
Growth

Modern economic growth

- Economic growth is a relatively recent phenomenon
- Maddison:
  - World income per capita same in 500 and 1500 AD
  - In 1500-1820 cumulative growth of 15% (0.04% p.a.)
  - Since then growth at 1.2% a year (doubles every 58 years)

Growth in this course

- Aggregate growth models

  Harrod-Domar

  Solow = Harrod-Domar + endogenous capital-output ratio

  Ramsey = Solow + endogenous savings

  Endogenous growth = Ramsey + endogenous human capital / R&D

- Cross-country evidence
- Micro evidence
- New growth paradigm: disaggregated growth model

Harrod-Domar

GDP is proportional to physical capital $Y=AK$

(neither labor nor human capital matter, motivated by Great Depression)

Capital accumulation: $\Delta K = -\delta K + I$

(δ - depreciation rate)

Hence growth is a linear function of investment

$\Delta Y/Y = \Delta K/K = -\delta + I/K = -\delta + AI/Y$

Investment immediately brings growth

Numerical example

- Productivity of capital A =Y/K=0.25 p.a.
- Depreciation 0.05 p.a.
- Want to achieve 6% p.a. growth
- Hence 0.06=-0.05+0.25*I/Y
- Targeted investment rate I/Y=(0.06+0.05)/0.25=0.44
- What if savings are just 14% GDP? Then

  'Financing gap'=S/Y-I/Y= - 30% GDP

Implications

- Raise investment whatever it takes
- If savings<targeted investment rate, then bridge the financing gap
- Hence: Aid for investment
- BUT: capital flight and misplaced investment
  - Aid is channeled back through offshore

Soviet industrialization

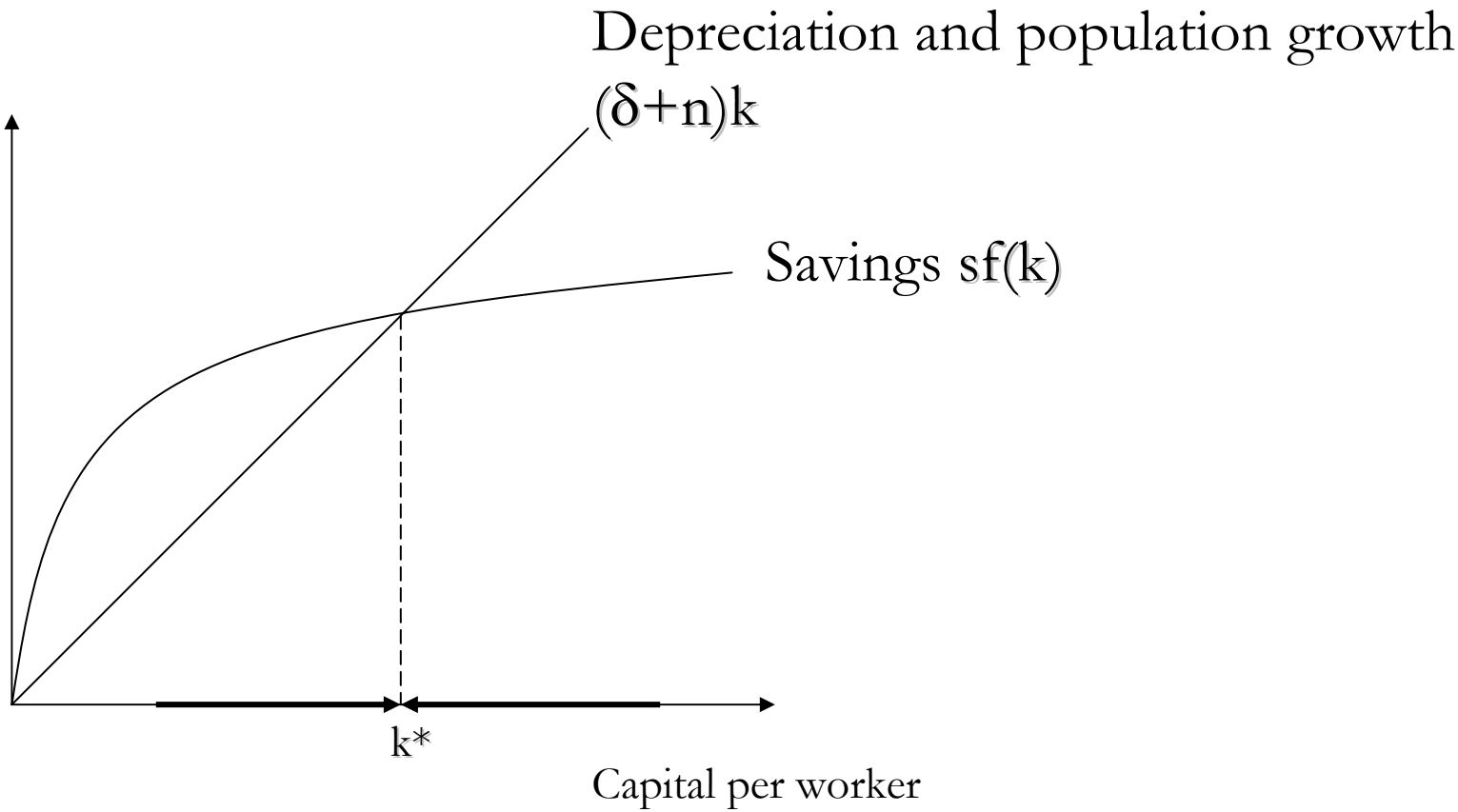
- Implementation of Harrod-Domar
  - Domar refers to Soviet 1920s economists
- Industrialization within three ‘five-year plans’
  - Impressed many development economists and developing countries
- ‘Perspiration not inspiration’
  - High investment
    - At the expense of consumption
  - Increase in industrial labor force
    - At the expense of agriculture
  - Low (if positive) wages

Solow model

- Substitution between capital and labor
  - Production function $Y=F(K,L)$
    - Constant returns to scale: $Y=LF(K/L,1)$ or $y=f(k)$
    - Diminishing returns to each factor: $f'>0$, $f'' <0$
  - Harrod-Domar is a particular case with $Y=AK$, or $Y=\min\{AK,BL\}$
  - More general case: substitution, e.g. Cobb-Douglas $Y=K^{\alpha} L^{1-\alpha}$
- Labor grows at an exogenous rate n
- Savings rate $s=S/Y$ is fixed

