Economic Growth: Models and Global Evidence

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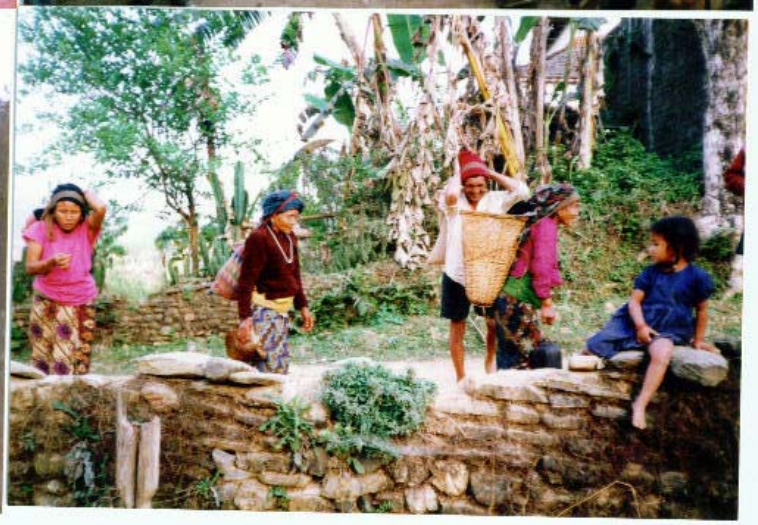
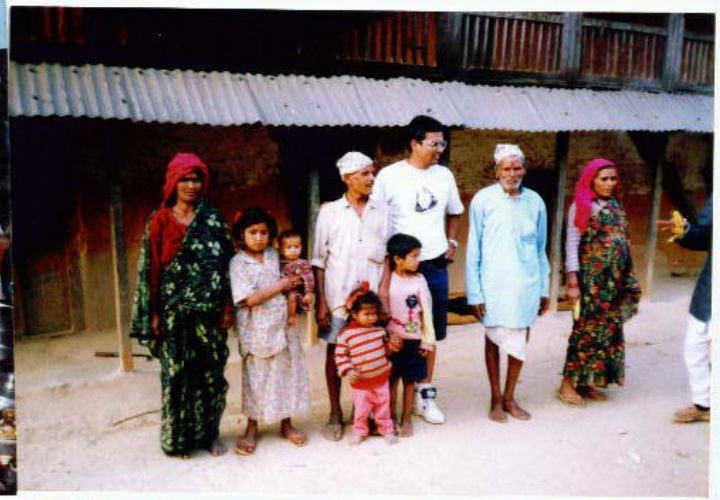
Business School

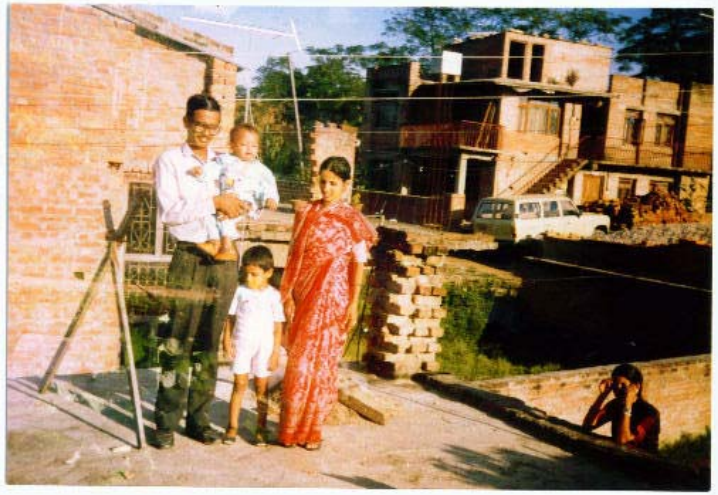
Economic growth has made the World a Small Village.

Source: http://www.GraphicMaps.Com

Why are some rich and others poor?



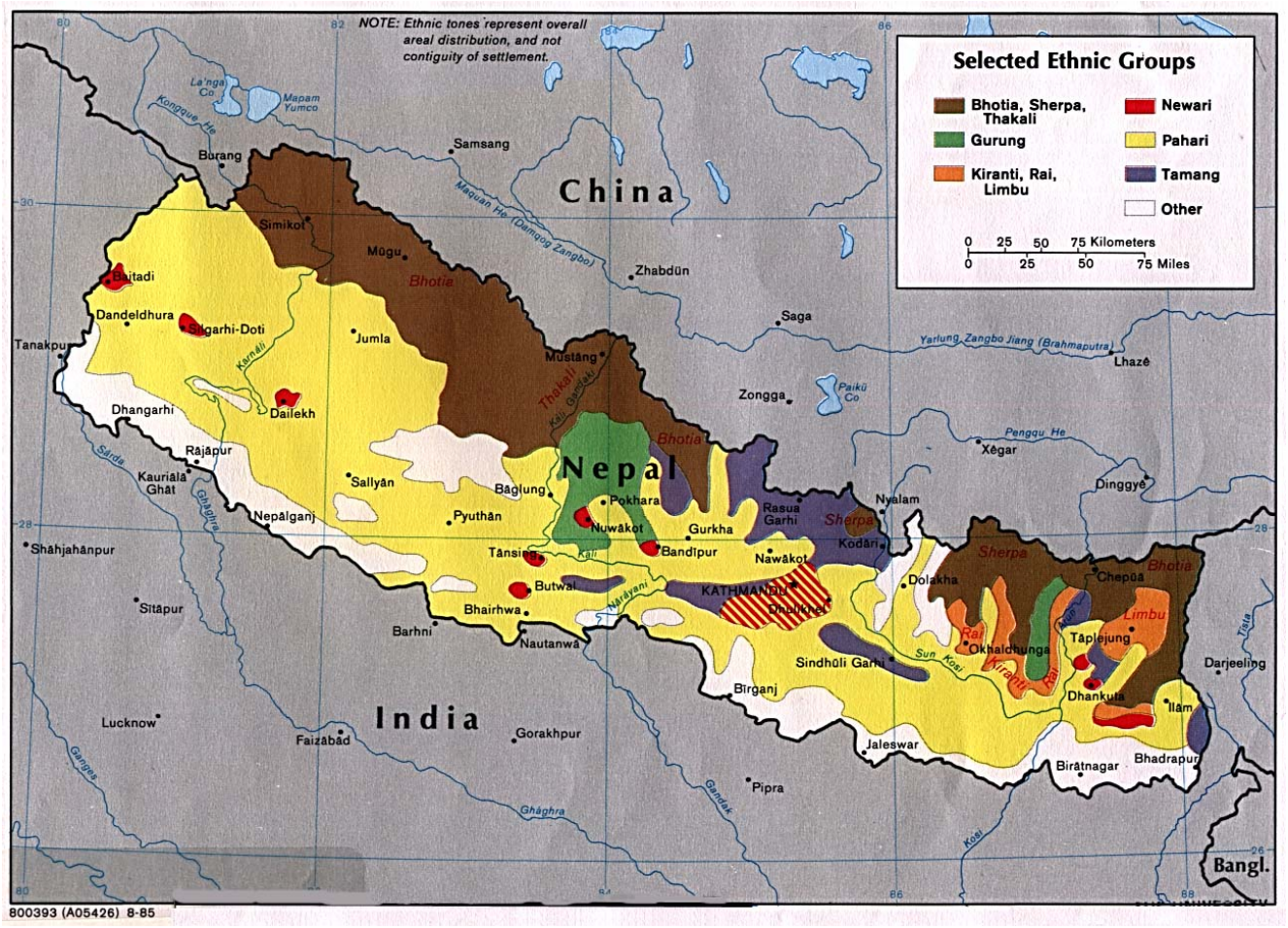





WERELDKAART


FIRE ACTION

Why Nepal could not grow like India and China?



