Economics 216:
The Macroeconomics of Development

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Lecture 4
The Sources of Economic Growth in Developed and Developing Economies

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Introduction

- Tangible capital accumulation is the most important source of growth in developing economies
- Technical progress is the most important source of economic growth in developed economies
- The controversy over the role of technical progress in postwar East Asian economic growth
  - Kim and Lau (1992, 1994a, 1994b)
  - Paul Krugman (1994)
  - The World Bank (1993)
  - Alwyn Young (1992, 1995)

Empirical Evidence for the Hypothesis of No Technical Progress in East Asian NIEs

- Tsao (1985) and Young (1992) for Singapore
- Kim & Lau (1992, 1994a, 1994b) and Young (1995) for the four East Asian NIEs
- Paul Krugman (1994)
- Kim and Lau (1995) extend the same finding to a model with human capital explicitly distinguished as an additional input of production
- Kim & Lau (1996) extend the same finding to other East Asian economies--China, Indonesia, Malaysia, Philippines, and Thailand
- Senhadji (1999) find the same for East Asian and South Asian economies
- Lau and Park (2003) re-affirm the findings of Kim and Lau above as well as extend the same finding to a model with both human capital and R&D capital explicitly distinguished as additional inputs of production

Empirical Evidence Against the Hypothesis of No Technical Progress

- Young (1992) for Hong Kong
- The World Bank (1993)
- Collins and Bosworth (1997)
- Klenow and Rodriguez-Clare (1997)
- Sarel (1997) for the ASEAN economies
- Easterly and Levine (2001)
- Iwata, Khan and Murao (2002).
- Credibility of such studies undermined by restrictive maintained hypotheses such as the maintained hypothesis of the traditional growth-accounting formula:
  - CONSTANT RETURNS TO SCALE
  - NEUTRALITY OF TECHNICAL PROGRESS &
  - INSTANTANEOUS COMPETITIVE PROFIT MAXIMIZATION

  and
  - IDENTICAL COBB-DOUGLAS PRODUCTION FUNCTIONS

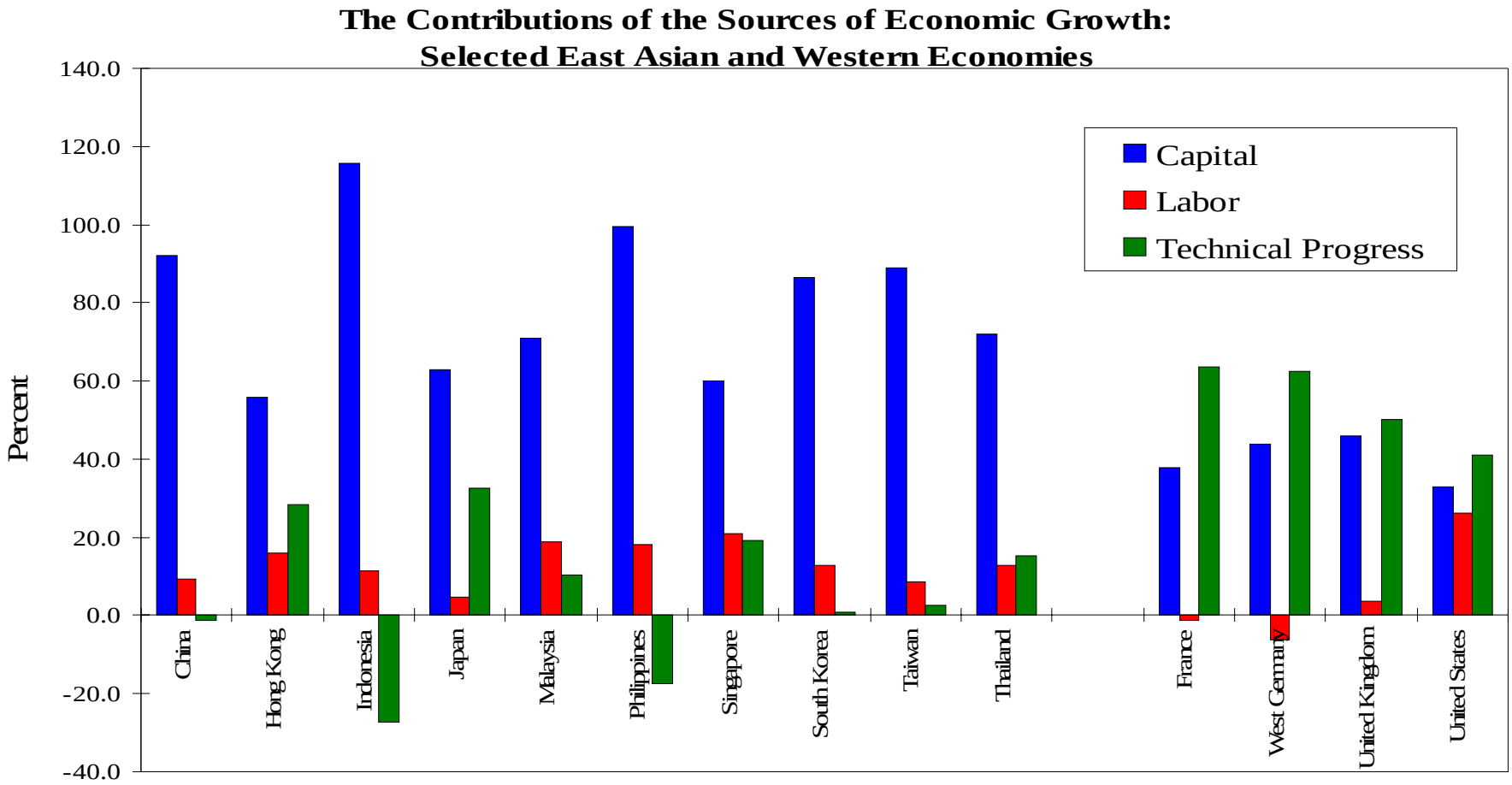
  (World Bank 1993 and Easterly and Levine (2001)

The Sources of Economic Growth: Selected East Asian Economies and G-5 Countries

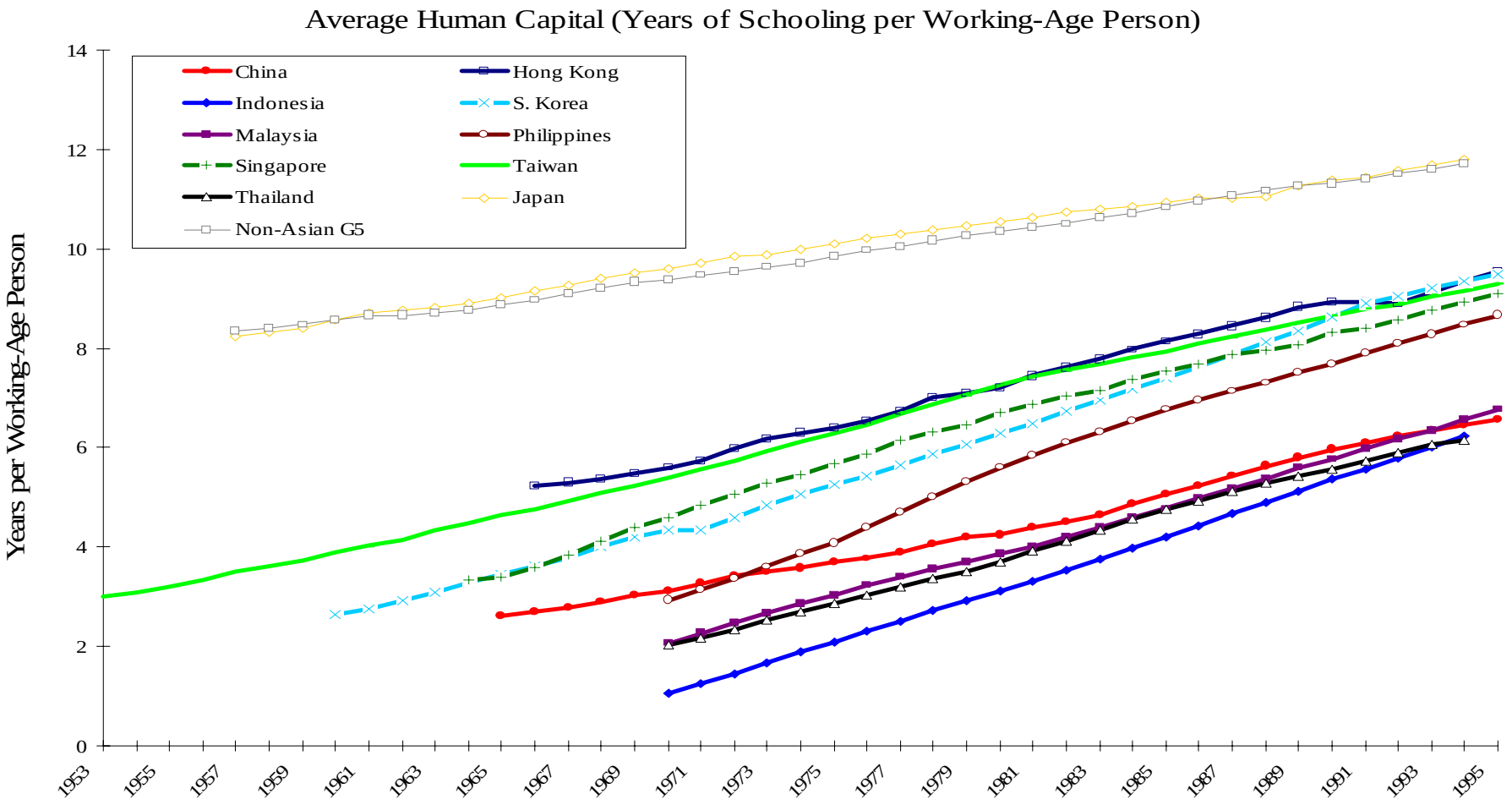
The Contributions of the Sources of Growth (percent)

	Capital	Labor	Technical Progress
East Asian Economies			
China	92.2	9.2	-1.4
Hong Kong	55.8	16.0	28.2
Indonesia	115.7	11.5	-27.2
Japan	62.9	4.7	32.4
Malaysia	70.9	18.7	10.4
Philippines	99.5	18.0	-17.5
Singapore	60.0	20.9	19.1
South Korea	86.3	12.7	1.0
Taiwan	88.9	8.6	2.5
Thailand	71.9	12.7	15.4
Western Industrialized Economies			
France	37.8	-1.3	63.5
West Germany	43.7	-6.3	62.6
United Kingdom	46.0	3.7	50.3
United States	32.9	26.2	40.9

The Sources of Economic Growth: Selected East Asian and Western Economies



Human Capital



Sources of Economic Growth with Explicit Inclusion of Human Capital

Table 2.3: Relative Contributions of the Sources of Economic Growth (percent)						
			Intangible Capital			
	Tangible Capital	Labor	Human Capital	R&D Capital	Technical Progress	Total
Hong Kong	66	22	11	NA	0	11
Singapore	63	25	13	NA	0	13
S. Korea	67	19	14	NA	0	14
Taiwan	75	14	11	NA	0	11
Japan	48	6	3	NA	43	46
Non-Asian G-5	32	7	5	NA	57	62

Simultaneous Capital- and Human Capital-Augmenting Technical Progress

$$Y = A_0(t)\, F(A_K(t)K, A_H(t)H, A_L(t)L)$$

$$= A_0 F(A_K(t)K, A_H H, A_L L)$$

$$= A_0 F(A_K K, A_H(t)H, A_L L)$$

$$= A_0 F(A(t)K^{\alpha}H^{\beta}, A_L L)$$

Sources of Economic Growth with Explicit Inclusion of Human and R&D Capital

Table 2.4: Relative Contributions of the Sources of Economic Growth (percent)						
			Intangible Capital			
	Tangible Capital	Labor	Human Capital	R&D Capital	Technical Progress	Total
Korea	62	18	5	15	0	20
Singapore	56	22	5	16	0	21
Taiwan	65	15	4	16	0	20
Japan	37	5	1	8	49	58
Non-Asian G-7	40	4	4	10	43	56

Why is There No Measured Technical Progress in East Asian NIEs? (1)

- (1) Low level of investment in intangible capital (human capital, R&D capital, knowledge capital, goodwill, software, brand names, business methods and models, and other forms of intangible capital)
  - The effects of technical progress in these production function studies are essentially captured by the estimated parameters of the time trend, which is supposed to reflect the influence of the changes in the omitted or unmeasured inputs, such as human capital, R&D capital, R&D capital, knowledge capital, land or more generally the natural endowment of resources, and other intangible "investments" such as software and market development.
  - However, since the developing East Asian economies, until very recently, have invested relatively little in intangible capital (e.g., R&D, especially in basic research), such omitted or unmeasured variables are actually unlikely to be important in them. Thus the indigenously generated improvements in technology have been quite scarce in developing East Asian economies other than Japan.