Steady state

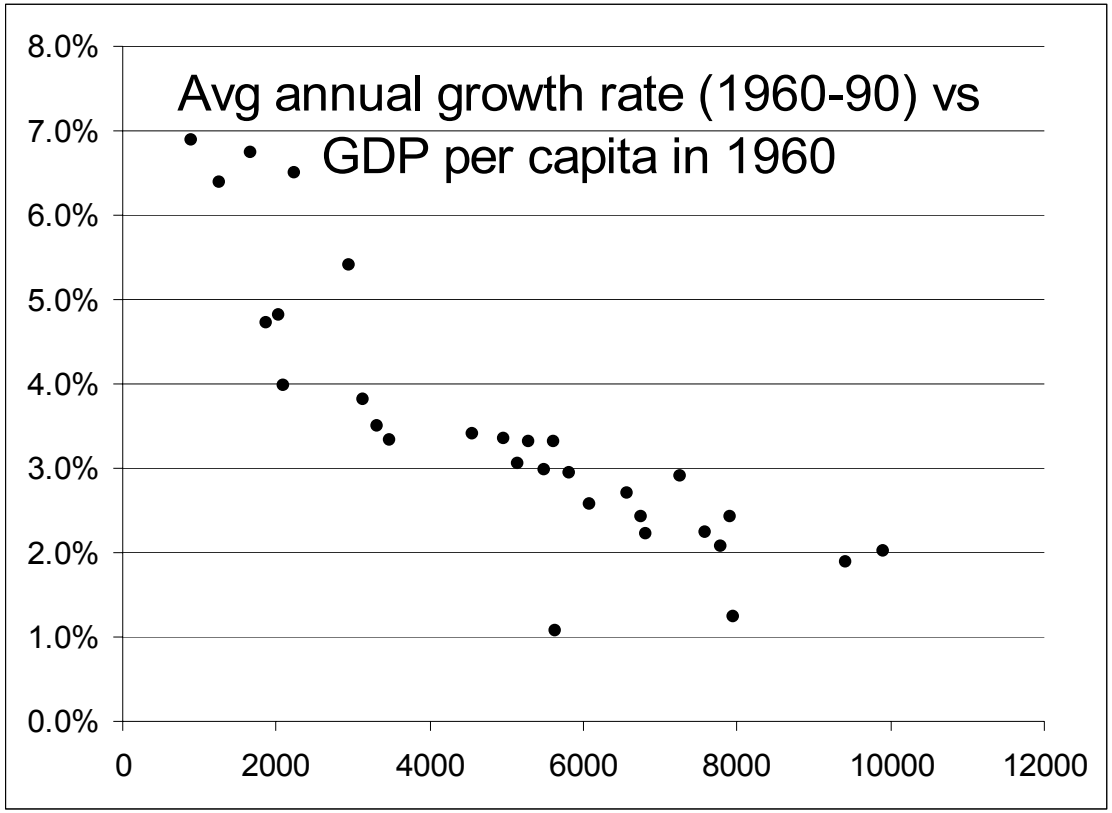
$dk/dt=sf(k)-(\delta+n)k$



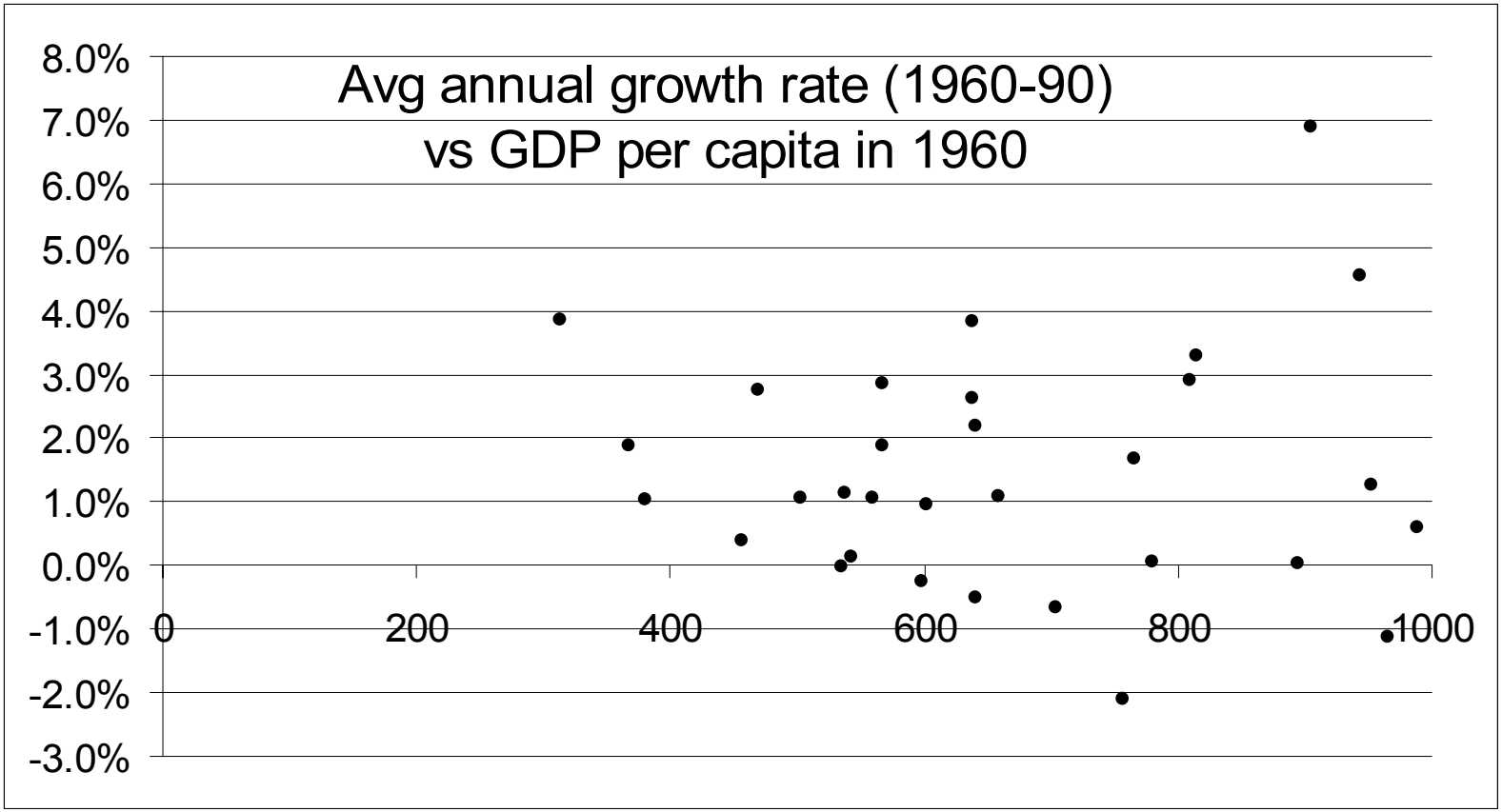
Solow: Implications

- Long-term: no per capita growth
  - Need models with technological progress to explain growth
  - Savings and population growth only affect
- Short-term: transition path, convergence to the same per capita capital k^* and per capita income $f(k^*)$
  - All countries have access to frontier technology
  - Backward countries grow faster
  - The lower initial income, the higher the growth rate