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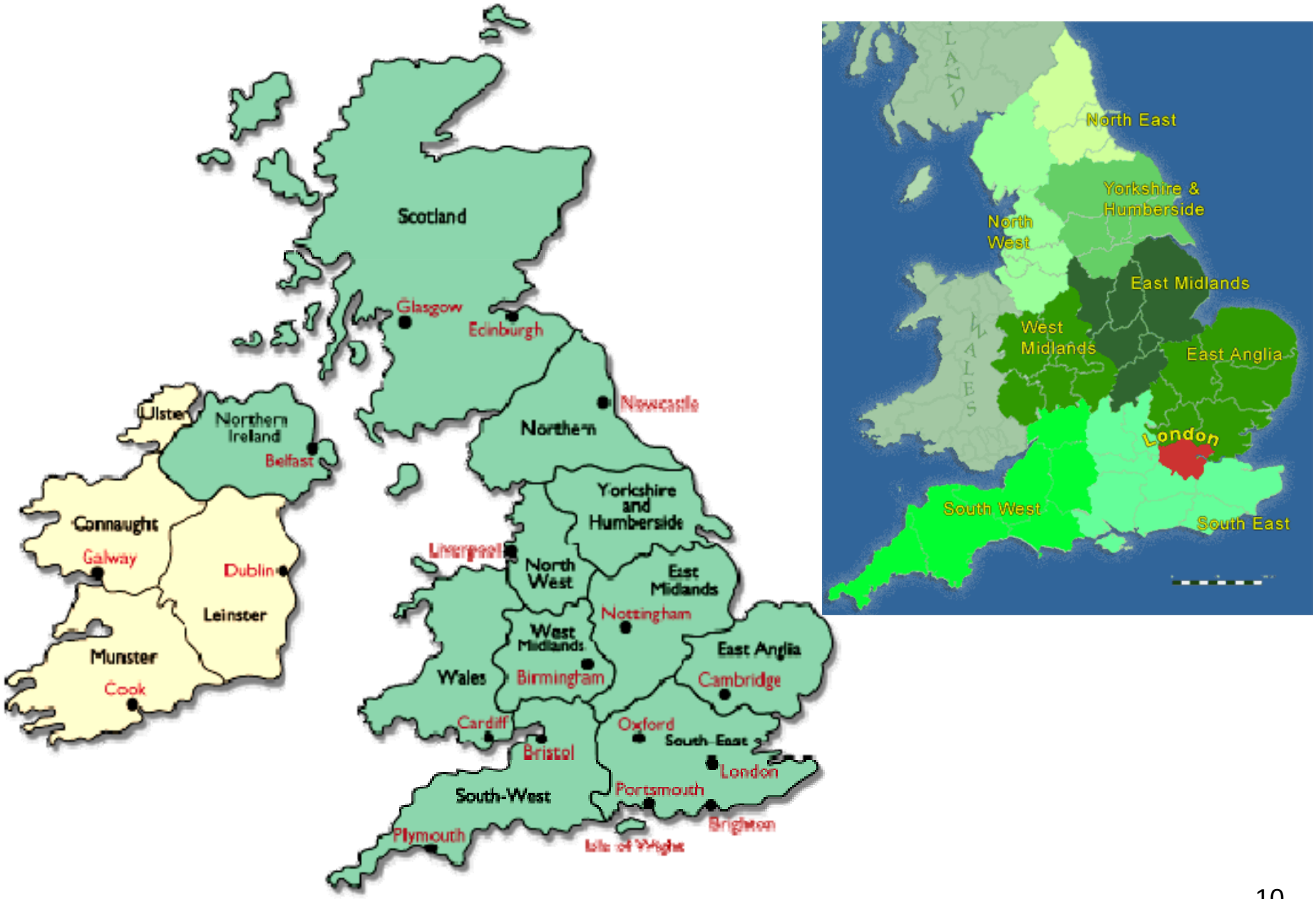


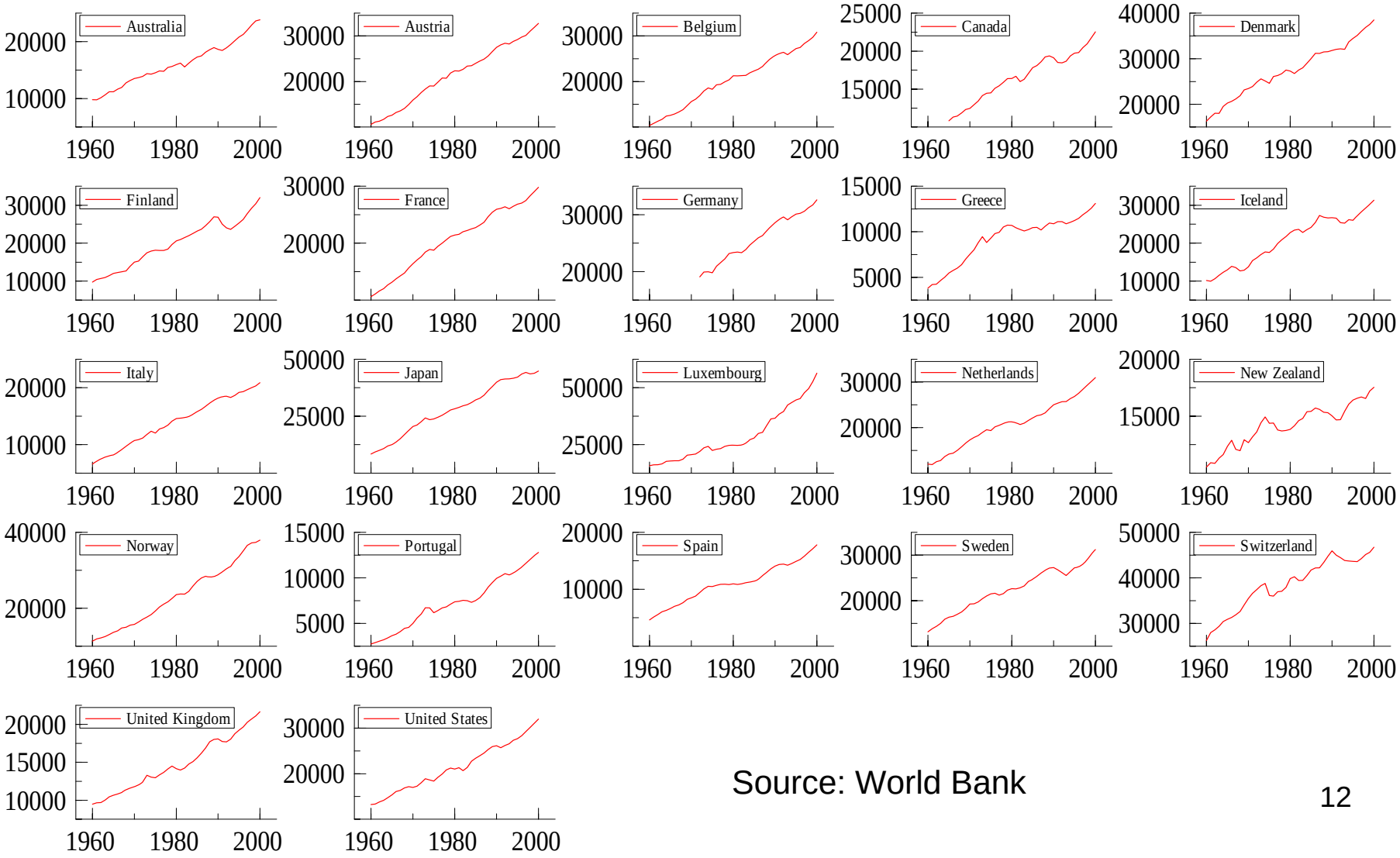
Source: http://www.GraphicMaps.Com

Motivation

- Why Nepal is not growing like China and India?
- What made East Asian Economies Achieve Growth Miracles and Sub-Saharan Africa to stagnate or retard?
- What do major theories of economic growth suggest? Classical to endogenous growth models?
- What is the evidence on the prediction of those theories?
- How much is known and how much is unknown ? Why growth depends on country specific factors?
- Will there be convergence in next 100 years?
- Why did industrial revolution mainly started from the UK spread to the Western Europe and North America but not to developing economies?

Evidence on Economic Growth-1

Per Capita GDP in OECD Economies (1960-2000)



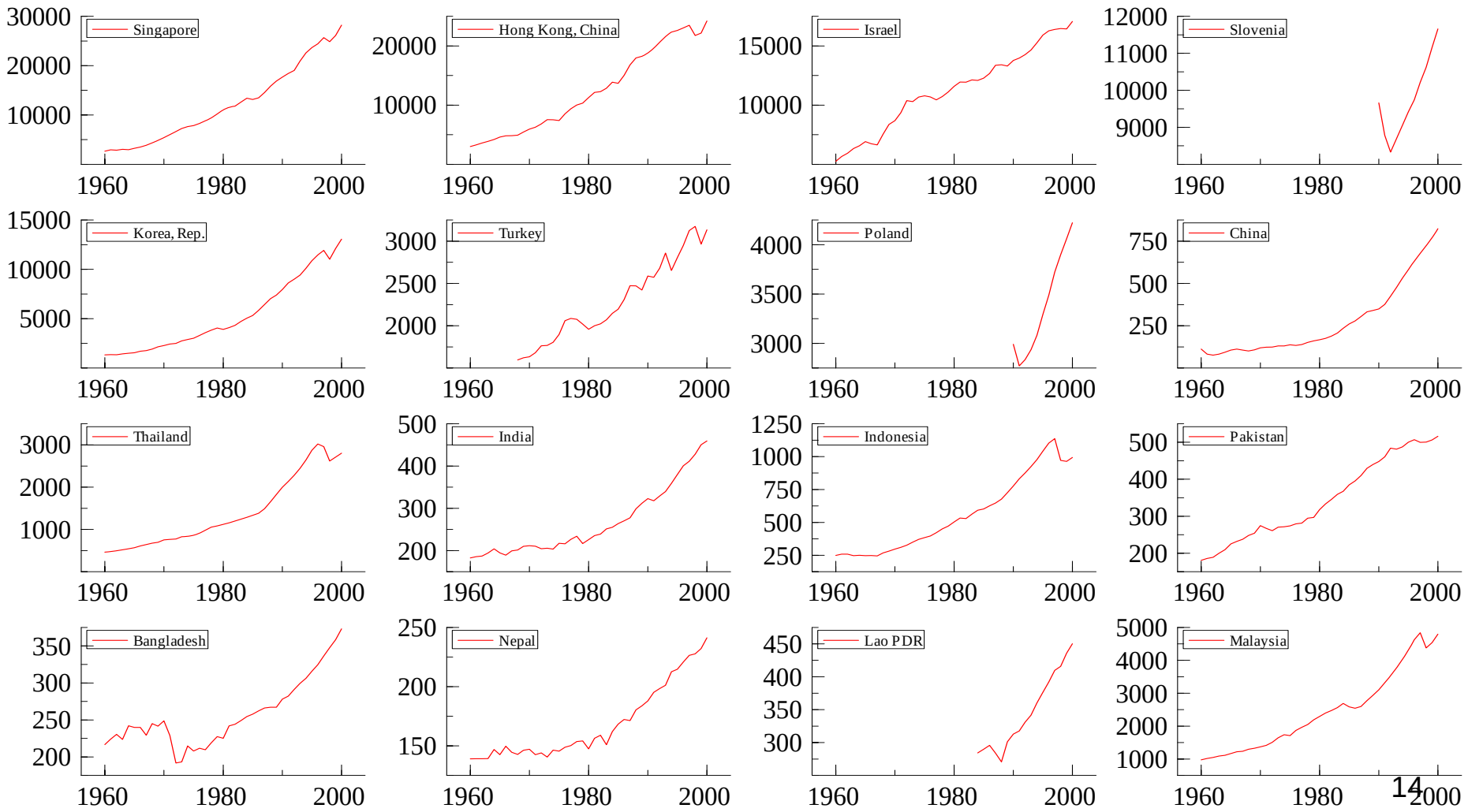
Source: World Bank

High Income Economies.

