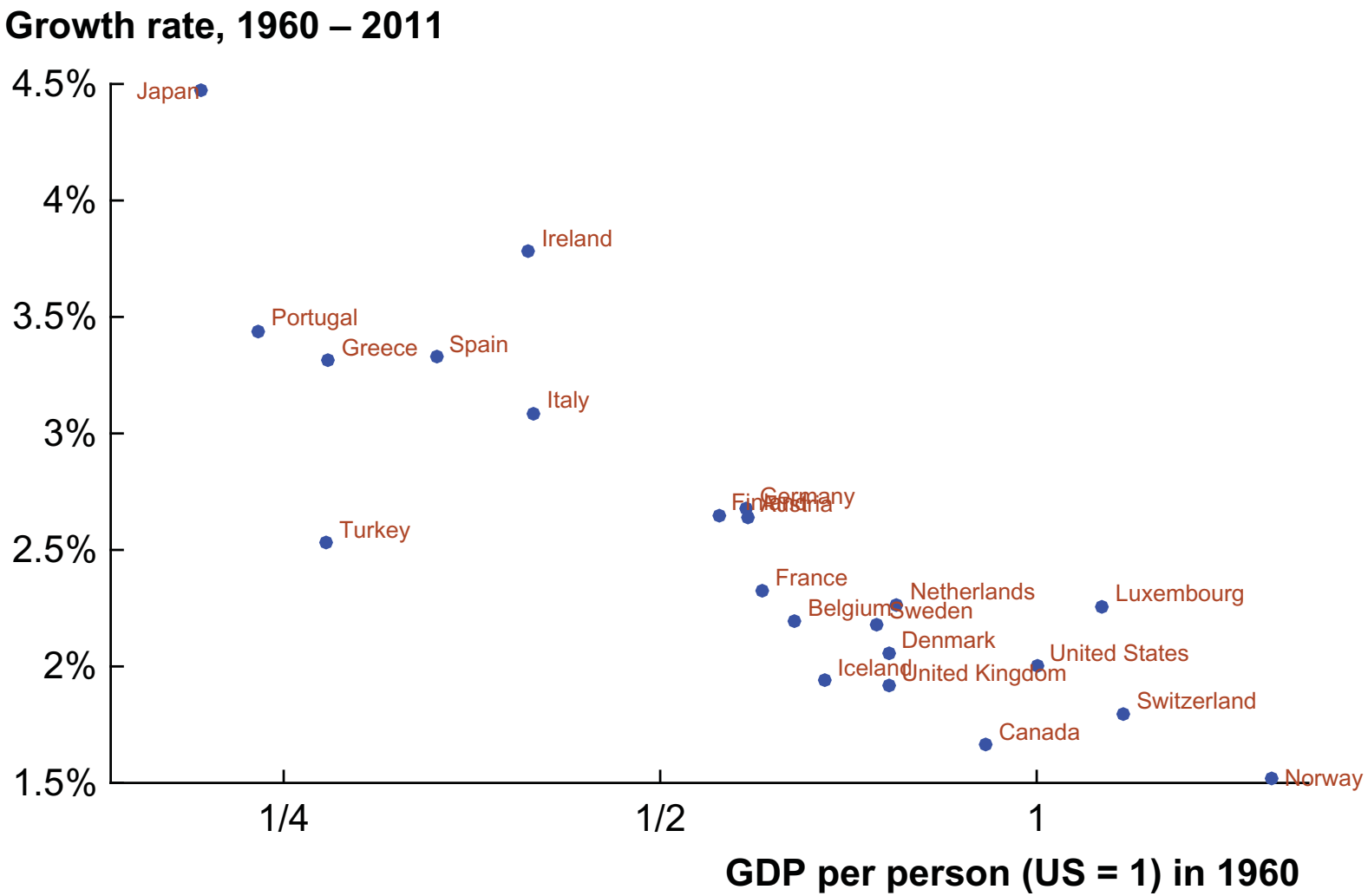

Figure: Convergence in the OECD, 1960-2011.

Source: Jones (2016) using The Penn World Tables 8.0. Annual growth rate of GDP per worker between 1960 and 2011 versus log GDP per person in 1960 for core OECD countries.

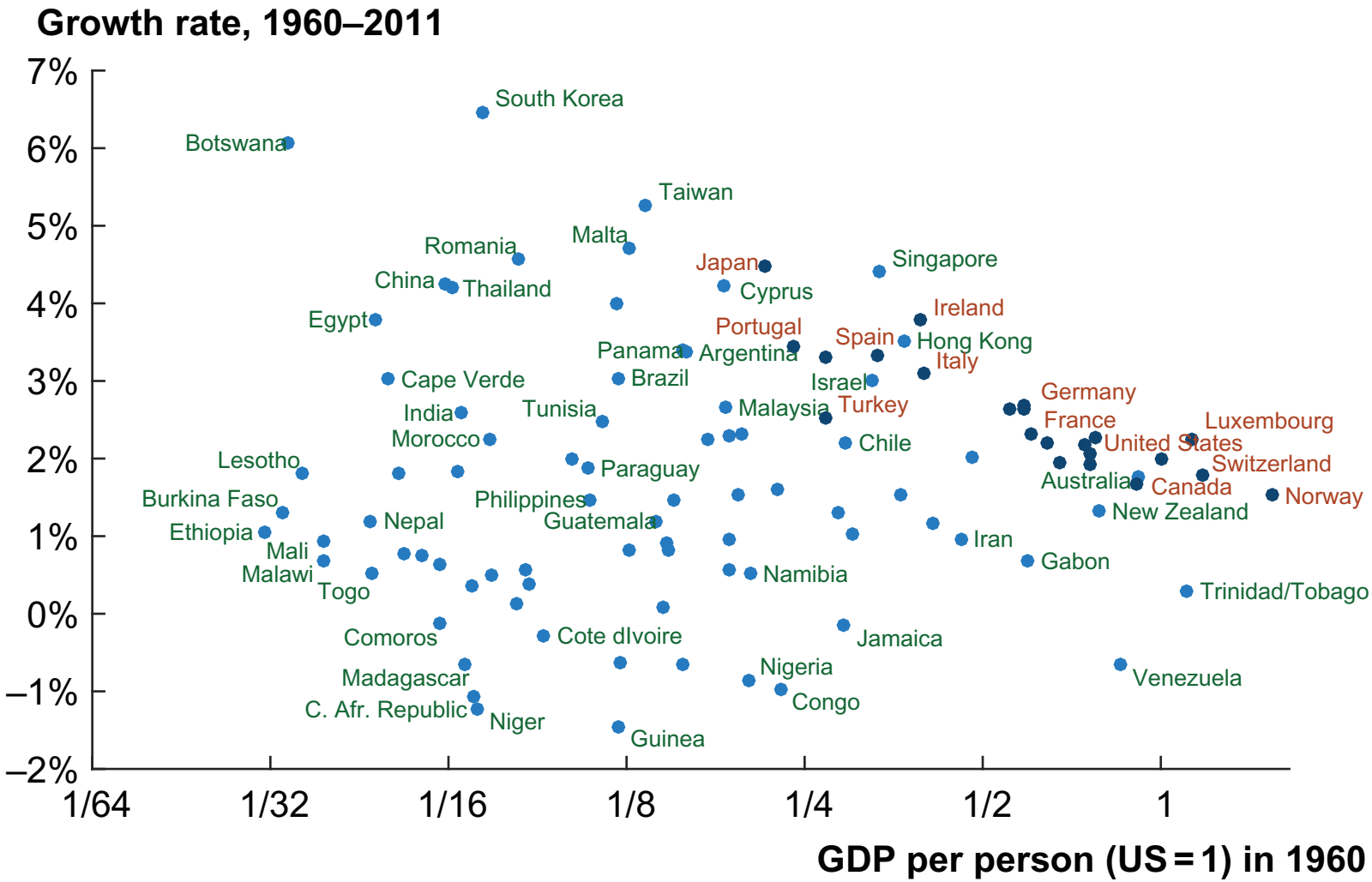

Figure: The lack of convergence worldwide.

Source: Jones (2016) using The Penn World Tables 8.0. Annual growth rate of GDP per worker between 1960 and 2011 versus log GDP per person in 1960 worldwide.