Why is There No Measured Technical Progress in East Asian NIEs? (1)

- By contrast, the industrialized economies invest a significant percentage of their GDP in R&D and even greater amounts in innovation and other productivity-enhancing activities.
- Thus, it should not be surprising that technical progress, or the "residual", is much larger in the industrialized economies than in the developing East Asian economies.
- Moreover, utilization of other countries' intangible capital is not costless--royalties, license fees, maintenance and service contracts, cross-licensing, full pricing of capital goods
- Complementary indigenous investment, or strategically competitive investment, is frequently required, e.g., the new rice varieties of the Green Revolution; the compressor technology

Why is There No Measured Technical Progress in East Asian NIEs? (2)

- (2) The distribution of "Innovation Rents" (quite properly) favors the innovators and investors
  - The industries in the developing East Asian economies typically employ mature technologies with limited innovation possibilities but the capital goods and technology for which, mostly imported, have been fully priced (i.e., the acquisition as well as royalty costs fully reflect the possible efficiency gains and the amortization of R&D and other developmental costs) in the international market, so that there may be little or no net increase in value added, over and above the normal returns to the factor inputs. In other words, the "innovation rents" have been largely captured by the inventors, manufacturers and distributors of the new equipment or intermediate inputs in the industrialized economies in markets that are only very imperfectly competitive.

Why is There No Measured Technical Progress in East Asian NIEs? (2)

- The "rents" can also take the form of royalties and licensing fees paid to the foreign technology licensors by the developing East Asian economies, or through transfer pricing by foreign direct investors, reducing correspondingly the domestic part of the real value-added.
- Monopolistic pricing of capital equipment, technology licenses and critical components (e.g., systems integration capability for aircraft manufacturers; plastic lens for cameras), and the control over marketing through the establishment of brand names limit the value added by manufacturers/assemblers in developing East Asian economies, e.g., notebook computers
- Monopsonistic pricing for OEM manufacturers--the benefits of learning-by-doing on the part of the OEM manufacturers accrue mostly to the owners of brand names, designs, and marketing organizations
- Consequently, even if a new technology were adopted, its effect might not be reflected in the form of a higher real domestic value-added, holding measured factor inputs constant. (The value-addeds in packaging potato chips and semi-conductor chips are almost the same; similarly the value-addeds in the assembly of transistor radios and notebook computers are not that different.)

Why is There No Measured Technical Progress in East Asian NIEs? (3)

- (3) Problems of Measurement of Capital
  - Fixed investment in equipment in industrialized economies are typically measured, at factor costs, net of the intangible inputs required, whereas fixed investment in equipment in developing economies, being mostly imported from developing economies, are measured inclusive of intangible inputs, returns to intellectual capital, monopoly rents, turnkey installation costs; warranty costs and contract maintenance costs.
    - E.g., the fixed investment in equipment of the same semiconductor fabrication plant may well be higher in a developing economy as compared to an industrialized economy
    - A simple way to understand this point is that capital equipment in industrialized economies may be sold unbundled with the "soft" costs (including software), whereas capital equipment in developing economies are typically sold bundled with the "soft" costs

Why is There No Measured Technical Progress in East Asian NIEs? (4)

- (4) Aggregation
  - It is possible, in fact likely, that there may have been positive technical progress in certain efficient (tradable) sectors and industries in the developing East Asian economies.
  - However, this may be largely offset by rising inefficiency in certain other industries, especially those in the nontradable sectors.
  - The economy as a whole may exhibit little or no measured technical progress.
  - Rising inefficiency can persist only in protected markets under monopolistic or oligopolistic conditions. Thus, technical progress at the microeconomic or industrial level may be nullified by the inefficiency caused by the lack of competition in certain sectors in the domestic market.

Why is There No Measured Technical Progress in East Asian NIEs? (5)

- (5) Economies of Scale
  - There are significant measured economies of scale, in all inputs taken together, for the developing East Asian economies. For economies in which both output and inputs have been growing, economies of scale and technical progress provide alternative explanations for the ability of producing more than doubled the output by merely doubling the inputs.
  - What we have found is that, as far as the developing East Asian economies are concerned, it is economies of scale, rather than technical progress, that have helped to contribute to the outstanding economic performance.

Why is There No Measured Technical Progress in East Asian NIEs? (6)

- (6) Omission of the value of the quality of life
  - It is also possible that in some East Asian economies, such as Singapore, some public infrastructural investments have been made for the purpose of improving the quality of life, e.g., cleaner air and water, less traffic congestion, etc., rather than increasing measured real GNP directly. Since these non-pecuniary benefits are not reflected in the measurement of the output (real GNP) but are included in the measurement of inputs (tangible capital), it may appear, from considering the growth of measured economic output alone, that tangible capital has not been employed efficiently, and that the efficiency of its use has not improved over time.

The Non-Uniqueness of the Postwar East Asian Experience

- Abramovitz and David (1973): U. S. economic growth in the 19th Century can be largely attributed to the growth of inputs
- Tostlebee (1956): The growth in U.S. agriculture in the 19th Century can be attributed to the growth of inputs, with a negative rate of growth of total factor productivity
- Hayami and Ogasawara (1999): Japanese economic growth between the Meiji Restoration and the World War I can be largely attributed to the growth of inputs, principally capital
- Godo and Hayami (1999): Confirm the lack of technical progress in prewar Japan (with human capital included)

The Sources of Economic Growth--Developing Economies

- Different types of measured inputs play different roles at different stages of economic growth
- Tangible capital accumulation is the most important source of growth in the early stage of economic development
- But simply accumulating tangible capital is not enough--it must also be efficiently allocated
- Efficient tangible capital accumulation is the major accomplishment of the East Asian NIEs in the postwar period
  - Market-directed allocation of new investment, aided by export orientation, promotes efficiency
  - Private enterprises have the incentives for prompt self-correction
  - Human capital accumulation also contributes to the efficiency of investment
- Intangible capital accumulation becomes important only after a certain level of tangible capital per worker is achieved but has begun to be important for some East Asian NIEs such as South Korea and Taiwan

The Sources of Economic Growth--Industrialized Countries

- The most important source of economic growth for industrialized countries is technical progress, accounting for more than half of the growth of output
- Tangible capital is the next important source of economic growth, accounting for almost a third
- Technical progress reflects the effects of intangible capital--R&D capital, knowledge capital, goodwill, etc.
- The United States is a leader in human capital and R&D capital

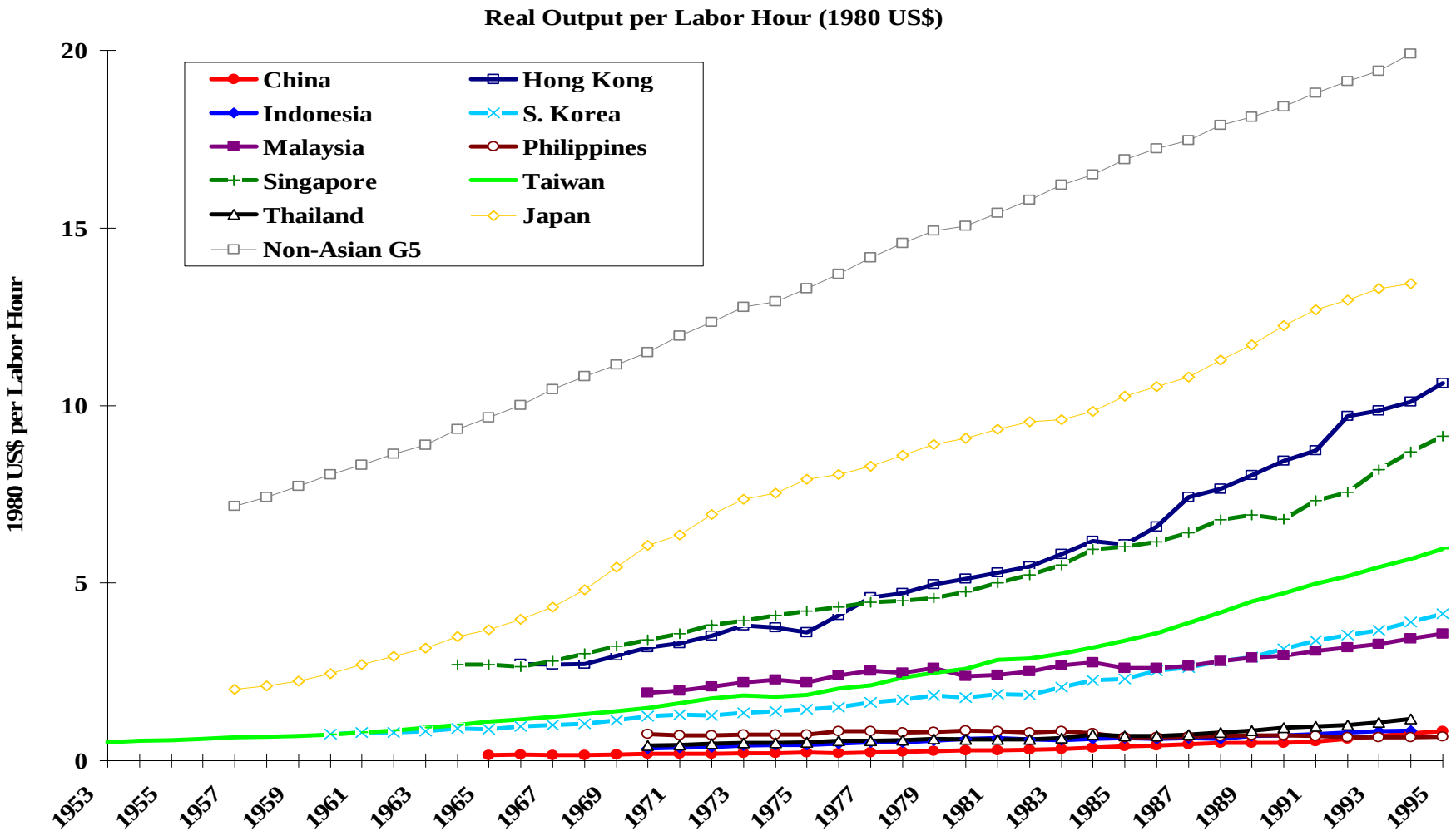
Rates of Growth of Inputs & Outputs of the East Asian Developing & the G-7 Countries