Source: http://www.GraphicMaps.Com

Evidence on Economic Growth -2

Per capita income in growth miracle countries 1960-2000

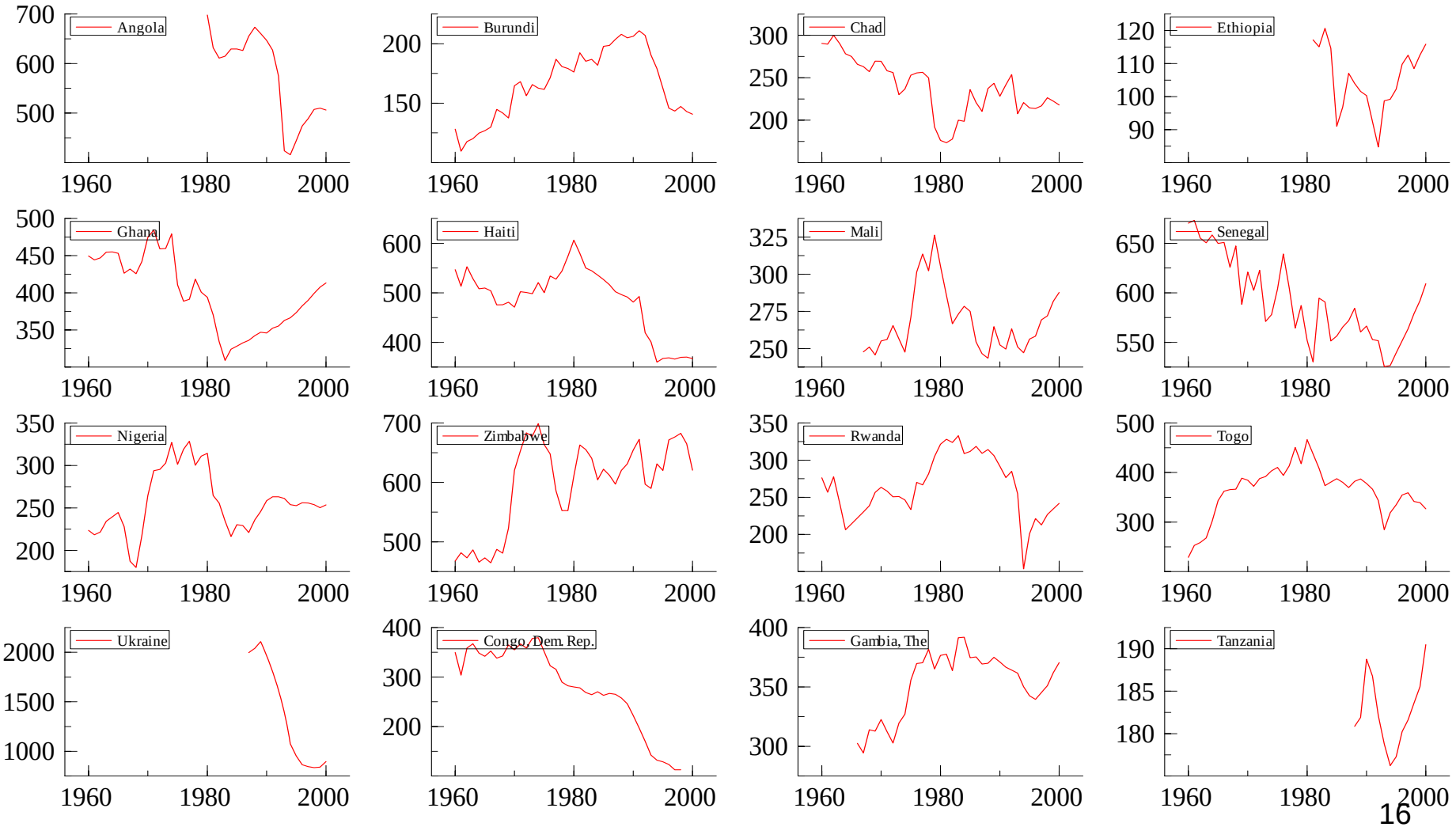


Source: World Bank

Source: http://www.GraphicMaps.Com

Evidence on Economic Growth -3

Per Capita GDP in Growth Disaster Economies 1960-2000

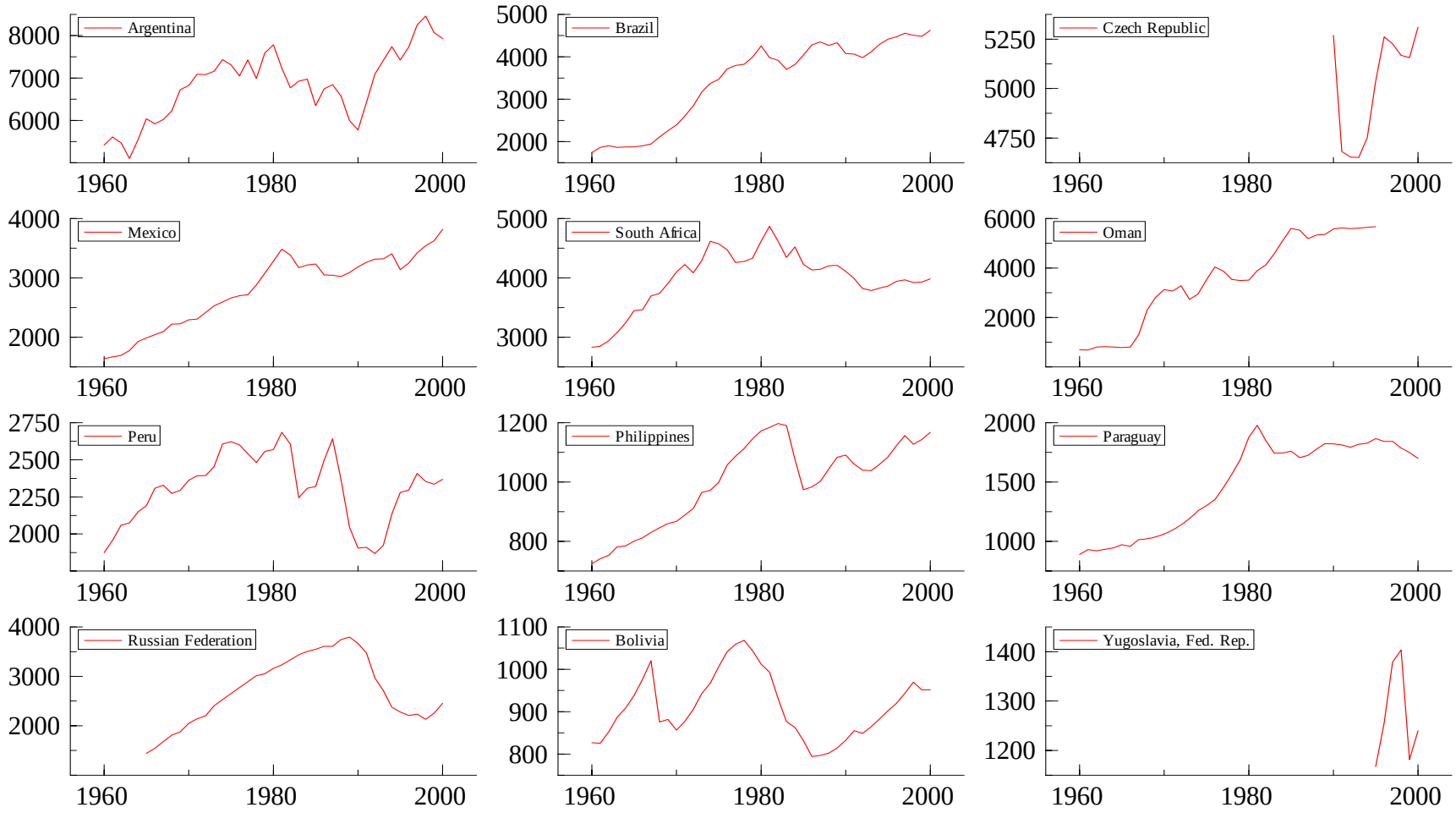


Source: World Bank

