Fifth Summer School in Trade, Industrialization, and Development 2006

University of Milan, Palazzo Feltrinelli, Gargnano, Italy

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Outsourcing and International Fragmentation of Production: Implications for Developing Countries

Lecture 3: International Fragmentation, Trade and Growth

International Fragmentation, Trade and Growth

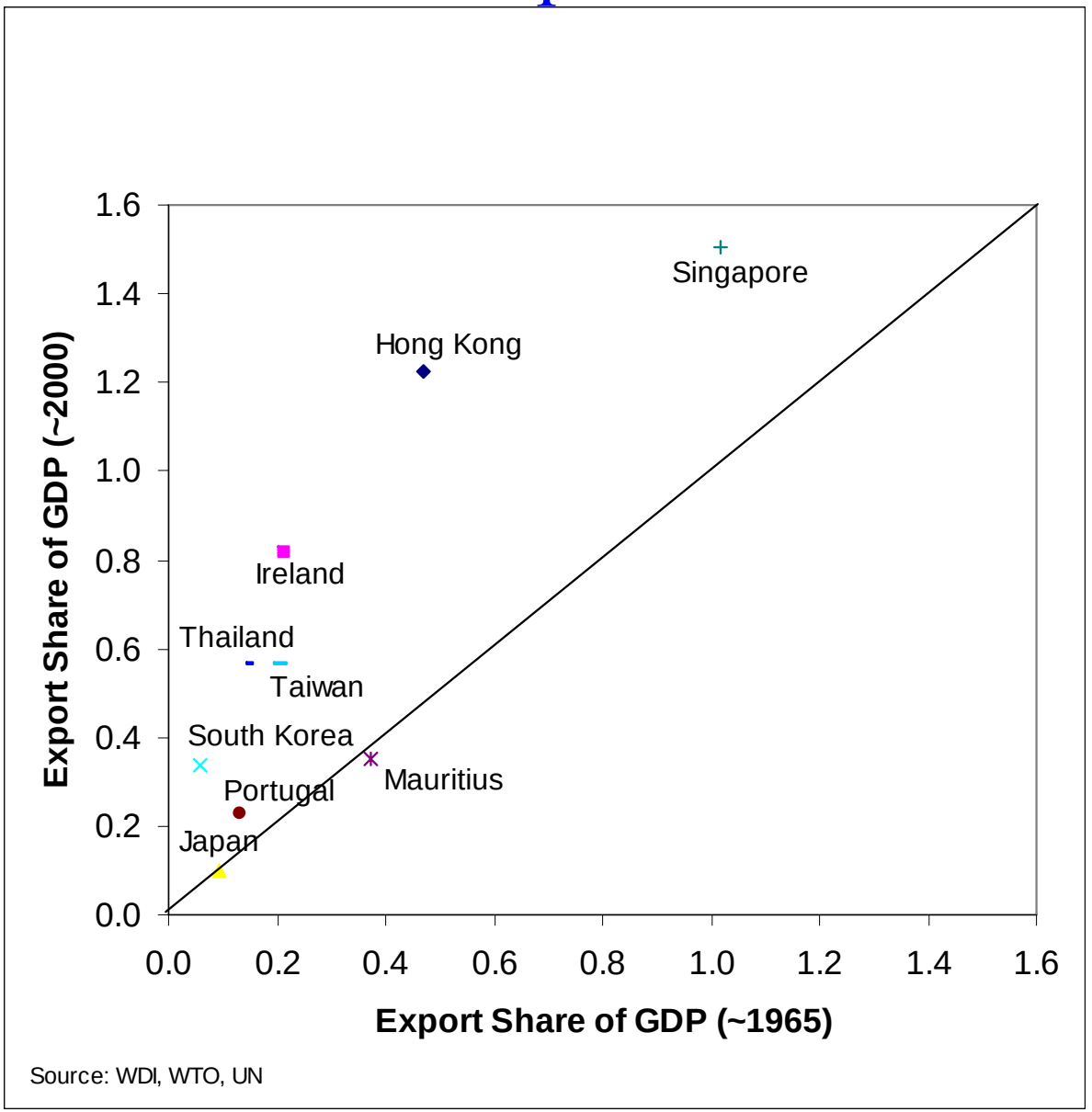
Large gains from openness and trade seem possible

• "I do not see how one can look at figures like these without seeing them as representing *possibilities*. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what exactly? If not, what is it about the 'nature of India' that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else." Robert E. Lucas, Jr. (1988, "On the Mechanics of Economic Development", *Journal of Monetary Economics*, p. 5)

Great Deal of Theoretical and Empirical Research on Trade, Openness and Growth

- Theoretical research: Grossman and Helpman, *Innovation and Growth in the Global Economy*, 1991, Cambridge, MA: MIT Press
- Empirical research has been around longer. Many studies (100?), but they are problematic. (cf. Rodriguez and Rodrik, NBER Macro Annual, 2000)
  - Causality issues
  - Omitted variable bias
- Overall evidence on causality from trade or openness to growth is mixed

Growth Miracle Countries Tend to Have Large Increases in their Export Share of GDP



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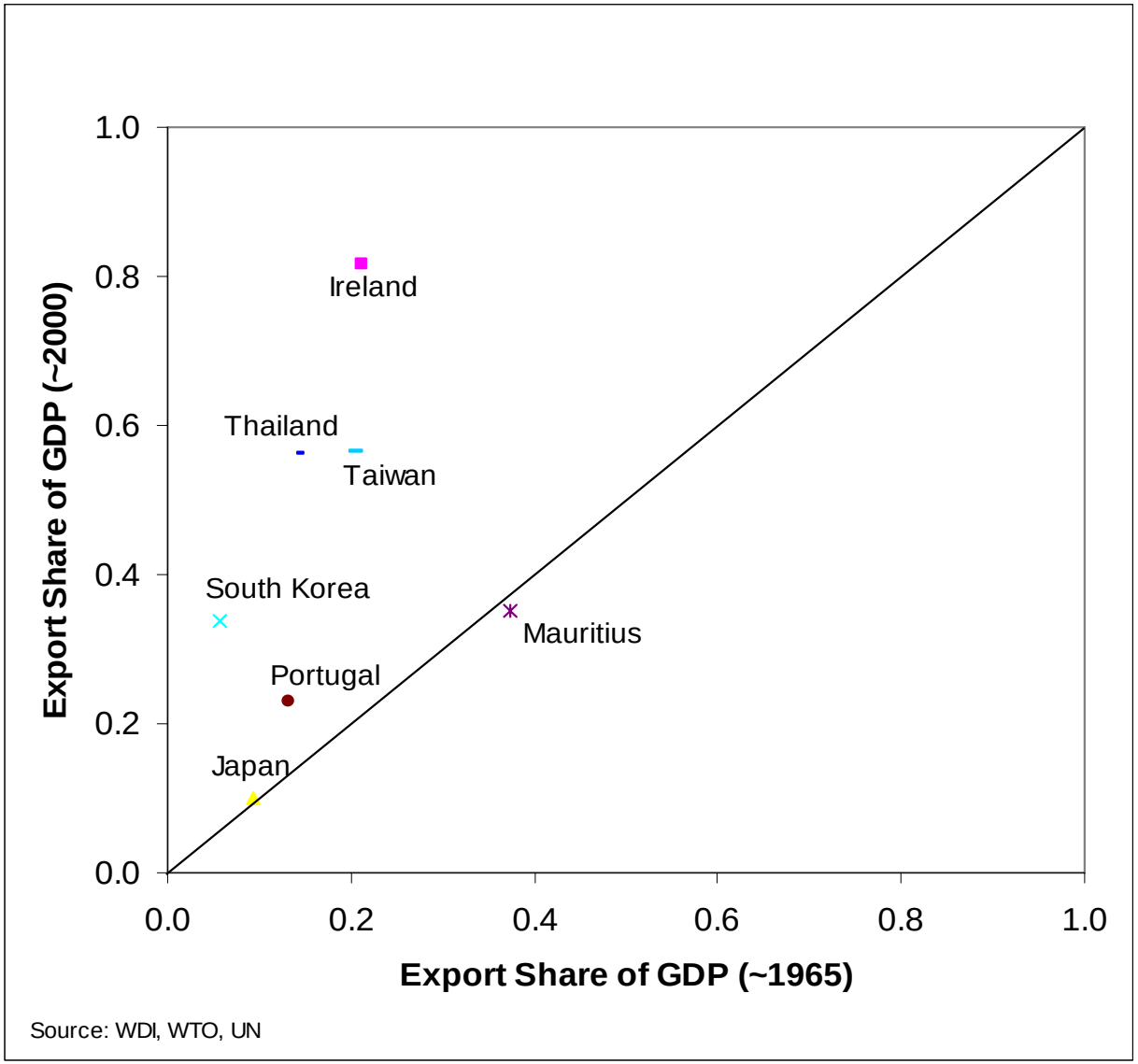


Growth Miracle Countries Also Tend to Have Large Amounts of Fragmentation

- Korea, Taiwan, Ireland: 30-35%
- Singapore and Hong Kong

Two Suggestive Facts on Fragmentation and Growth

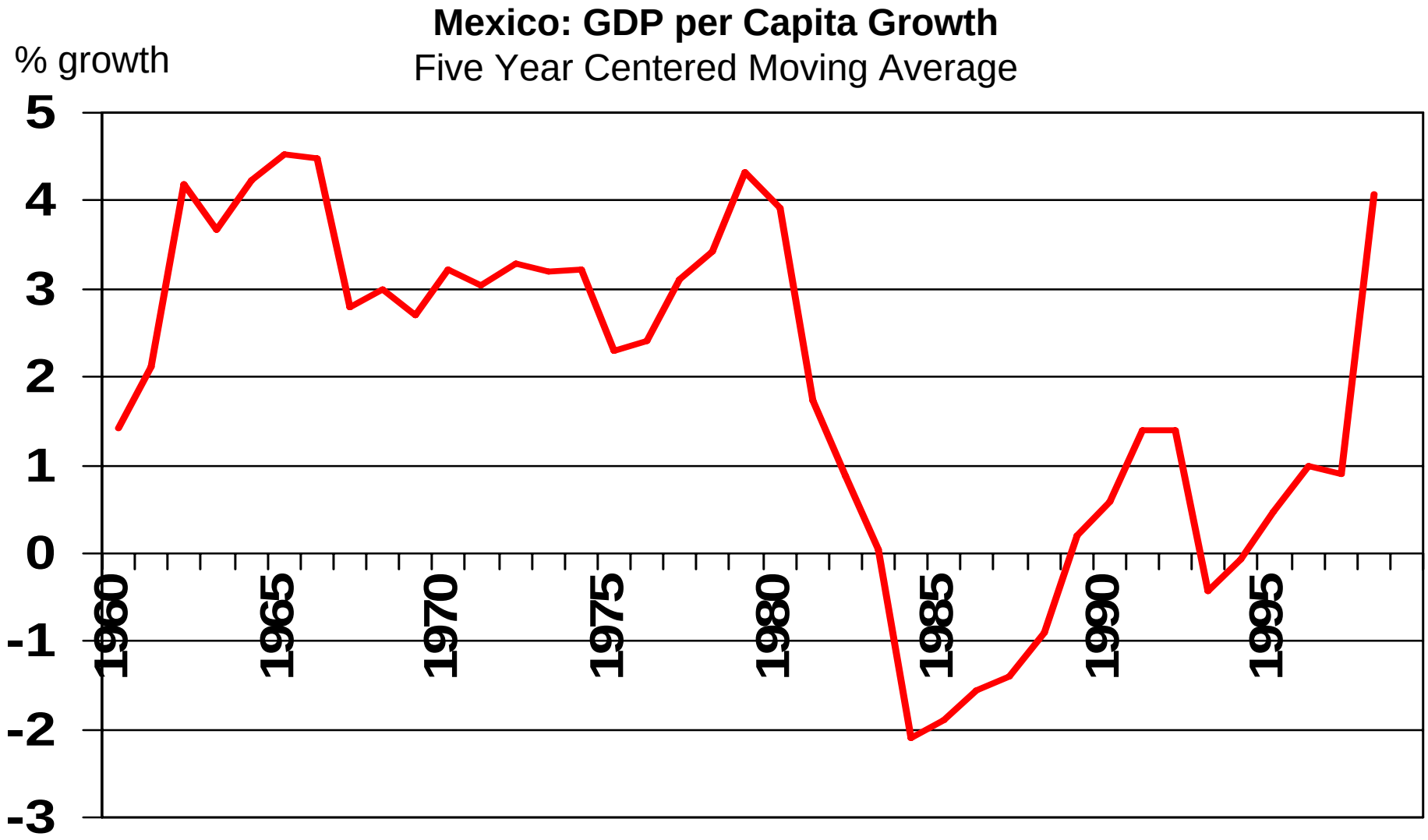
- Growth miracle countries tend to have large growth in export share of GDP
    - Median increase in export share of GDP is about 50% between 1962 and mid-1990s.
- These countries also have high fragmentation shares
- India and China appear to fit this pattern, too