Table 1.1: Average Annual Rates of Growth of Real Output and Inputs (Entire Sample Period), percent

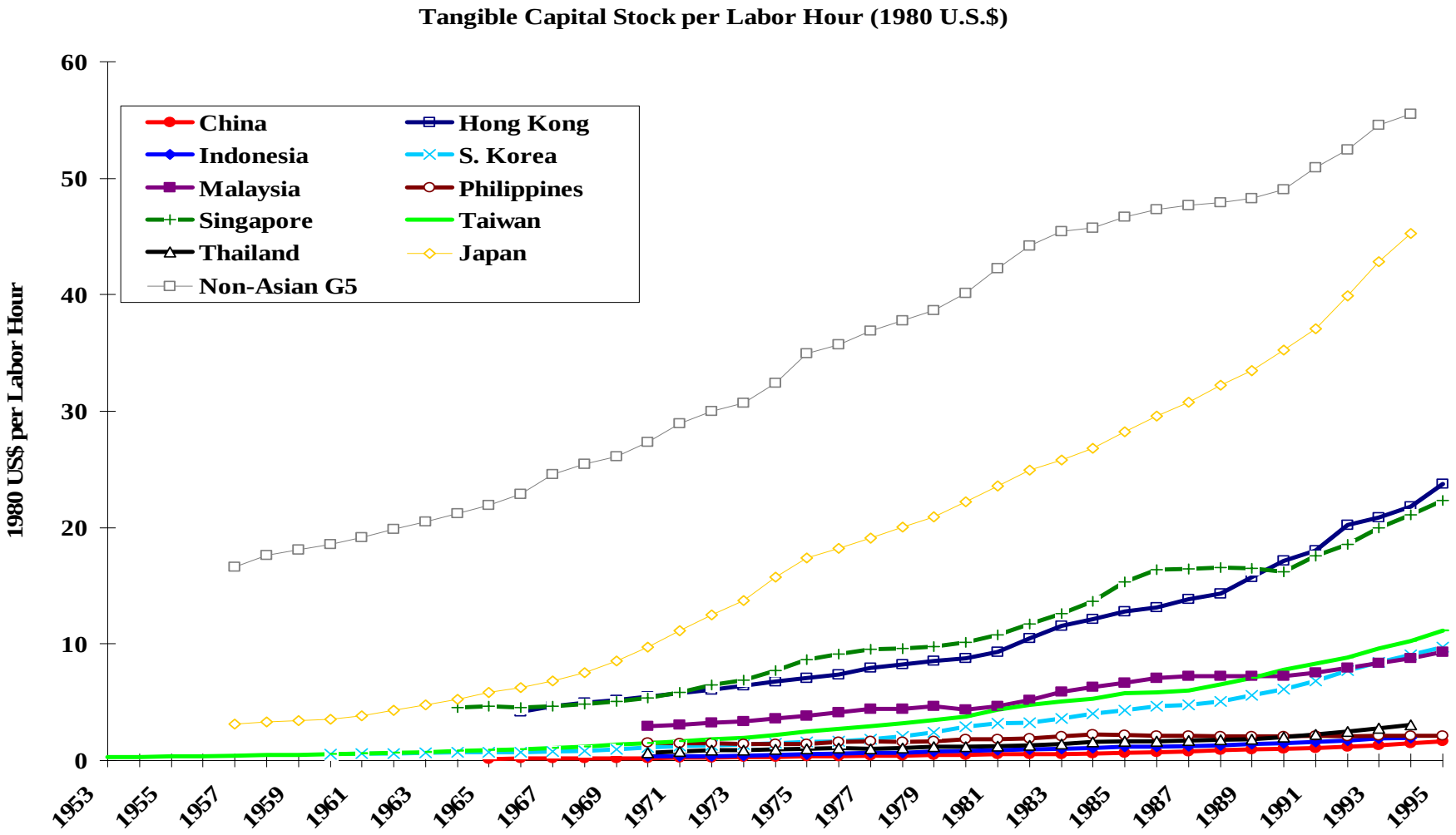
	Sample Period	Output (Real GDP)	Tangible Capital Stock	Utilized Tangible Capital	Employment	Total Labor Hours	Average Years of Education of the Working-Age Population[1]	Total Years of Education of the Working-Age Population[1]	Average Share of Labor Earnings to GDP
Hong Kong	**66-95**	**7.36**	**8.79**	**8.79**	**2.56**	**2.44**	**2.09**	**4.80**	**0.51**
South Korea	**60-95**	**8.49**	**12.28**	**12.28**	**3.06**	**3.35**	**3.72**	**6.31**	**0.37**
Singapore	**64-95**	**8.88**	**10.23**	**10.23**	**4.29**	**4.70**	**3.28**	**5.92**	**0.38**
Taiwan	**53-95**	**8.45**	**11.76**	**11.76**	**2.69**	**2.33**	**2.72**	**5.40**	**0.44**
Indonesia	**70-94**	**6.68**	**10.73**	**10.88**	**2.72**	**2.72**	**7.70**	**10.34**	**0.31**
Malaysia	**70-95**	**7.32**	**9.65**	**9.65**	**4.15**	**4.68**	**4.88**	**8.02**	**0.34**
Philippines	**70-95**	**3.53**	**5.32**	**5.40**	**3.37**	**3.94**	**4.46**	**7.41**	**0.33**
Thailand	**70-94**	**7.74**	**9.69**	**9.68**	**2.74**	**2.93**	**4.75**	**8.00**	**0.25**
China	**65-95**	**8.30**	**11.60**	**11.63**	**2.55**	**2.55**	**3.12**	**5.99**	**0.54**
Japan	**57-94**	**5.88**	**8.12**	**7.98**	**1.12**	**0.56**	**0.98**	**2.15**	**0.62**
France	**57-94**	**3.33**	**3.93**	**3.88**	**0.40**	**-0.24**	**1.11**	**1.95**	**0.64**
West Germany	**57-94**	**3.25**	**3.25**	**3.09**	**0.08**	**-0.29**	**1.00**	**1.55**	**0.66**
United Kingdom	**57-94**	**2.41**	**3.90**	**3.81**	**0.23**	**-0.11**	**0.83**	**1.14**	**0.65**
United States	**49-94**	**3.13**	**3.03**	**3.30**	**1.71**	**1.31**	**0.81**	**2.06**	**0.66**

Note: 1. Working-age population is defined as the number of persons in the population aged between 15 and 64, inclusive.

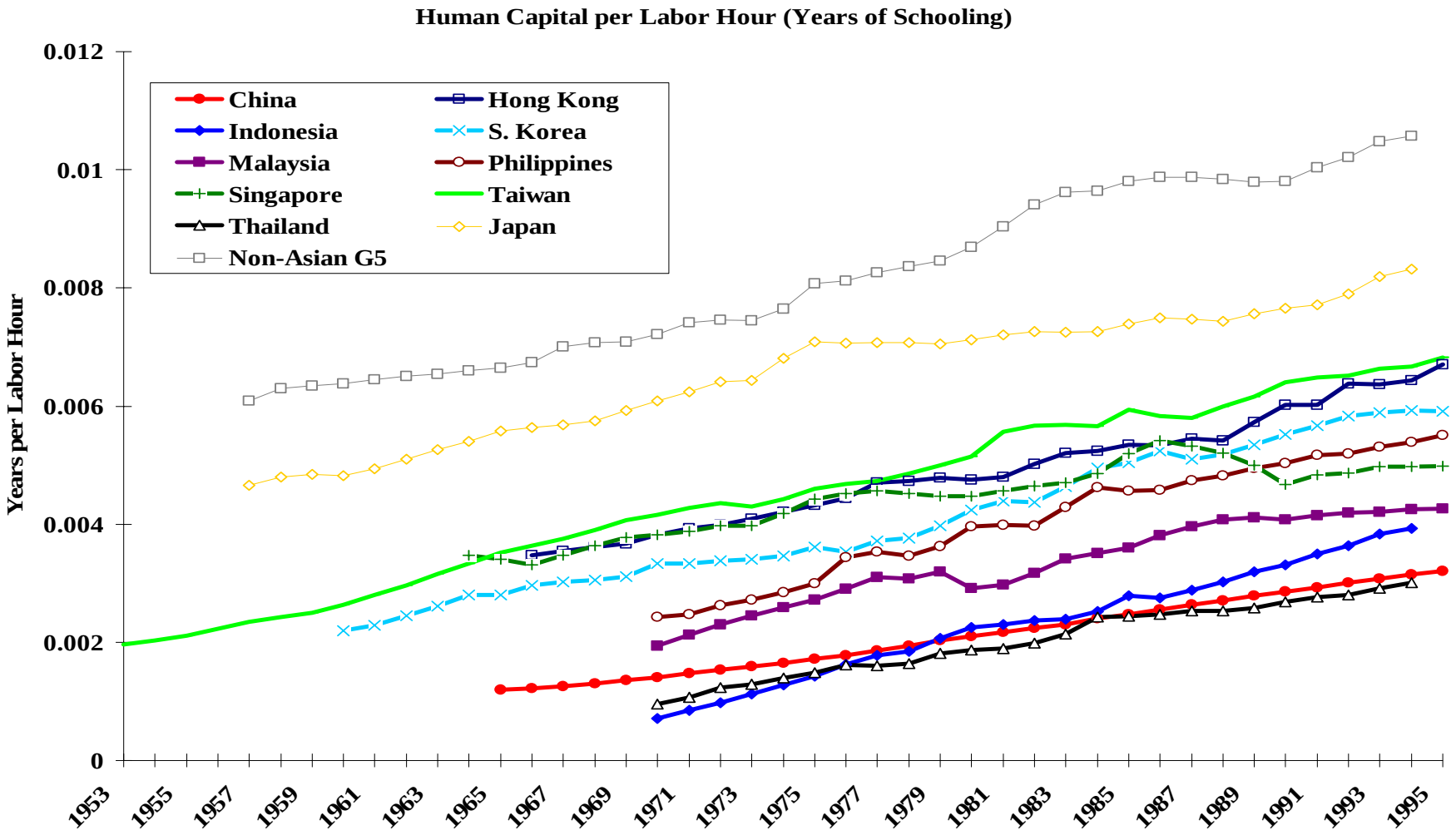
Real Output per Labor Hour (1980 US$)