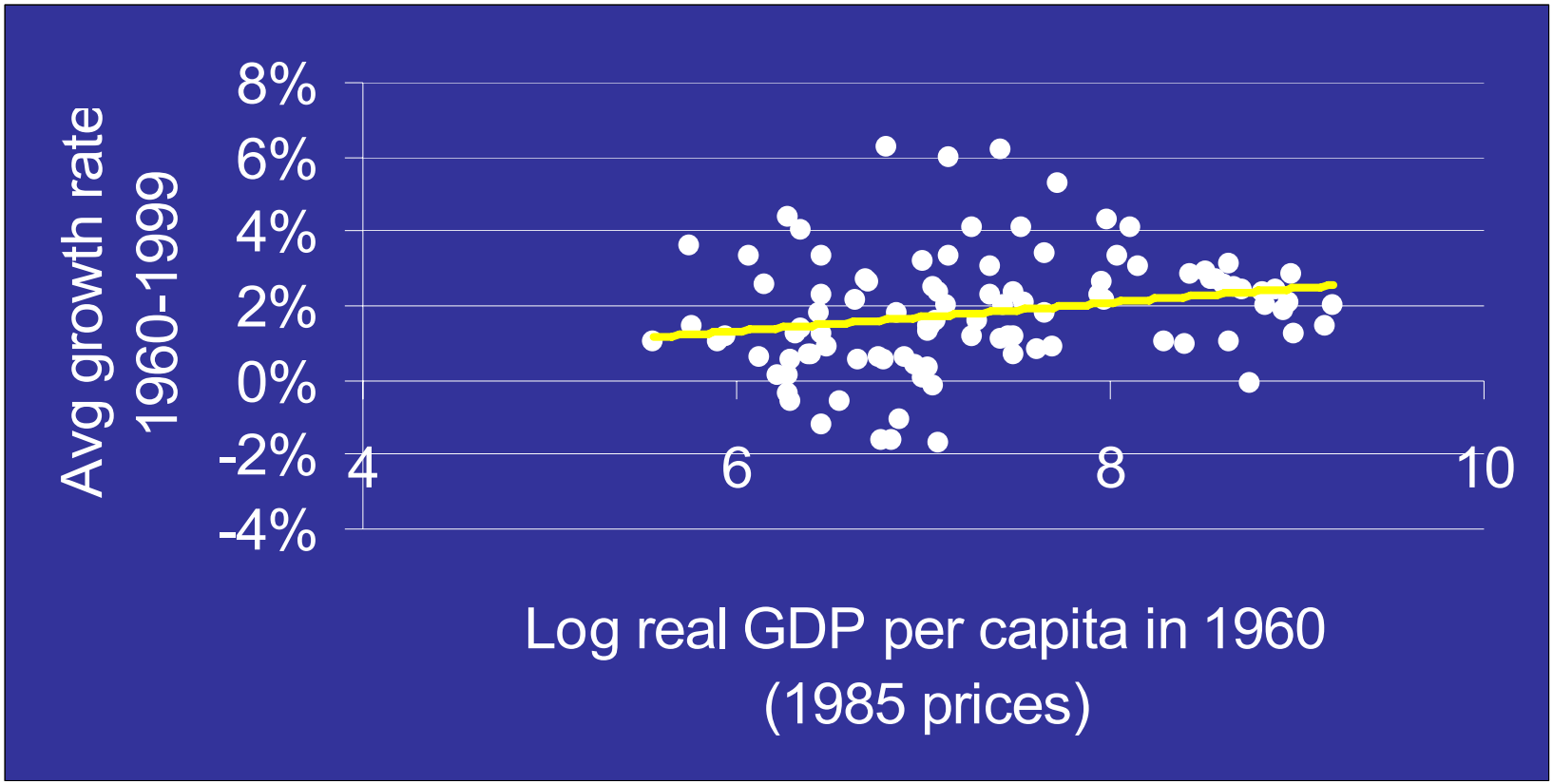
Evidence (rich countries) …



But not for the poor



Whole sample, 1960-1999

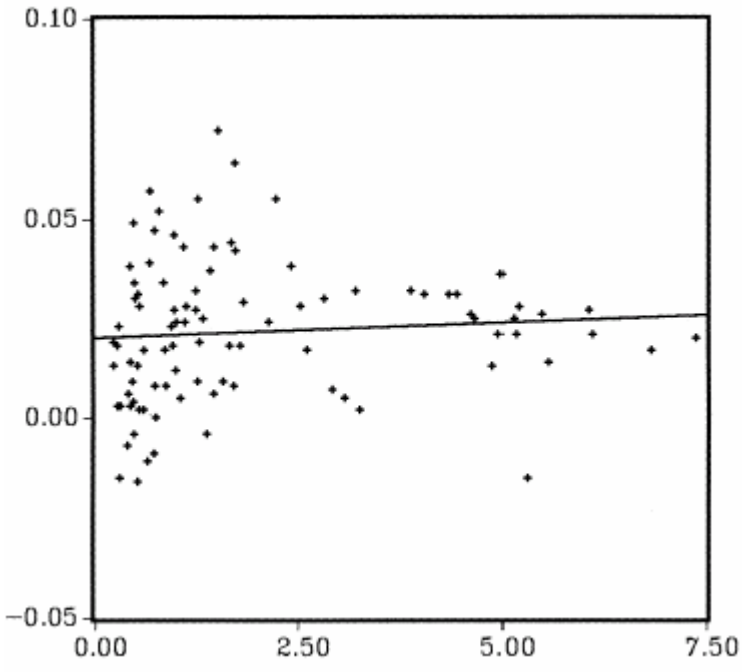


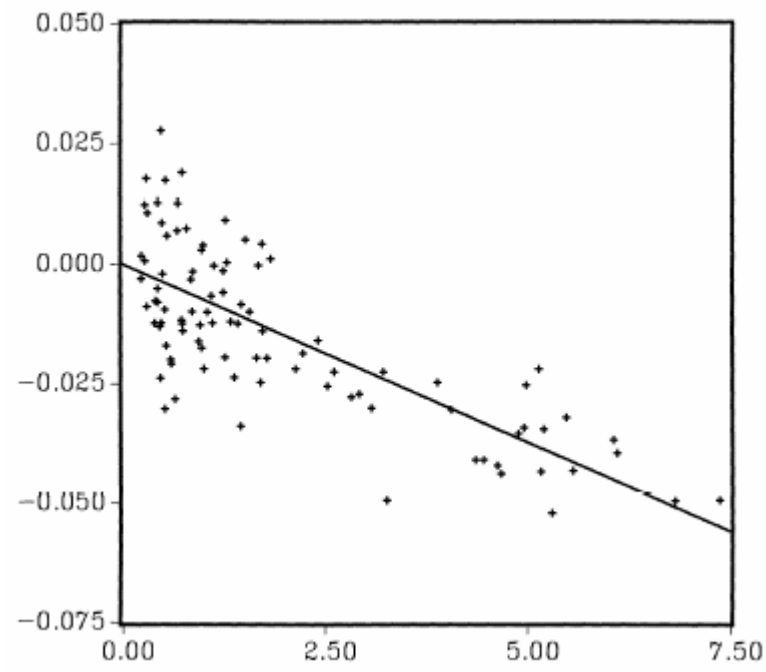
No absolute convergence

- Neither in the postwar period
- Nor in modern growth era (since 1820, Maddison)
- So all countries grow at the same rate? (could use Harrod-Domar?)
  - Need careful empirical analysis
  - There is *conditional* convergence
    - Countries differ in s and n
    - Hence may converge to different steady states

Conditional convergence

- Barro (1991): growth rate as a function of initial conditions (pairwise, left, and controlling for other factors, right)



