

# The Sources of East Asian Economic Growth Revisited

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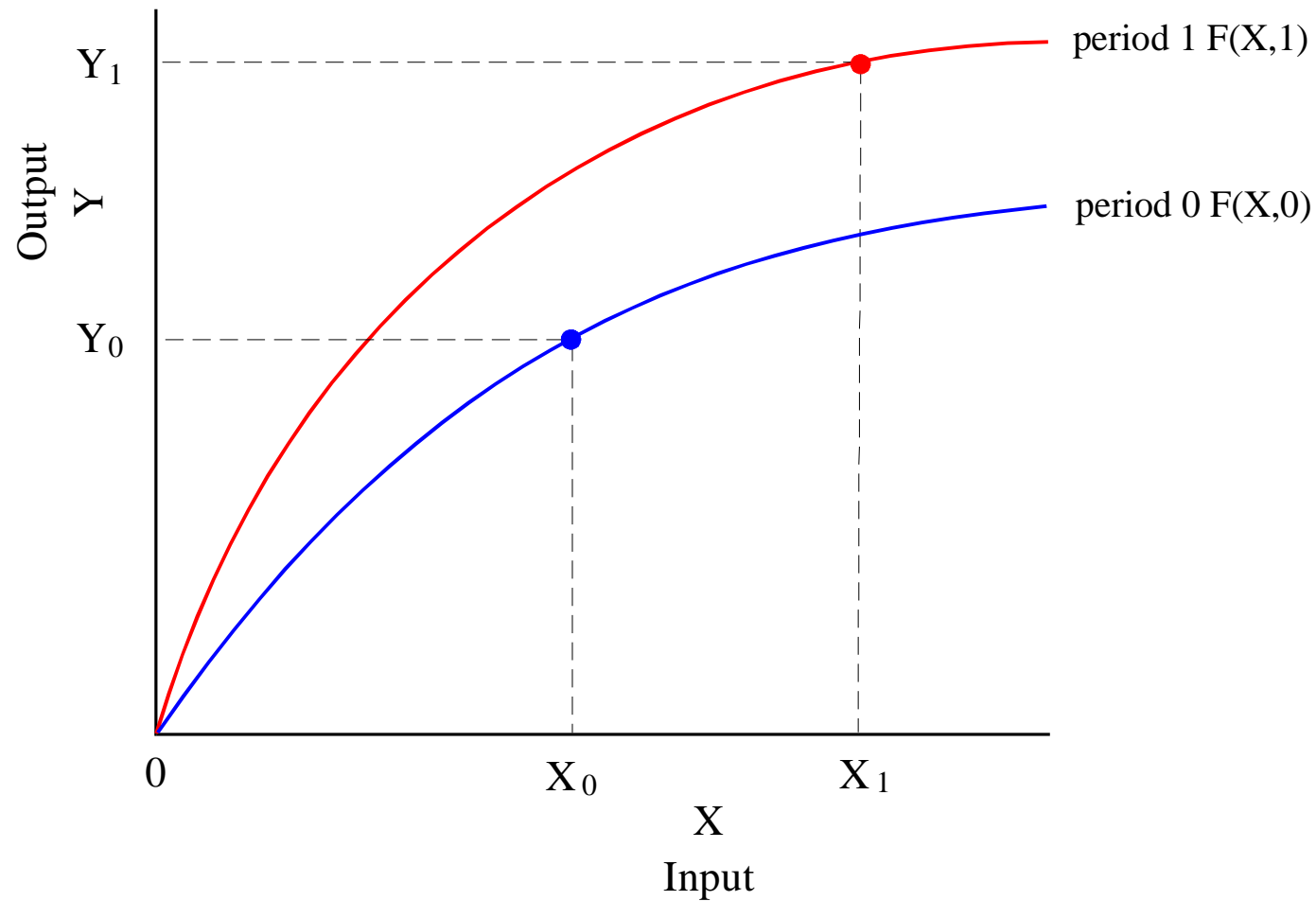
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