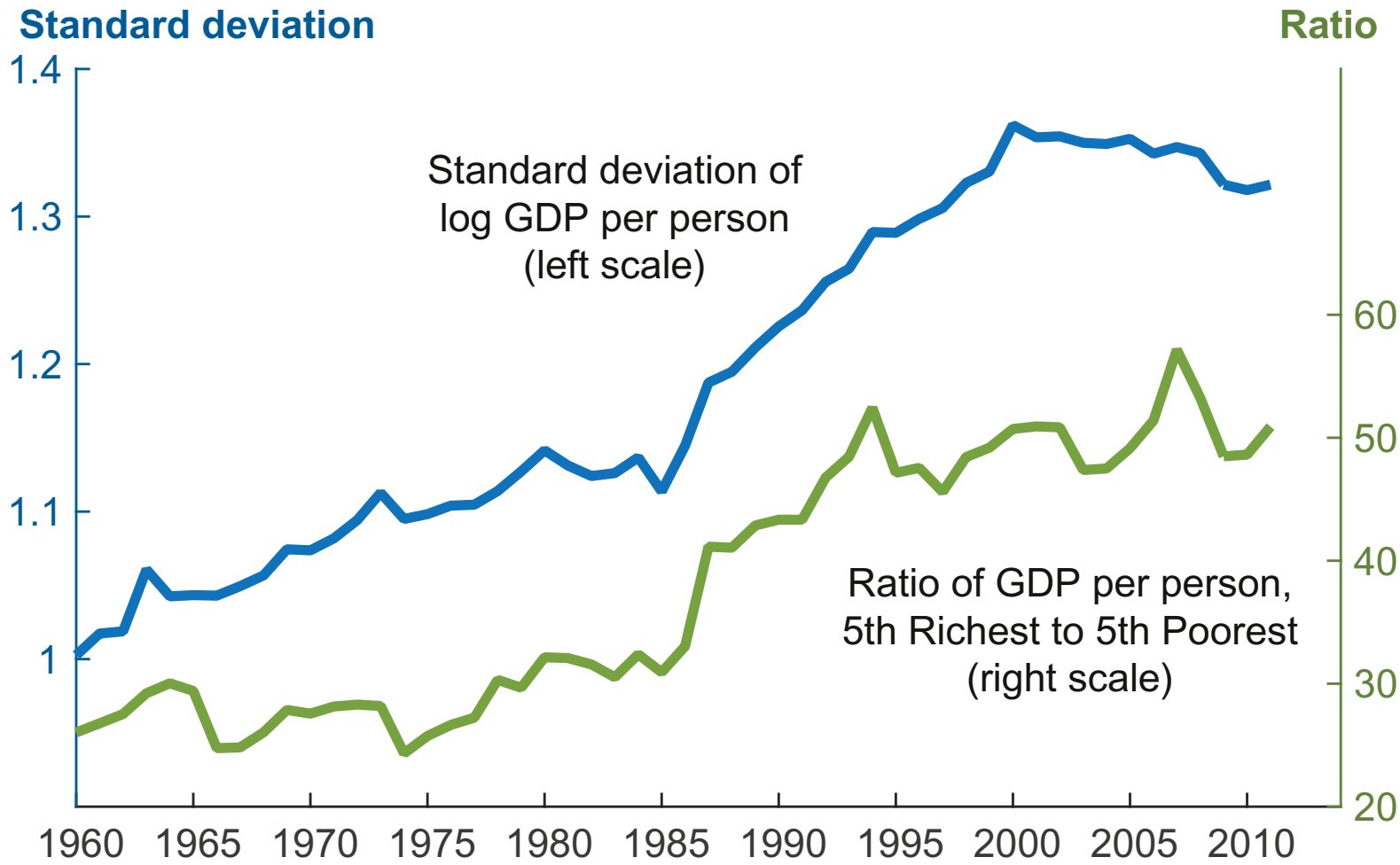

Figure: Divergence since 1960.

Source: Jones (2016) using The Penn World Tables 8.0. across a stable set of 100 countries.

Do countries converge?

- Noticeable increase in inequalities across nations post WWII (not necessarily across individuals in the world economy).
- Absence of convergence unconditionnally worldwide. Countries with lower GDP per capita do not grow faster.
- But convergence among similar countries (or regions).

▸ Convergence US States ▸ Convergence EU Regions

- **Consistent with theory?**

Conditional Convergence

- Barro (1991) looks at conditional convergence, i.e. the income gap between countries that *share the same characteristics*.
- Conditional convergence in 'Barro growth regressions'

$$\underbrace{g_{t,t-1}}_{\text{growth}} = \beta \underbrace{ln(y_{t-1})}_{\substack{\text{initial} \\ \text{income}}} + \underbrace{X'_{t-1}}_{\textit{characteristics}} \alpha + \underbrace{\varepsilon_t}_{\substack{\text{unobserved} \\ \text{variability}}}$$

- Useful for describing the data, but not for estimating causal effects of the variables in X_{t-1}.
- Strong evidence of conditional convergence although at a low rate ('Iron law of convergence'). Takes about 30 years to eliminate half of the income gap.

An aside—Income and Welfare

- Why do we care about differences in income per capita?
- Income per capita is not a sufficient statistic for the welfare of the average citizen.
- Development of other indices (OECD Better Life Index, Human Development Index, Index developed by Jones and Klenow, ...)
- Indices measuring various dimensions of welfare: health, education, income inequality, leisure, institutional quality, quality of the environment, ...
- Many dimensions of welfare correlate with income, not perfectly though.

	Consumption-equivalent welfare	Income	Log ratio	Life exp.	Decomposition			
					C/Y	Leisure	Cons. ineq.	Leis. ineq.
United States	100.0	100.0	0.000	0.000	0.000	0.000	0.000	0.000
United Kingdom	96.6	75.2	0.250	0.086	−0.143	0.073	0.136	0.097
France	91.8	67.2	0.312	0.155	−0.152	0.083	0.102	0.124
Italy	80.2	66.1	0.193	0.182	−0.228	0.078	0.086	0.075
Spain	73.3	61.1	0.182	0.133	−0.111	0.070	0.017	0.073
Mexico	21.9	28.6	−0.268	−0.156	−0.021	−0.010	−0.076	−0.005
Russia	20.7	37.0	−0.583	−0.501	−0.248	0.035	0.098	0.032
Brazil	11.1	17.2	−0.436	−0.242	0.004	0.005	−0.209	0.006
S. Africa	7.4	16.0	−0.771	−0.555	0.018	0.054	−0.283	−0.006
China	6.3	10.1	−0.468	−0.174	−0.311	−0.016	0.048	−0.014
Indonesia	5.0	7.8	−0.445	−0.340	−0.178	−0.001	0.114	−0.041
India	3.2	5.6	−0.559	−0.440	−0.158	−0.019	0.085	−0.028
Malawi	0.9	1.3	−0.310	−0.389	0.012	−0.020	0.058	0.028

Notes: The consumption-equivalent welfare numbers in the first column use a conventional utility function to "add up" the contributions from consumption, leisure, mortality, and inequality and express them in a consumption-equivalent manner. The income column reports GDP per person. The "decomposition" columns report an additive decomposition of the log difference between welfare and income.
Source: These numbers are taken from table 2 of Jones, C.I., Klenow, P.J. 2015. Beyond GDP: Welfare across countries and time. Stanford University, unpublished manuscript, and are based on data from household surveys in each country, from the World Bank (for mortality), and from the Penn World Tables 8.0 for a year close to 2005.

Figure: Beyond GDP: Welfare across countries.

Source: Jones (2016).

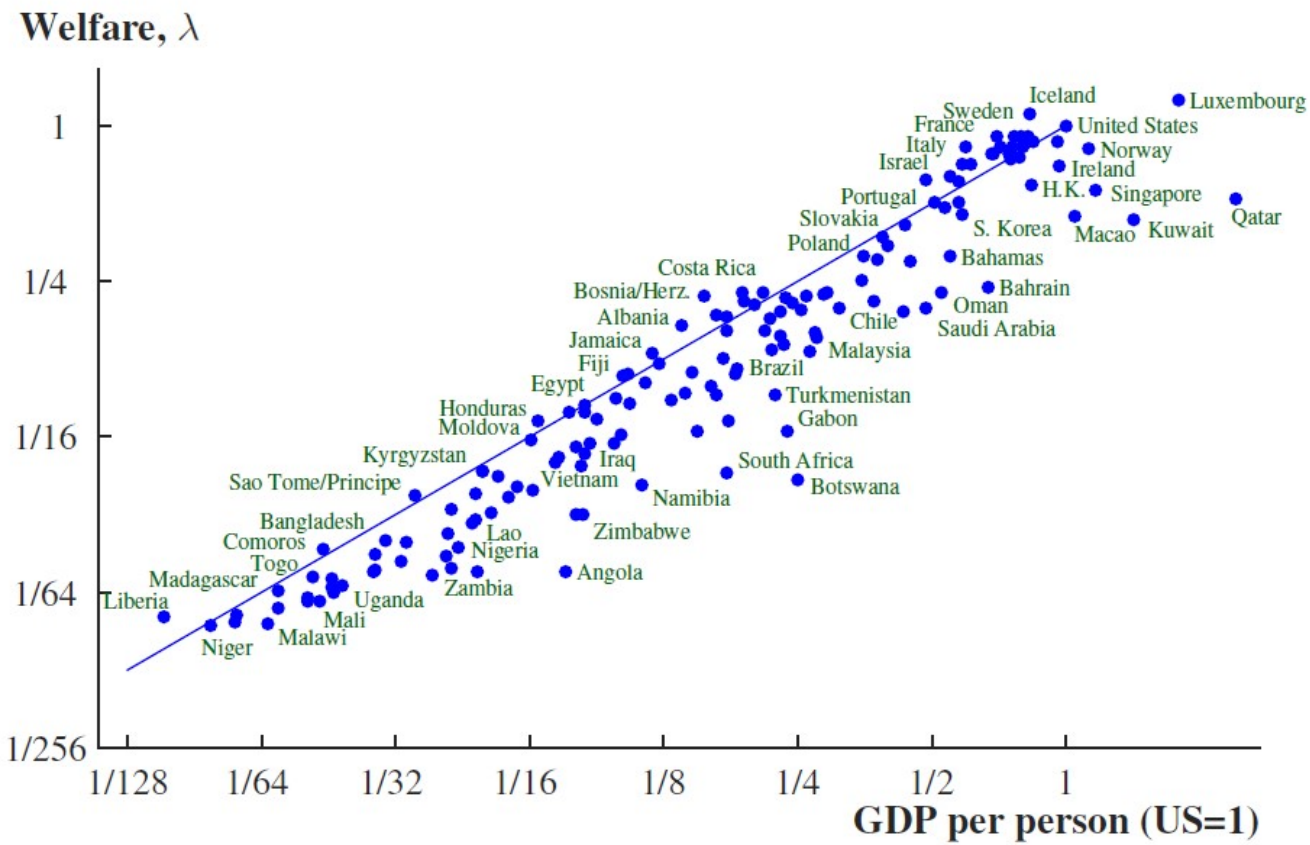

Figure: Beyond GDP: Welfare across countries.

Source: Jones (AER, 2016).

The Production Function

Production Function

- Technology to produce output at date t

$$Y(t) = F(K(t), L(t), Z(t))$$

- $F(\cdot)$ **production function increasing in all its arguments**.
- $K(t)$ and $L(t)$ factors of production

  $K(t)$ capital (equipment and structure)

  $L(t)$ labor (sometimes $H(t)$ when adjusted for quality = human capital)
- $Z(t)$ level of knowledge/technology

  = **Total Factor Productivity** (TFP).
- no intermediate inputs $\Rightarrow$ output measured as value added

Neoclassical Production Function

1. constant returns to scale in K and L (CRS), for any $\lambda > 0$

$$F(\lambda K, \lambda L, Z) = \lambda F(K, L, Z)$$

2. marginal product of K and L are

- positive:

$$MPK = \frac{\partial F}{\partial K} = F_K > 0 \qquad MPL = \frac{\partial F}{\partial L} = F_L > 0$$

- diminishing:

$$\frac{\partial F_K}{\partial K} = \frac{\partial^2 F}{\partial K^2} < 0 \qquad \frac{\partial F_L}{\partial L} = \frac{\partial^2 F}{\partial L^2} < 0$$

3. Inada conditions

$$\lim_{K \to 0} F_K = \infty \qquad \lim_{K \to \infty} F_K = 0$$

$$\lim_{L \to 0} F_L = \infty \qquad \lim_{L \to \infty} F_L = 0$$

Cobb-Douglas Production Function

$$Y(t) = F(K(t), L(t), Z(t)) = Z(t)K(t)^{\alpha}L(t)^{1-\alpha}$$

With capital per worker $k(t) = \frac{K(t)}{L(t)}$,

$$\text{Output per worker} = y(t) = \frac{Y(t)}{L(t)} = Z(t)k(t)^{\alpha}$$

$$MPK = \frac{\partial F}{\partial K} = \alpha Z(t)(\frac{L(t)}{K(t)})^{1-\alpha} = \alpha Z(t)k(t)^{\alpha-1} > 0$$

$$MPL = \frac{\partial F}{\partial L} = (1-\alpha)Z(t)(\frac{K(t)}{L(t)})^{\alpha} = (1-\alpha)Z(t)k(t)^{\alpha} > 0$$

MPK (resp. MPL) is decreasing (resp. increasing) in k.