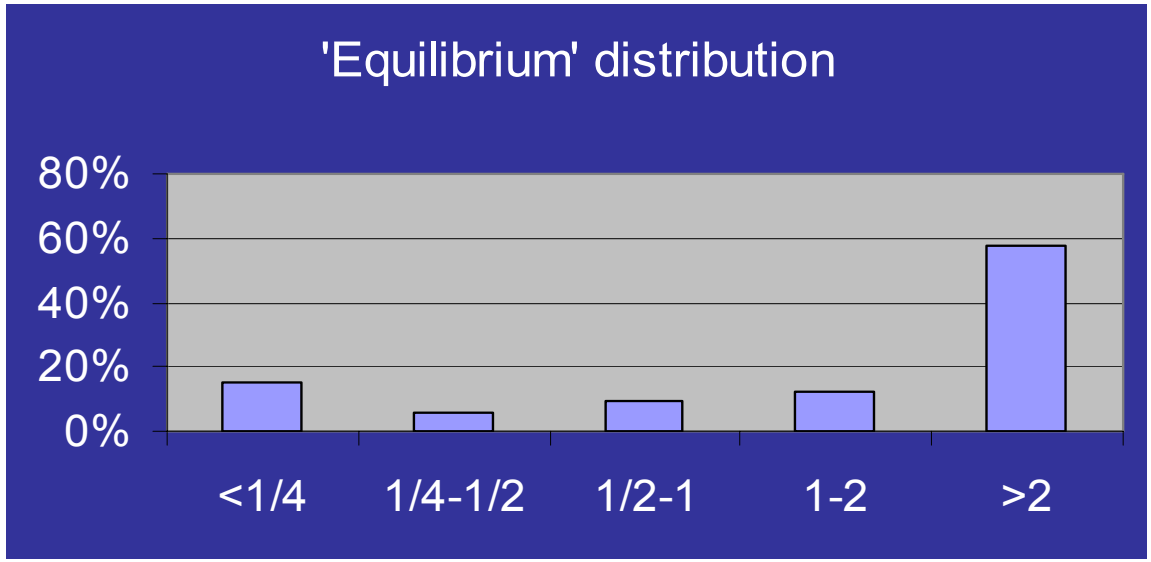


Mobility matrix (Quah, 1993)

1984 1962	<¼	¼-½	½-1	1-2	>2
<¼	0.76	0.12	0.12	0	0
¼-½	0.52	0.31	0.10	0.07	0
½-1	0.09	0.20	0.46	0.26	0
1-2	0	0	0.24	0.53	0.24
>2	0	0	0	0.05	0.95

Implications

- Substantial mobility (both upward and downward) especially in middle-income range
- No convergence: converges to ‘bimodal’ distribution
  - Word of caution (recent results): standard errors are too large to make any prediction



‘Convergence clubs’

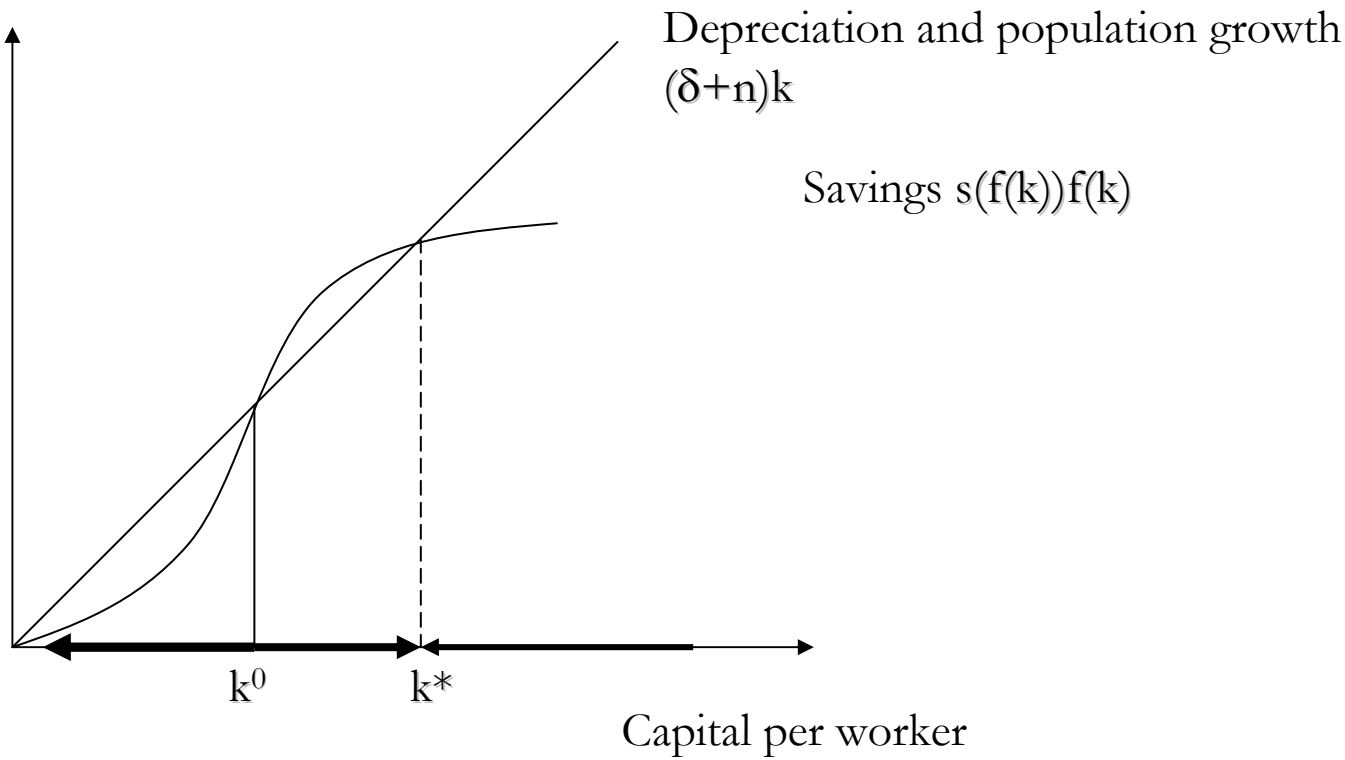
- Several clusters of countries converging to different steady states
  - Some middle income countries ‘converge downward’
- Can be explained with underdevelopment traps / multiple equilibria

Underdevelopment traps in Solow model

- Modified Solow model
  - Subsistence constraint:
    - Savings rate lower at low incomes
  - Population growth
    - Population growth higher at low incomes