Source: http://www.GraphicMaps.Com

Evidence on Economic Growth -4

Per capita income in Trouble-prone Mid-income countries 1960-2000

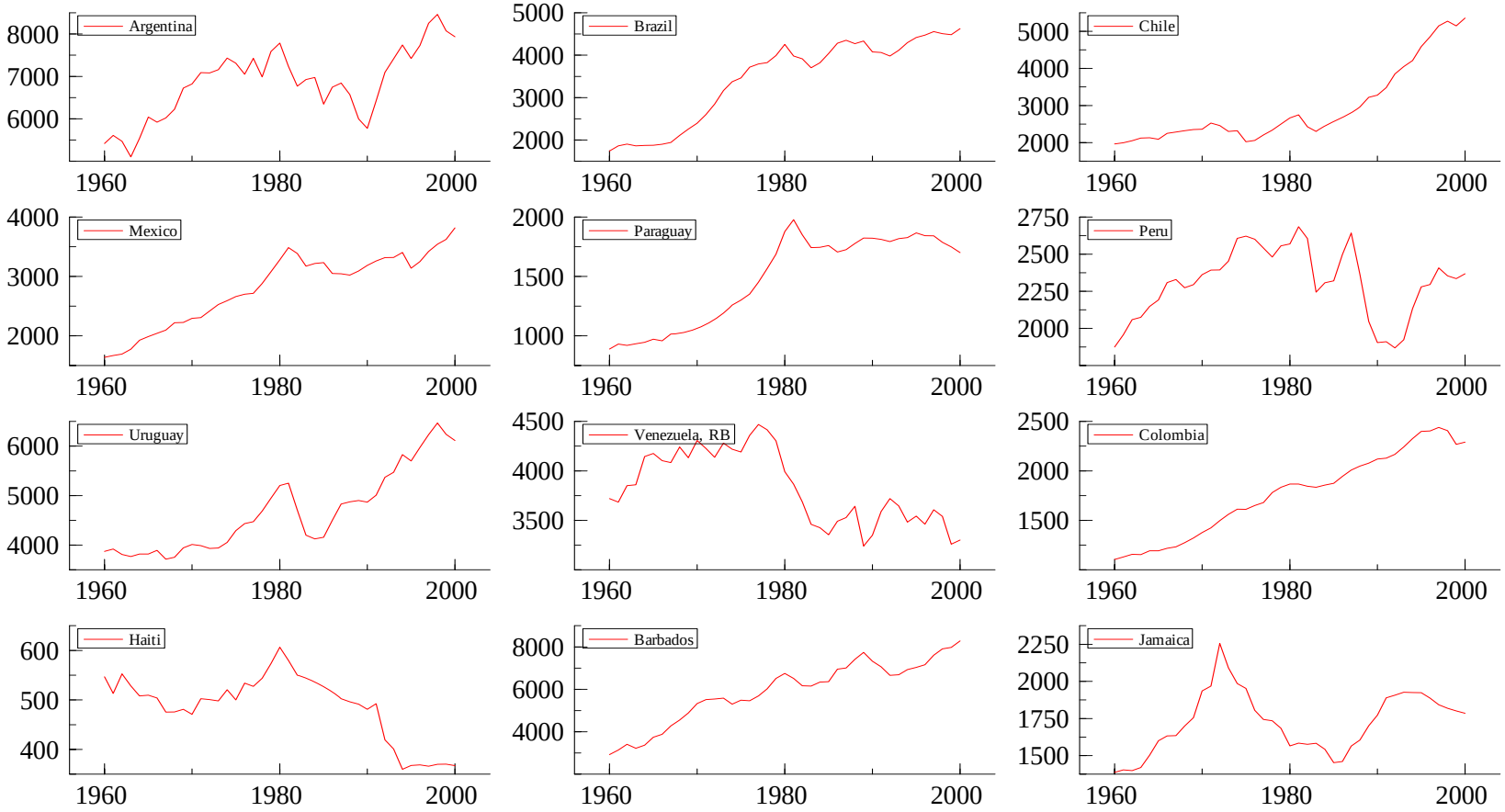


Source: World Bank

Source: http://www.GraphicMaps.Com

Evidence on Economic Growth -5

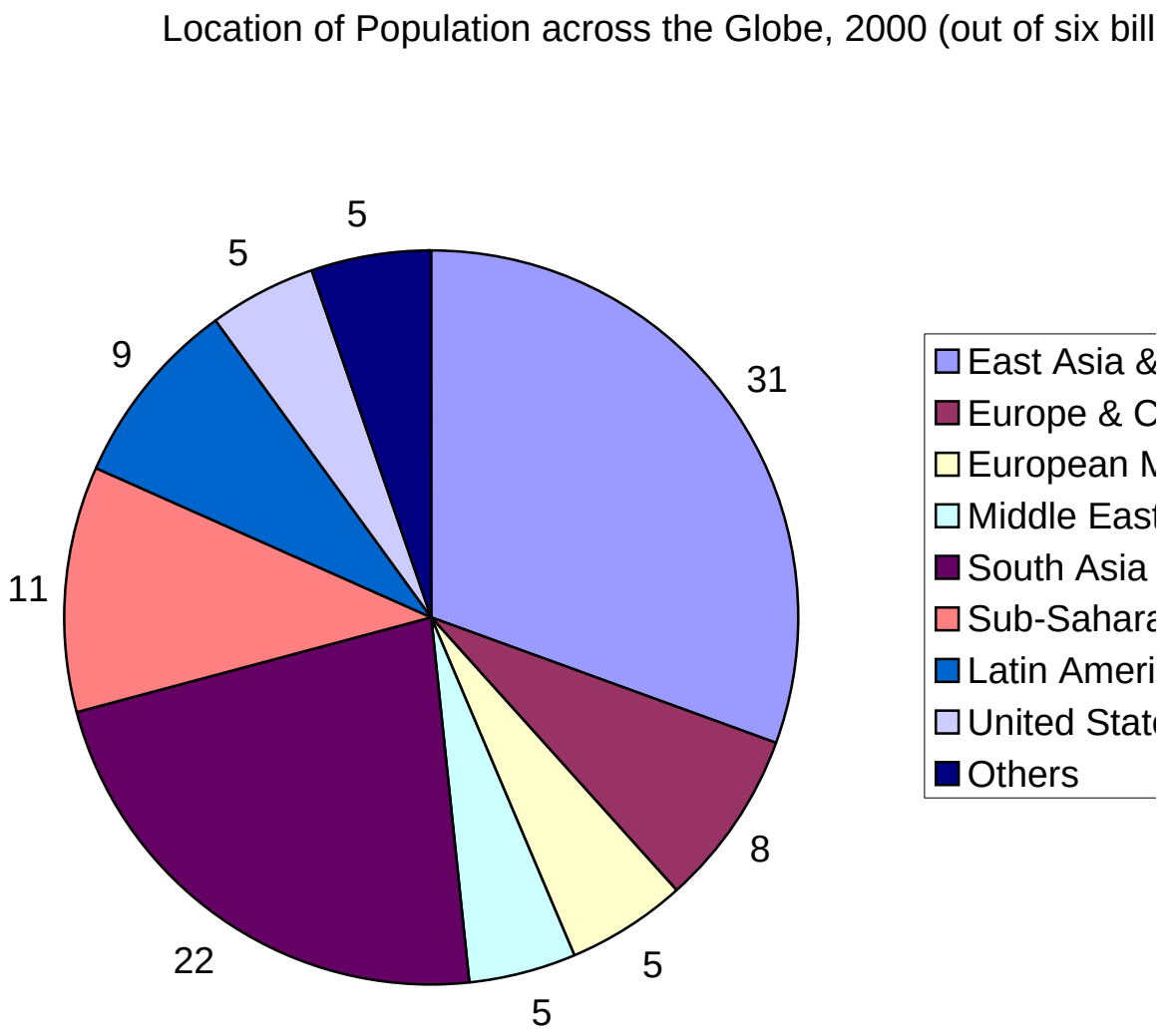
Per capita income Latin and Central American and Caribbean countries 1960-2000