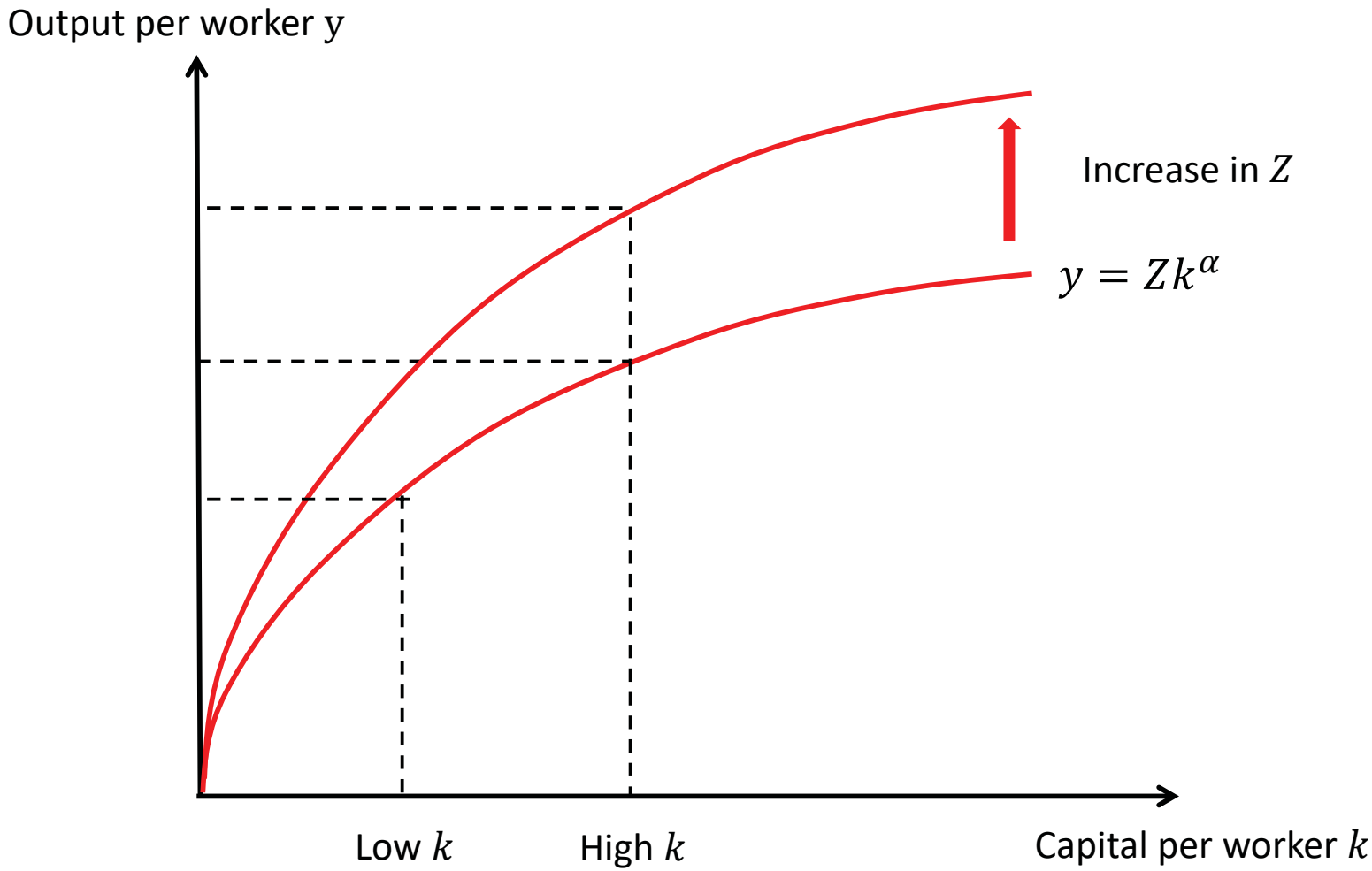

Figure: Output per worker and the production function.

Factor payments

- **Firm optimization.** Firms facing a static problem

$\Leftrightarrow$ current choices do not impact future possibilities

$\Rightarrow$ choose K and L to maximize profits period by period

$$\max_{\{K(t),L(t)\}} F(K(t), L(t), Z(t)) - w(t)L(t) - R(t)K(t)$$

with wage $w(t)$ and rental rate of capital $R(t)$.

- **Optimality.** Factors are paid their marginal productivity,

$R(t) = MPK = \alpha Z(t)k(t)^{\alpha-1}$ and $w(t) = MPL = (1-\alpha)Z(t)k(t)^{\alpha}$

$R(t)$ decreasing with k due to diminishing returns.

$w(t)$ increasing with k.

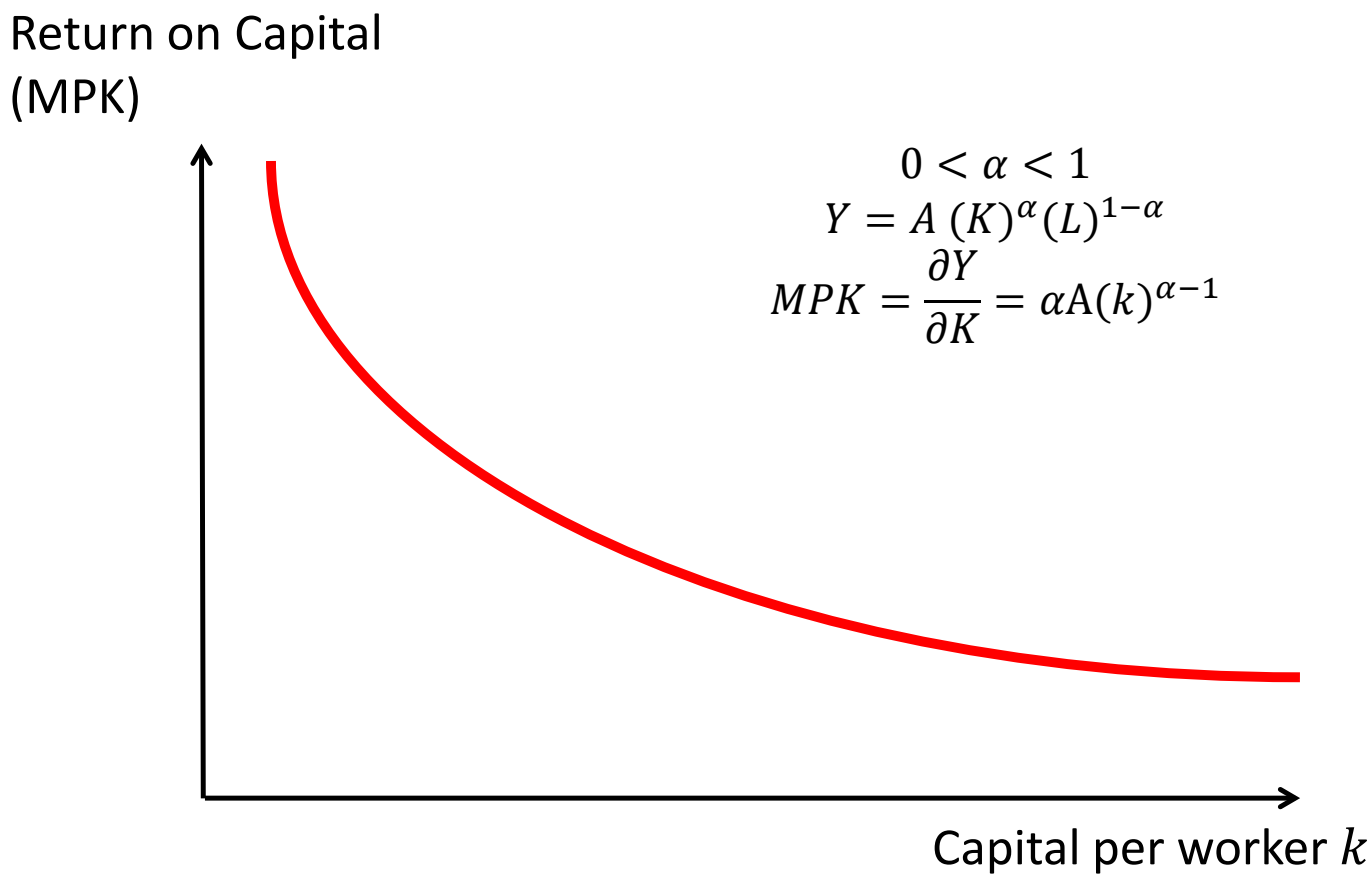

Figure: Diminishing returns to capital.