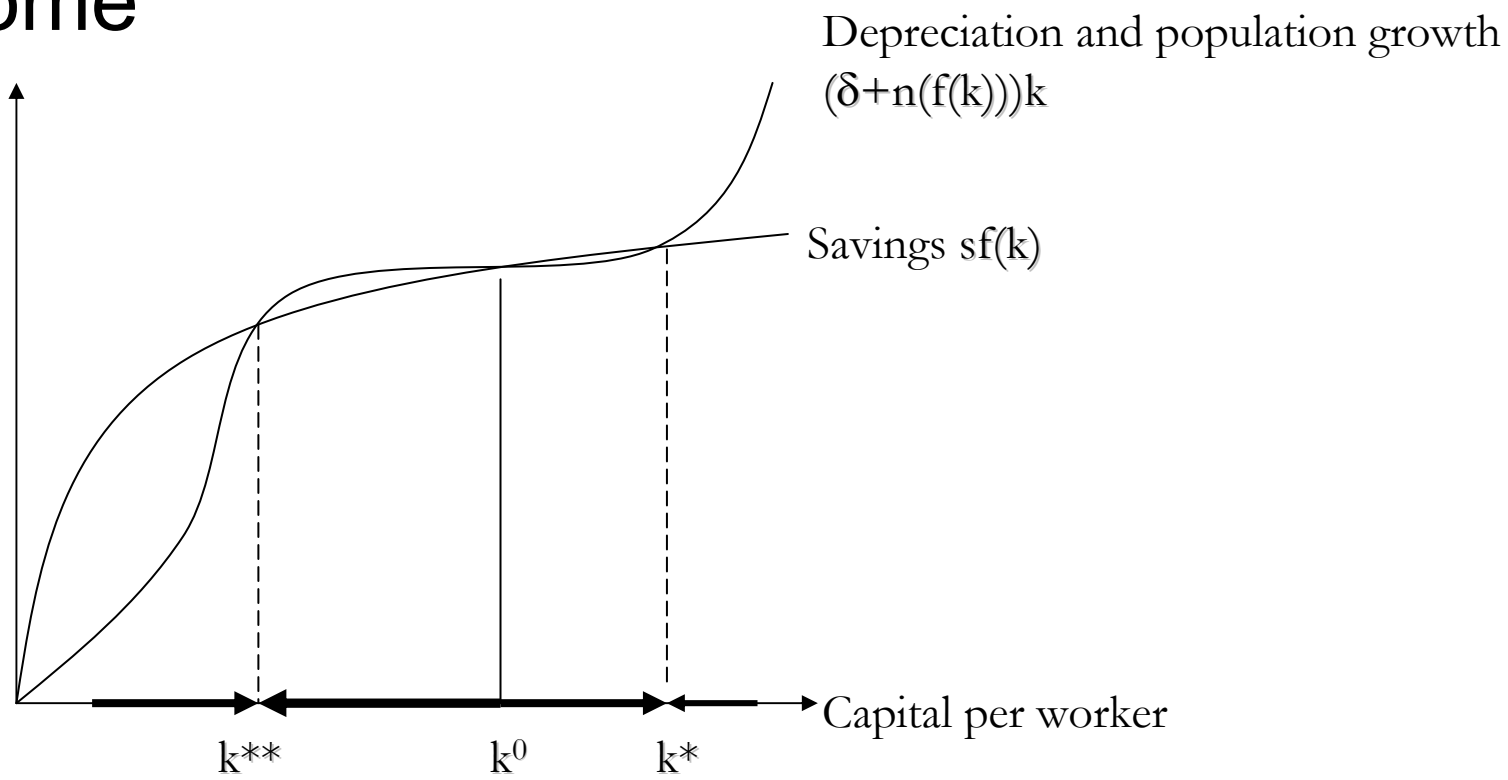
Subsistence constraint

s(y)=s(f(k)) increasing function of income



Endogenous population

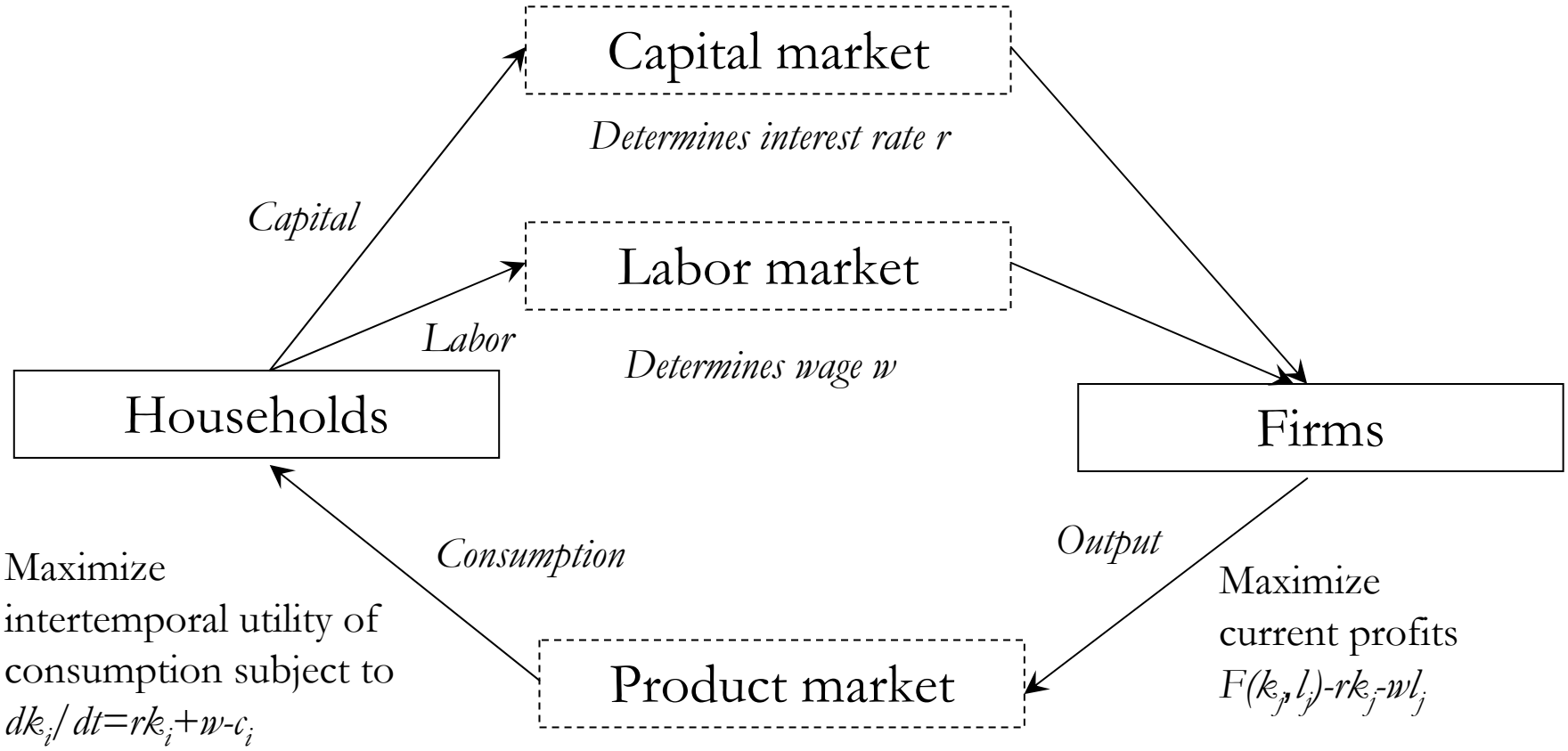
n(y)=s(f(k)) increases and then falls with income