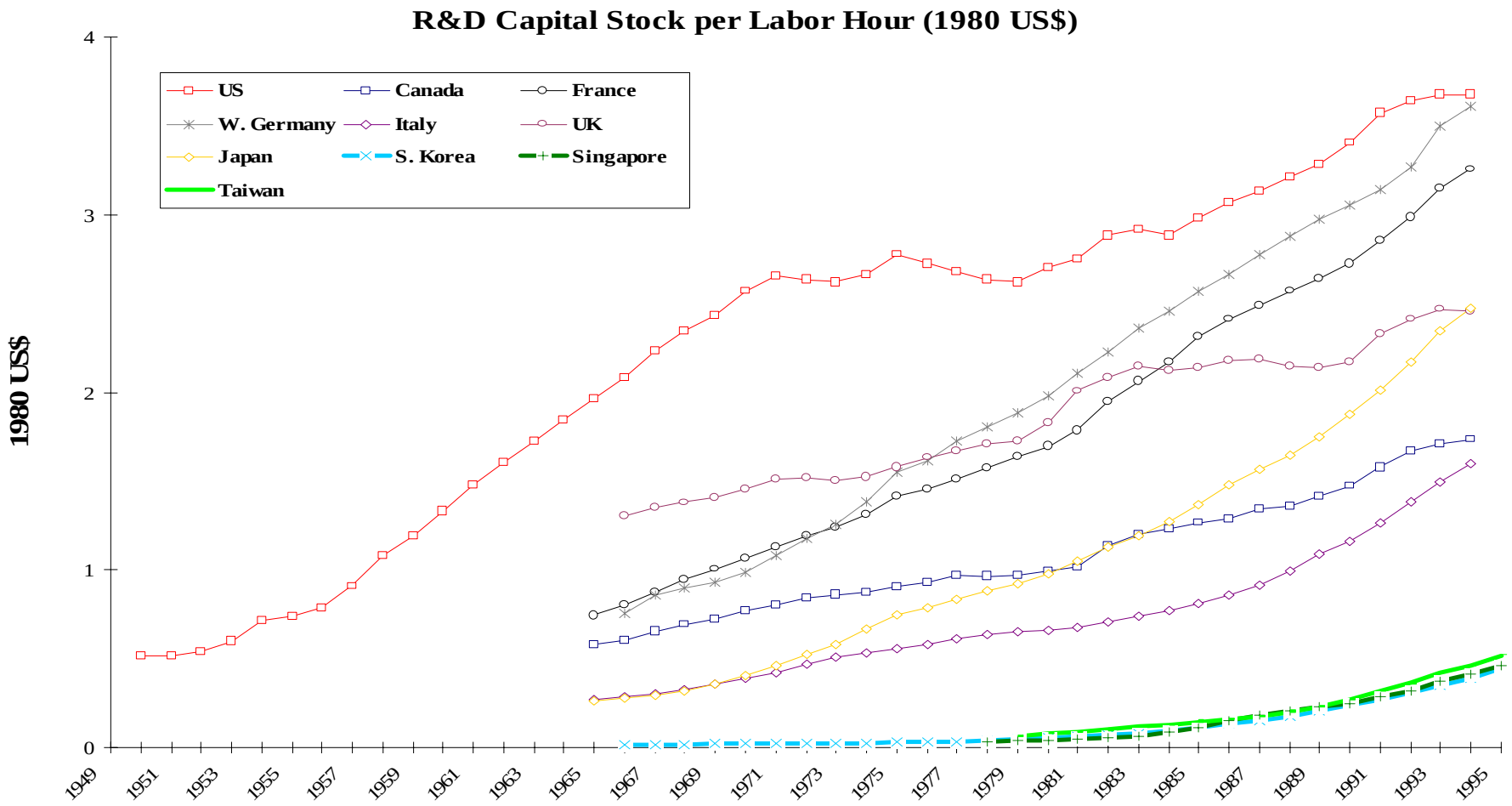
Tangible Capital Stock per Labor Hour (1980 US$): Selected Economies



Human Capital per Labor Hour (Years of Schooling): Selected Economies



R&D Capital Stock per Unit Labor



The Hypothesis of No Technical Progress: Selected Economies—Augmented Sample

Table 5.2: p-Values for Tests of the Hypothesis of No Technical Progress (Two-Input Model)		
	Sample	
	Full sample for 4 NIEs and G-5	Full Sample for 4 NIEs, 4 ASEAN, China and G-5
	$c_{iK}=0$	$c_{iK}=0$
4 NIEs	0.06243	0.01907
4 ASEAN + China	N.A.	0.21692
9 Developing Economies	N.A.	0.07782
G-5	0.00000	0.00000
All Economies	0.00000	0.00000

The Sources of Economic Growth: Selected East Asian Developing and G-5 Economies

Table 5.4: Growth Accounts: Contributions of the Sources of Growth
(Two-Input Model)

(1) Full Sample : 4 NIEs and G-5

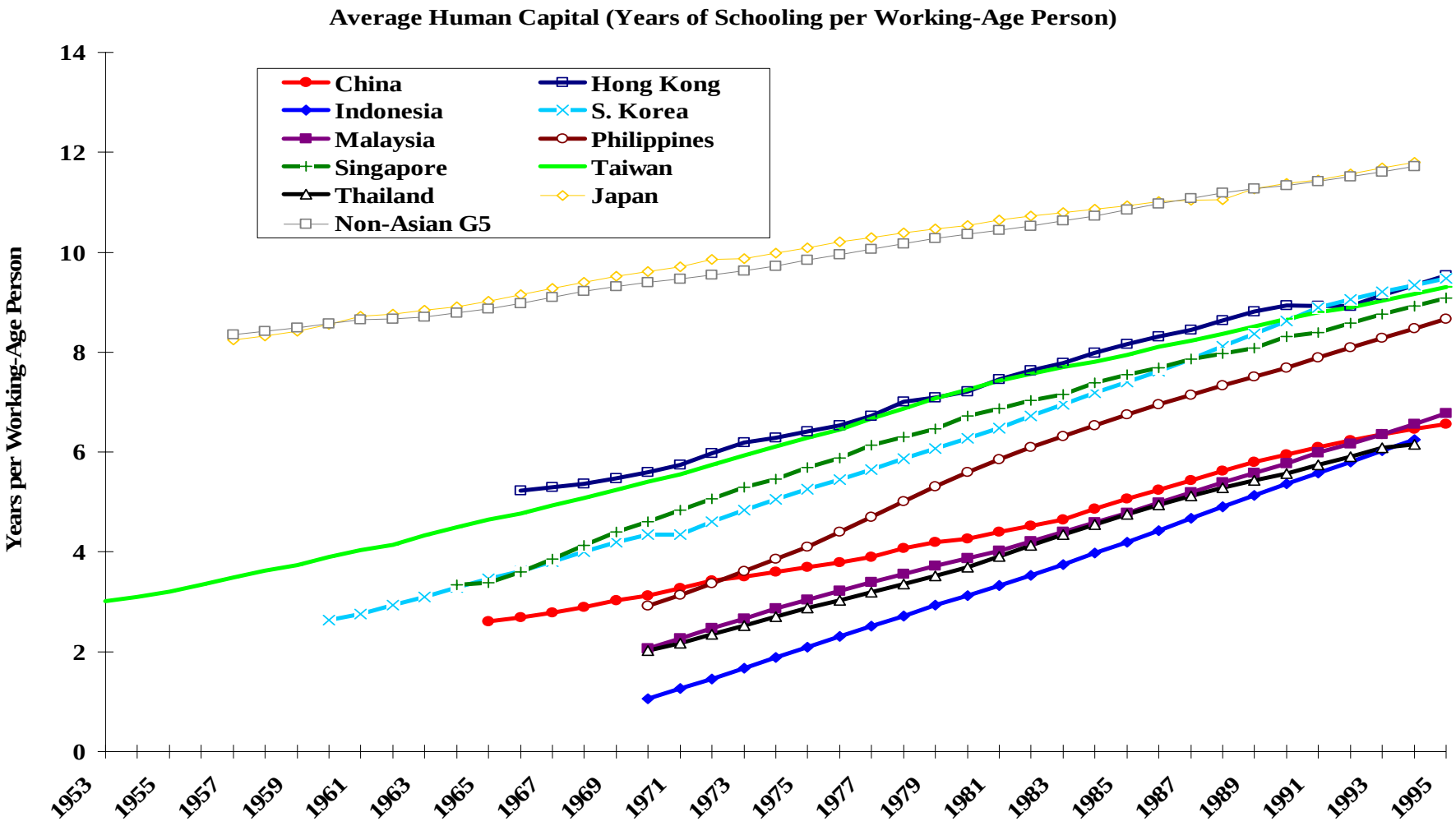
	Tangible Capital	Labor	Technical Progress
Hong Kong	74.46	25.54	0.00
South Korea	78.20	21.80	0.00
Singapore	64.80	35.20	0.00
Taiwan	84.04	15.96	0.00
Japan	49.90	4.84	45.26
Non-Asian G-5 Countries	38.71	2.77	58.52

(2) Full Sample: 4 NIEs, 4 ASEAN, China and G-5

	Tangible Capital	Labor	Technical Progress
Hong Kong	74.61	25.39	0.00
South Korea	82.95	17.05	0.00
Singapore	63.41	36.59	0.00
Taiwan	86.60	13.40	0.00
Indonesia	88.79	11.21	0.00
Malaysia	66.68	33.32	0.00
Philippines	66.10	33.90	0.00
Thailand	83.73	16.27	0.00
China	94.84	5.16	0.00
Japan	55.01	3.70	41.29
Non-Asian G-5 Countries	41.51	1.97	56.53

Note: The parameters are taken from Table 5.3 and have been estimated under the restrictions of $c_{iK}=0$ for all East Asian developing economies.

Average Human Capital (Years/Working-Age Person: Selected Economies)



Simultaneous Capital- and Human Capital-Augmenting Technical Progress

$$Y = A_0(t)\, F(A_K(t)K, A_H(t)H, A_L(t)L)$$

$$= A_0 F(A_K(t)K, A_H H, A_L L)$$

$$= A_0 F(A_K K, A_H(t)H, A_L L)$$

$$= A_0 F(A(t)K^{\alpha}H^{\beta}, A_L L)$$

The Hypothesis of No Technical Progress: Selected Economies—No Breaks

Table 6.2: p-Values for Tests of the Hypothesis of No Technical Progress (Three-Input Model with Human Capital)		
	Sample	
	Full sample for 4 NIEs and G-5	Full Sample for 4 NIEs, 4 ASEAN, China and G-5
	$c_{iK}=0$	$c_{iK}=0$
4 NIEs	0.12332	0.02546
4 ASEAN + China	N.A.	0.08986
9 Developing Economies	N.A.	0.02954
G-5	0.00000	0.00000
All Economies	0.00000	0.00000

Sources of East Asian Economic Growth with 3 Inputs and Technical Progress—No Breaks

Table 6.4: Growth Accounts: Contributions of the Sources of Growth
(Three-Input Model with Human Capital)

(1) Full Sample : 4 NIEs and G-5

	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	62.85	31.38	5.77	0.00
South Korea	62.34	30.00	7.67	0.00
Singapore	56.50	36.36	7.14	0.00
Taiwan	70.16	23.37	6.47	0.00
Japan	40.01	8.77	1.81	49.40
Non-Asian G-5 Countries	31.15	6.22	2.92	59.71