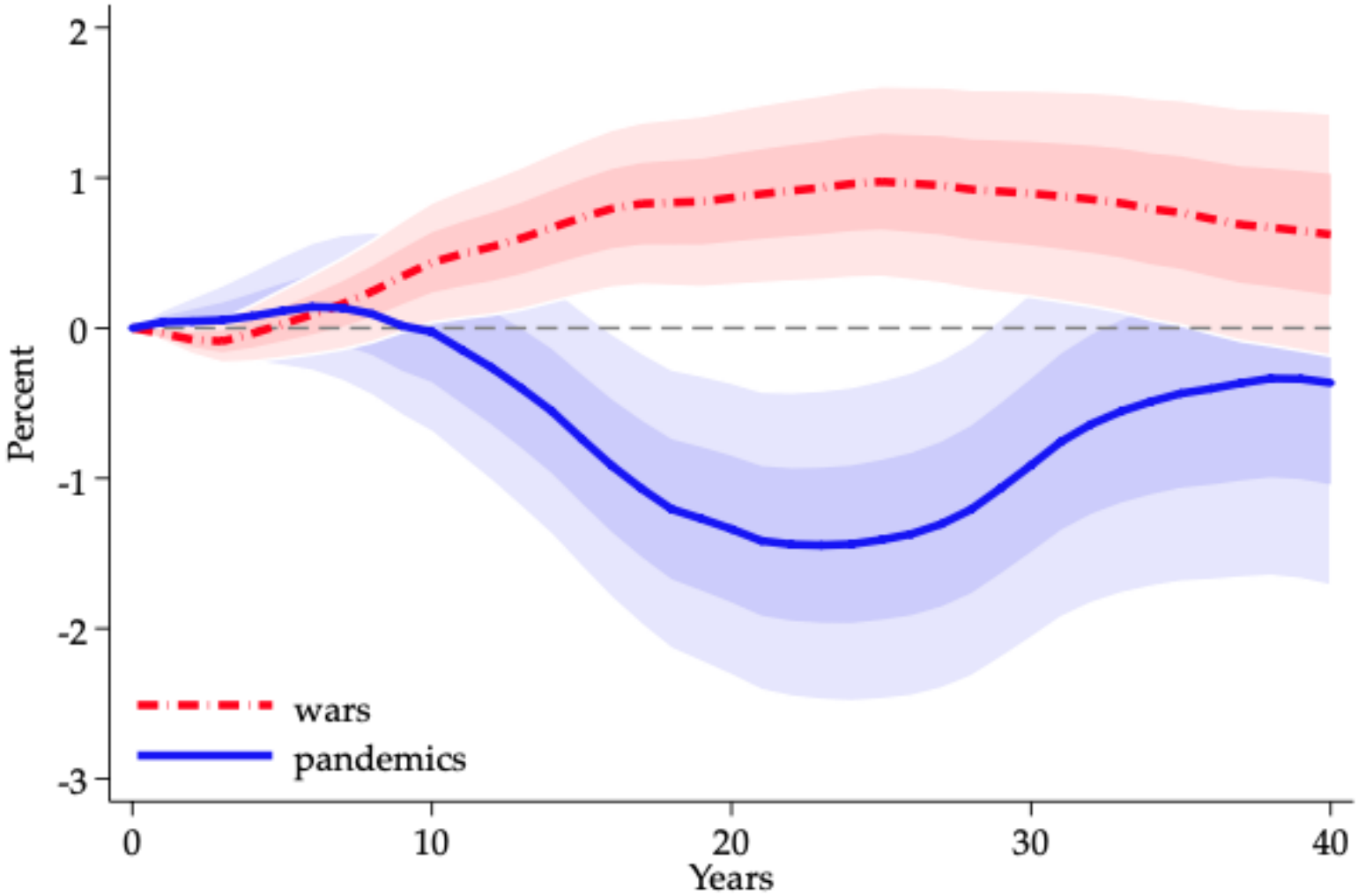

Figure: Diminishing returns to capital.
The response of the real natural rate to pandemics and to wars.

Source: Jorda et al. (2020).

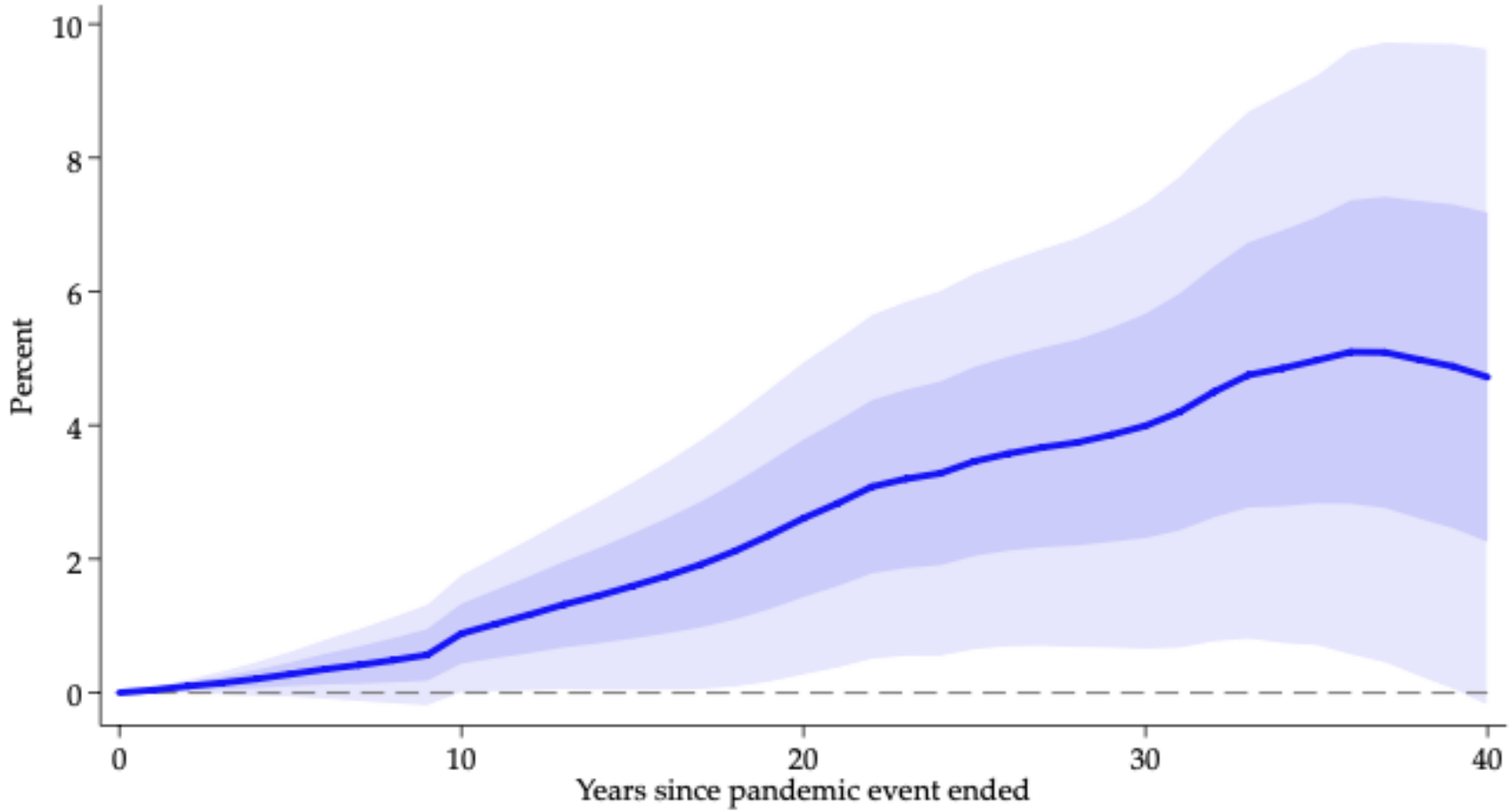

Figure: The response of real wages to pandemics.

Source: Jorda et al. (2020).

Factor shares

- Distribution of income.

$$R(t)K(t) = \alpha Y(t) \text{ and } w(t)L(t) = (1-\alpha)Y(t)$$

- With Cobb-Douglas, factor shares are constant.

Capital share $= \frac{R(t)K(t)}{Y(t)} = \alpha.$

Labour share $= \frac{w(t)L(t)}{Y(t)} = 1 - \alpha.$

In the data, $\alpha \approx 1/3$.

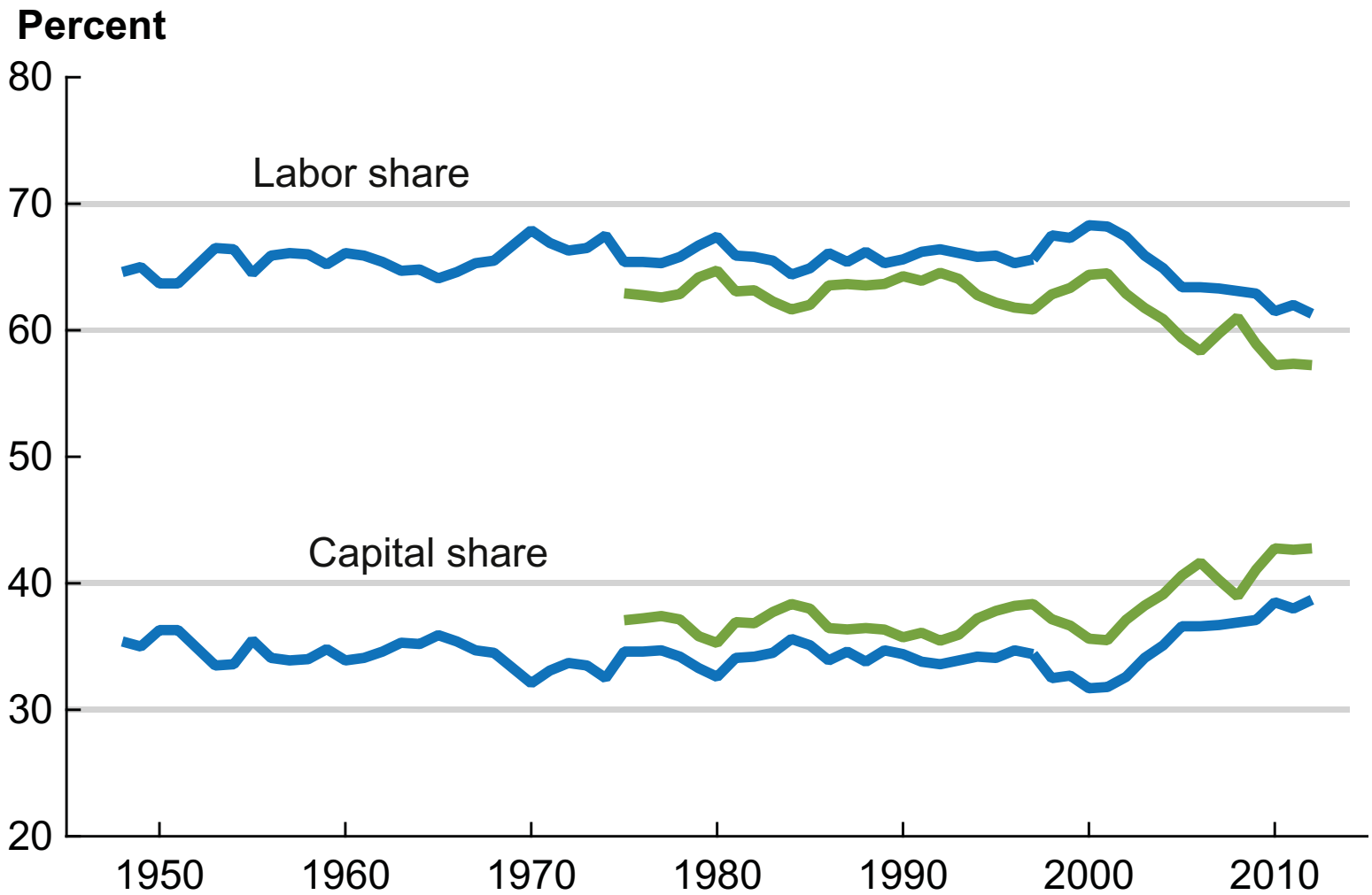

Figure: Capital and labor shares of factor payments, United States.