Source: World Bank

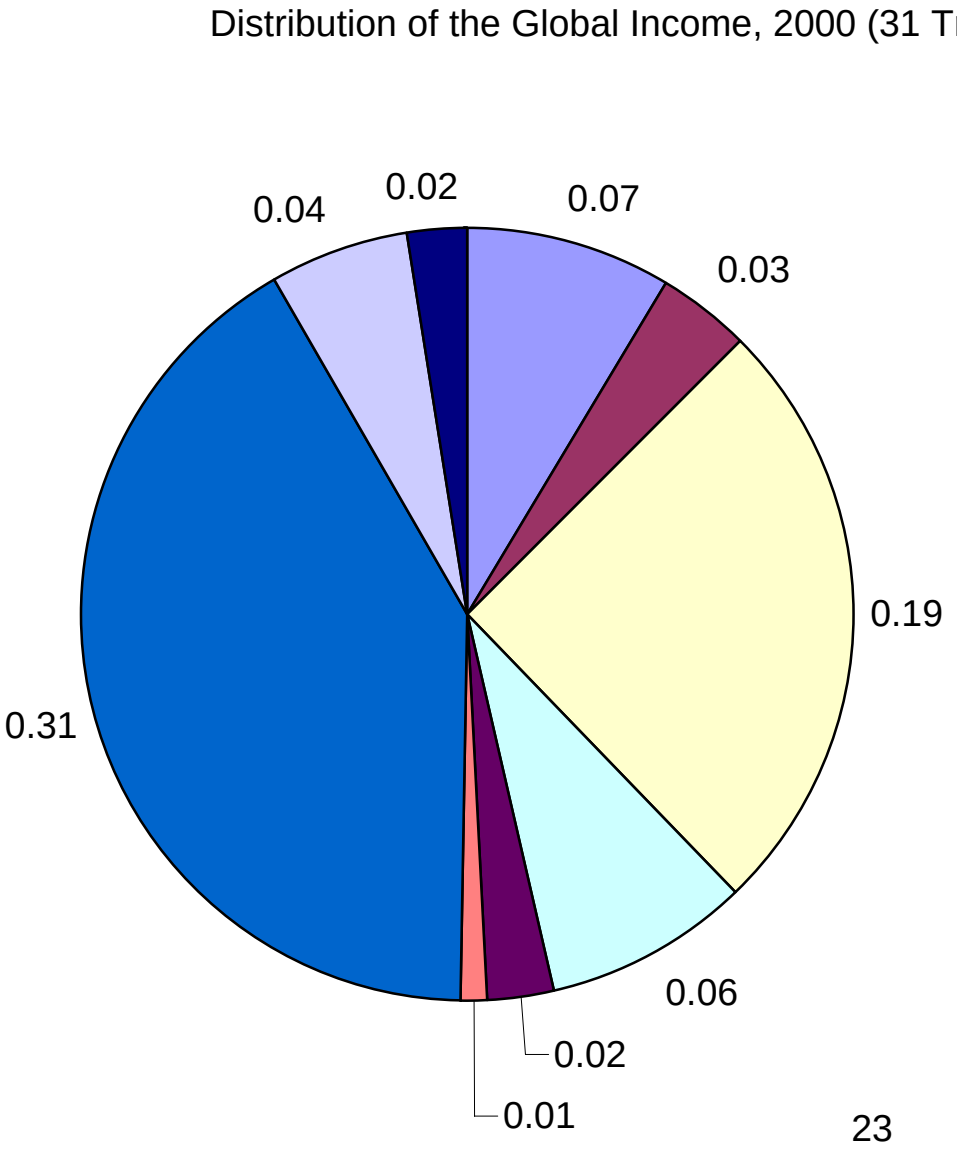
Source: http://www.GraphicMaps.Com

Population, total	2000
East Asia & Pacific	1,855,200,000
Europe & Central Asia	474,310,000
European Monetary Union	303,980,000
Middle East & North Africa	295,180,000
South Asia	1,355,100,000
Sub-Saharan Africa	658,940,000
Latin America & Caribbean	515,710,000
United States	281,550,000
Others	317,330,000
Heavily indebted poor countries (HIPC)	632,160,000
Low income	2,459,800,000
High income	902,850,000
Low & middle income	5,154,400,000
High income nonOECD	50,794,000
High income OECD	852,060,000
Least developed countries (UN classification)	660,030,000
Lower middle income	2,047,600,000
Middle income	2,694,600,000
Upper middle income	647,010,000
World	6,057,300,000



Source: World Bank

GDP (current US$)	2,000.00
East Asia & Pacific	2,059,100,000,000.00
Europe & Central Asia	942,080,000,000.00
European Monetary Union	6,048,400,000,000.00
Latin America & Caribbean	2,000,500,000,000.00
Middle East & North Africa	659,690,000,000.00
Sub-Saharan Africa	322,730,000,000.00
United States	9,837,400,000,000.00
United Kingdom	1,414,600,000,000.00
South Asia	596,790,000,000.00
World	31,493,000,000,000.00
Heavily indebted poor countries (HIPC)	200,880,000,000.00
High income	24,927,000,000,000.00
High income non-OECD	857,350,000,000.00
High income OECD	24,073,000,000,000.00
Least developed countries (UN classification)	190,520,000,000.00
Low & middle income	6,560,600,000,000.00
Low income	1,048,300,000,000.00
Lower middle income	2,347,200,000,000.00
Middle income	5,513,200,000,000.00
Upper middle income	3,170,500,000,000.00



Source: World Bank

Growth Models

- Classical
- Harrod-Domar (Keynesian)
- Neo-classical (Solow-Swan)
- Endogenous (Lucas, Romer)
- Human Capital, technology adoption (Parente-Prescott)
- Case study approach
- Socio-Political and Institutional Approach
- Growth Regressions

Relevant Literature (there are too many to list!!!)

Growth Theories and Sessions in this conference

One or two sector growth models

Ramsey (1928), Harrod (1939), Domar (1947), Solow (1956), Cass (1965),
Koopman (1965), Uzawa (1962), Lucas (1988), Rebelo (1991)
Romer (1989), Barro (1998) and Barro and Sala-i-Martin(1995), Quah (1997),
Parente and Prescott (1993) Rankin (1992) Dixon H (1987) Jones (1995)
Greenwood and Jovanovic (1990), Turnovskey (1993)

Empirical growth study

Maddison (1991). Nicolas Kaldor (1961) Rodrik (1999) Mankiw et. al. (1992), Hendry D.F. (1997)
Temple (1999) McMahon G and L. Squire(2003) Holly S and M Weale Eds.(2000)
Perroti (1996) Grossmand and Helpman (1991) HM Treasury (2002)

Dynamic General Equilibrium Models and stochastic DGEM

Debreau (1954),Solow (1956), Cass(196),King and Fullerton (1984),
Miller and Spencer (1977), Aurback and Kotlikoff (1987), Ballard, Fullerton, Shoven and Whalley(1985), Piggott and Whalley (1985), Bhattarai and Whalley (1999),
Hutton and Kenc (1994), Perroni (1995), Rutherford (1995),
Bhattarai (1997,1999) Doornik and Hendry (2001), Cooly (1995)

Solow Growth Model

Production function with Labour augmenting technology

(Close Economy without Government)

Firms' Production Function $Y_t = K_t^{\alpha}\left(AL\right)_t^{\beta}$

Market clearing: $Y_t = C_t + I_t$

Households' Saving: $S_t = sY_t$

Investment requirement: $I_t = \left(n + \delta + g_a\right)K_t$

Closure rule: $S_t = I_t$

Dynamics: Capital accumulation: $K_t = \left(1-\delta\right)K_{t-1} + I_t$

Capital Stock and output in the Steady State in the Solow Model with technical progress

Fundamental equation of economic growth:

$$\frac{d\tilde{k}}{\tilde{k}} = s\tilde{k}^{\alpha-1} - \left(\delta + n + g_a\right)$$

In steady state $\frac{d\tilde{k}}{\tilde{k}} = 0$ ➔ $s\tilde{k}\alpha - 1 = \delta + n + g_a$

Per Capita Effective Capital Stock in the Steady State: $\tilde{k}ss = \left(\frac{s}{\delta + n + g_a}\right)^{\frac{1}{1-\alpha}}$

Per Capita Effective Output in the Steady State: $\tilde{y}ss = \left(\frac{s}{\delta + n + g_a}\right)^{\frac{\alpha}{1-\alpha}}$

Endogenous Growth Model (Romer (1989), Jones (1995))

Output: $$Y = K^{\alpha}\left(AL_Y\right)^{\beta}$$

A = Stock of knowledge

Labour use: $$L = L_y + L_A$$

The stock of knowledge rises if more people do research:

$$\dot{A} = \bar{\delta} L_A^{\lambda} = \delta A^{\phi} L_A^{\lambda}$$

Growth rate of knowledge: $$g_A = \frac{\dot{A}}{A} = \frac{\delta A^{\phi} L_A^{\lambda}}{A}$$

Capital Accumulation:

$$K_t = K_{t-1}\left(1-\delta\right) + I_t$$

Market clearing: $$Y_t = C_t + I_t$$

Here technology is endogenous to efforts in production and application of research.

Neo-classical Ramsey Growth Model

Preference: $\int_0^{\infty} e^{-\rho t} \frac{C_t^{1-\sigma}}{1-\sigma} dt$

Technology: $Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$ assume $A_t = 1 \;\; N_t = 1$

Capital accumulation: $\dot{K}_t = Y_t - N_t C_t - \delta K_t$

Current value Hamiltonian of this problem

$$H(c, K, \theta) = \frac{C_t^{1-\sigma}}{1-\sigma} + \theta\left[K_t^{\alpha} - C_t - \delta K_{t-1}\right] \quad (1)$$

C is control, K is state variable, θ is co-state variable.