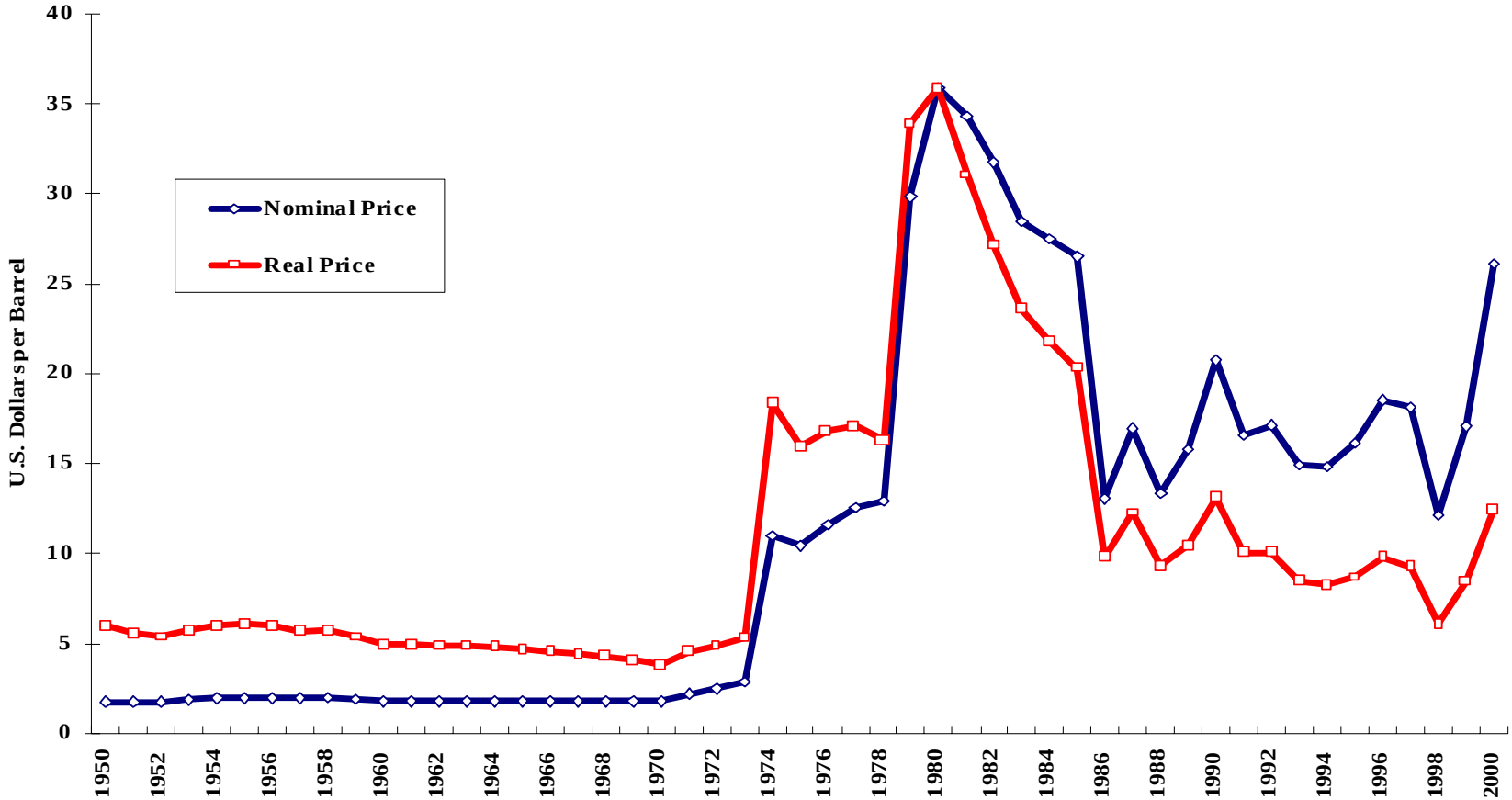
(2) Full Sample: 4 NIEs, 4 ASEAN, China and G-5

	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	69.37	29.08	1.55	0.00
South Korea	75.44	22.33	2.23	0.00
Singapore	59.36	38.82	1.82	0.00
Taiwan	80.83	17.37	1.80	0.00
Indonesia	77.49	17.36	5.15	0.00
Malaysia	59.48	37.68	2.83	0.00
Philippines	54.60	41.24	4.16	0.00
Thailand	73.91	22.66	3.44	0.00
China	83.75	14.12	2.13	0.00
Japan	50.44	5.70	0.56	43.30
Non-Asian G-5 Countries	37.79	3.54	0.86	57.81

Note: The parameters are taken from Table 6.3, and have been estimated under the restrictions of $c_{iK}=0$ for all East Asian developing economies.

Nominal and Real Price of Oil

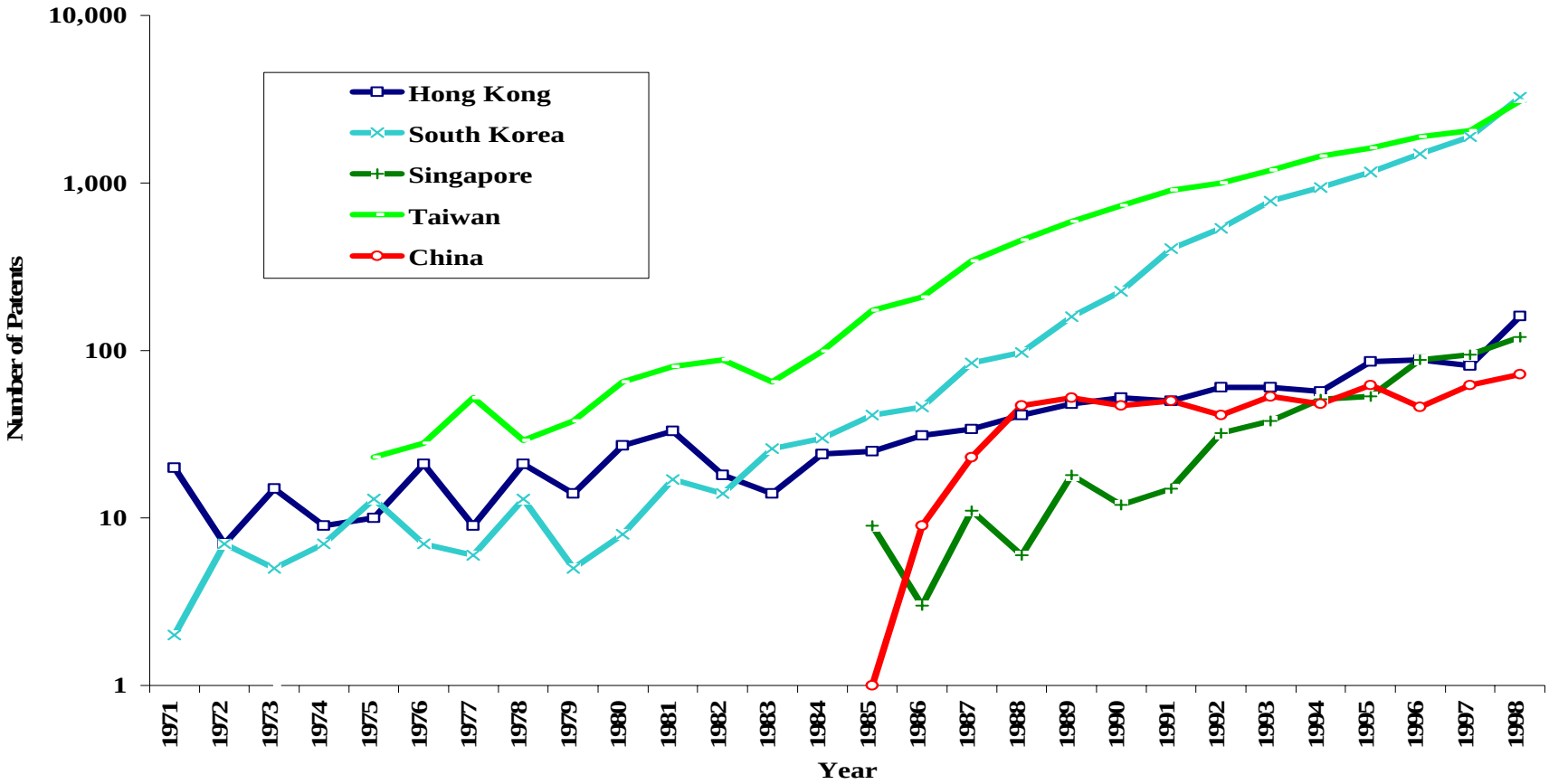
Figure 7.1: Nominal and Real Prices of Oil*



*Note: The nominal price of oil is the U.S. dollar price per barrel of United Arab Emirates Dubai Fateh petroleum, from International Monetary Fund, International Financial Statistics. The real price of oil is the nominal price deflated by the U.S. Consumer Price index (CPI) (1980=1.0).

Patents Granted in the United States—East Asian NIEs and China

Figure 7.1: Number of Patents Granted Annually in the United States, Four East Asian NIEs and China



Tests of the Hypothesis of the Constancy of the Capital-Augmentation Factors

Table 7.2: p-Values for Tests of Hypotheses on the Stability of the Rates of Capital-Augmentation (Three-Input Model with Human Capital)

(1) Full Sample : 4 NIEs and G-5

	Pre-1973 $c_{iK0}=0^1$	1974-1985 $c_{iK1}=0^1$	Post-1986 $c_{iK2}=0^1$
4 NIEs	0.58720	0.72308	0.00149
G-5	0.00000	0.30028	0.21305
All Economies	0.00000	0.46567	0.00774

(2) Full Sample: 4 NIEs, 4 ASEAN, China and G-5

4 NIEs	0.45782	0.70328	0.00122
4 ASEAN + China	0.14608	0.26901	0.00006
4 ASEAN	0.11033	0.68627	0.00002
China	0.03952	0.03702	0.05631
G-5	0.00000	0.25169	0.29292
All Economies	0.00000	0.28956	0.00213

Sources of East Asian Economic Growth with 3 Inputs and Technical Progress-Breaks in 1973, 1985

Table 7.5a: Growth Accounts: Contributions of the Sources of Growth (3 Sub-Periods)
(Three-Input Model with Human Capital and Shifts in the Rates of Capital-Augmentation)
Full Sample for 4 NIEs, 4 ASEAN, China and G-5

(1) Pre-1973

	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	66-73	57.58 (9.67)	32.35 (3.10)	10.07 (5.57)	0.00
South Korea	60-73	55.66 (11.58)	27.99 (4.14)	16.35 (7.70)	0.00
Singapore	64-73	48.87 (12.73)	36.87 (7.56)	14.26 (9.17)	0.00
Taiwan	53-73	65.56 (13.21)	22.20 (2.63)	12.24 (6.73)	0.00
Japan	57-73	44.02 (11.43)	9.14 (0.82)	3.24 (2.87))	43.59
Non-Asian G-5 Countries	57-73	33.94 (4.62)	9.65 (4.24)	4.42 (1.70)	51.99

(2) 1974–1985

	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	74-85	53.79 (9.58)	36.76 (3.40)	9.46 (5.67)	0.00
South Korea	74-85	62.33 (13.28)	25.99 (2.83)	11.68 (6.41)	0.00
Singapore	74-85	56.19 (9.94)	31.86 (3.42)	11.96 (5.48)	0.00
Taiwan	74-85	65.51 (11.89)	25.04 (2.23)	9.44 (4.98)	0.00
Japan	74-85	31.26 (6.73)	14.44 (0.93)	2.83 (1.69)	51.46
Non-Asian G-5 Countries	74-85	28.49 (2.65)	-10.90 (-0.42)	7.62 (1.90)	74.79