- However, Mexico has a large amount of fragmentation, but no growth miracle

Mexico's VS Exports

Source: Hummels, Ishii, Yi (2001)

Growth in fragmentation does not imply higher GDP growth: the case of Mexico



Source: Penn World Tables 6.1 (rgdpch-chain weighted constant prices International $)

Outline

- Review China's recent trade and growth experience
- Review South Korea's growth miracle
- Outline 3 frameworks to think about Korea's growth miracle
  - Basic "AK" model with Ricardian trade
  - AK model with Ricardian trade and continuum of goods
  - AK model with Ricardian trade, continuum of goods, and vertical specialization

Relevant Readings

1. Acemoglu, Daron and Jaume Ventura. "The World Income Distribution", *Quarterly Journal of Economics*, 2002 (117), 659-694.
2. Grossman, Gene and Elhanan Helpman. *Innovation and Growth in the Global Economy*, 1991, Cambridge, MA: MIT Press.
3. Hall, Robert, and Charles I. Jones. "Why do Some Countries Produce So Much More Output per Worker Than Others?" *Quarterly Journal of Economics*, 1999 (114), 83-116.
4. Hummels, David and Peter J. Klenow. "The Variety and Quality of a Nation's Exports", *American Economic Review*, 2005 (95), 705-723.
5. Jones, Larry and Rody Manuelli. "A Convex Model of Equilibrium Growth: Theory and Policy Implications", *Journal of Political Economy*, October 1990, 1008:1038.
6. Lucas, Robert E., Jr. "Making a Miracle", *Econometrica*, 1993 (61), 251-272.
7. "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence," (with Francisco Rodríguez), Macroeconomics Annual 2000, eds. Ben Bernanke and Kenneth S. Rogoff, MIT Press for NBER, Cambridge, MA, 2001.

China

- Growth facts
- Trade facts
- Suggestive of fragmentation's role

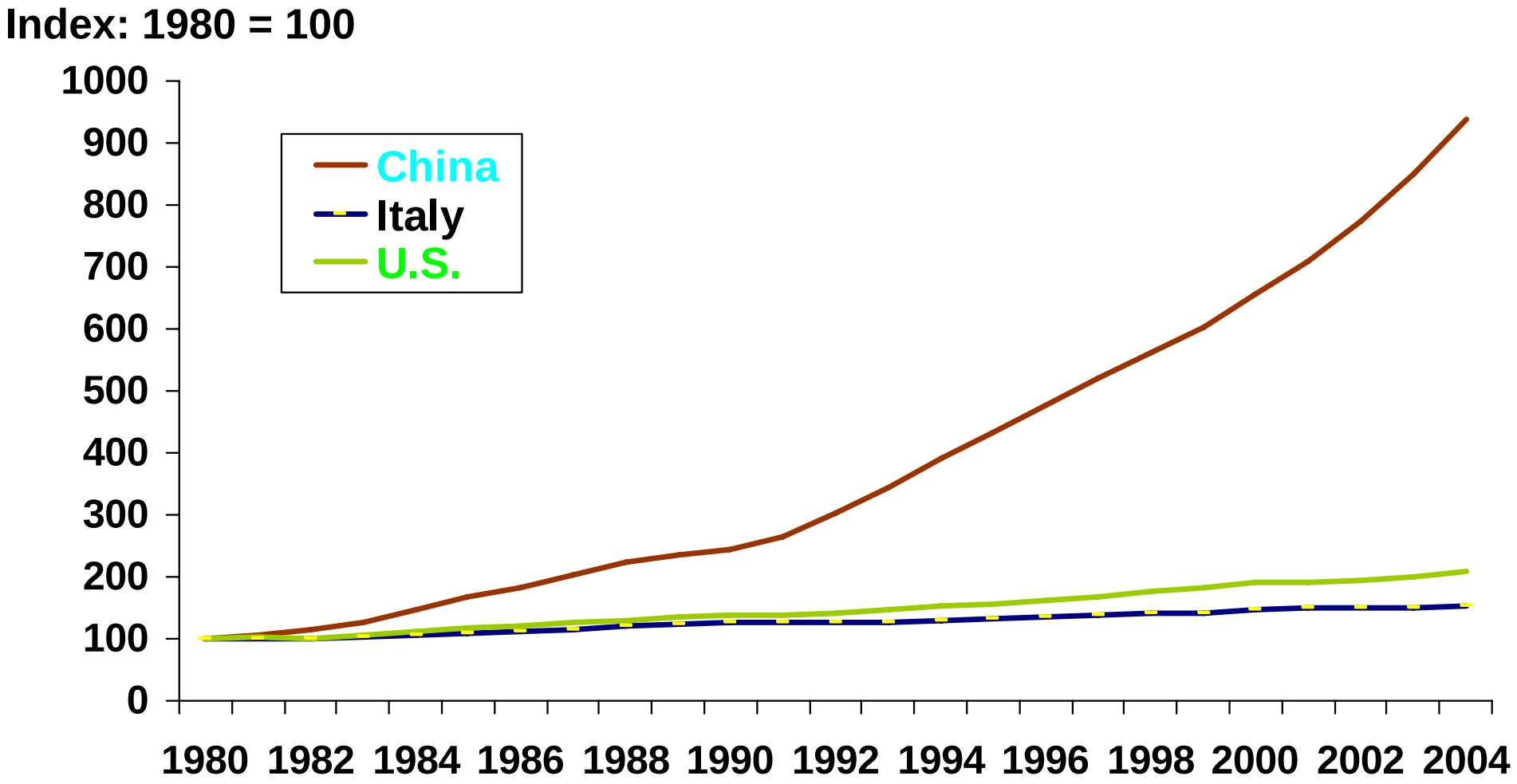
Is China taking over the world?

- China makes 90% of all bicycles, footwear sold in the U.S.
- Almost 50% of U.S. wood and metal furniture imports are from China (4 times more than from Canada).
- In 2004, Wal-Mart (reportedly) sourced about $18 billion of products from China

- China is now the world's largest producer of computer hardware, mobile phones, cement and steel.
  - It is the world's largest market for mobile phones, cement, and steel

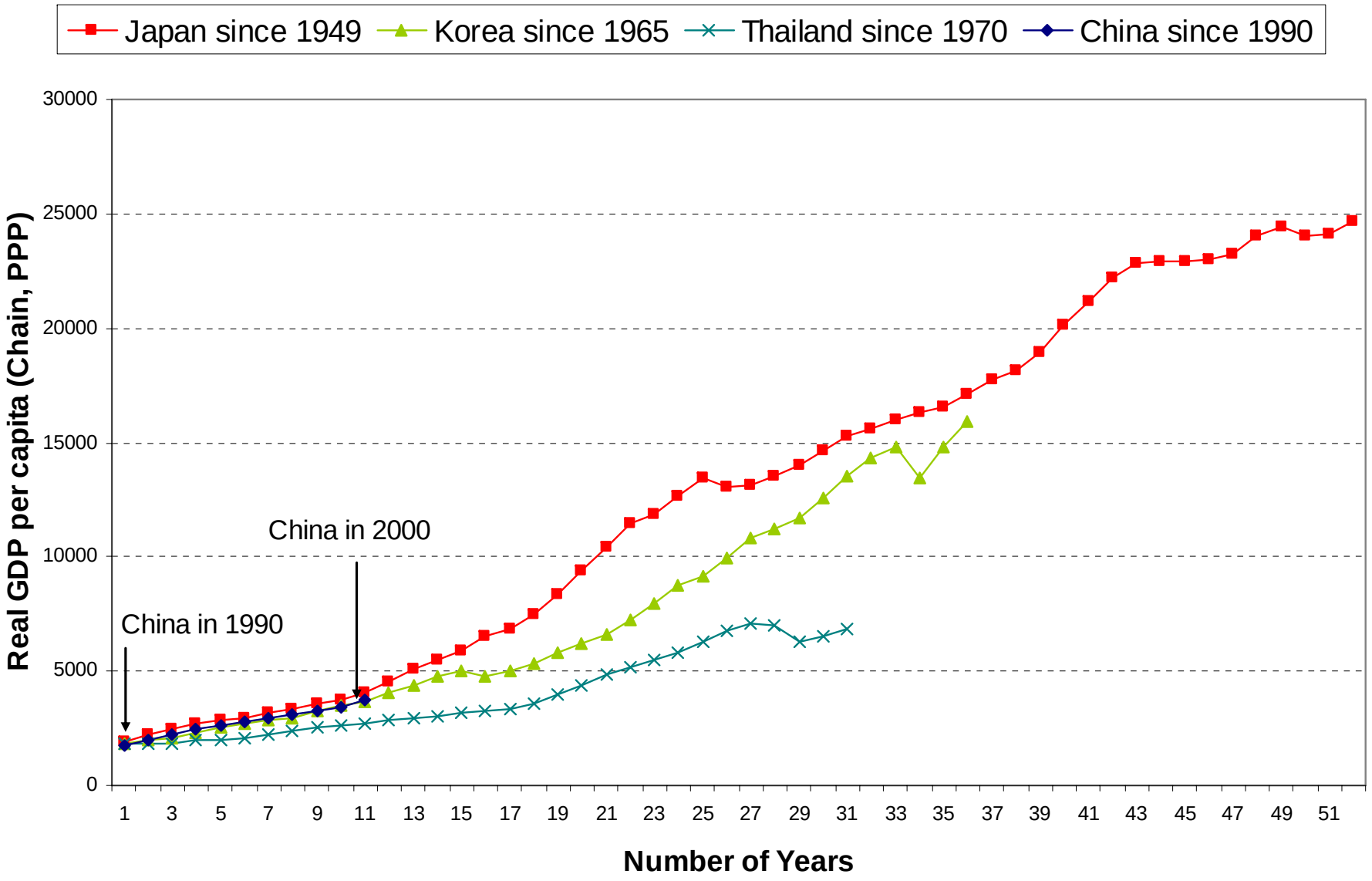
- China is the world's 2nd largest consumer of oil

China's GDP Growth Over the Past 24 Years Outpaced the U.S. and Italy



SOURCE: World Development Indicators

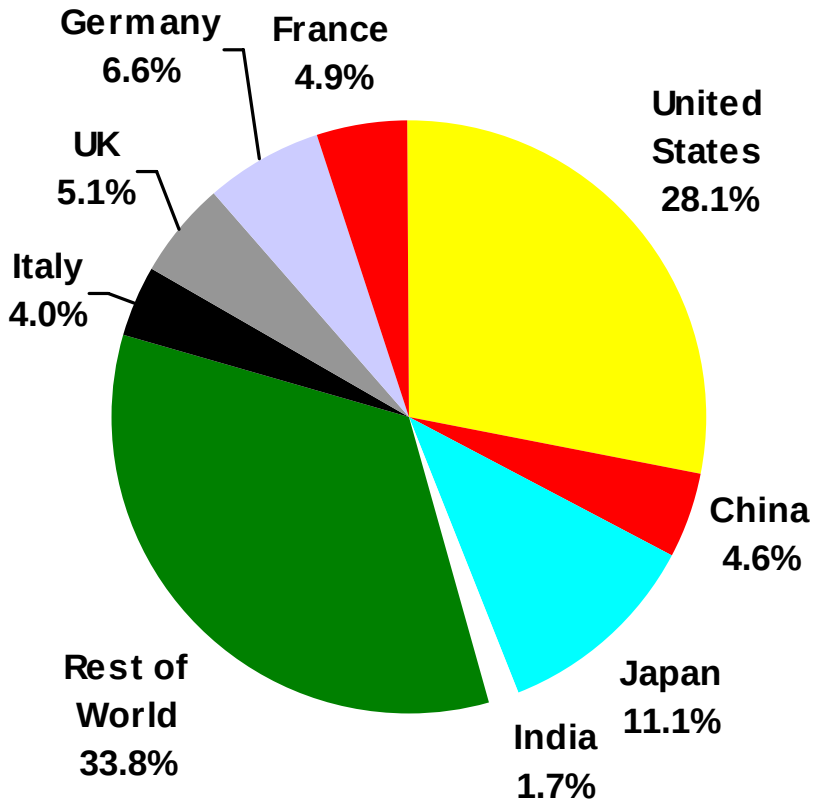
Is China the next growth miracle?