Optimality and Boundary Conditions

First order conditions

$$\frac{\partial H}{\partial C_t} = 0 \rightarrow C_t^{-\sigma} = \theta_t \quad (2)$$

$$\dot{\theta}_t = \rho\theta_t - \frac{\partial H_t}{\partial K_t} \rightarrow \dot{\theta}_t = \rho\theta_t - \theta_t \left[\alpha K_t^{\alpha-1} - \delta\right] \quad (3)$$

$$\dot{K}_t = K_t^{\alpha} - N_t C_t - \delta K_t \quad (4)$$

Transversality condition

$$\lim_{n \to \infty} e^{-\rho t}\theta_t K_t = 0 \quad (5)$$

Characterisation of the Balanced Growth Path

Capital stock, consumption and the shadow price of capital remain constant in the balanced growth path $\frac{\dot{C}}{C} = g_c$; $\frac{\dot{K}}{K} = g_K$ and $\frac{\dot{\theta}_t}{\theta_t} = g_\theta$. From (3)

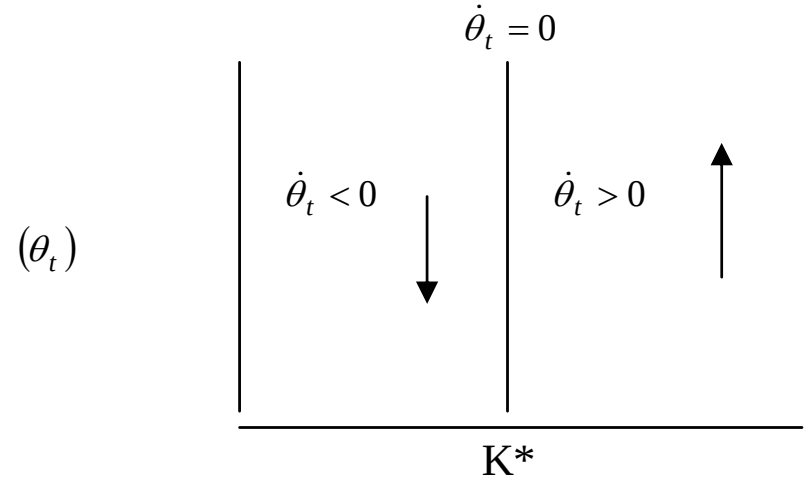
$$\frac{\dot{\theta}_t}{\theta_t} = \rho - \left[\alpha K_t^{\alpha-1} - \delta\right] \rightarrow \alpha K_t^{\alpha-1} = \rho - \frac{\dot{\theta}_t}{\theta_t} + \delta \quad (6)$$

Since the RHS is constant , therefore LHS also should be constant $\frac{\dot{K}}{K} = 0$. If capital stock is not growing output is not growing $\frac{\dot{Y}}{Y} = 0$ and consumption is not growing $\frac{\dot{C}}{C} = 0$.

From (2) $\frac{\dot{\theta}_t}{\theta_t} = -\sigma \frac{\dot{C}_t}{C_t} \rightarrow \frac{\dot{\theta}_t}{\theta_t} = 0$ (7)

Transitional Dynamics-1

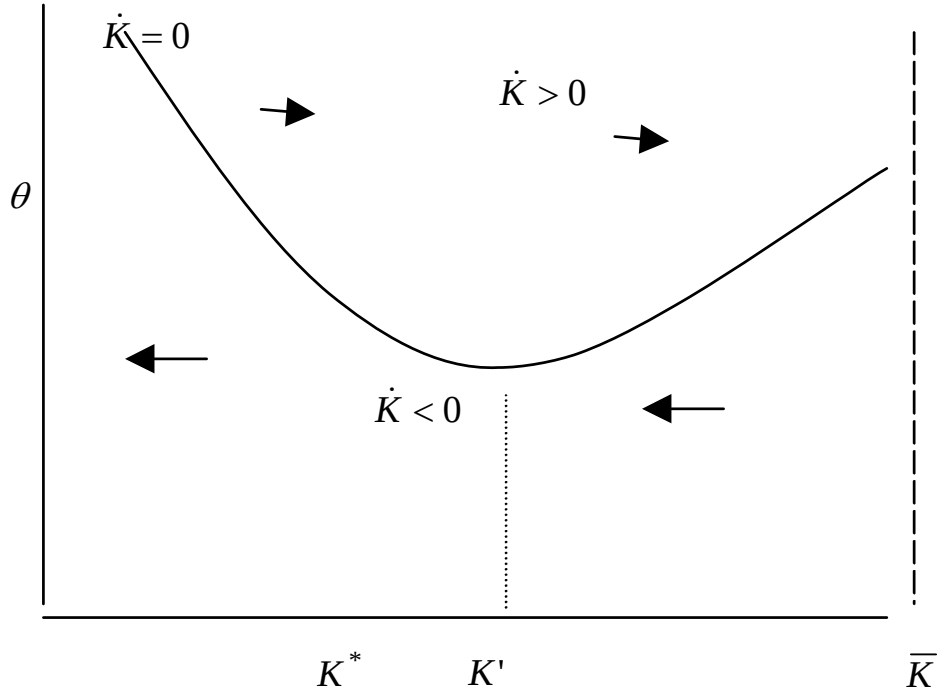
In (θ_t, K_t) space the transition dynamics of the shadowprice θ_t relative to the steady state capital stock is that



$$K^* = \left[\frac{\alpha}{\rho + \delta - \frac{\dot{\theta}}{\theta}} \right]^{\frac{1}{1-\alpha}}$$

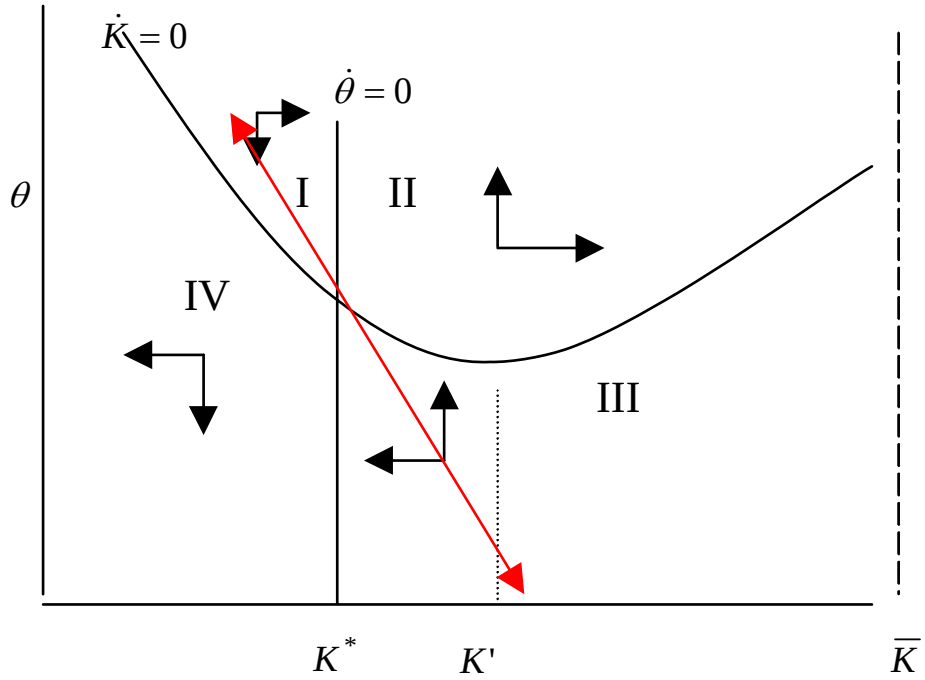
Transitional Dynamics-2

$\overline{K} > K^* > K'$.



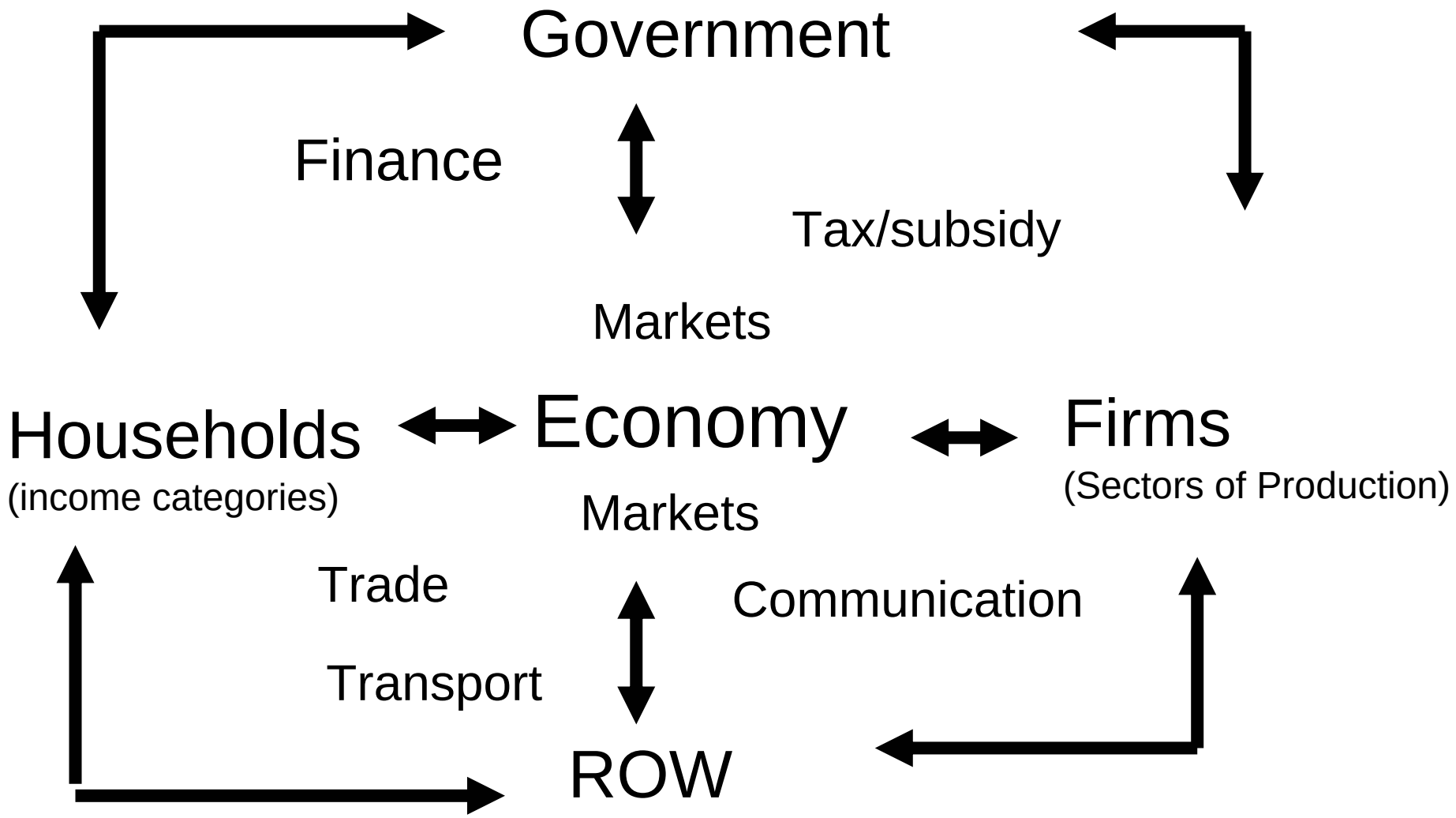
Saddle Point Solution

Putting all these things together the convergence to the steady state can be summarised in the following diagram.