(3) Post-1986

	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	86-95	36.82 (7.56)	9.65 (0.53)	5.32 (3.10)	48.21
South Korea	86-95	34.82 (11.90)	19.28 (2.76)	5.26 (4.15)	40.65
Singapore	86-95	33.62 (8.50)	29.39 (4.32)	5.26 (3.38)	31.73
Taiwan	86-95	35.15 (9.01)	13.71 (1.34)	4.32 (3.13)	46.82
Japan	86-94	29.84 (4.86)	4.69 (0.11)	3.42 (1.44)	62.05
Non-Asian G-5 Countries	86-94	21.08 (2.76)	18.42 (5.37)	4.68 (1.36)	55.81

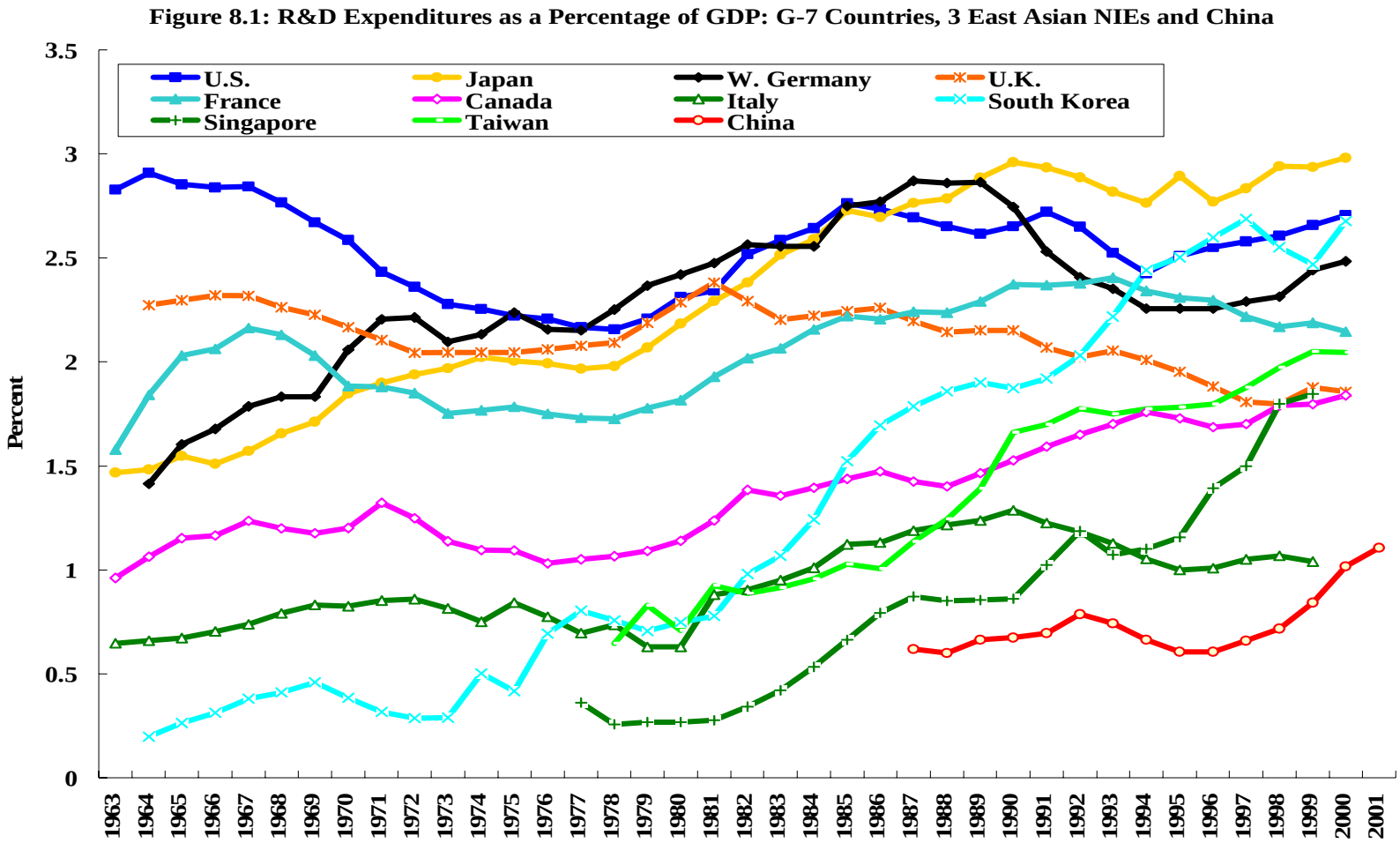
Sources of Economic Growth with Breaks in the Rates of Capital Augmentation (1985)

Sample (G-5 + 4 NIEs)				
	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	48.41	27.57	8.16	15.86
South Korea	51.23	24.78	11.59	12.4
Singapore	46.73	32.43	10.86	9.99
Taiwan	58.26	21.61	9.87	10.27
Japan	38.89	9.17	3.24	48.7
Non-Asian G-5	30.13	7.09	5.21	57.57
Sample (G-5 + 9 Asian)				
	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	56.89	23.65	2.51	16.94
South Korea	65.45	18.62	3.84	12.08
Singapore	53.1	33.94	3.23	9.73
Taiwan	71.26	15.61	3.15	9.99
Indonesia	71.2	14.59	9.38	4.83
Malaysia	54.22	32.47	5.12	8.19
Philippines	54.05	37.81	8.15	-0.01
Thailand	60.84	18.06	5.65	15.44
China	83.87	11.92	4.21	0
Japan	49.04	5.23	1.08	44.65
Non-Asian G-5	37.44	3.36	1.7	57.49

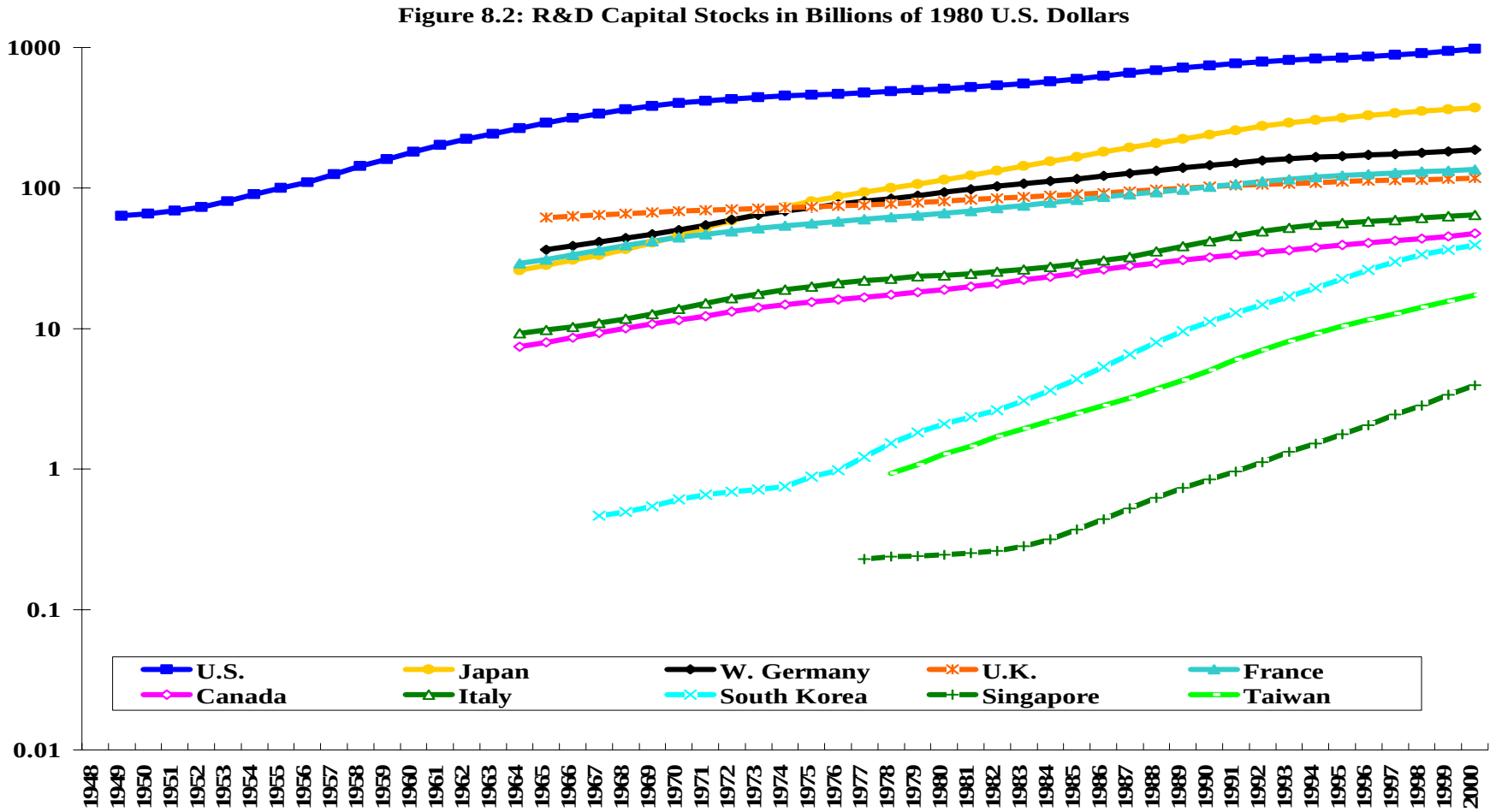
Sources of Economic Growth with Breaks: Sub-periods

Sample (G-5 + 9 Asian)				
1960s-1985				
	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	65.34	31.65	3	0
South Korea	74.66	20.58	4.76	0
Singapore	60.09	35.97	3.94	0
Taiwan	79.92	16.43	3.64	0
Indonesia	76.44	12.41	11.15	0
Malaysia	61.14	32.69	6.17	0
Philippines	55.78	35.36	8.86	0
Thailand	70.77	20.92	8.31	0
China	83.05	12.36	4.59	0
Japan	50.84	5.48	1.06	42.62
Non-Asian G-5	39.69	0.88	1.71	57.72
1986-1995				
Hong Kong	40.81	8.61	1.58	49
South Korea	44.96	14.19	1.8	39.06
Singapore	37.35	29.19	1.6	31.86
Taiwan	41.45	12.61	1.4	44.53
Indonesia	60.25	19.09	5.63	15.03
Malaysia	43.3	32.04	3.44	21.22
Philippines	49.71	44.03	6.29	-0.03
Thailand	49.01	14.61	2.51	33.86
China	85.75	10.9	3.35	0
Japan	34.99	3.17	1.19	60.64
Non-Asian G-5	27	14.66	1.63	56.72