Source: Jones (2016). The series starting in 1975 are from Karabarbounis, L., Neiman, B. 2014. and measure the factor shares for the corporate sector, which the authors argue is helpful in eliminating issues related to self-employment. The series starting in 1948 is from the Bureau of Labor Statistics. The factor shares add to 100%.

Development and Growth Accounting

A Primer on Development Accounting

- Output per worker (no time indice for simplicity)

$$y = Zk^{\alpha}$$

- Country (i) relative to US,

$$\frac{y_i}{y_{US}} = \left(\frac{Z_i}{Z_{US}}\right)\left(\frac{k_i}{k_{US}}\right)^{\alpha}$$

- Differences in output per worker across countries reflect
  - differences in TFP, Z
  - differences in capital stock per worker, k
- Measure y and k to determine Z and assess the source of income differences.

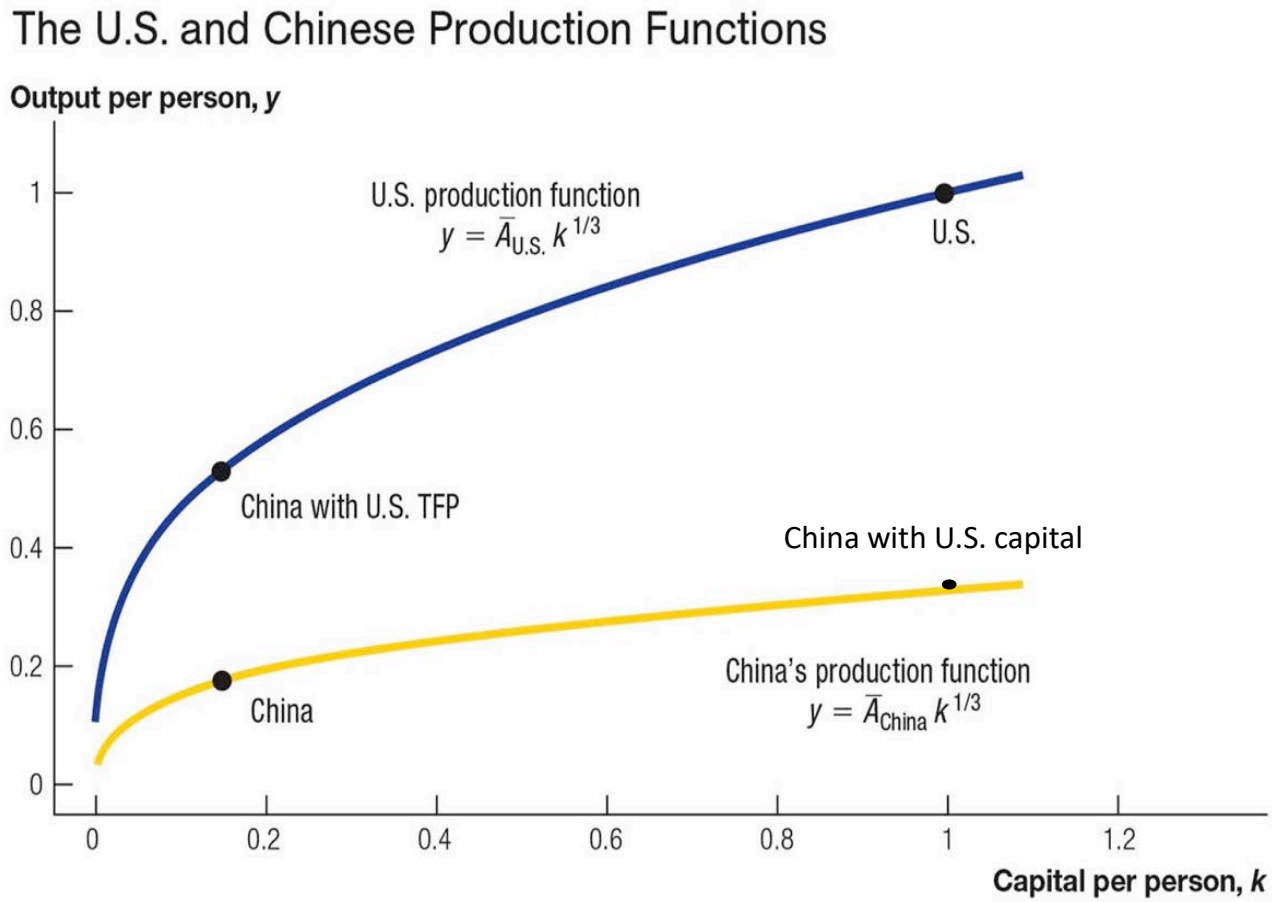

Figure: Development Accounting: US versus China.

Source: Jones.

Country	Observed capital per person, $\bar{k}$	Predicted per capita GDP with U.S TFP	Observed per capita GDP
United States	1.000	1.000	1.000
Switzerland	1.269	1.083	0.966
Japan	1.178	1.056	0.760
Italy	0.926	0.975	0.686
Spain	0.840	0.944	0.661
United Kingdom	0.671	0.876	0.828
Brazil	0.174	0.559	0.201
South Africa	0.162	0.546	0.182
China	0.147	0.528	0.172
India	0.061	0.394	0.084
Burundi	0.006	0.180	0.010

Figure: Development Accounting. The importance of TFP.

Source: Jones.

Production Function with Human Capital

- Human capital is an important driver of worker productivity. If missing, one might overstate the role of TFP.
- Technology to produce output

$$Y(t) = F(K(t), H(t), Z(t)) = Z(t)K(t)^{\alpha}H(t)^{1-\alpha},$$

with $H(t)$ the level of human capital.

- With some rewriting, following Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), output per worker

$$y(t) = Z(t)^{1/(1-\alpha)} \left(\frac{K(t)}{Y(t)}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{H(t)}{L(t)}\right)$$

Check the formula.
Hint: Divide $Y(t)$ on both sides by $Y(t)^{\alpha}$ and solve for $Y(t)$.

Development Accounting

- Output per worker

$$y(t) = Z(t)^{1/(1-\alpha)} \left(\frac{K(t)}{Y(t)} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{H(t)}{L(t)} \right)$$

- Differences in output per worker across countries reflect
  - differences in labor-augmenting TFP, $Z(t)^{1/(1-\alpha)}$
  - differences in capital-output ratio, $\frac{K(t)}{Y(t)}$
  - differences in human capital per worker, $\frac{H(t)}{L(t)}$
- Measure y, $\frac{K(t)}{Y(t)}$ and $\frac{H(t)}{L(t)}$ to determine $Z(t)^{1/(1-\alpha)}$ and assess the source of income differences.

	GDP per worker, y	Capital/GDP $(K/Y)^{\alpha/(1-\alpha)}$	Human capital, h	TFP	Share due to TFP
United States	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%
United Kingdom	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%
1/Average	4.720	1.021	1.418	3.260	69.2%

The product of the three input columns equals GDP per worker. The penultimate row, "Average," shows the geometric average of each column across 128 countries. The "Share due to TFP" column is computed as described in the text. The 69.2% share in the last row is computed looking across the columns, ie, as approximately 3.5/(3.5 + 1.5).
Source: Computed using the Penn World Tables 8.0 for the year 2010 assuming a common value of $\alpha = 1/3$.

Figure: Development Accounting, 2010

Source: Jones (2016).