Convergence to the steady state lies in region I and III as shown by the double arrow red line.

$$K^* = \left(\frac{\alpha}{\rho + \delta}\right)^{\frac{1}{1-\alpha}} \qquad K' = \left(\frac{\alpha}{\delta}\right)^{\frac{1}{1-\alpha}} \qquad \overline{K} = \left(\frac{1}{\delta}\right)^{\frac{1}{1-\alpha}}$$



General equilibrium in all markets

Some Studies on Global Evidence

- Abramovitch (1986)
- Maddison (1991): OECD economies
- Barro (1991)
- Mankiw-Romer-Weale (1992)
- Barrow and Sala-i-Martin (1995)
- Jones (1995)
- Qua (1997)
- Temple (1999)
- Yifu (2003)
- World Bank Annual Reports

Major Growth issues

- Capital accumulation
- Technology and its adoption
- Openness, trade and growth
- Tax policy
- Human Capital, Education
- Country specific factors
- Political Freedom and Market Economy

Determinants of Growth: Panel Regression Model

$$y_{i,t} = \alpha_i + x_{i,t}\beta_{i,t} + \lambda_t + e_{i,t}$$

$$\begin{bmatrix} y_{i,1} \\ y_{i,2} \\ . \\ . \\ y_{i,T} \end{bmatrix} = \begin{bmatrix} x_{i,1}\beta \\ x_{i,2}\beta \\ . \\ . \\ x_{i,T}\beta \end{bmatrix} + \begin{bmatrix} \alpha_i \\ \alpha_i \\ \\ \\ \alpha_i \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \\ \\ \lambda_T \end{bmatrix} + \begin{bmatrix} e_{1i} \\ e_{2i} \\ \\ \\ e_{mi} \end{bmatrix}$$

$$y_i = x_i\beta + \lambda_t + \iota_i\alpha_i + e_i$$

Baltagi (1995), Doornik and Hendry (2001)

Estimator of a Panel Data Model

$$y_i = x_i \beta + D_i \delta + e_i$$

$$y = W\beta + e$$

$$\hat{\beta} = \left(W'W\right)^{-1} W'y$$

Dynamic Panel Data Model

$$y_{i,t} = \sum_{s=1}^{p} a_k y_{i,t-s} + \beta^t (L) x_{i,t} + \lambda_t + \alpha_i + e_{i,t}$$

$$y_i = W_i \delta + \iota_i a_i + e_i$$

GMM Estimator (Baltagi (1995),Doornik and Hendry (2001)):

$$\hat{\delta} = \left[\left(\sum_i W_i^* Z_i \right) A_N \left(\sum_i Z_i' W_i \right) \right]^{-1} \left(\sum_i W_i^* Z_i \right) A_N \left(\sum_i Z_i' y_i^* \right)$$

$$A_N = \left(\frac{1}{N} \sum_i Z_i' H_i Z_i \right)^{-1}$$

Determinants of Economic Growth in Newly Emerging Growth Miracle Economies.

2-step estimation using dynamic panel data model				
	Coefficient	Std.Error	t-value	t-prob
Gdpprcap(-1)	0.12036	0.01812	6.64000	0.00000
GDP60	-0.00159	0.00043	-3.73000	0.00000
china	0.00288	0.00137	2.11000	0.03700
Hkong	-0.00171	0.00077	-2.21000	0.02800
Ireland	0.00110	0.00128	0.86300	0.38900
Korea	0.00335	0.00074	4.53000	0.00000
Malta	-0.00197	0.00068	-2.90000	0.00400
Portugal	-0.00061	0.00096	-0.63700	0.52500
Singapore	0.00113	0.00027	4.21000	0.00000
Sratio	0.15583	0.04257	3.66000	0.00000
Irattio	0.18329	0.02995	6.12000	0.00000
Prindex	-0.00510	0.00487	-1.05000	0.29700
rint	-0.02795	0.06357	-0.44000	0.66100
xmratio	-0.00461	0.00097	-4.74000	0.00000
Japan	-0.00056	0.00086	-0.65300	0.51500
sigma 4.914753	sigma^2 24.1548			
RSS 3526.6004	TSS 2240.0576			
no. of observations 161	no. of parameters 15			

Table 2
Determinants of Growth across OECD Countries

	Coefficient	Std.Error	t-value	t-prob
Grpercap(-1)	0.180988	0.05395	3.35	0.00
Sy	0.216942	0.03	7.23	0.00
Iy	-0.00045	0.05464	-0.00824	0.99
Xmy	0.0648251	0.01251	5.18	0.00
Popg	-1.88968	0.4329	-4.37	0.00
Govy	-0.203699	0.0558	-3.65	0.00
Txy	-0.132421	0.0445	-2.98	0.00
Australia	0.972477	0.4075	2.39	0.02
Austria	-1.6312	0.3127	-5.22	0.00
Belgium	-1.8475	0.3254	-5.68	0.00
Canada	-0.463298	0.1385	-3.34	0.00
Denmark	-0.170403	0.04258	-4	0.00
Finland	-0.209737	0.05947	-3.53	0.00
France	0.077469	0.07293	1.06	0.29
Germany	-0.362554	0.04693	-7.73	0.00
Greece	-0.585984	0.06581	-8.9	0.00
Iceland	-0.207666	0.05016	-4.14	0.00
Ireland	-0.411256	0.0768	-5.35	0.00
Italy	-0.0800266	0.0598	-1.34	0.18
Japan	-0.398036	0.06241	-6.38	0.00
Luxembourg	-0.718133	0.1419	-5.06	0.00
Netherlands	-0.221358	0.04843	-4.57	0.00
New Zealand	-0.127106	0.04085	-3.11	0.00
Norway	-0.153097	0.03551	-4.31	0.00
Portugal	-0.216048	0.04225	-5.11	0.00
Spain	-0.114415	0.0264	-4.33	0.00
Switzerland	-0.330109	0.04088	-8.07	0.00
United Kingdom	-0.0111015	0.01851	-0.6	0.55
Constant	6.88023	0.9513	7.23	0.00
Sigma 1.645049 ; sigma^2 2.71; R^2 = 0.453642; N =390; K 29				
Wald (joint): Chi^2(28) = 580.8 [0.000] **				
Wald (dummy): Chi^2(1) = 52.31 [0.000] **				
AR(1) test: N(0,1) = 3.091 [0.002] **				
AR(2) test: N(0,1) = -0.1074 [0.915]				

Table 5
Determinants of growth in Growth-disaster Countries.

	Coefficient	Std.Error	t-value	t-prob
Sy	0.0536652	0.0578	0.929	0.357
Iy	0.387516	0.03472	11.2	0
Popg	1.58804	0.6546	2.43	0.018
Xmy	-0.0645406	0.04199	-1.54	0.13
Infl	-0.000239639	5.52E-05	-4.34	0
Govy	-0.254936	0.05758	-4.43	0
Rint	-0.0128252	0.001408	-9.11	0
Rexch	-0.00829239	0.0006404	-12.9	0
Central African Rep.	-0.567217	1.896	-0.299	0.766
Ghana	0.764814	0.909	0.841	0.404
Nicaragua	-0.267793	0.1168	-2.29	0.025
Sierra Leone	-0.0683136	0.128	-0.534	0.596
Venezuela, RB	-0.294535	0.1456	-2.02	0.048
Constant	-0.894037	2.785	-0.321	0.749
Sigma	4.263287	Sigma^2	18.17	562
R^2	0.3457624			
RSS	1072.361362	TSS	1639.1007	168
No. of observations	79	no. of	parameters	20
Wald (joint):	Chi^2(19)	180.1	[0.000]	
Wald (dummy):	Chi^2(1)	0.103	[0.748]	
AR(1) test:	N(0,1)	-0.9735	[0.330]	
AR(2) test:	N(0,1)	-1.269	[0.204]	

Table 7
Determinants of growth in Latin and Central American countries.
Panel GMM (one Step) Estimation with Individual Effects