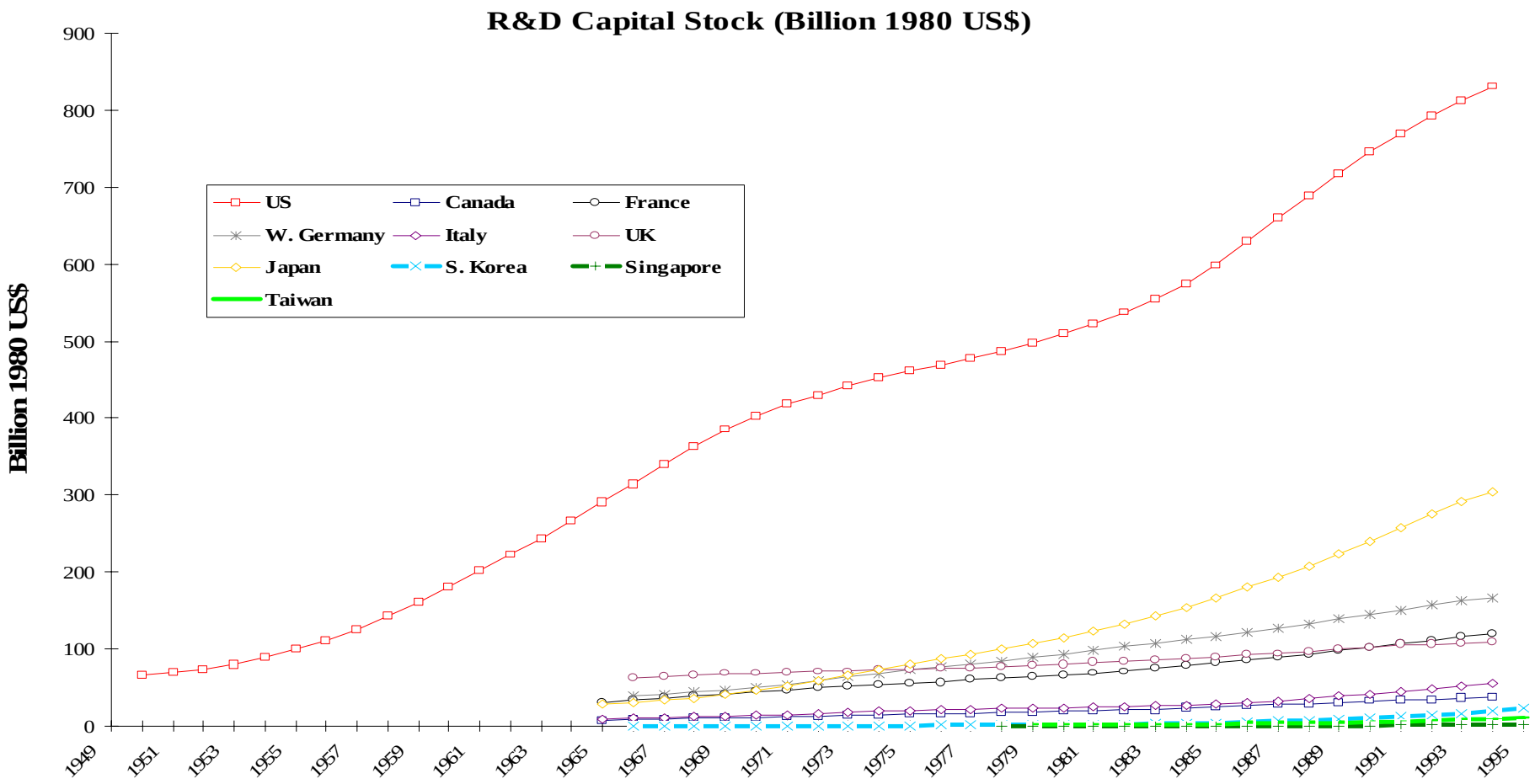
R&D Expenditures as a Ratio of GDP: G-7 Countries, 3 East Asian NIES & China



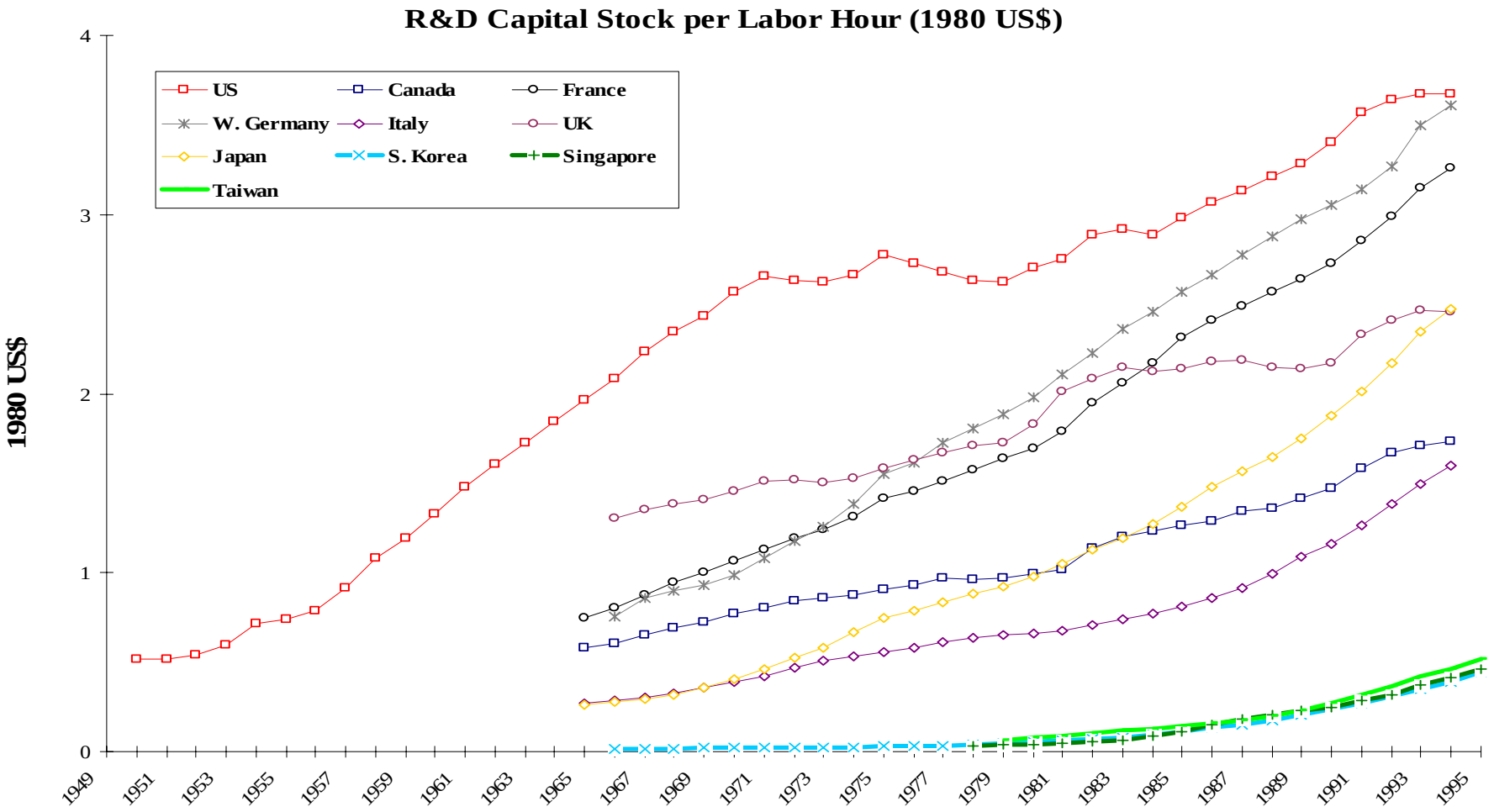
R&D Capital Stocks: G-7 Countries and 3 East Asian NIEs



R&D Capital

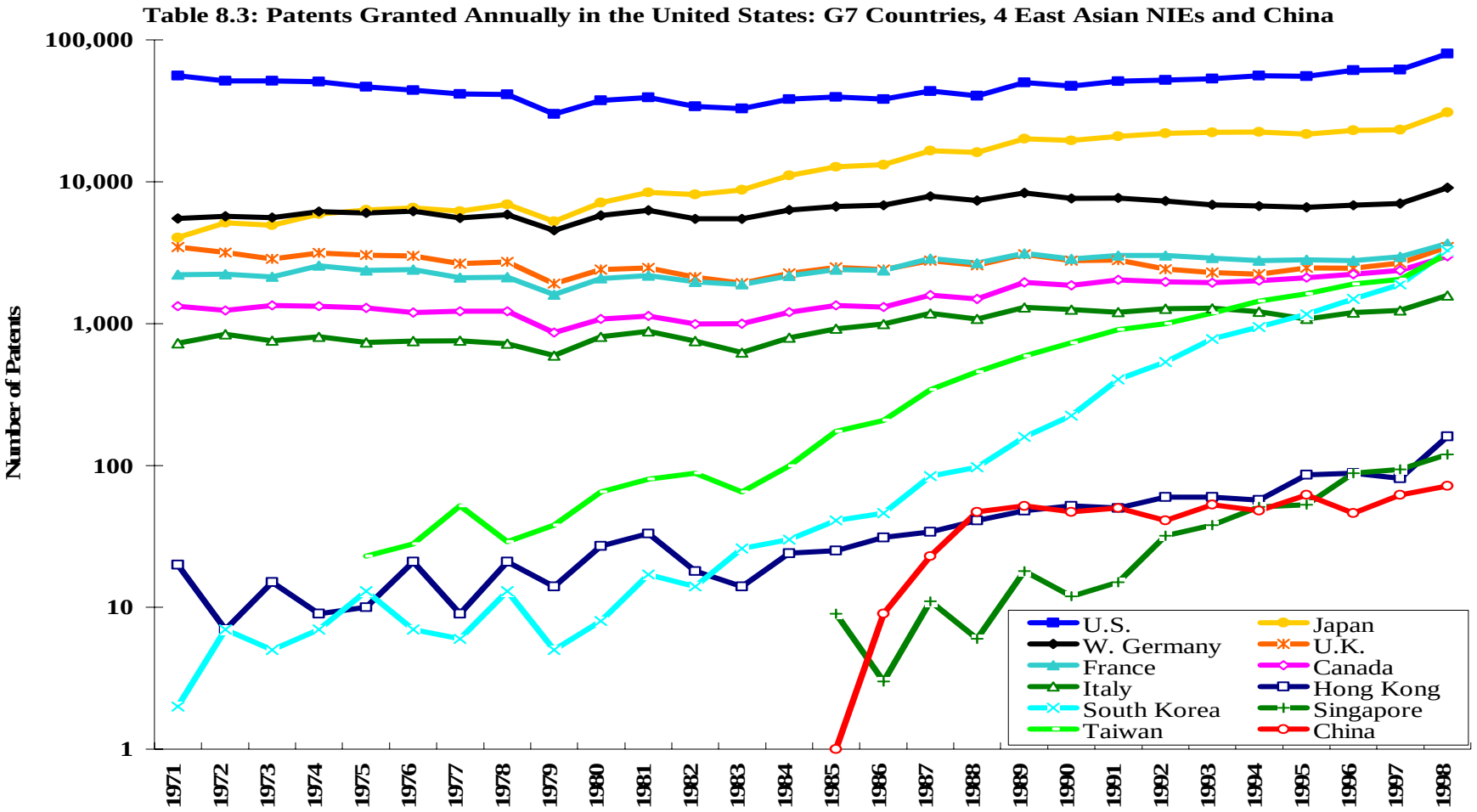

R&D Capital Stock (Billion 1980 US$)
Billion 1980 US$
900
800
700
600
500
400
300
200
100
0
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
US
Canada
France
W. Germany
Italy
UK
Japan
S. Korea
Singapore
Taiwan