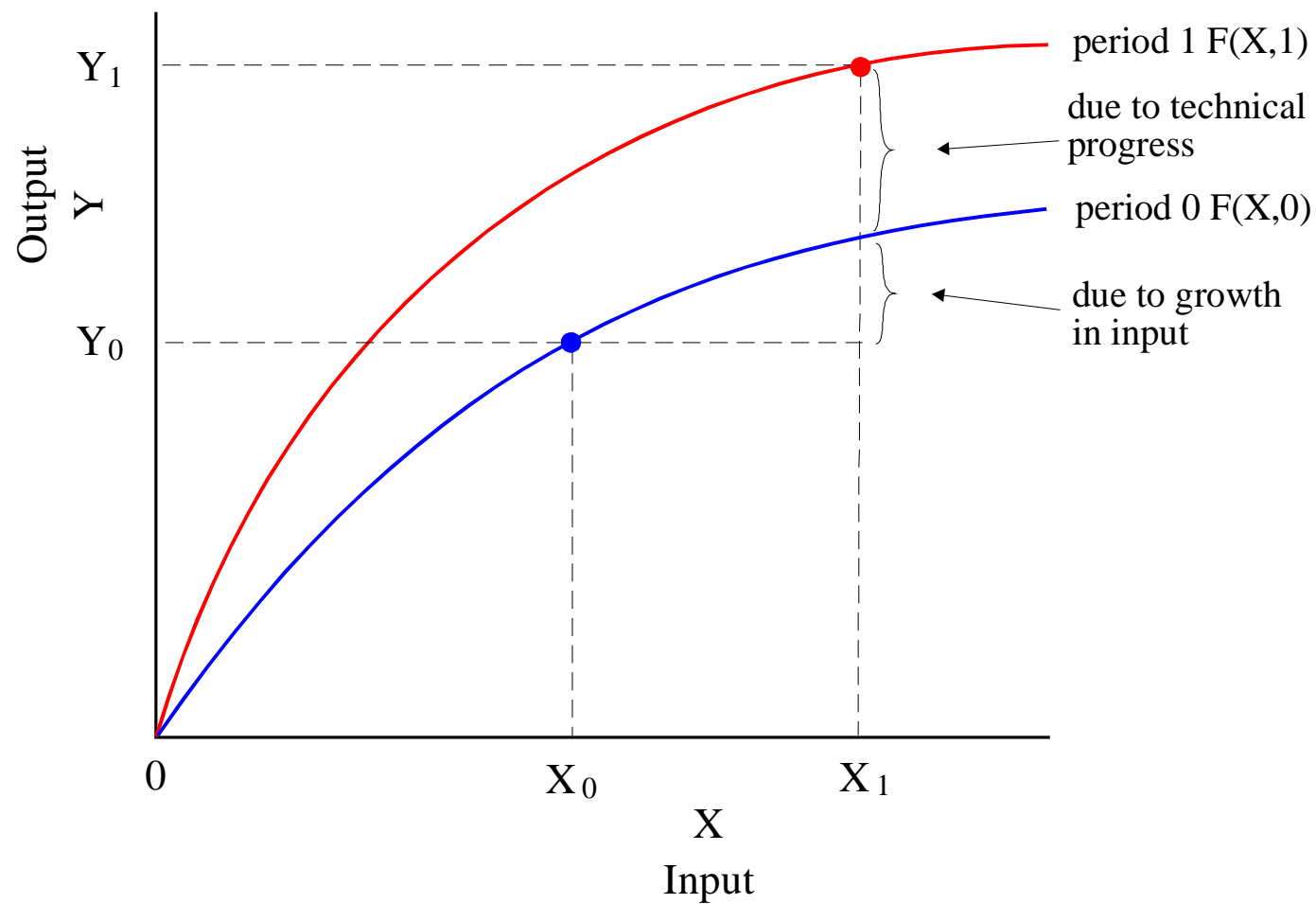
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# Technical Progress: The Single-Output, Single-Input Case