China is Now Big

Share of World GDP

Current Exchange Rates (2004)



SOURCE: World Development Indicators, IMF

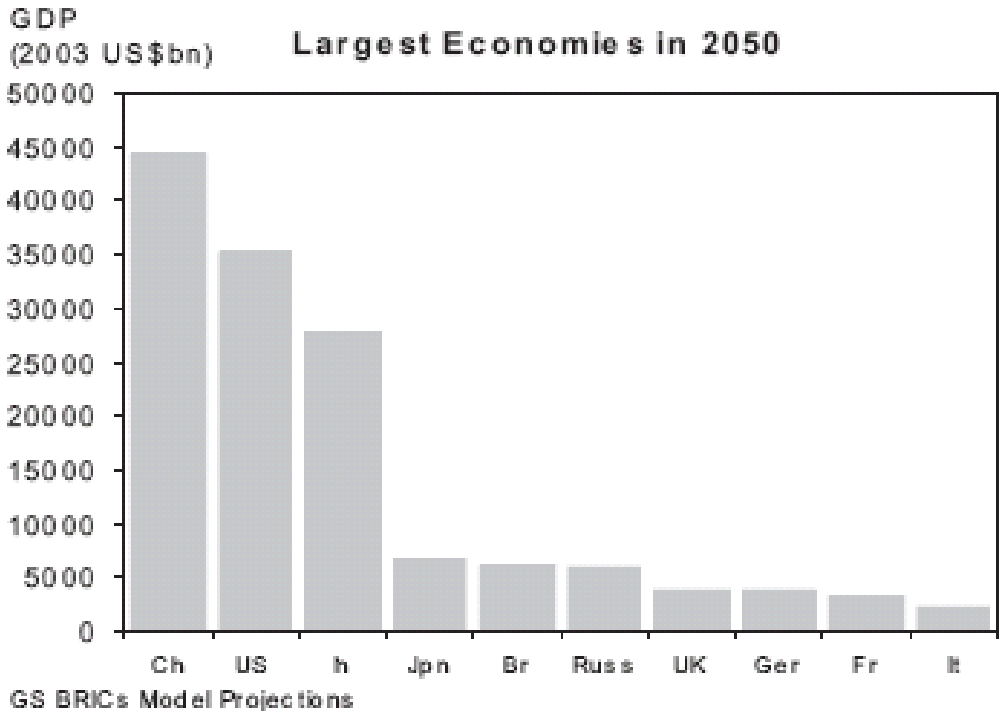
But China is still poor…

- 25+ years after economic reforms, per capita GDP in 2004 (measured in 2000 prices, and adjusted for lower costs of services in China, i.e., PPP-adjusted) was $5419.
  - 1/7 of U.S. level
  - South Korea's level in early 1980s
  - Suggests that China has a lot of growth ahead

So in 2050 China will be much richer than today, but not as rich as US, though much bigger than US!!

	CHINA/US	
	Per Capita GDP	GDP
Case 1	0.43	2.00
Case 2 (optimistic)	0.58	2.63

Goldman Sachs Predictions, 2004

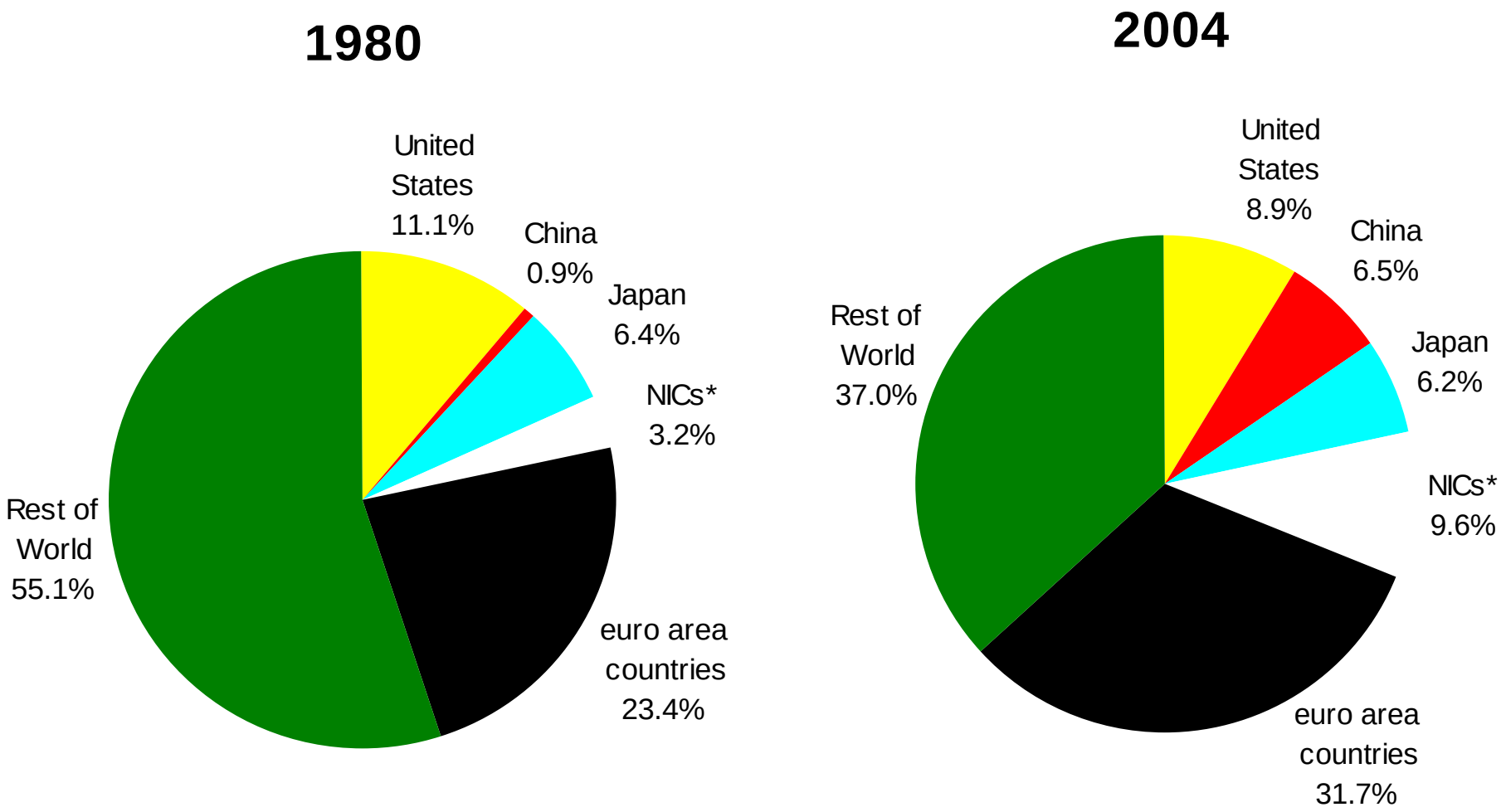


When Will China's GDP Surpass U.S. GDP?

- Evolution in China's Economic Size:
  - 10 years ago: Canada
  - Now (2004): France
    - -1.15 times Italy
    - -1/6 of U.S.
  - In 15-25 years: U.S.

Source: World Development Indicators

China's Share of World Exports has Increased by Over 600%

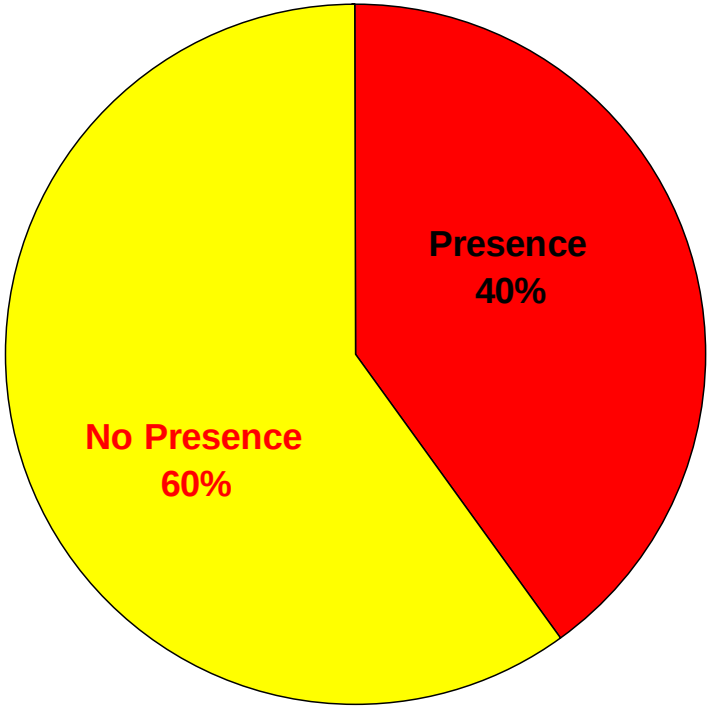


SOURCE: WTO

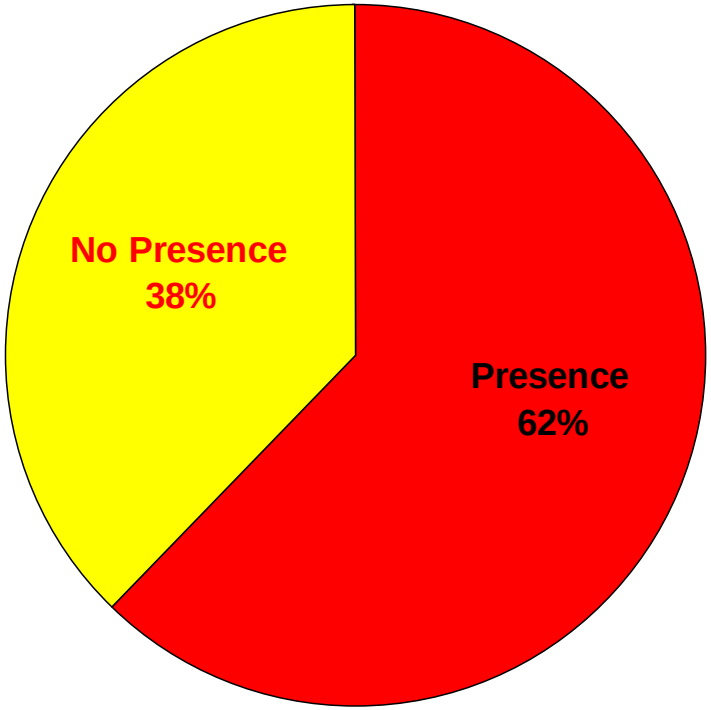
China Is Rapidly Expanding the Number of Markets it Competes In

NUMBER of goods the U.S. imports from China (share of total number of goods imported by U.S.)

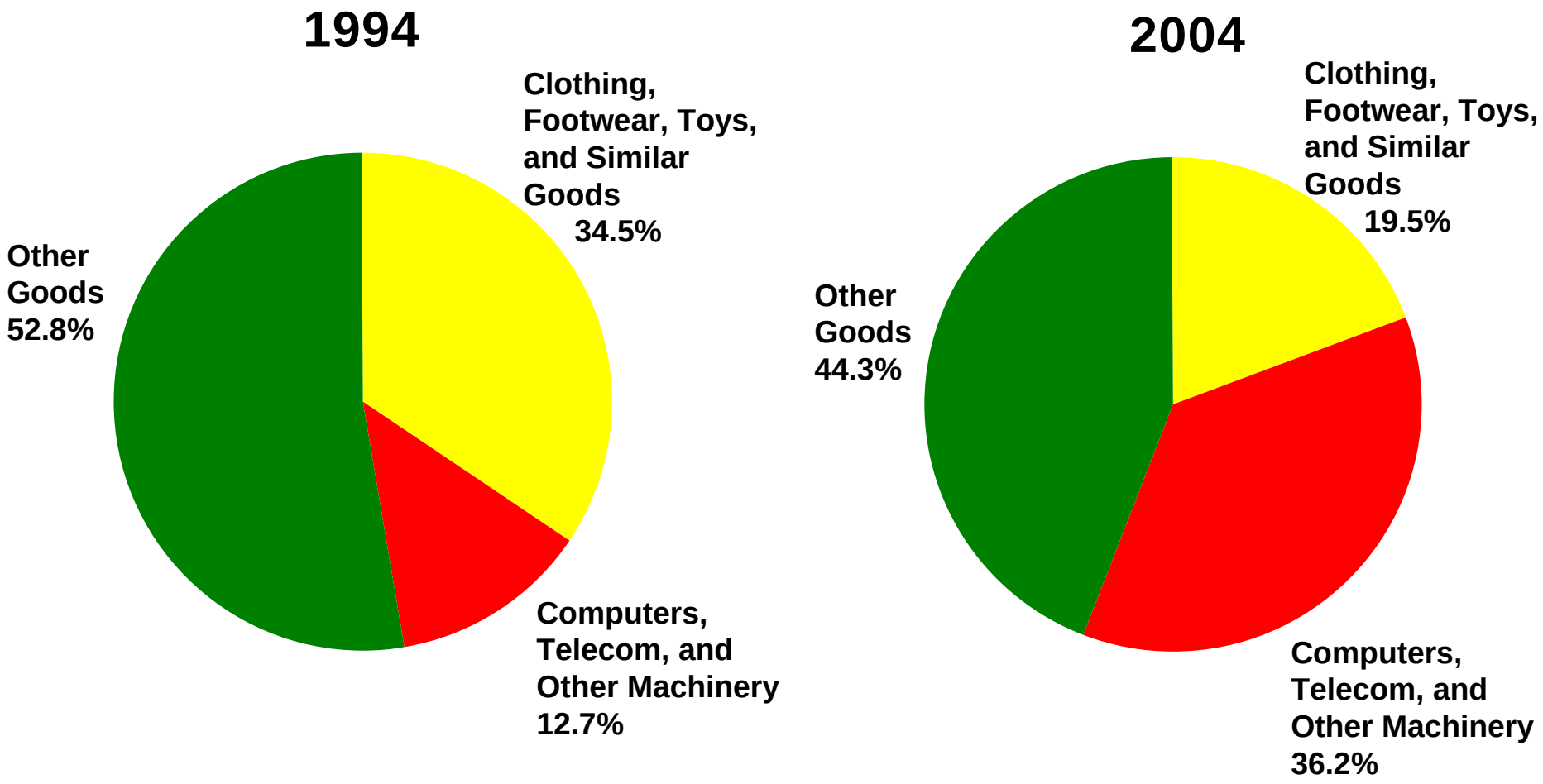
1989 (5,560 out of 13,900)