Ramsey model

- General equilibrium model with infinitely lived consumers
- Consumers maximize intertemporal utility subject to budget constraint (wages+capital income=consumption+savings)
  - endogenous savings rate
- Firms maximize profits
- Same results for a closed economy as Solow:
  - Steady state savings rate $s=(n+\delta)/(n+\delta+\rho)$ where ρ is representative consumer's discount rate

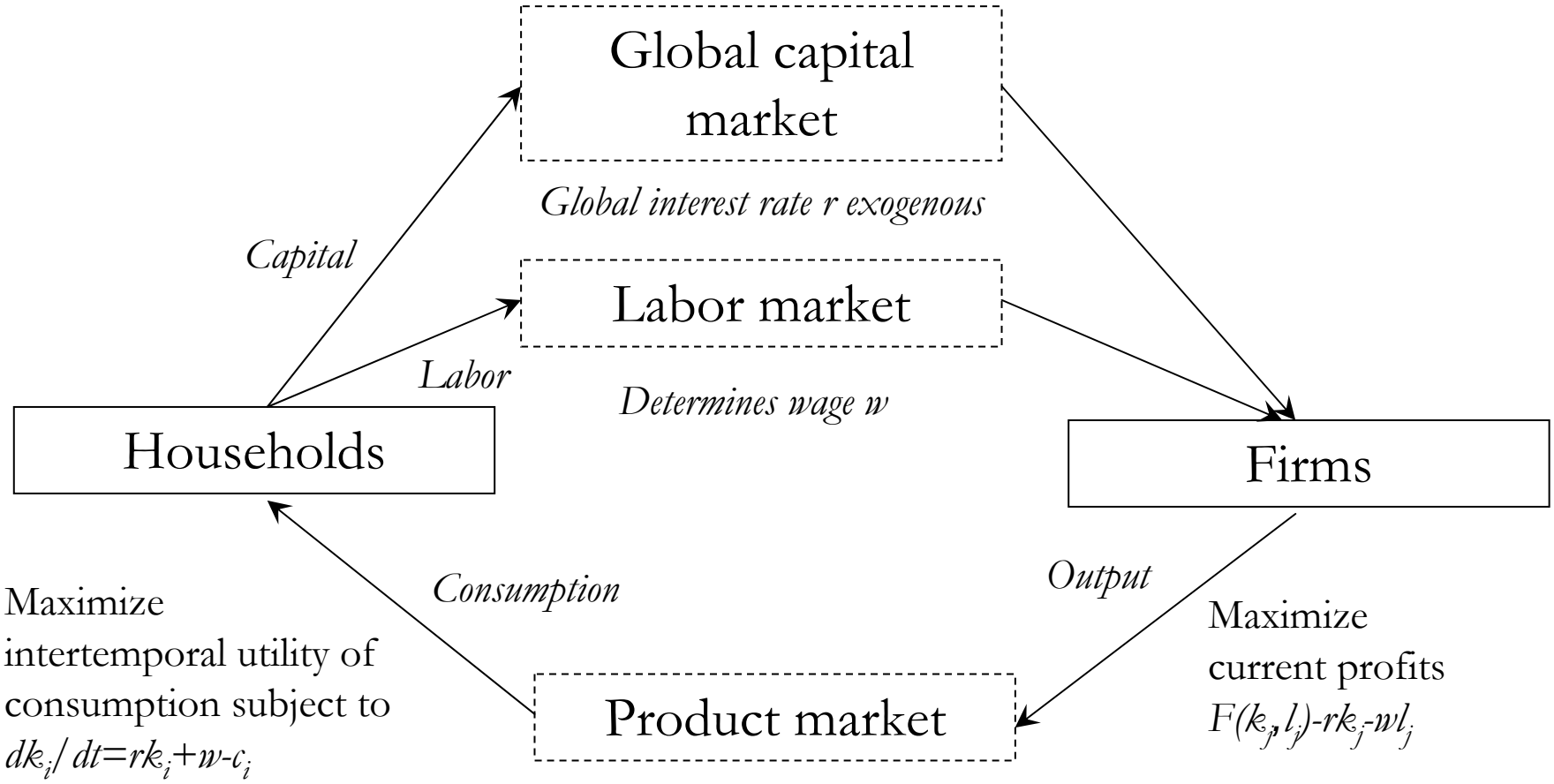
Ramsey: closed economy



Ramsey: open economy

- Assumptions:
  - Mobile capital
    - Interest rate should be the same in all economies
  - Immobile labor
    - Countries may differ in terms of wage, capital/worker, income/worker
- Equilibrium
  - Marginal productivity of capital should be higher in poor countries
  - Capital should move from rich to poor countries
- Evidence:
    - US is the largest recipient of FDI
    - OECD receive >90% FDI

Ramsey: open economy



Exogenous technical progress:

- To explain growth, add exogenous technical progress
  - *Y=F(K,HL)*
  - Human capital *H* grows at an exogenous rate γ
- Same, except replacing labor *L* with 'effective labor' *HL*
  - Steady state:
    - Capital per unit of effective labor K/(HL)=k^* constant
      - Higher H $\Rightarrow$ Higher capital per worker K/L=Hk^*
    - No growth of output per unit of effective labor,
      - Hence growth per capita at γ per cent p.a.

Growth accounting and Solow residual

$Y=A K^{\alpha} L^{1-\alpha}$

[α is estimated using national accounts, share of capital and labor income in GDP,
L – labor force rather than population]

Hence

$\Delta Y/Y= \Delta A/A+ \alpha \Delta K/K +(1- \alpha) \Delta L/L$

A – is Total Factor Productivity (TFP)

$\Delta A/A$ – is growth in TFP

(TFP *level* does not matter)

In per capita terms

$\Delta y/y= \Delta A/A+ \alpha \Delta k/k$

Growth accounting, numerical example

Capital's share in GDP is 0.3

Capital per worker grows at 10% p.a.

GDP grows at 5% p.a.

Hence TFP grows at 5-0.3*10=2% p.a.

- Can also adjust for human capital etc.

Growth accounting and East Asian Miracle

- Korea, Taiwan, Singapore, and Hong Kong have been growing at astronomic rates since 1960
- Worldbank (1993): 'East Asian Miracle', 'productivity-based catching-up'
- Young, Krugman:
  - Mostly based on factor accumulation
    - Education: from 35 to 88%
    - Labor force participation rates: from 27 to 36%
    - Savings rate higher than in other developing economies by 10-20% GDP
  - Growth accounting gives <3% TFP growth
    - Not higher than in other economies

Factor accumulation is endogenous to technological progress

- Productivity increases incentives to accumulate
  - Human capital
  - Physical capital
- Klenow, Rodriquez-Clare:
  - If take into account the response of capital to TFP growth then TFP growth accounts for a substantial share of East Asian Miracle

Exogenous technical progress: implications

- Increase in productivity (e.g. education) $\Rightarrow$ growth of GDP per capita
- Worldbank and others have achieved a dramatic improvement in education in recent 40 years
- No market for human capital $\Rightarrow$ low quality, inefficient matching, and braindrain
- In most developing countries, modern technologies are accessible, but no incentives to use them

Education and GDP growth, 1965-85 [Easterly, 2001]

	Education growth, % p.a.	Growth of GDP per capita, % p.a.
Botswana	6	9
Lesotho	2	5
Senegal	7	-1
Madagascar	5	-1
Ghana	4	-1
Subsaharan Africa	4	0.5
East Asia	3	4