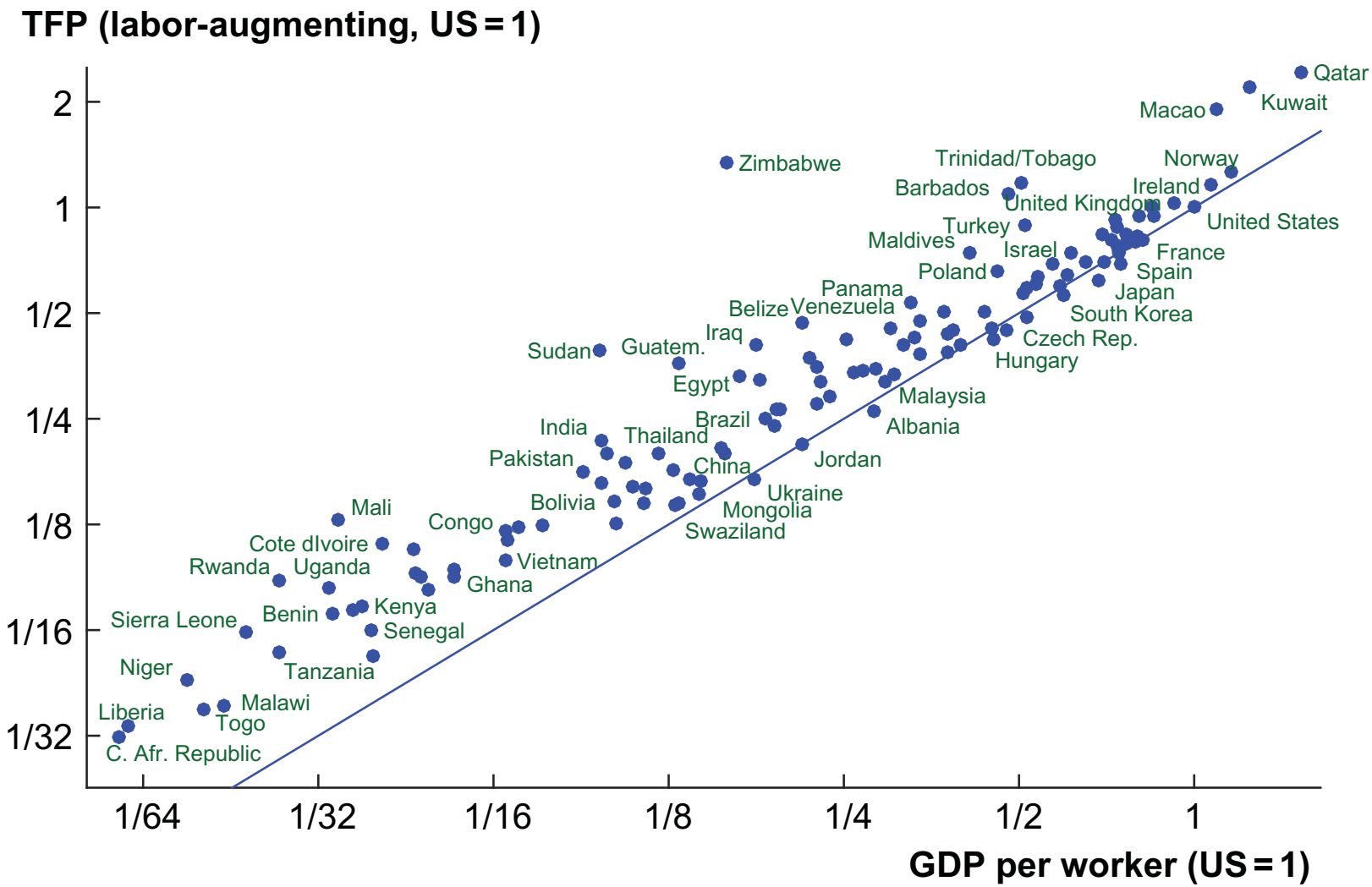

Figure: Total factor productivity, 2010.

Source: Jones (2016) using The Penn World Tables 8.0. assuming a common $\alpha = 1/3$.

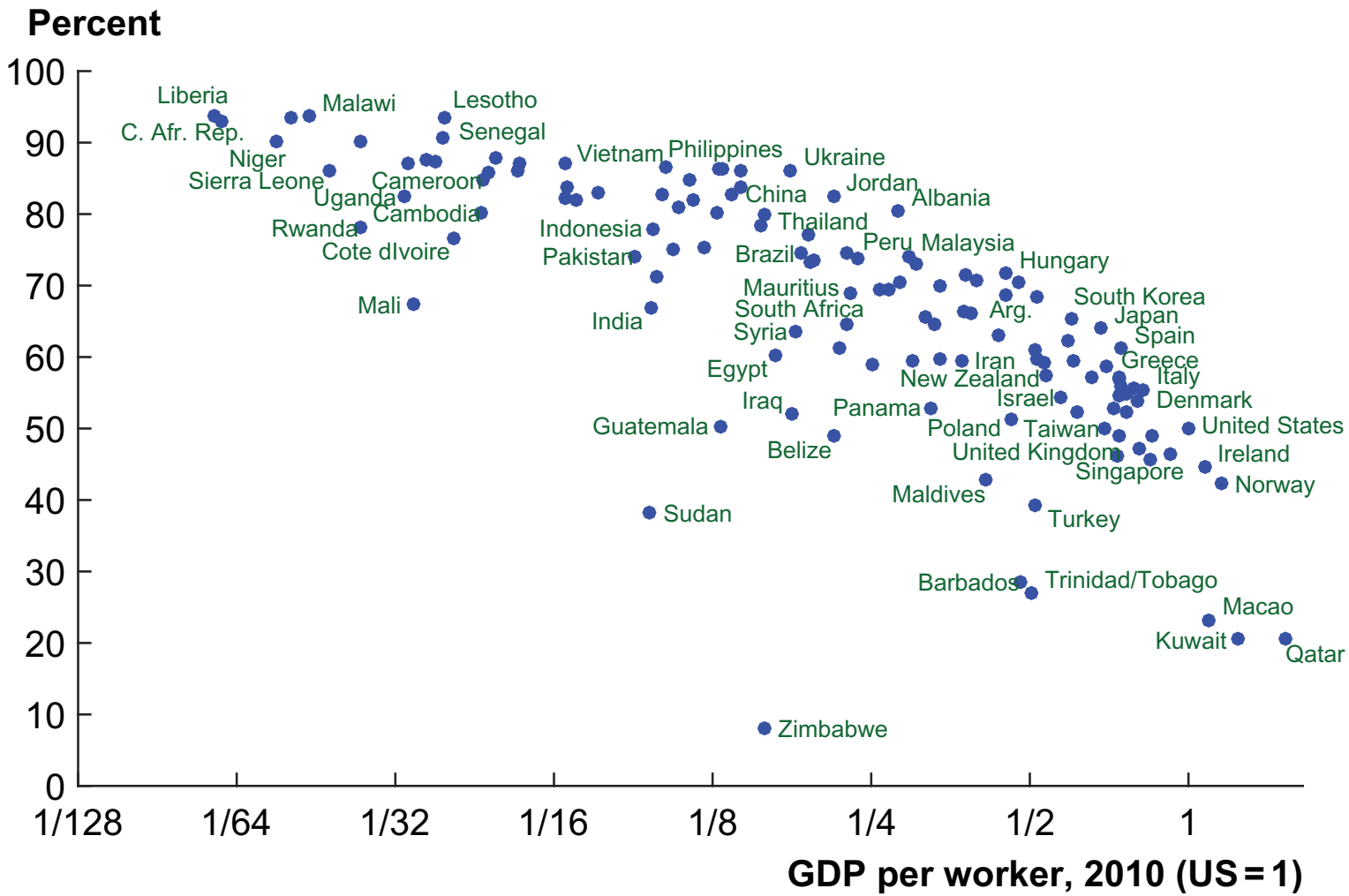

Figure: The share of TFP in development accounting, 2010.

Source: Jones (2016) using The Penn World Tables 8.0. assuming a common $\alpha = 1/3$.

Growth Accounting

- Growth of output per worker,

  [Hint: first differentiate log of output per worker]

$$\Delta \ln y(t) = \frac{1}{1-\alpha}\Delta \ln Z(t) + \frac{\alpha}{1-\alpha}\Delta \ln \left(\frac{K(t)}{Y(t)}\right) + \Delta \ln \left(\frac{H(t)}{L(t)}\right)$$

- Growth of output per worker $\Delta \ln y(t)$ reflect
  - change in TFP, $\Delta \ln Z(t)$
  - change in capital-output ratio, $\Delta \ln \left(\frac{K(t)}{Y(t)}\right)$
  - change in human capital per worker, $\Delta \ln \left(\frac{H(t)}{L(t)}\right)$

Period	Output per hour	Contributions from		
		K/Y	Labor composition	Labor-Aug. TFP
1948–2013	**2.5**	**0.1**	**0.3**	**2.0**
1948–1973	3.3	−0.2	0.3	3.2
1973–1990	1.6	0.5	0.3	0.8
1990–1995	1.6	0.2	0.7	0.7
1995–2000	3.0	0.3	0.3	2.3
2000–2007	2.7	0.2	0.3	2.2
2007–2013	1.7	0.1	0.5	1.1

Note: Average annual growth rates (in percent) for output per hour and its components for the private business sector, following Eq. (3).
Source: Authors calculations using Bureau of Labor Statistics, *Multifactor Productivity Trends*, August 21, 2014.

Table: Growth accounting for the United States.

Source: Jones (2016).

Development and Growth Accounting

- Even when adjusting for human capital, TFP differences are crucial to understand differences in output per worker across countries.
- Over time, for an advanced economy (e.g. US post-WWII), change in TFP is the main source of productivity growth.
- **Caveat.** TFP is a residual. Not measured directly but inferred to match data on output per worker.
- **What is behind TFP?**

What is behind TFP?

- **Efficiency.** A country may use its factors of production inefficiently and produce below the possibility frontier. *Misallocation* of resources.
- **Technology.** A country may produce at the production possibility frontier but improvements in technology push the frontier out.
- Starts with efficiency. Technological progress and innovation covered later. What makes a country more or less efficient?
- Many possible dimensions but among some fundamental causes of long-run development: Geography, Institutions, Culture & History.
- Focus on **Institutions**. Might generate very persistent income differences.