2001 (10,168 out of 16,400)



China's Exports Shifting from Traditional Goods to Machinery



Source: SourceOECD, SITC, rev. 3

China not Competing with U.S. in Major World Markets in 1992

Top US Exports to World, 1992	% of Exports	Top Chinese Exports to World, 1992	% of Exports
Airplanes	5.6	Petroleum oils, crude oil	3.3
Other motor vehicle parts	3.9	Toys	2.8
Special transactions & commodities	3.3	Jerseys & similar articles	1.9
Motor vehicles	3.3	Footwear - Sneakers	1.6
Parts, accessories of office machines	2.5	Pants, men	1.5
Electronic integrated circuit	2.3	Other maize, unmilled	1.4
Parts of airplanes	2.2	Other radio-broadcast receivers	1.4
Digital processing units	1.3	Bed, table, toilet and kitchen linen	1.3
Parts of the engines & motors	1.2	T-shirts & vests	1.3
Other maize, unmilled	1.1	Dress shirts, for men	1.2
Soya beans	1.0	Other Footwear	1.1

SOURCE: SourceOECD

China Beginning to Compete With U.S. in World Markets in 2004

Top U.S. Exports to World, 2004	% of Exports	Top Chinese Exports to World, 2004	% of Exports
Electronic microcircuits	5.2	Parts, data proc machines	4.1
Other motor vehicle parts	3.8	Computers, etc.	3.9
Motor vehicles	3.1	Input or output units for computers	3.9
Special transactions and commodities not	3.1	Parts, telecom equip	3.1
Airplanes (large)	2.6	TV,radio transmitters, etc.	2.8
Parts,data proc machines	2.3	Sound,video recordng etc	2.7
Parts,nes,aircraft,equip	2.0	Electronic microcircuits	1.9
Parts,jet,gas turbine eng	1.5	Storage units for data processing	1.3
Medicaments, nes	1.3	Liq.crystal devices; lasers	1.2
Parts, telecom equip	1.3	Jerseys, pullovers, cardigans, waistcoats	1.2

SOURCE: UN

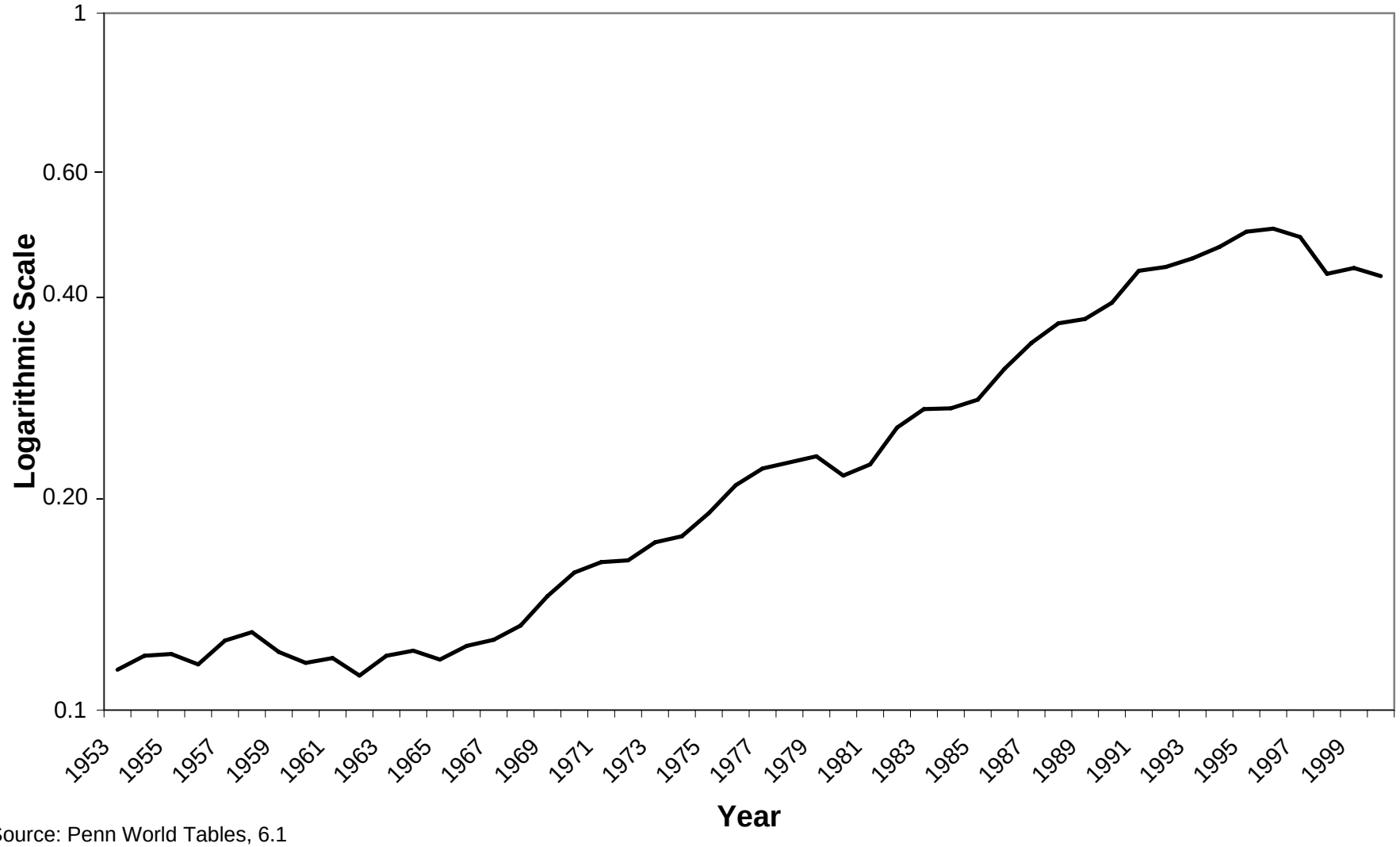
Trade Policy and South Korea's Growth Miracle

Michelle Connolly, Department of Economics, Duke University
Kei-Mu Yi, Research Department, Federal Reserve Bank of Philadelphia

OUTLINE

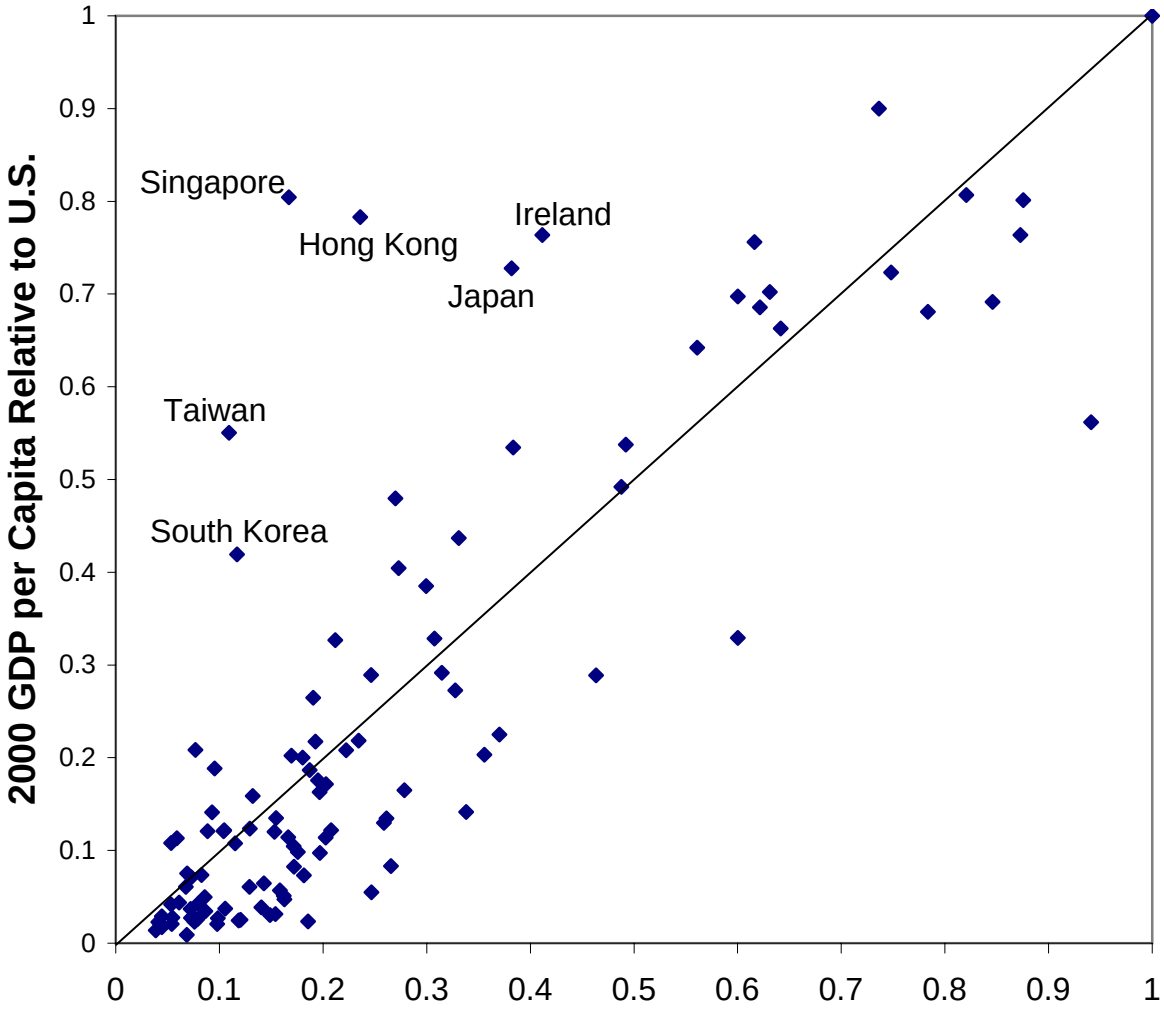
- Motivation
- Sketch three Ricardian frameworks to examine the effects of trade policy on long run growth.
    - 2 good Ricardian trade – AK growth (cf. Jones and Manuelli)
    - Continuum of goods Ricardian trade and AK growth
    - Continuum of goods Ricardian trade, AK growth and vertical specialization
- Ultimate Goal:
    - Careful parameterization and calibration of model; simulate effects of Korea's trade policies

Ratio of South Korea GDP per Capita to US GDP per Capita



Source: Penn World Tables, 6.1

1960 and 2000 per-Capita GDP Relative to U.S.