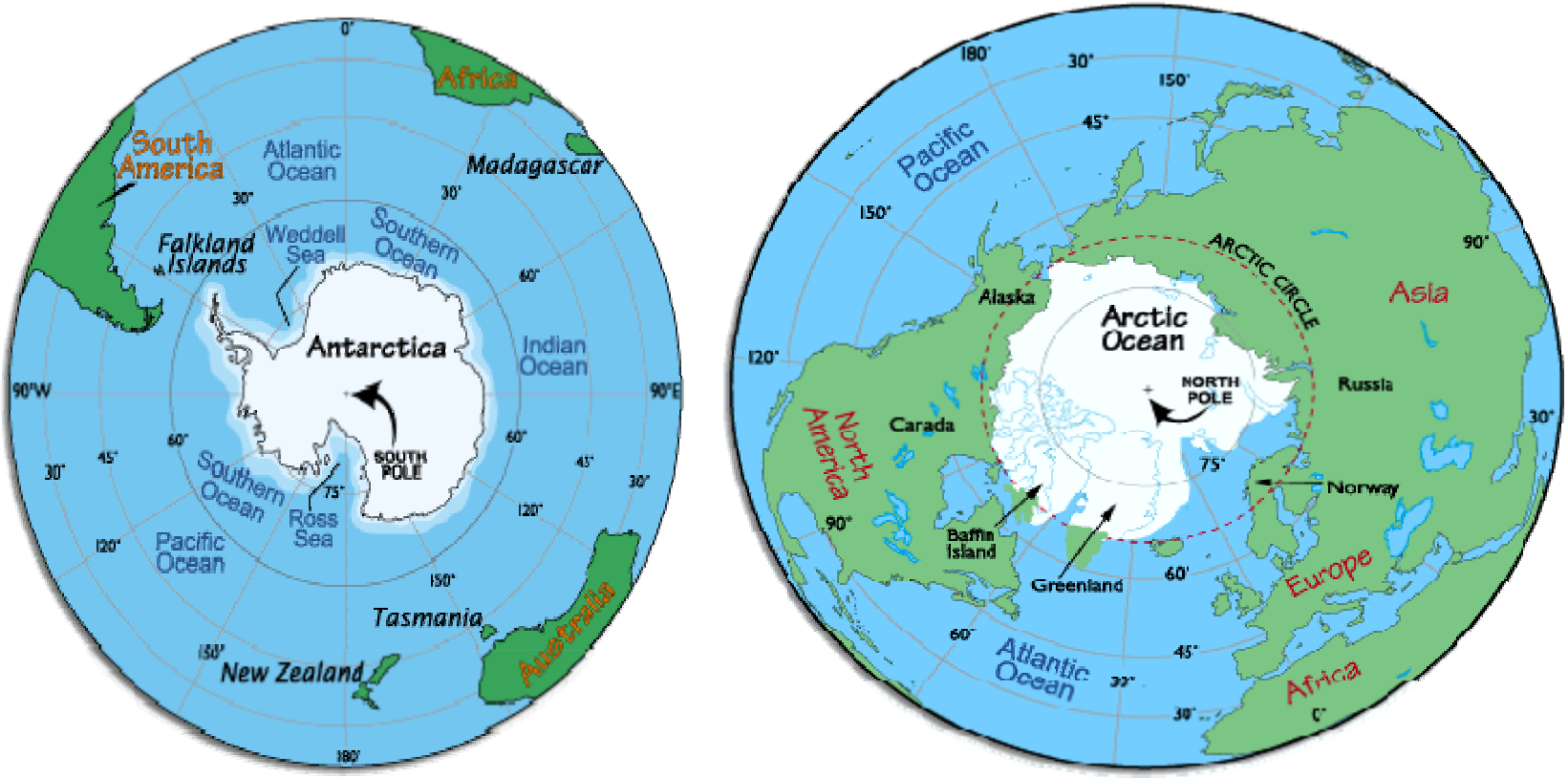
	Coefficient	Std.Error	t-value	t-prob
iy	0.1306	0.0522	2.5000	0.0130
xmy	0.0302	0.0209	1.4500	0.1490
infl	-0.0009	0.0002	-4.0000	0.0000
cadef	0.0475	0.0306	1.5500	0.1220
Constant	-4.4425	3.6730	-1.2100	0.2270
Antigua and Barbuda	2.3244	3.0800	0.7550	0.4510
Argentina	0.3609	1.0630	0.3390	0.7340
Bahamas, The	-0.0664	1.2470	-0.0533	0.9580
Barbados	0.9192	1.0350	0.8880	0.3750
Belize	1.4098	2.5280	0.5580	0.5770
Bolivia	2.5282	3.0420	0.8310	0.4060
Brazil	3.9497	2.2790	1.7300	0.0840
Chile	2.1572	2.7650	0.7800	0.4360
Colombia	0.6180	1.8630	0.3320	0.7400
Costa Rica	2.1726	2.1460	1.0100	0.3120
Dominican Republic	0.1568	2.3280	0.0674	0.9460
Ecuador	0.8159	2.3880	0.3420	0.7330
El Salvador	1.1222	1.0850	1.0300	0.3010
Grenada	1.5311	2.6970	0.5680	0.5700
Guatemala	-2.7476	0.4757	-5.7800	0.0000
Guyana	-0.3287	2.7390	-0.1200	0.9050
Haiti	-0.9212	1.9150	-0.4810	0.6310
Honduras	-1.3697	1.3050	-1.0500	0.2940
Jamaica	1.5202	2.5750	0.5900	0.5550
Mexico	-0.1066	2.1300	-0.0500	0.9600
Nicaragua	0.2862	1.8670	0.1530	0.8780
Panama	-0.3209	2.1480	-0.1490	0.8810
Paraguay	1.0235	2.7600	0.3710	0.7110
Peru	1.0299	0.7821	1.3200	0.1880
Puerto Rico	0.9467	0.6354	1.4900	0.1370
St. Kitts and Nevis	0.8115	0.6603	1.2300	0.2200
St. Lucia	0.1886	2.1710	0.0869	0.9310
St. Vincent and the Grenadines	-0.3299	1.7820	-0.1850	0.8530
Suriname	2.5300	2.6500	0.9550	0.3400
Trinidad and Tobago	-0.8258	2.4170	-0.3420	0.7330
sigma	4.494	Observations	617	
sigma^2	20.19	Parameters	35	
R^2	0.194			
Wald (Joint)	Chi^2(4)	31.11	[0.000]	**

Wide gap exists in living standards among rich and poor countries.

These gaps can be narrowed if the technical idea, capital and labour could flow freely among them.

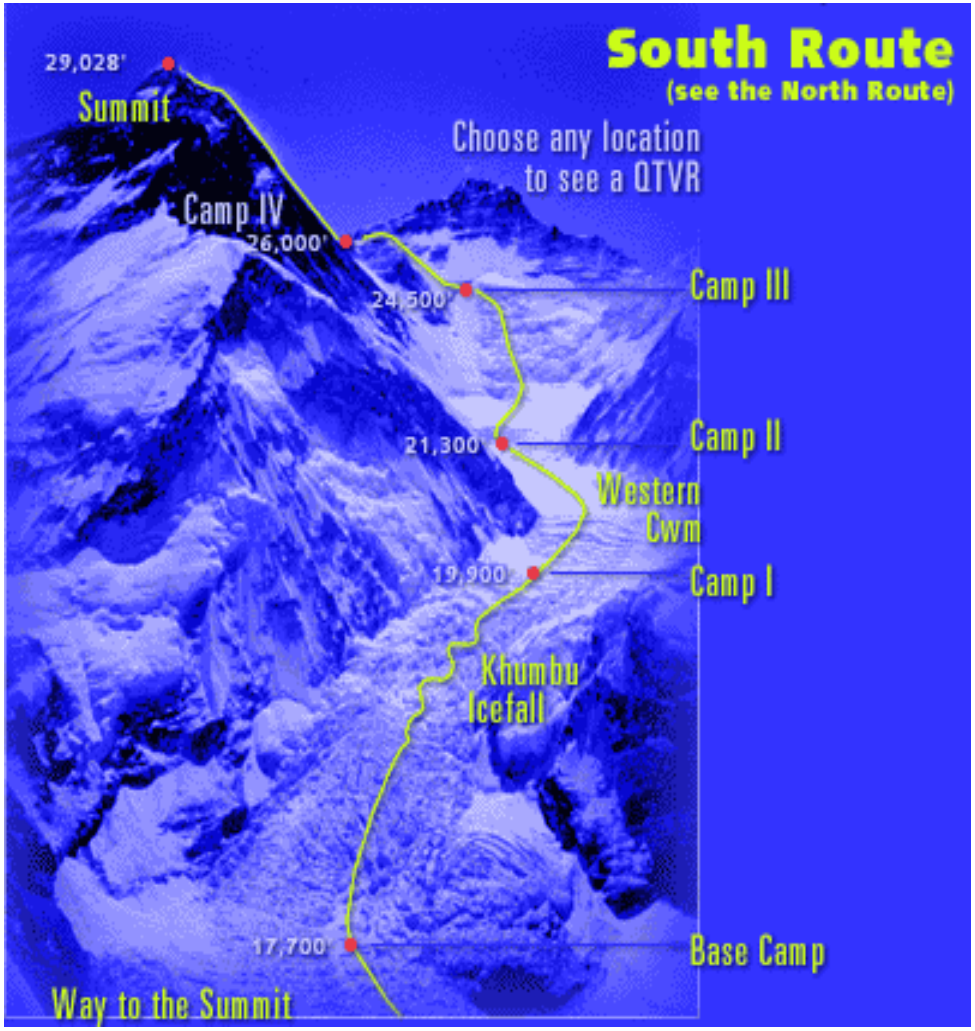
It is not possible unless growth in the major objective of households, firms and governments.

Is There Anything in the North and South Pole On in Deep Oceans Between them that Can Promote Growth for all?



Source: http://www.GraphicMaps.Com

Growth
Mountain?



Which Root
To Take?