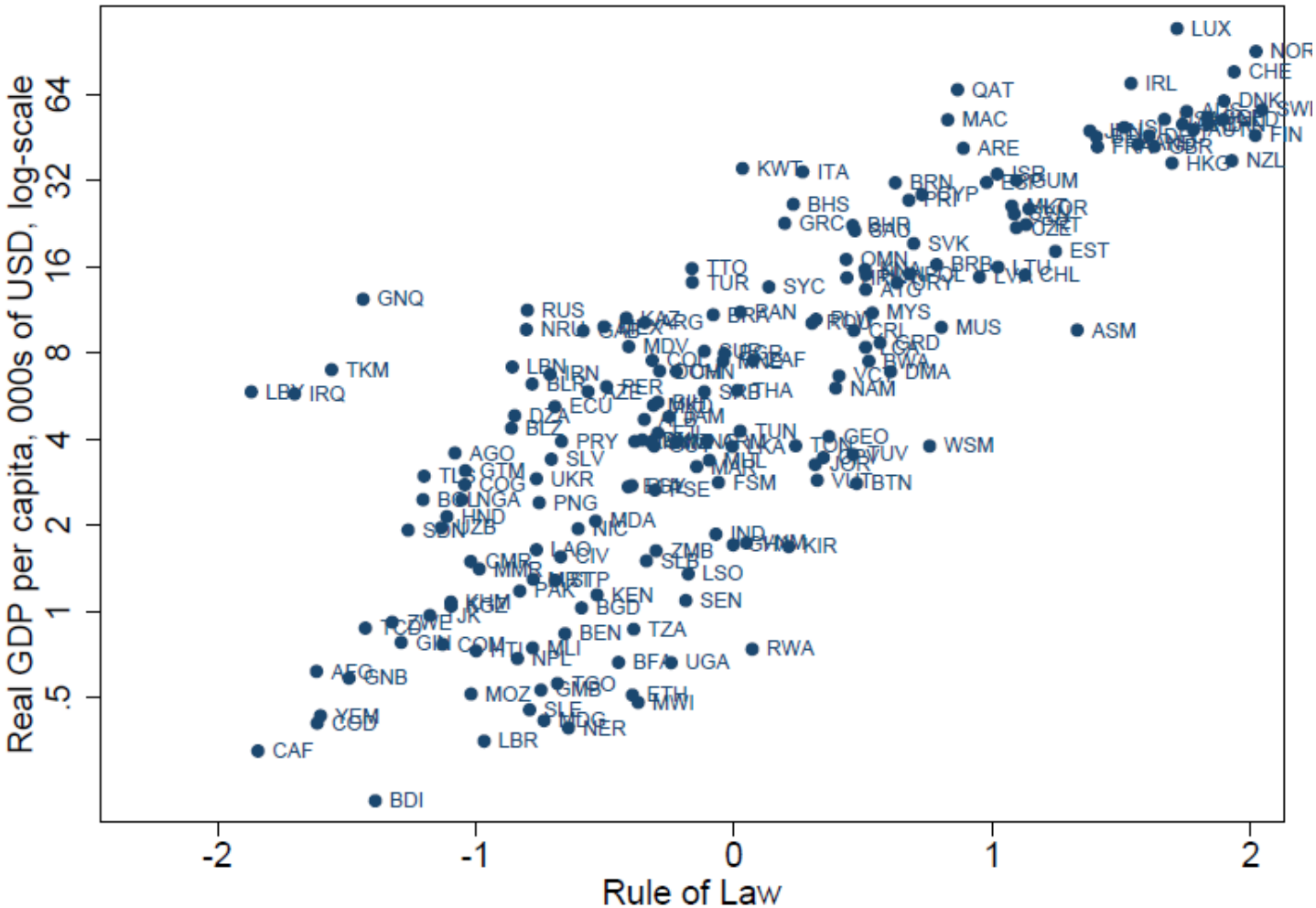

Figure: Institutions and Level of Development.
Do better institutions lead to higher GDP per capita?

Source: World Bank, 2016 data

Institutions and level of development

- Does better institutions increase output per capita or the other way around?
- Institutions endogenous to the process of development. Correlation is **not** causality.
- How can we identify the sense of the causality?
  - Find 'exogenous changes' in institutions in a given country (or a set of countries) and then look at growth outcomes.
  - 'Natural experiment'.
  - 'Instrumental variables' (Acemoglu et al.(2001)).

Satellite Image of North and South Korea at Night, 2008

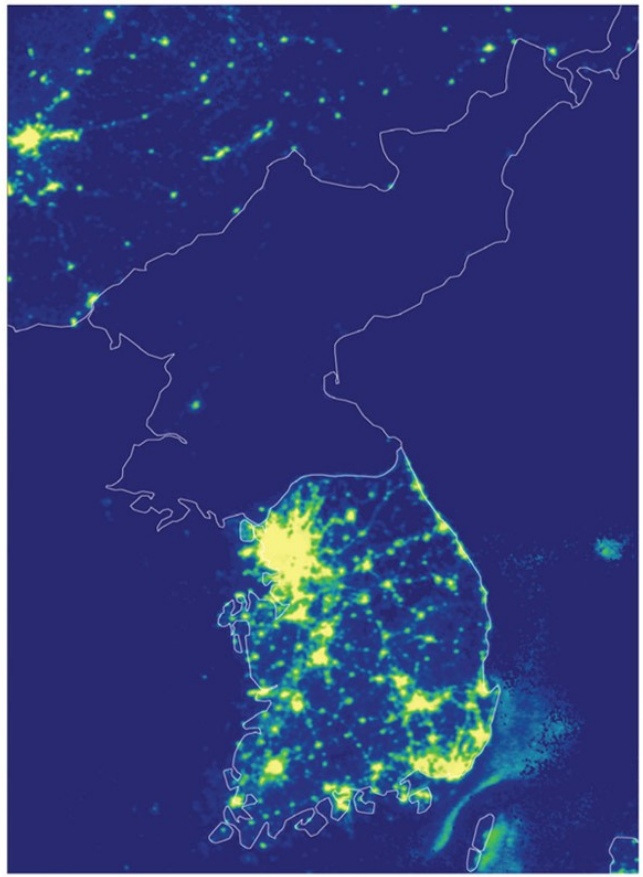

Figure: Do institutions matter? North and South Korea.

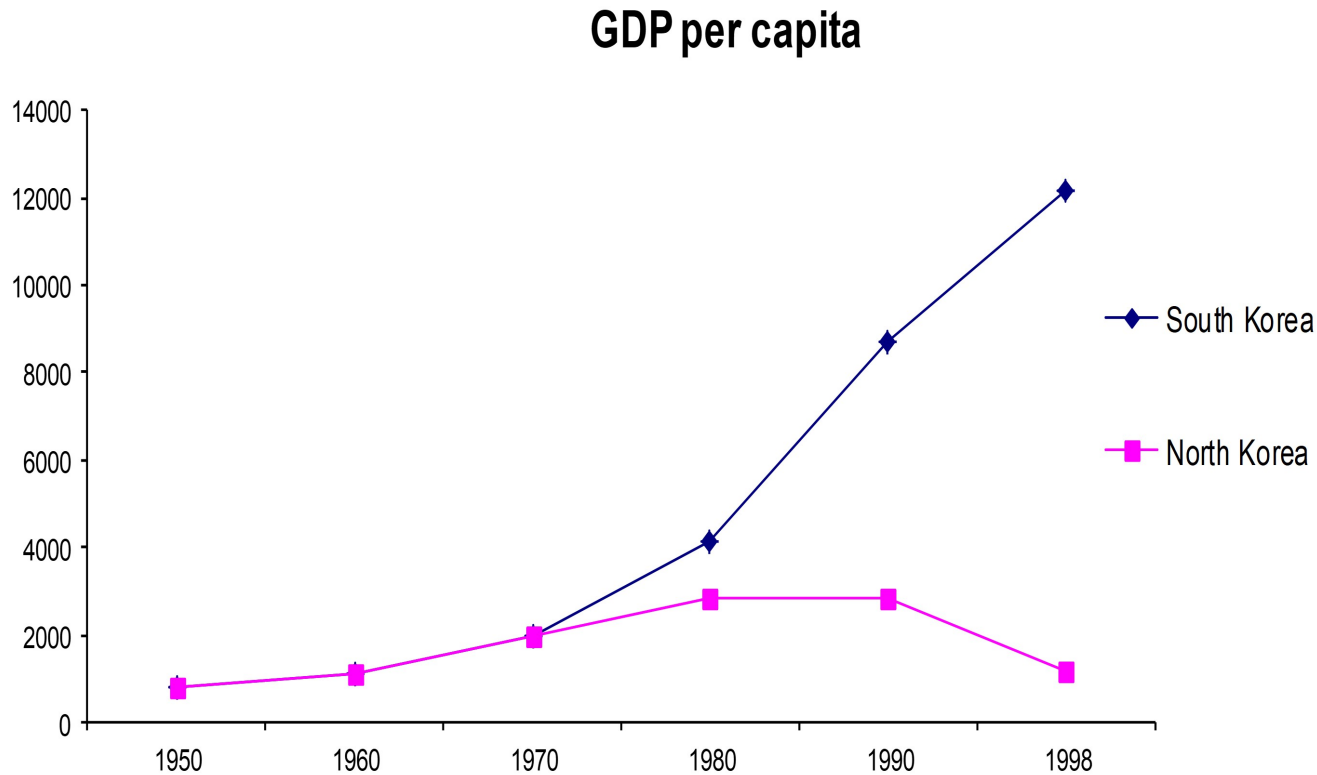

Figure: Do institutions matter? North and South Korea.