Source: Penn World Tables, 6.1

South Korea: GDP per Capita Growth

Five-year Centered Moving Average

Source: Penn World Tables, 6.1

Korea: Relative Levels Accounting

(cf. Hall and Jones, 1999)

$$Y = K^{\alpha}(AH)^{1-\alpha}$$

$$H = e^{\phi}L; h \equiv H / L$$

$$Y^{1-\alpha} = \left(\frac{K}{Y}\right)^{\alpha}(AH)^{1-\alpha}$$

$$\left(\frac{Y}{L}\right)^{1-\alpha} = \left(\frac{K}{Y}\right)^{\alpha}(Ah)^{1-\alpha}$$

$$\frac{Y}{L} = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}Ah$$

Productivity Calculation

Ratios of South Korea Values to United States Values

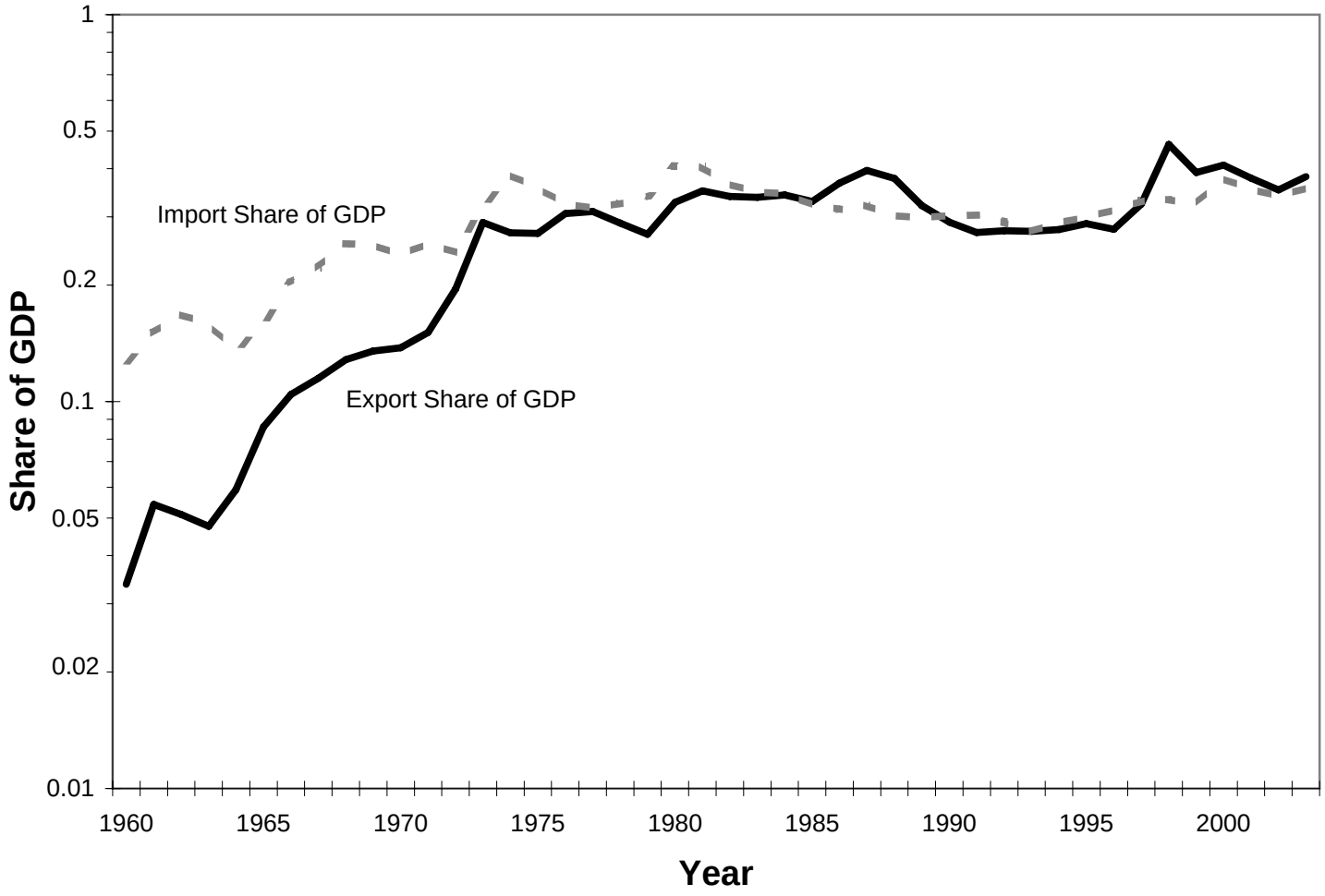
Year	Y/L	Contribution from:		
		$(K/Y)^{\alpha/(1-\alpha)}$	H/L	A
1965	0.147	0.686	0.615	0.349
1999	0.555	1.146	0.835	0.580

Fraction of logarithmic change in Y/L due to K and H: 0.617

Fraction of logarithmic change in Y/L due to A: 0.383

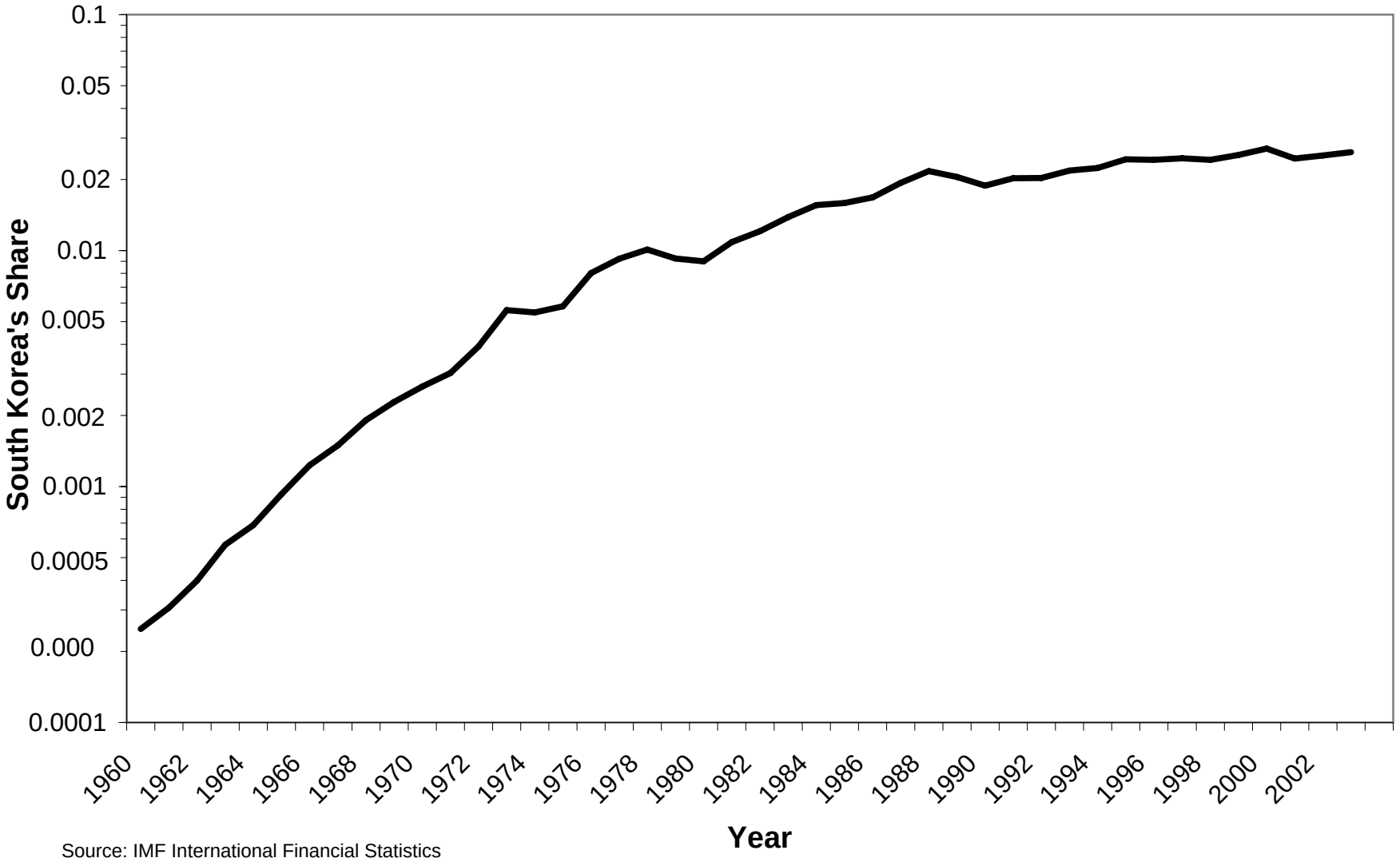
Source: Penn World Tables, 6.1

South Korea's Exports and Imports



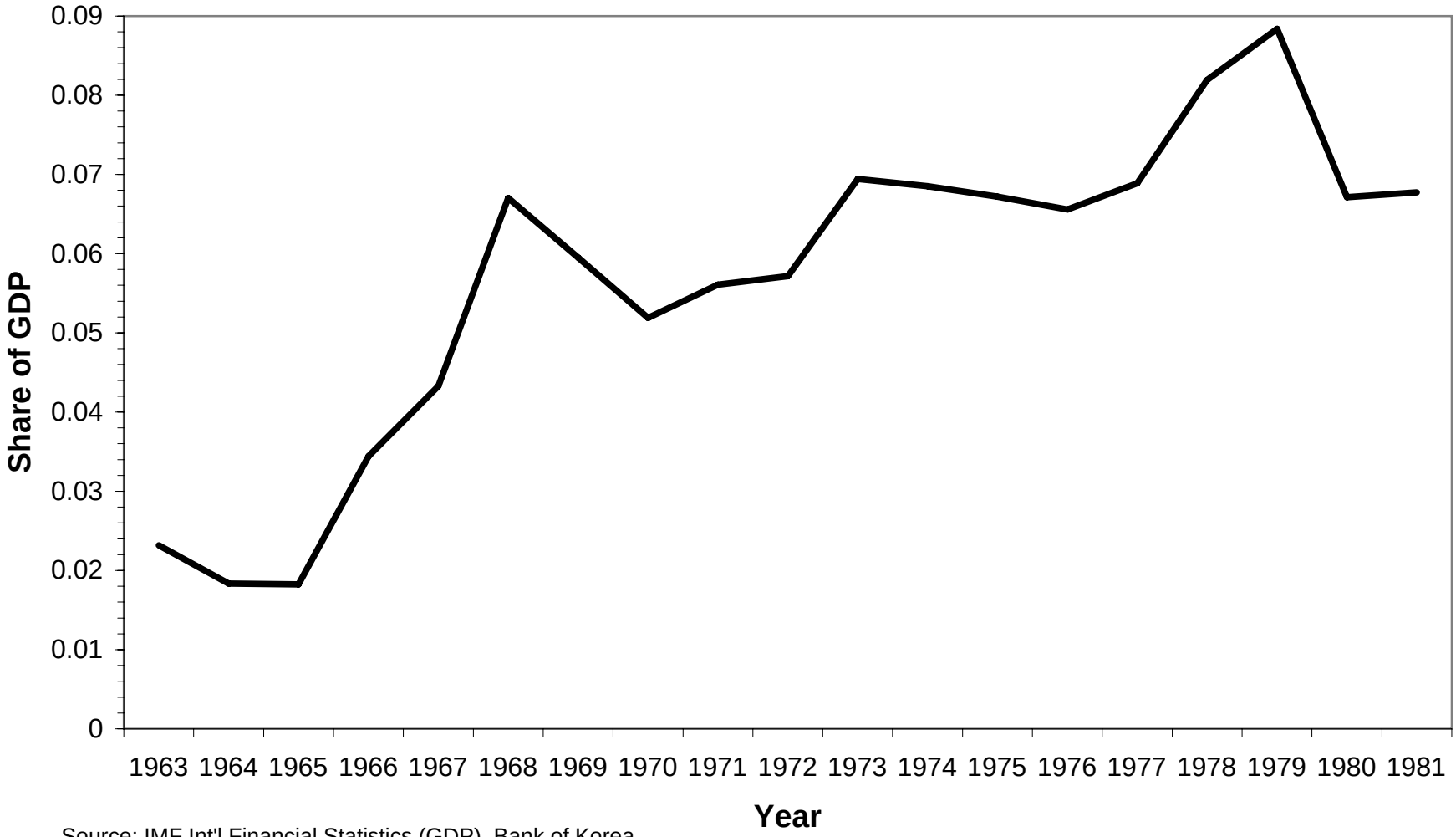
Source: IMF International Financial Statistics