R&D Capital Stock per Unit Labor

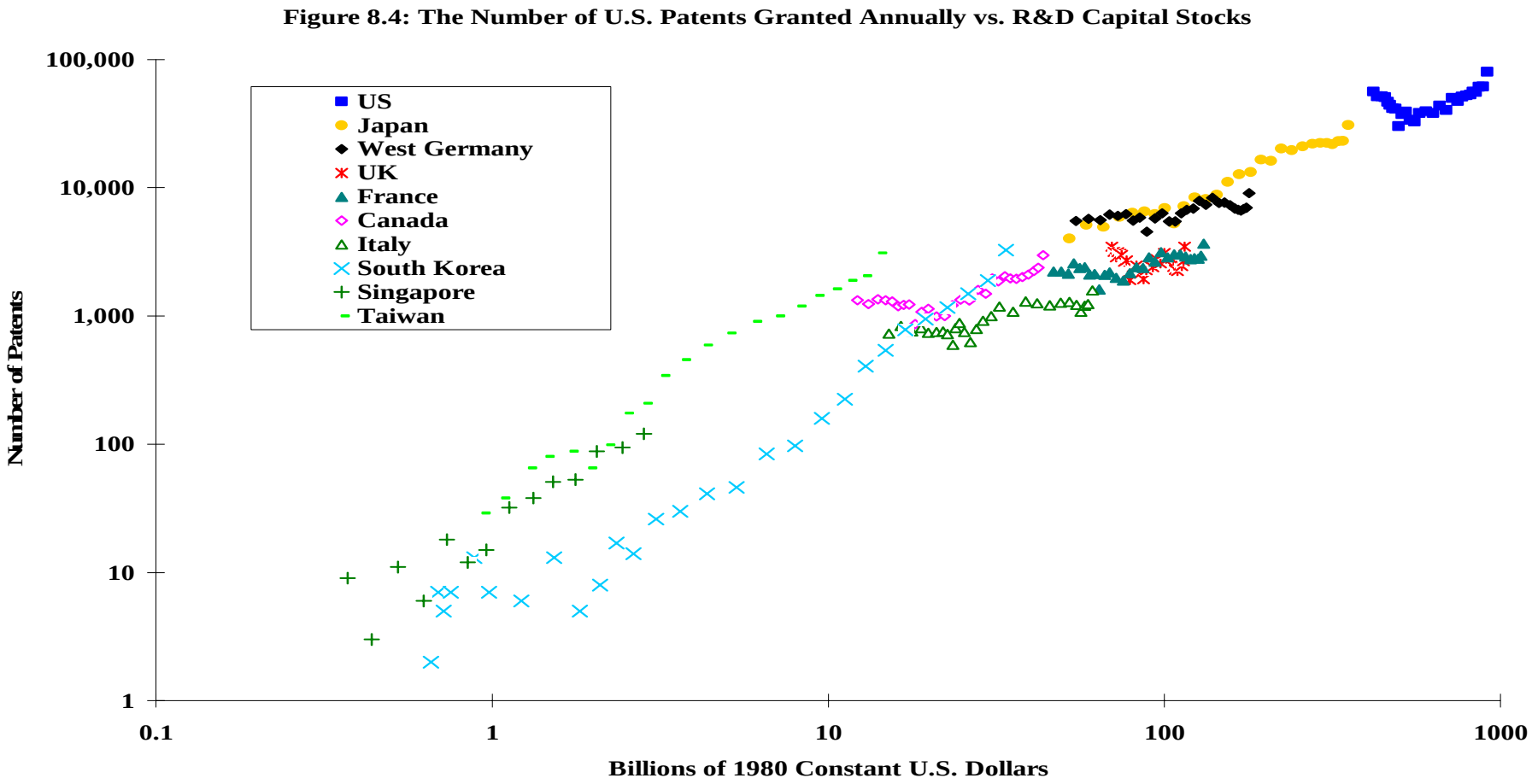


R&D Expenditures: China

Patents Granted in the United States: G-7 Countries, 4 East Asian NIEs & China



Patents Granted in the United States and R&D Capital Stocks, Selected Economies



Tests of the Hypothesis of No Technical Progress--Tangible Capital, Labor, Human & R&D Capital

Table 8.1: p-Values for the Tests of Hypothesis of No Technical Progress
(4-Input Model with Human Capital and R&D Capital)

	Full Sample for G-7 + 3 NIEs[1]
	$c_{iK}=0$, all i
3 NIEs	0.06939
G-7	0.00284
All Economies	0.00020

Sources of East Asian Economic Growth with 4 Inputs and Technical Progress

Table 8.3 Growth Accounts: Contributions of the Sources of Growth (Percent)
(4-Input Model with Human Capital and R&D Capital)

G-7 + 3 NIEs

	Sample Period	Tangible Capital	Labor	Human Capital	R&D Capital	Technical Progress
South Korea	65-95	62.42	13.64	2.07	21.87	0.00
Singapore	77-95	48.51	21.98	1.39	28.12	0.00
Taiwan	78-95	57.44	11.11	1.28	30.44	0.00
Japan	64-94	43.95	5.21	0.94	15.10	34.84
Non-Asian G-7 Countries	65-94	33.31	3.70	1.30	13.11	48.58

Was East Asian Economic Growth a Miracle or a Bubble?

- Past economic growth neither a miracle nor a mere bubble
  - Economic growth experience replicated in different East Asian economies
  - Sustained economic growth over decades
  - Recent crisis due to many factors, of which “irrational exuberance” is only one
  - Economic fundamentals remain sound--high savings rates, investment in human capital, and more recently in R&D capital, entrepreneurship, market orientation
- Past economic growth inputs-driven rather than technical progress-driven--it is attributable to growth in inputs, particularly the efficient and rapid accumulation of tangible capital

Where Is the “Miracle”?

- Achievement of a high savings rate
- Translating domestic savings into investments--the role of self-fulfilling expectations
- Creating and maintaining an environment in which investments are productive--a market-friendly environment
- Philippines as a counter-example

Is Economic Growth Sustainable? Krugman's Worry about East Asia

- If the major source of economic growth is the growth of tangible capital, then given the diminishing marginal productivity of tangible capital, as more and more tangible capital is accumulated, each additional unit of tangible capital will be less productive than the unit before it. Eventually economic growth must slow down and then stop altogether.
- The former Soviet Union was used as an example where a great deal of tangible capital was accumulated but failed to be productive; Mainland China prior to the beginning of its economic reforms in 1979 would be another example

Is East Asian Economic Growth Sustainable?

- East Asian economies lag far behind in both tangible and intangible capital per unit labor.
- There is therefore still considerable room for the continuation of rapid tangible inputs-driven economic growth in the future--tangible capital per unit labor, with the exception of Japan, still lags significantly behind the developed economies
- Investment in intangible capital, e.g., R&D investments, has begun to increase in the East Asian NIEs--in terms of stocks, intangible capital per unit labor lags even further behind, offering additional opportunities for improvement
- Boskin and Lau (1990) found that tangible capital and technical progress (intangible capital) are complementary—at the microeconomic level, this phenomenon is manifested in the form of capital-skill complementarity
- Investment in intangible capital can enhance the productivity of tangible capital because of its complementarity with tangible capital and retard the decline in the marginal productivity of tangible capital and hence counteract the "Krugman effect"
  - JAPAN HAS SHOWN HOW THIS CAN BE DONE!

Is East Asian Economic Growth Sustainable?

- The attractiveness of investment in intangible capital depends on the protection of intellectual property rights, which in turn depends on whether a country is a producer of intellectual property--some of the East Asian economies, e.g., Hong Kong, South Korea, Singapore and Taiwan are ahead of other East Asian economies with the possible exception of Japan on this score
- Intangible capital is different from tangible capital in three important aspects:
  - Intangible capital is freely mobile across countries
  - Intangible capital is simultaneously deployable in different locations without diminution of its effectiveness (increasing returns in the utilization of intangible capital)
  - Intangible capital enhances the productivity of existing tangible capital whereas additional tangible capital diminishes the productivity of existing tangible capital
- Investment in intangible capital, e.g., R&D investments, has begun to increase in the East Asian NIEs
- There is also evidence of positive technical progress in the more recent period in South Korea, Singapore and Taiwan, reflecting their increased investment in intangible capital

Implications for East Asian NIEs (1)

- Maintaining the growth in tangible capital
  - Encouraging savings and investment
  - Preserving a low-tax environment
  - Affirming property rights
  - Keeping inflation under control
  - Maintaining free flows of capital, labor and goods
  - Maintaining an orderly and stable foreign exchange market
  - Providing needed infrastructure
  - Avoiding open-ended social welfare programs
  - Strengthening capital markets

Implications for East Asian NIEs (2)

- Assuring the efficiency of tangible capital
  - Commitment to an open economy
  - Continued liberalization and deregulation
  - Preserving open competition in all markets
  - Maintaining the rule of law
  - Providing needed infrastructure
    - Traditional economy requires physical infrastructure--railroads, roads, ports, airports, power, etc.
    - New economy requires, in addition, virtual infrastructure--Telecommunication (Telephone and internet access from every village; Fiber optic links); Wireless; National and international delivery services--United Parcel Service (UPS), Federal Express; Generic trading platforms; Enabling technologies and services (Internet service providers; portals)
  - Eschewing market intervention

Implications for East Asian NIEs (3)

- Closing the gap on intangible capital
  - Investment in human capital (formal, technical, on-the-job training, and re-training); universal secondary education
  - Upgrading the universities to be the among the best in the world
  - Support for basic science
  - Tax incentives and subsidies for education and re-training and R&D
  - Investment in R&D capital
  - Investment in other forms of intangible capital (design, goodwill, brand name, market development, information systems and software, etc.)
  - Protection of intellectual property rights (transformation from a consumer to a producer of intellectual capital)
  - Development of new modes of education and information dissemination

Investment in R&D Capital

- Investment in R&D Capital--necessary for both learning and diffusion
  - Essentiality of indigenous R&D for the successful exploitation of imported technology, e.g., new rice variety
  - The distribution of gains from technology trade and transfer is biased in favor of the innovators and the owners of intangible capital (e.g. brand names) and not the imitators
  - Licensing frequently takes the form of cross-licensing
  - R&D projects as an instrument of industrial policy (Strategic R&D)
  - Focus on development rather than basic or applied research
  - Consortium approach

Prospects for Future Economic Growth Remain Good

- Prospects for continued economic growth in East Asia remain good—room for continuation of tangible-input-driven growth
- Fundamentals are sound—high savings rates, priority for education, market-oriented economy
- The experience of developed economies, especially that of Japan, and that of the East Asian NIEs in the more recent period, suggest that investment in R&D capital and other forms of intangible capital has high returns once a level of tangible capital per unit labor has been achieved
- The people of East Asia are entrepreneurial, hard-working, and thrifty--all they need is a good, market-friendly, predictable and stable environment