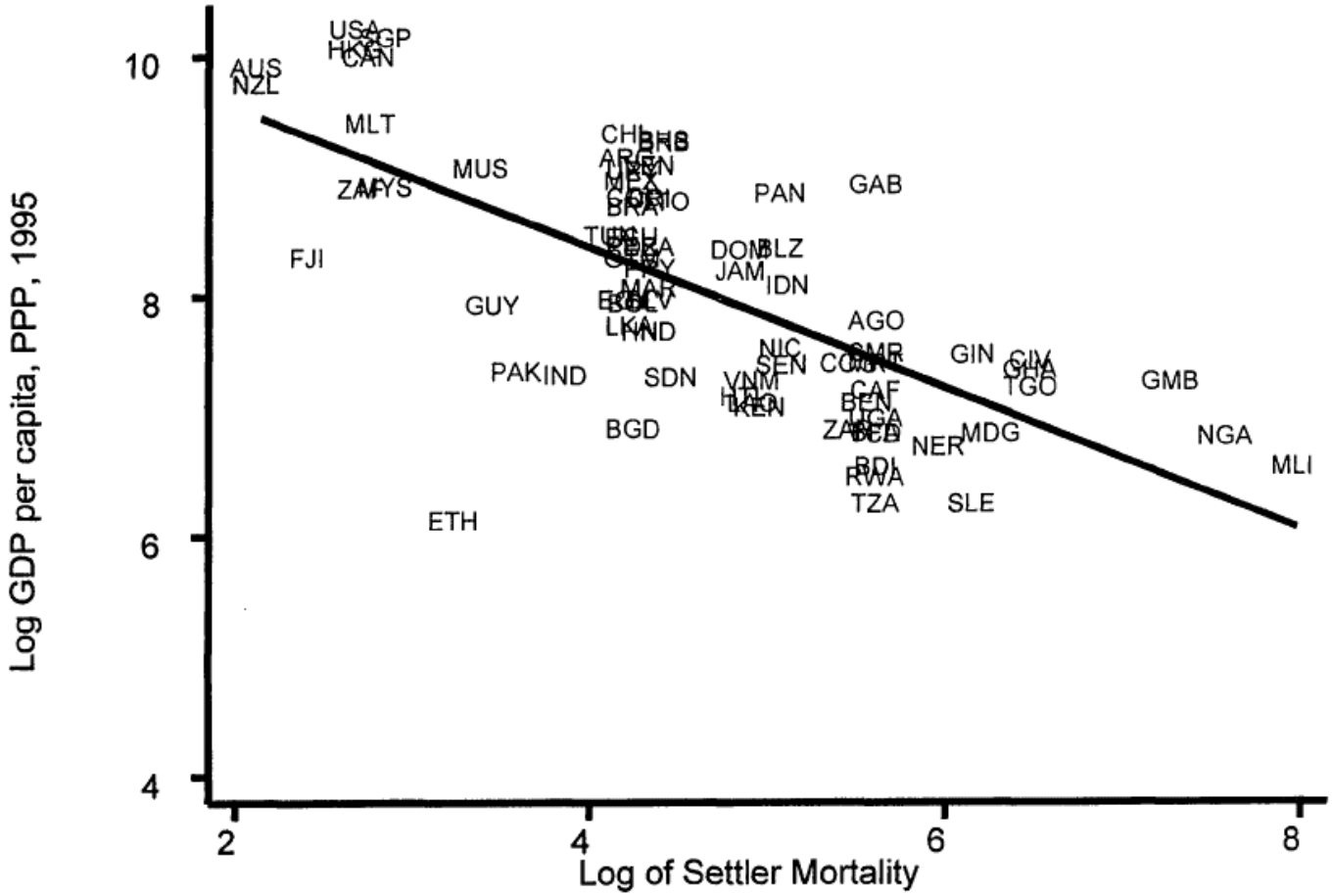

FIGURE 1. REDUCED-FORM RELATIONSHIP BETWEEN INCOME AND SETTLER MORTALITY

Figure: Do institutions matter?
The colonial origins of comparative development.

Source: : Acemoglu, Johnson and Robinson (2001).

Conclusion

- Large differences in income per capita since the Industrial Revolution.
- Largely explained by differences in TFP.
- TFP is a wide-ranging concept measuring how efficient is the economy in using its resources but also the technology and knowledge available.
- Need theory to understand the patterns of growth across countries.
- Why do some countries experiment growth miracles, while others experiment growth disasters?
- What is fostering capital accumulation? Innovation and technological progress?

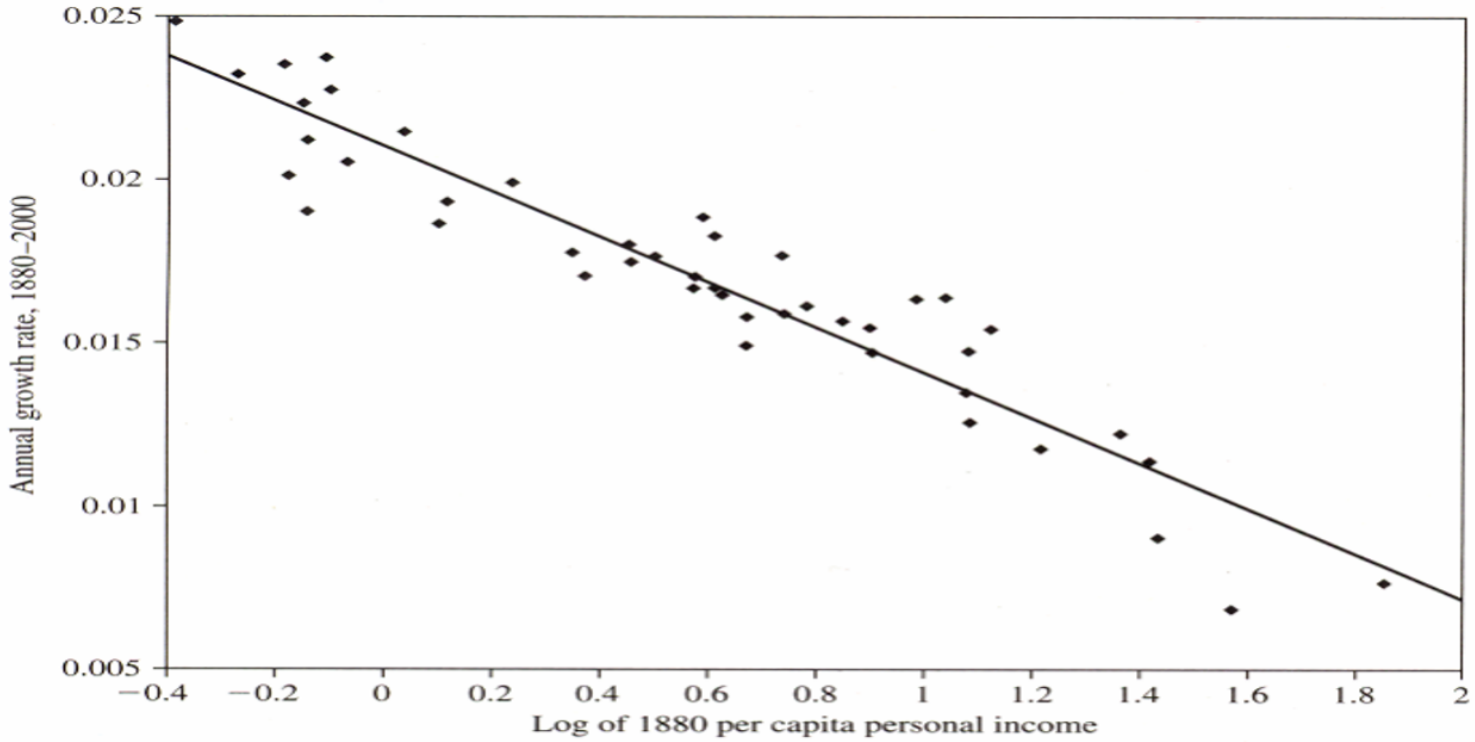

Figure 11.2
Convergence of personal income across U.S. states: 1880 personal income and 1880–2000 income growth. The average growth rate of state per capita income for 1880–2000, shown on the vertical axis, is negatively related to the log of per capita income in 1880, shown on the horizontal axis. Thus, absolute β convergence exists for the U.S. states.

Figure: Convergence among US states, 1880-2000.

▸ back

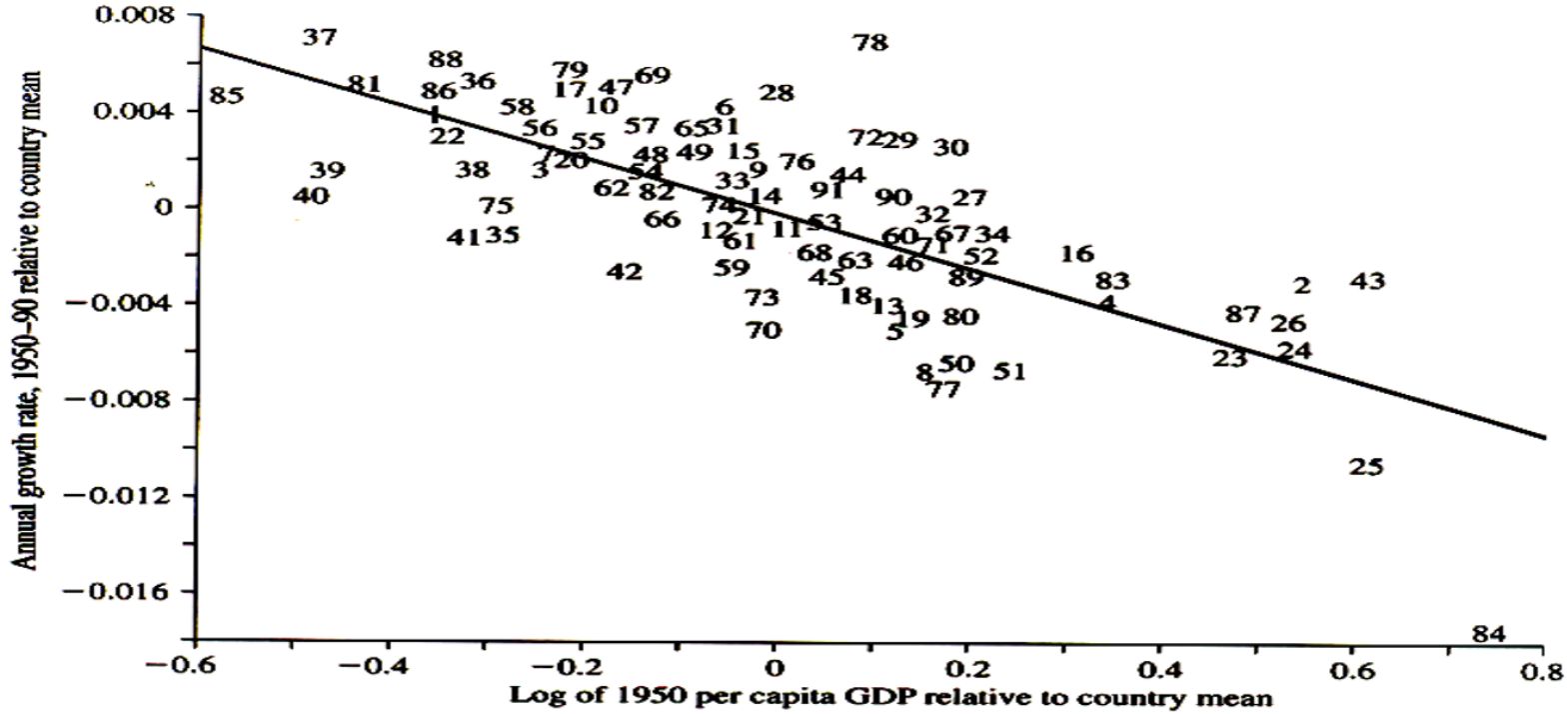

Figure 11.8
Growth rate from 1950 to 1990 versus 1950 per capita GDP for 90 regions in Europe. The growth rate of a region's per capita GDP for 1950–90, shown on the vertical axis, is negatively related to the log of per capita GDP in 1950, shown on the horizontal axis. The growth rate and level of per capita GDP are measured relative to the country means. Hence, this figure shows that absolute β convergence exists for the regions within Germany, the United Kingdom, Italy, France, the Netherlands, Belgium, Denmark, and Spain. The numbers shown identify the regions; see table 11.9.

Figure: Convergence among European Regions, 1950-1990.

▸ back