South Korea's Exports as a Share of World Exports

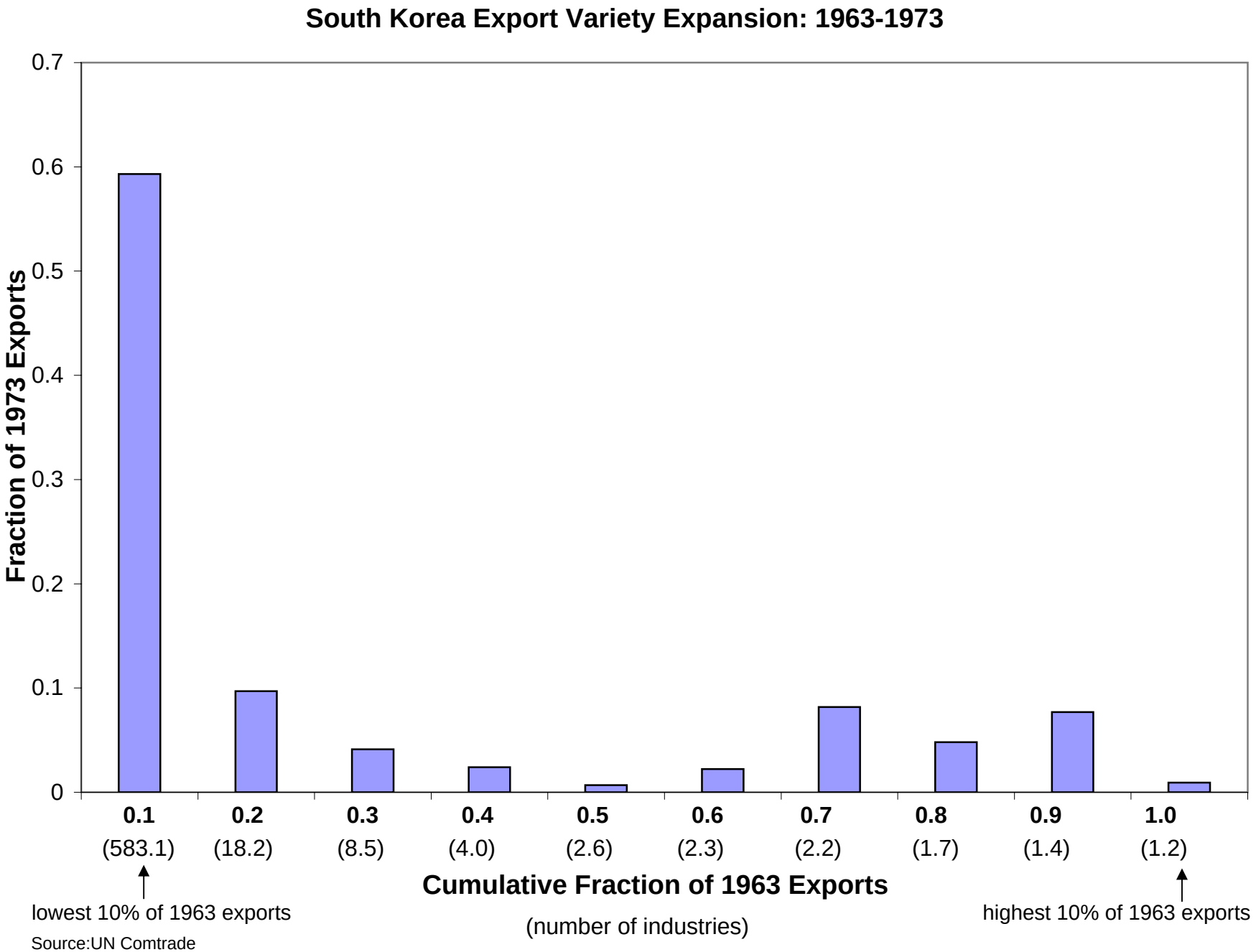


Source: IMF International Financial Statistics

South Korea's Capital Goods Imports



Source: IMF Int'l Financial Statistics (GDP), Bank of Korea
Economic Statistics Yearbooks (Capital Goods Imports)


South Korea Export Variety Expansion: 1963-1973
Fraction of 1973 Exports
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
(583.1)
0.2
(18.2)
0.3
(8.5)
0.4
(4.0)
0.5
(2.6)
0.6
(2.3)
0.7
(2.2)
0.8
(1.7)
0.9
(1.4)
1.0
(1.2)
Cumulative Fraction of 1963 Exports
(number of industries)
lowest 10% of 1963 exports
highest 10% of 1963 exports
Source:UN Comtrade

Hummels-Klenow Extensive and Intensive Margins for Korea

Country Set	Year	Extensive Margin	Intensive Margin
Group A*	1963	0.082	0.012
	1968	0.210	0.016
	1973	0.376	0.026
	1983	0.506	0.035
	1993	0.785	0.030
	1995	0.776	0.032
Group B**	1973	0.349	0.024
	1983	0.488	0.033
	1993	0.761	0.030
	1995	0.761	0.032
Group C***	1995	0.752	0.034

Extensive Margin is the ratio of world exports in industries where Korea has positive exports to total world exports.

Intensive Margin is the ratio of total Korean exports to world exports in industries where Korea has positive exports.

* Set contains 14 countries
(Argentina, Australia, Belgium, Brazil, Canada, France, Hong Kong, Italy, Japan, Netherlands, Norway, Peru, Spain, and United States)

** Set contains 32 countries

*** Set contains 60 countries

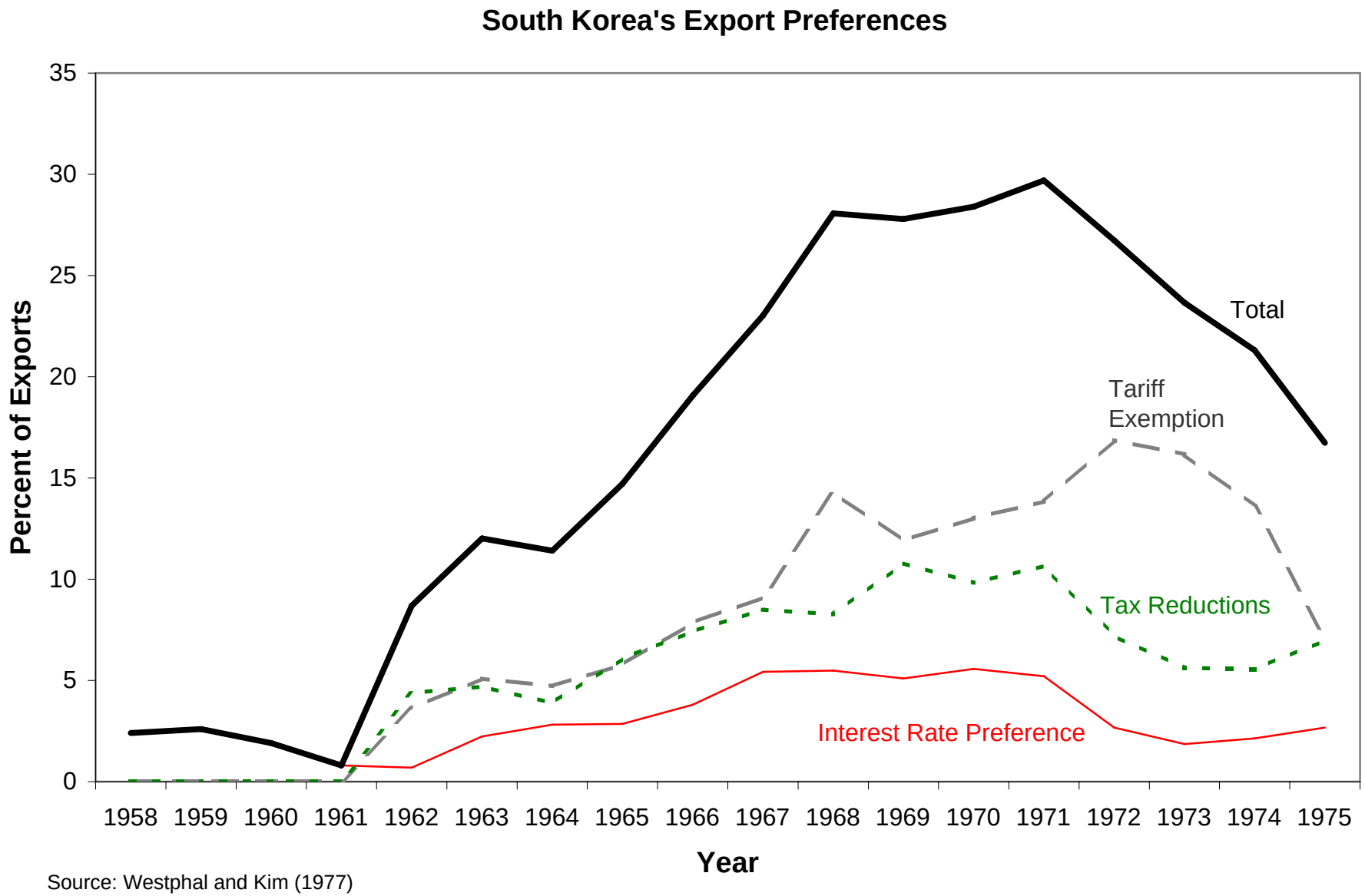
South Korea's Growth Miracle:

1. Per capita GDP as a share of U.S. per capita GDP rose from 0.11 in 1962 to 0.42 in 2000
2. Per capita growth rates rose from 0% in 1960 (5-year MA) to > 6% by the 1970s
3. Export share of GDP rose from 5% in 1962 to about 30% in the 1970s and 40% today
4. Export share of world trade rose from 0.04% in 1962 to 2.5% today
5. Almost 60% of exports in 1973 were in industries that accounted for only 10% of exports in 1973
6. Korea's extensive margin (as defined by Hummels-Klenow) more than quadrupled, and its intensive margin doubled, between 1963 and 1973
7. Imports of capital goods rose from 2.3% in 1963 to 6.9% in 1973
8. Hall-Jones growth accounting suggests that "K" catch-up accounted for 62% of Korea's overall catch-up in per capita GDP between 1965 and 1999.

South Korea's Trade Policy Reforms

- Trade policies among the most important reforms in the early 1960s
- Four most important policies pertaining to trade:
  1. Reduced tariffs on imported inputs and capital goods for **exporters only**
  2. Lower direct and (mainly) indirect taxes for exporters
  3. Lower interest rates on loans taken out by exporters
  4. Exchange rate simplification and devaluation

- By the early 1970's the value of 1, 2, and 3 were equivalent to 25-30% of Korean exports
- Westphal (1990) concludes that net effect of these policies is that Korean exporters faced essentially a free-trade environment



Source: Westphal and Kim (1977)

GOALS

• We want to build, calibrate and simulate a model of Korea's trade and growth experience: How much of Korea's growth miracle was due to its more open trade policies?

• What kind of ingredients would such a model have?

- GDP per capita catch-up by follower
- Small country (Korea) and large country (Rest-of-World)
- Large capital accumulation, especially imported capital
- Technology acquisition via learning and imitation-type activities
- Enormous export expansion: volume, varieties and quality

Model: Preferences and Trade

• Preferences: Utility is constant intertemporal elasticity of substitution (IES) preferences: $\sum_{t=0} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}$

• Iceberg trade costs across countries

• Perfect competition

Model: Steady-State Growth

• Maximizing preferences subject to infinite horizon budget constraint leads to familiar consumption Euler equation: $\frac{C_{H,t+1}}{C_{H,t}} = \left[\beta\left(1-\delta+R_{H,t+1}\right)\right]^{\frac{1}{\gamma}}$

• Steady-State Growth rate depends on rental rate: $\beta(1-\delta+R_H)>0$ is necessary and sufficient for long run growth to occur

• Production specification will yield expression for R_H

  • Note: In neoclassical growth model, R_H decreases as capital is accumulated (because of diminishing returns), until $R_H = \frac{1}{\beta} - (1-\delta)$,

  in which there is no steady-state growth. In "AK" type growth models, the returns to capital are bounded from below at a level above $\frac{1}{\beta} - (1-\delta)$

Model 1: Simple Ricardian-AK Trade and Growth Model (cf. Jones and Manuelli)

- Production set up:
  - y=Ak; 2 goods: consumption good, c, and investment good, I
  - Home country: c + αI = y under autarky; α> 1
  - R_H = A/ α
  - In autarky, if $\beta(1-\delta+A/\alpha)>0$, then there is positive long run growth.
- Now open up to trade:
  - α=1 in foreign country. Foreign country has comparative advantage in investment good. Home country imports it.
  - Home country charges tariff (1+τ)
  - If (1+ τ) < α, then long run growth rates increases: $\beta(1-\delta+A/(1+\tau))>0$
  - Increase in growth rate is directly tied to decrease in τ