Endogenous growth and increasing returns

- Technology is non-excludable (leakages)
  - Constant returns at individual level but increasing returns at the economywide level
- Technology is non-rival
  - Once the technology is invented, marginal cost of dissemination is low
- Critical mass effect in R&D
- 'Standing on shoulders of giants': sequential innovation, threshold externalities
- Evidence: Kremer (1993)
  - Non-rivalry of technology, hence higher population $\Rightarrow$ higher growth
  - Consistent with longest-term data
- Geographical concentration of innovative activity
- Increasing returns $\Rightarrow$ Multiple equilibria

Endogenous growth theory

- Rational choice of R&D
- Technological progress is endogenous
- Schumpeterian growth:
  - Creative destruction
- Intellectual property rights and licensing:
    - Incentives to innovate vs dissemination of knowledge
- Imitation vs. innovation:
  - Different policies in early and later convergence

Increasing returns and Big Push

Big Push and market size externality

- Rosenstein-Rodan (1944) formalized by Murphy, Shleifer, Vishny (1989)
- Dual economy:
  - Traditional (subsistence production): constant returns $y_i=l_i$
  - Modern (industrial production): $l_i=ay_i+F$ where a<1, F – fixed cost of modernization
  - Efficiency wage: employees of modern firms must be paid v per cent more.
- Also describes introduction of new technologies/standards
  - QWERTY vs DVORAK
  - VHS vs BETACAM
  - Mobile phone standards

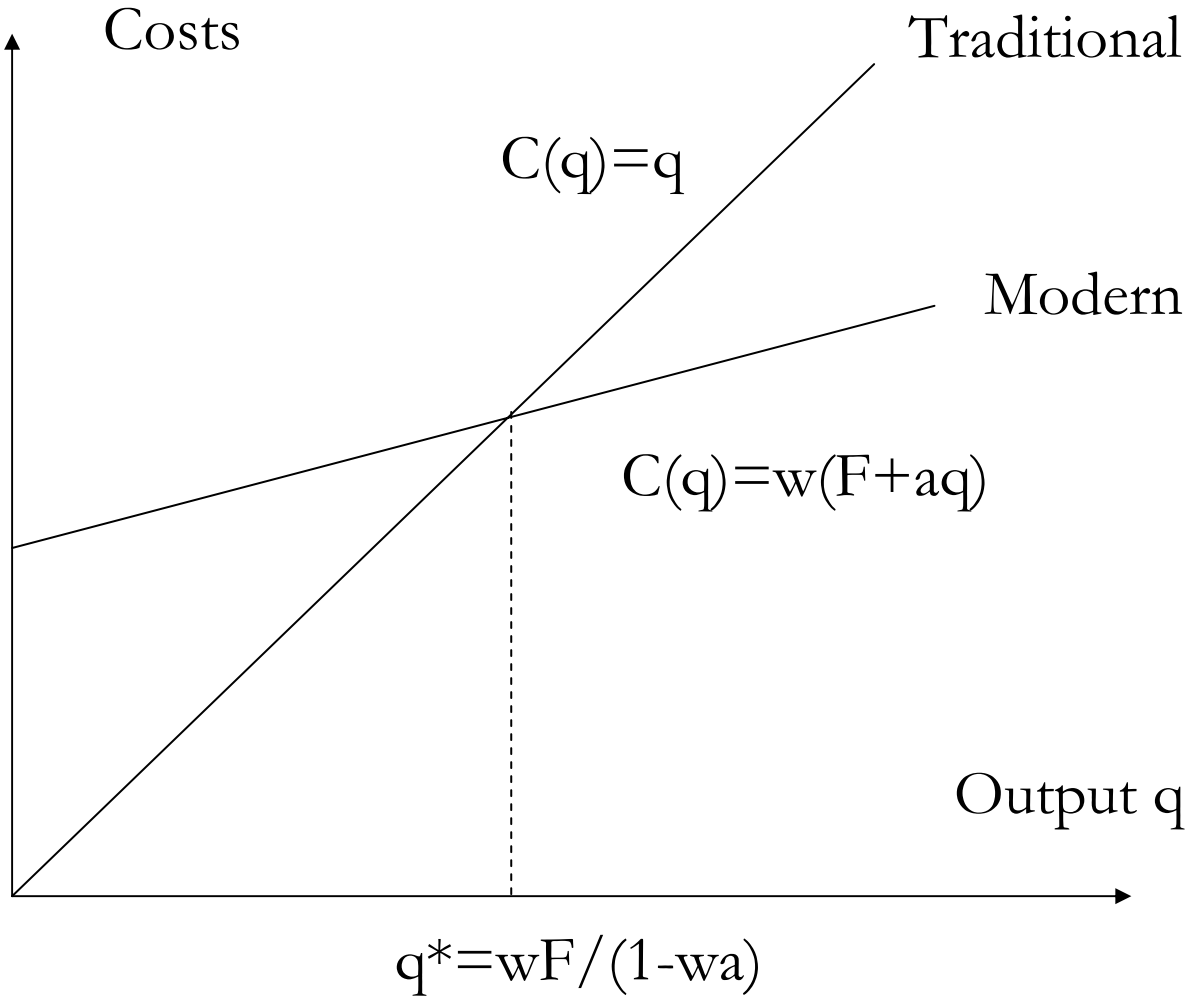
Market size externality

- Entrepreneur *i* modernizes $\Rightarrow$ workers at firm *i* his workers are better paid $\Rightarrow$ aggregate demand increases
- Demand for all products increases, including product *j*
- Makes easier for entrepreneur *j* to cover fixed costs
- Typical coordination game, multiple equilibria
  - Big Push, government intervention may be beneficial
- Another solution: increase market size through opening up and entering global market

The choice of technology

- N sectors, in each entrepreneur compares
  - Traditional technology: $l(q)=q$,
    - Productivity=wage=1
    - No fixed costs, but high marginal costs
  - Modern technology: $l(q)=F+aq$
    - Large fixed costs $F>0$,
    - Low marginal costs $a<1$
    - Wage must be $w>1$, $wa<1$

Modern technology is better whenever demand is high



Macroeconomic equilibrium

- GDP: $Y=Nq$ hence each firm's demand in equilibrium is $q=Y/N$
- Suppose that n firms choose modern technology
- Then labor market equilibrium:

  $L=n(F+qa)+(N-n)q=n(F+aY/N)+(N-n)Y/N$

  $q=(L-nF)/(N-n(1-a))$
- Compare q to q*

  If $q<q^*$, all firms remain traditional $n=0$

  $L/N < q^*=wF/(1-wa)$

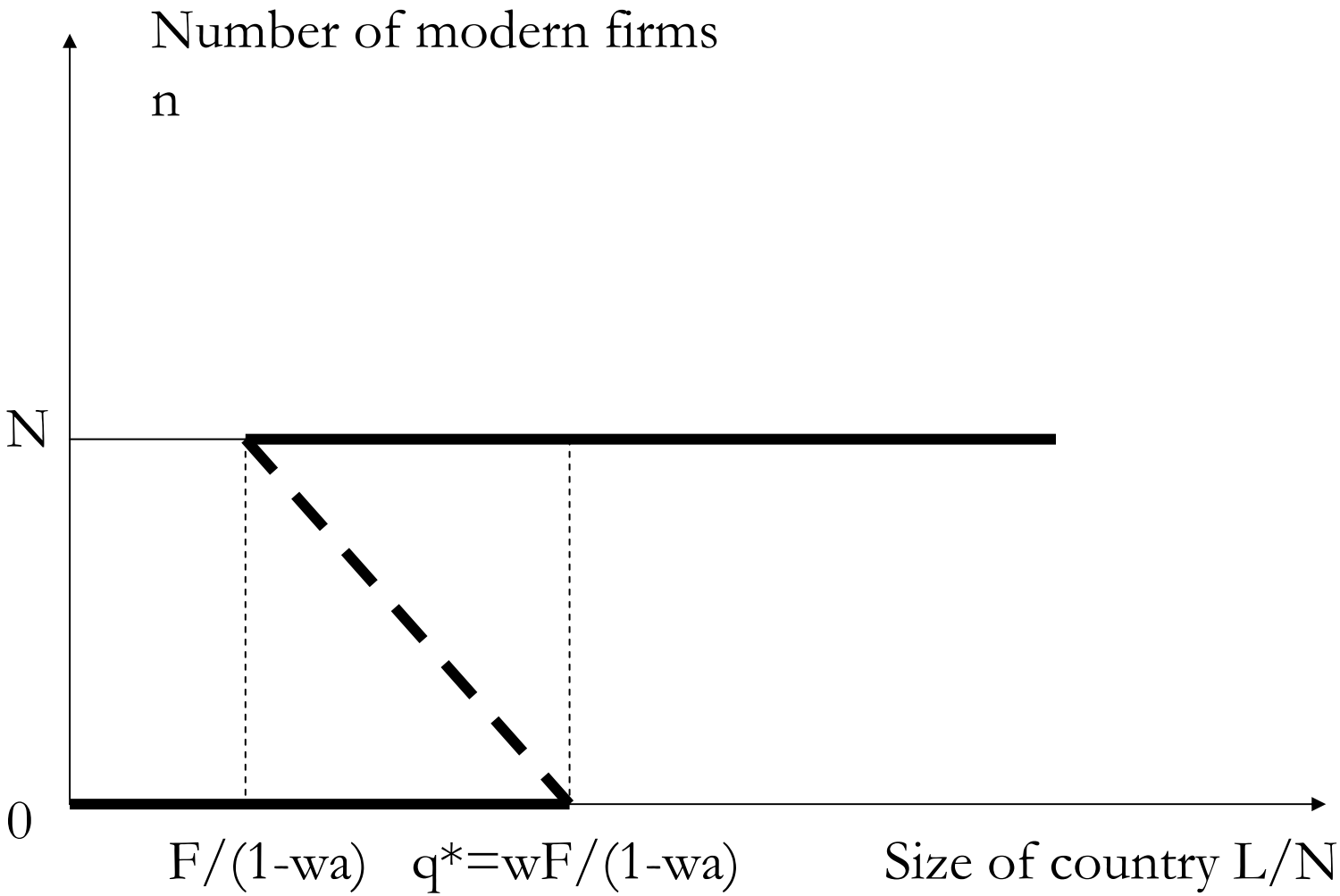
  If $q>q^*$, all firms choose modern technology $n=N$

  $L/N > F/(1-wa)$

  If $q=q^*$, some firms choose modern technology $0\le n\le N$

  - $F/(1-wa) < L/N < wF/(1-wa)$

Structure of equilibria



Recent literature on Schumpeterian growth

- Aghion et al.: “Distance to Frontier”
- The trade-off: imitate vs. innovate
  - Adopt technologies developed elsewhere vs
  - Develop new technologies
- If the country is far from frontier, imitation is optimal
  - Catching up growth: Korea and Japan until 1990s
  - Government intervention, larger vertical conglomerates etc.
- If the country is close to frontier, need to innovate
  - US, Western Europe
  - Decentralized, small firms, financial markets

Empirical research on growth

- Large sample of countries: data available only for postwar period
- Hence only cross-section analysis is feasible
- Vulnerable to omitted variable bias and endogeneity
  - Good instrumental variables are hard to find

Some cross-country datasets

- Summer Preston Penn World Tables Barro-Lee
  http://www.economics.harvard.edu/faculty/barro/data.html
- Barro-Sala-i-Martin
  www.columbia.edu/~xs23/
- World Bank
  www.worldbank.org
- Global Development Network
  www.gdnet.org

Meta-regressions

- Hundreds of cross-country regressions have been run producing different results
- Levine-Renelt AER 1992: extreme bounds test proves that no variables are robust
- Sala-i-Martin AER PP 1997 “I just ran 2 million regressions” uses a less extreme test
  - Select 62 variables
  - Add then in combination of fours with regression that already includes initial GDP per capita, life expectancy, primary school enrollment
  - Declare the variable “robust” if it is significant in 90% cases
  - Found 22 robust variables

Sala-i-Martin's 22 variables

Independent variable	(i) β	(ii) SD
Equipment investment	0.2175	0.0408
Number of years open economy	0.0195	0.0042
Fraction Confucian	0.0676	0.0149
Rule of law	0.0190	0.0049
Fraction Muslim	0.0142	0.0035
Political rights	−0.0026	0.0009
Latin America dummy	−0.0115	0.0029
Sub-Saharan Africa dummy	−0.0121	0.0032
Civil liberties	−0.0029	0.0010
Revolutions and coups	−0.0118	0.0045
Fraction of GDP in mining	0.0353	0.0138
SD black-market premium	−0.0290	0.0118
Primary exports in 1970	−0.0140	0.0053
Degree of capitalism	0.0018	0.0008
War dummy	−0.0056	0.0023
Non-equipment investment	0.0562	0.0242
Absolute latitude	0.0002	0.0001
Exchange-rate distortions	−0.0590	0.0302
Fraction Protestant	−0.0129	0.0053
Fraction Buddhist	0.0148	0.0076
Fraction Catholic	−0.0089	0.0034
Spanish colony	−0.0065	0.0032

Summary of cross-country growth regressions

- Conditional convergence:
  - Other things equal, poor countries grow faster
- Quantity and especially quality of human capital increases growth
- Quality rather than size of government
  - Inflation, corruption, exchange rate regulation negatively affect growth
- Economic institutions are good for TFP growth …
  - Property rights,
  - Rule of law
  - Financial development
- … as well as the determinants of economic institutions
  - Economic geography and natural resource endowments
  - Colonial legacies, legal origin, religion
  - Ethnolinguistic fractionalization

New Paradigm: Banerjee-Duflo / Rodrik

- Aggregate models miss the main issue (raised in Lucas, 1990):
  - The returns to investment in physical and human capital are different within poor countries
  - In aggregate models, there is no place for different rates of return
- The different rates of return are driven by poor institutions (property rights protection and contract enforcement), government predation, market failures, monopoly etc.
- Need disaggregated models that would describe this
  - And microeconomic evidence to test their predictions