Model 2: Ricardian-AK Trade and Growth Model

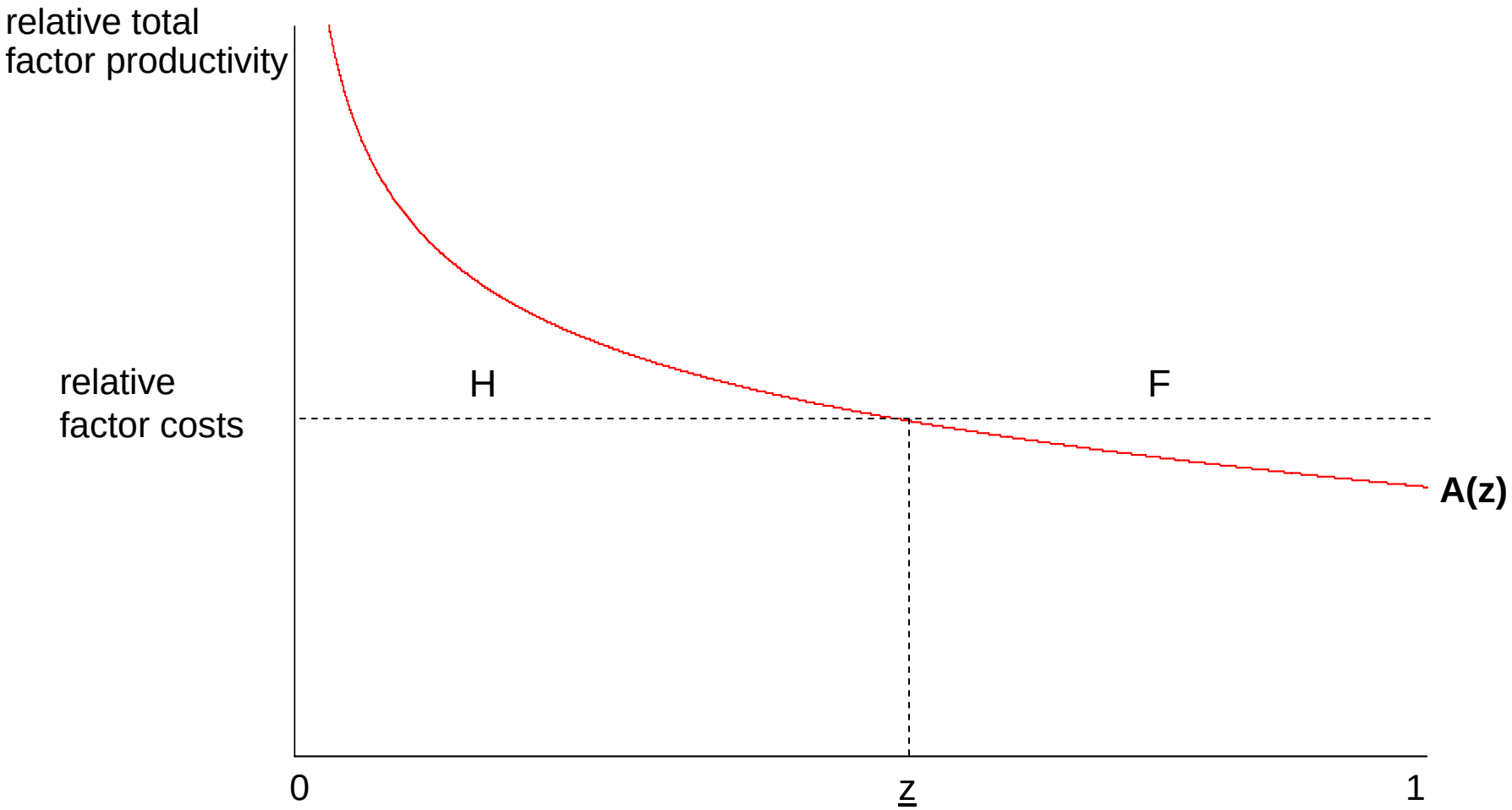
- Ricardian Trade:
  - Continuum of goods (cf. Dornbusch-Fischer-Samuelson, 1977)
  - Two countries: specialization and trade is based on comparatives advantage, which is determined by relative technology differences across goods and countries
  - Single factor of production: capital
- AK Growth:
  - Long run growth is positive
  - Due to specialization and trade, there are transition dynamics in response to technology or policy shocks

Model 2: Production and Technologies

- Each country possesses technologies for producing goods on [0,1] continuum
- A single non-traded final good is produced in two stages
  - Stage 1: $y^i(z) = A^i(z)k^i(z)$ i=H,F
  - Stage 2: $Y^i = \exp\left[\int_0^1 \ln(x^i(z))dz\right]$
- Final good is used for consumption and investment: Y = c + I
- Distribution of A's is Frechet (Eaton and Kortum, 2002)
  - $F(A) = e^{-TA^{-n}}$
  - T governs the "average" productivity
  - n governs the heterogeneity or variance of productivities

Figure 3

Standard DFS Model



Model 2: Steady-State Growth

- Rental rate on capital: $R_H = A_H \left(\frac{\rho}{1+\tau_H} \right)^{1-z_H}$
  - A is average of individual goods' A(z): $A_H = \exp\left[\int_0^{z_H} \ln(A_H(z))dz + \int_{z_H}^{1} \ln(A_F(z))dz \right]$
  - Rho is relative rental rate (home to foreign) R_H / R_F
  - z is cutoff between home and foreign goods

- Assume that Korea's capital stock is below its long run share of world capital.
- Lower tariff rates raise steady-state rental rate and growth rate, but reduce the steady-state relative rental rate.
- On impact lower tariffs raise growth rate; over time z falls, A increases, and rho falls. The net effect is a lower growth rate than the impact effect growth rate, but there is still a higher growth rate than the pre-reform growth rate. Both Korea and the rest-of-the-world will have equal growth rates.
- Under free trade, in balanced growth steady-state, rental rates (in common units) equalized across countries: Rho=1.

Model 3: Ricardian-AK Trade and Growth Model with Vertical Specialization

- Ricardian Trade:
  - Continuum of goods (cf. Dornbusch-Fischer-Samuelson, 1977)
  - Two countries: specialization and trade is based on comparatives advantage, which is determined by relative technology differences across goods and countries
  - Single factor of production: capital
- AK Growth:
  - Long run growth is positive
  - Due to specialization and trade, there are transition dynamics in response to technology or policy shocks
- Vertical Specialization:
  - Single non-traded final good is produced in three stages.
  - First two stages are tradable: Rest-of-world produces first stage
  - Captures a key feature of Korea's trade policy and allows for non-linear and magnified responses to changes in policy

Model 3: Production and Technologies

- Each country possesses technologies for producing goods on [0,1] continuum
- A single non-traded final good is produced in three stages
  - Stage 1: $y_1^F(z) = A_{1,F}(z)k_{1,F}(z)$ (Produced in the rest-of-the-world)
  - Stage 2: $y_2^i(z) = x_1^i(z)^\theta (A_2^i(z)k_2^i(z))^{1-\theta}$
  - Stage 3: $Y^i = \exp\left[\int_0^1 \ln(x_2^i(z))dz\right]$
- Final good is used for consumption and investment
- Distribution of A's is Frechet (Eaton and Kortum, 2002)
  - $F(A) = e^{-TA^{-n}}$
  - T governs the "average" productivity
  - n governs the heterogeneity or variance of productivities

Model 3: Steady-State Growth

- Consumption Euler equation: $\frac{C_{H,t+1}}{C_{H,t}} = \left[\beta\left(1-\delta+R_{H,t+1}\right)\right]^{\frac{1}{\gamma}}$

- Growth rate depends on rental rate $R_H = A_H\left(\frac{\rho}{1+\tau_H}\right)^{1+(\theta-1)z_H}$

  - A is average of individual goods' A(z):

$$A_H = \exp\left[\int_0^{z_H} \ln(A_{1,F}(z)^{\theta} A_{2,H}(z)^{1-\theta})dz + \int_{z_H}^{1} \ln(A_{1,F}(z)^{\theta} A_{2,F}(z)^{1-\theta})dz\right]$$

  - Rho is relative rental rate (home to foreign)
  - θ is the share of stage 1 inputs in stage 2 production
  - z is cutoff between home and foreign goods

- The greater is θ, the greater is the growth impact of changes in tariff rates.

- Intuition on transition dynamics is similar to previous model. When tariffs decline, on impact growth rate increases. Over time z falls, A increases, and rho falls. The net effect is a lower growth rate than the impact effect growth rate, but there is still a higher growth rate than the pre-reform growth rate. Both Korea and the rest-of-the-world will have equal growth rates.

Model 3: Transition Dynamics from Global Tariff Reduction

• Small country benefits more than large country, because small country relies more heavily on imported capital goods

• Rental rate rises on impact: Marginal product of capital is higher so more capital is accumulated. Growth rate rises.

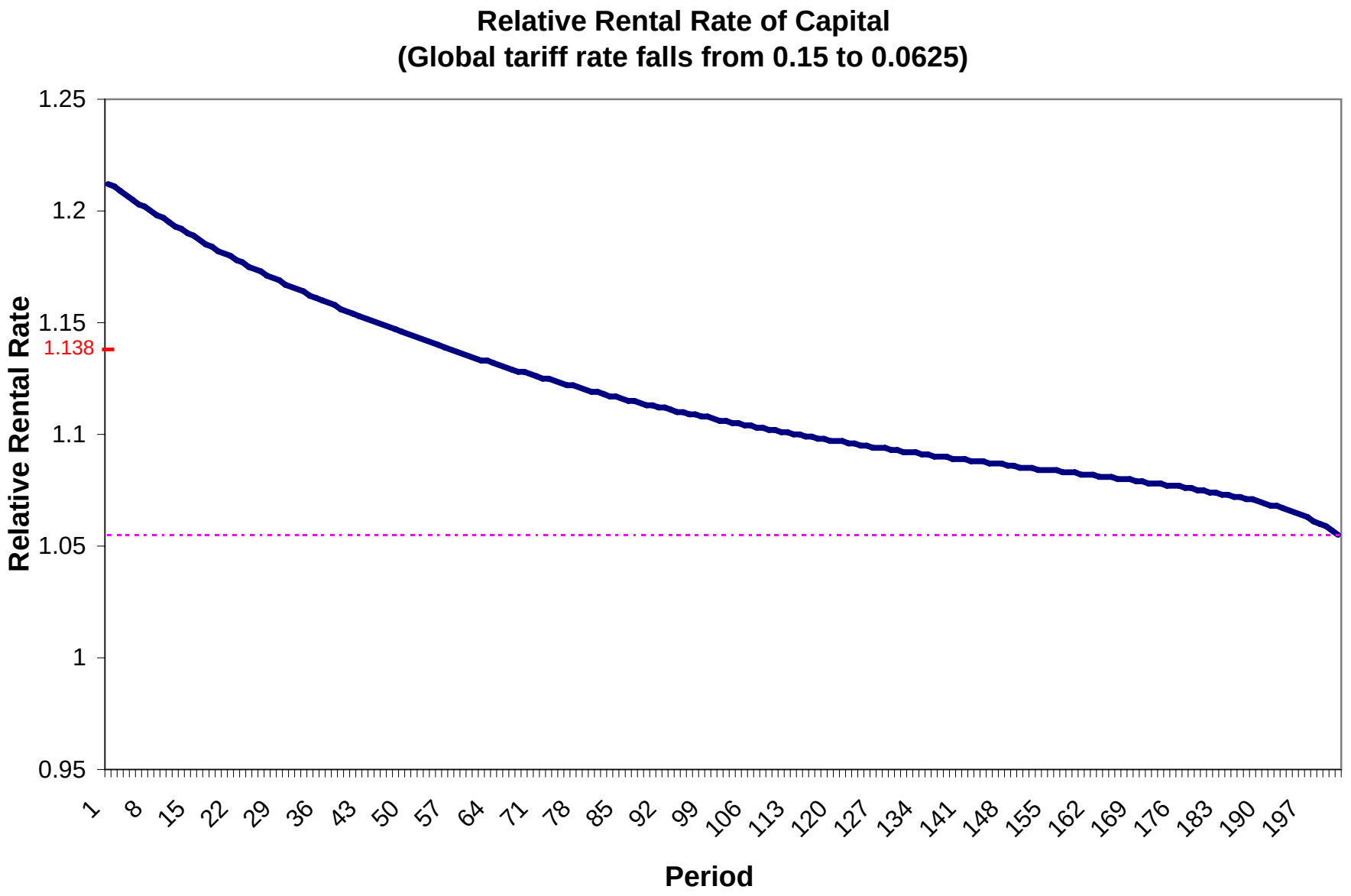
• Additional capital implies more resources available for production, so that Korea will expand the number of varieties it produces. This tends to reduce the terms of trade (and the relative rental rate).

• Next period: The return to capital is lower, so less capital is accumulated and growth rate decreases, but as long as the relative rental rate exceeds its new steady-state value, small country will grow faster than world average.

• In new steady-state growth path, small country is larger relative to world; produces greater fraction of goods. Steady-state rho is lower than before.

• Intuition similar to that in Acemoglu/Ventura (QJE, 2002)

• Effects are magnified in vertical specialization model relative to standard model.


Relative Rental Rate of Capital
(Global tariff rate falls from 0.15 to 0.0625)
Relative Rental Rate
1.25
1.2
1.15
1.138
1.1
1.05
1
0.95
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
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169
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183
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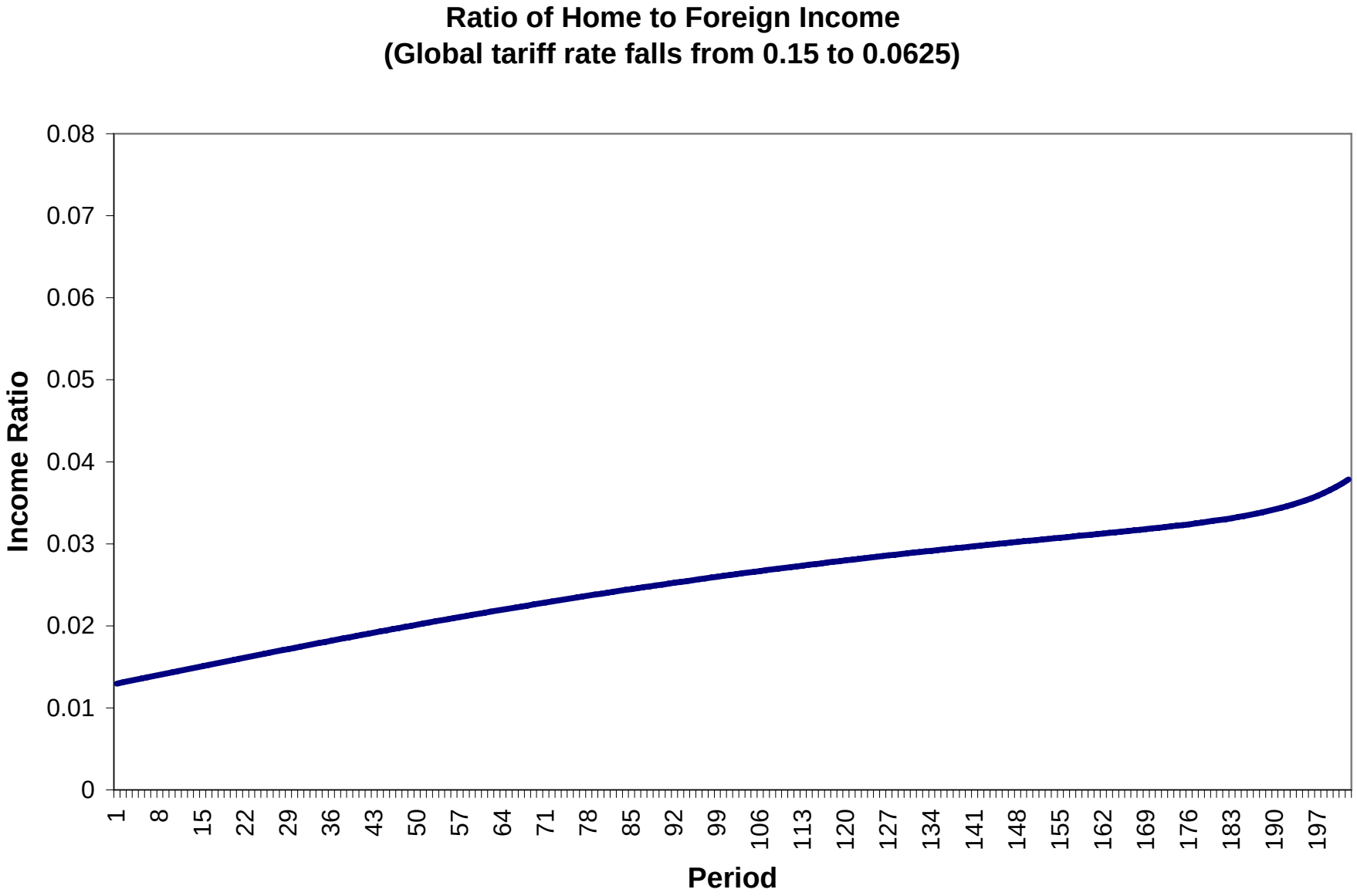
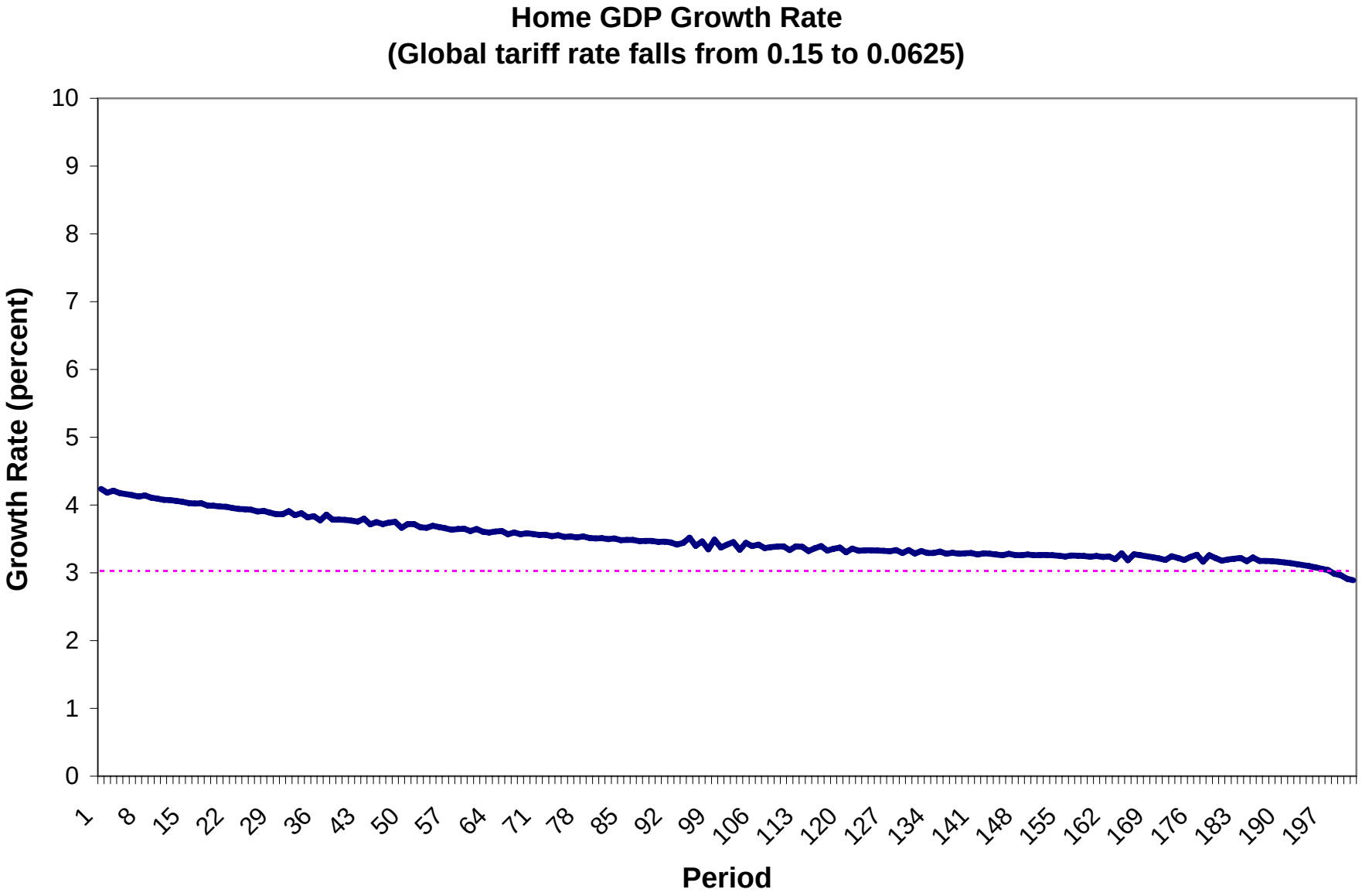
197
Period


Ratio of Home to Foreign Income
(Global tariff rate falls from 0.15 to 0.0625)
Income Ratio
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
169
176
183
190
197
Period


Home GDP Growth Rate
(Global tariff rate falls from 0.15 to 0.0625)
Growth Rate (percent)
10
9
8
7
6
5
4
3
2
1
0
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
169
176
183
190
197
Period

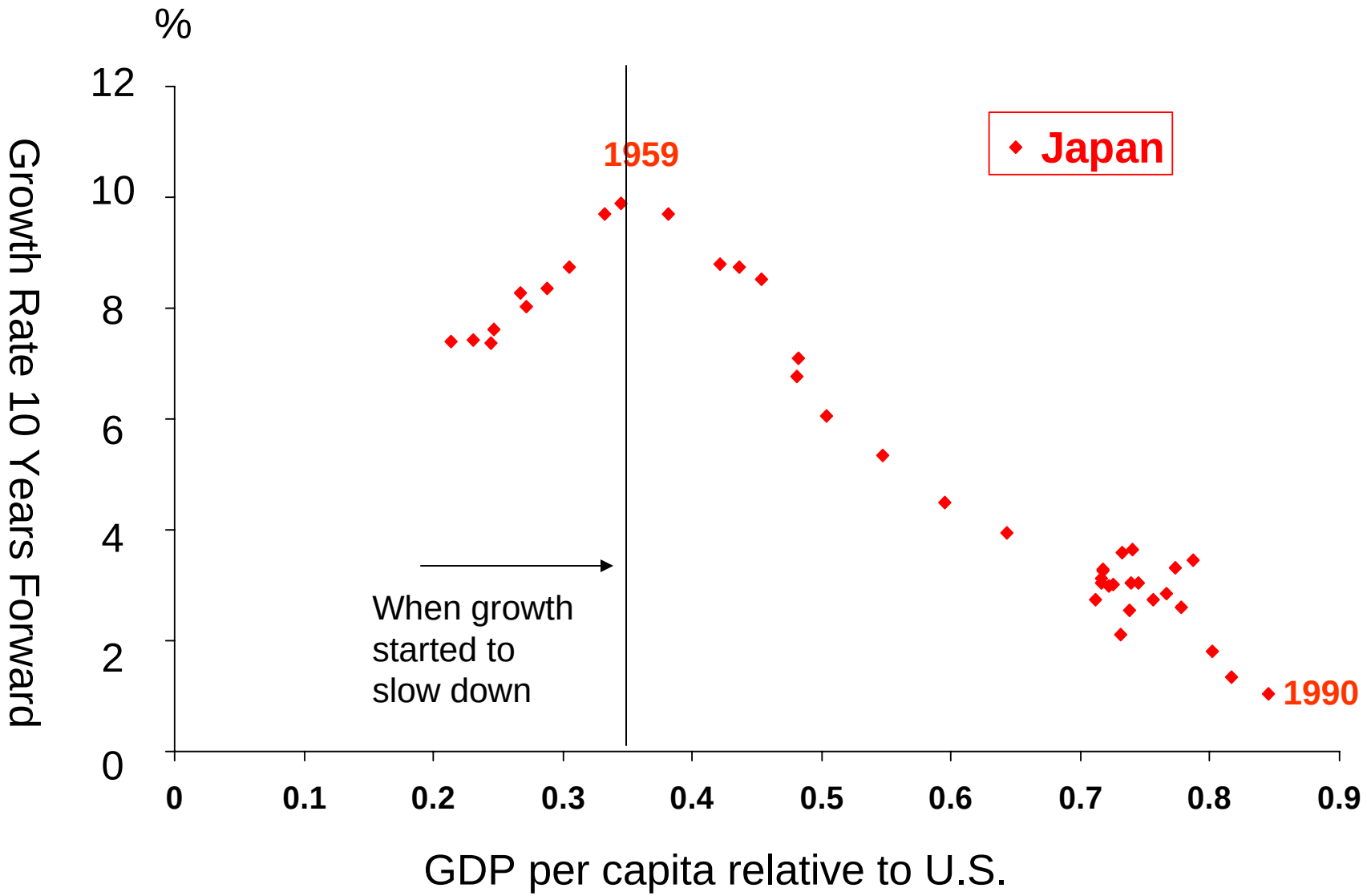
VERTICAL SPECIALIZATION MODEL COMPARED TO STANDARD MODEL

Steady-state home-to-foreign capital ratio

	Tariff Rate				
	0	**0.05**	**0.1**	**0.125**	**0.15**
Standard Model	0.085	0.043	0.021	0.015	0.011
Vertical Specialization Model	0.041	0.010	0.0024	0.0012	0.00061

Note: In vertical model, theta = 0.5; foreign technology is identical in stages 1 and 2. Home technology in stage 2 is same as in standard mod

As Japan caught up, its growth slowed



Further Work

- Model non-traded sectors better
- Allow for production function "switching" as a way to assimilate new technologies
- Some combination of increasing human capital, access to better technologies, and fragmentation seems to be key
- Allow for imports of both intermediate inputs and capital goods
- Careful calibration

- Calibration must match:
    - Trade growth (volume, variety, quality)
    - GDP growth (total, A, K)