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# Decomposition of the Growth of Output



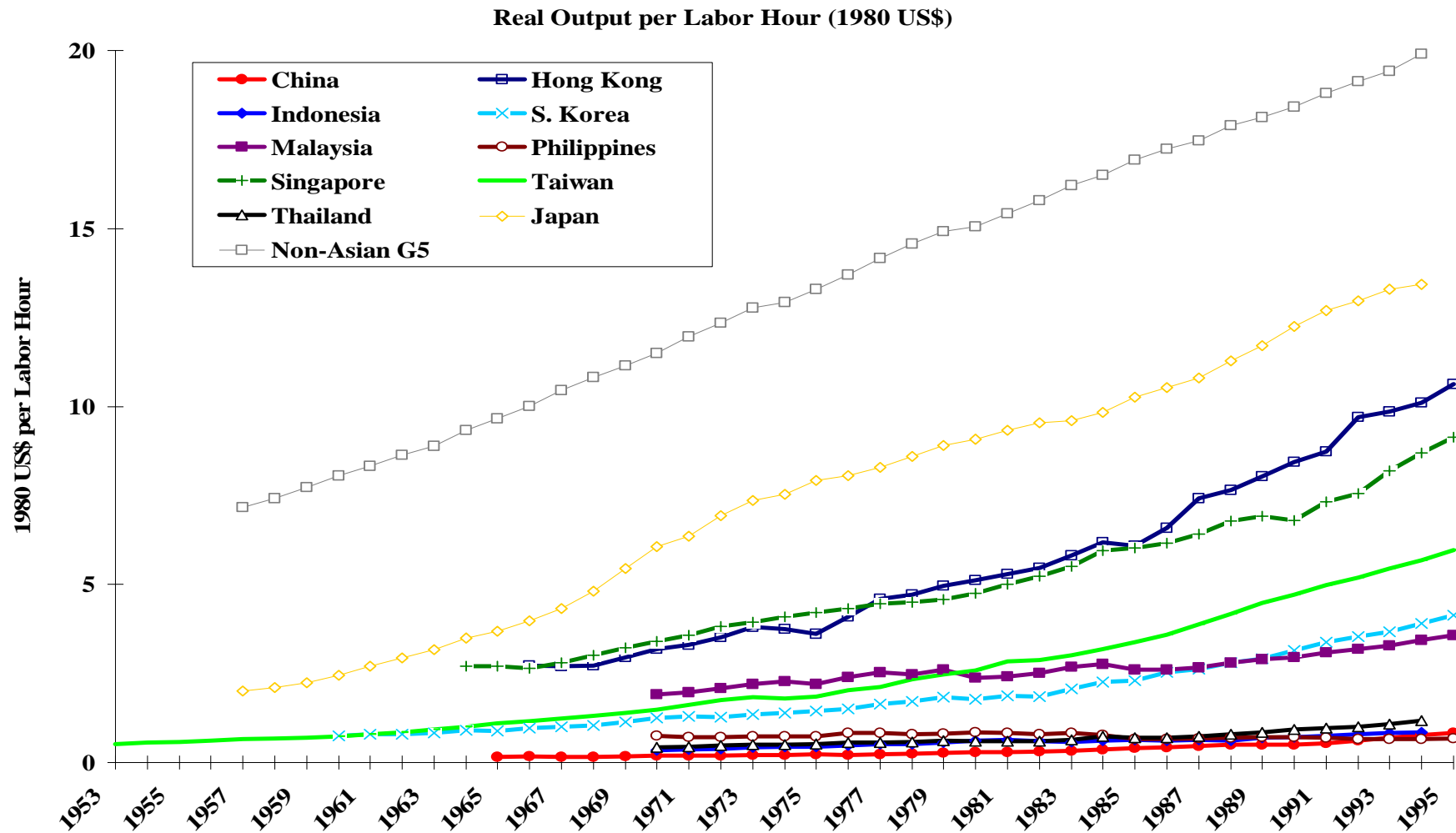
# Rates of Growth of Inputs & Outputs of the East Asian Developing & the G-7 Countries

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

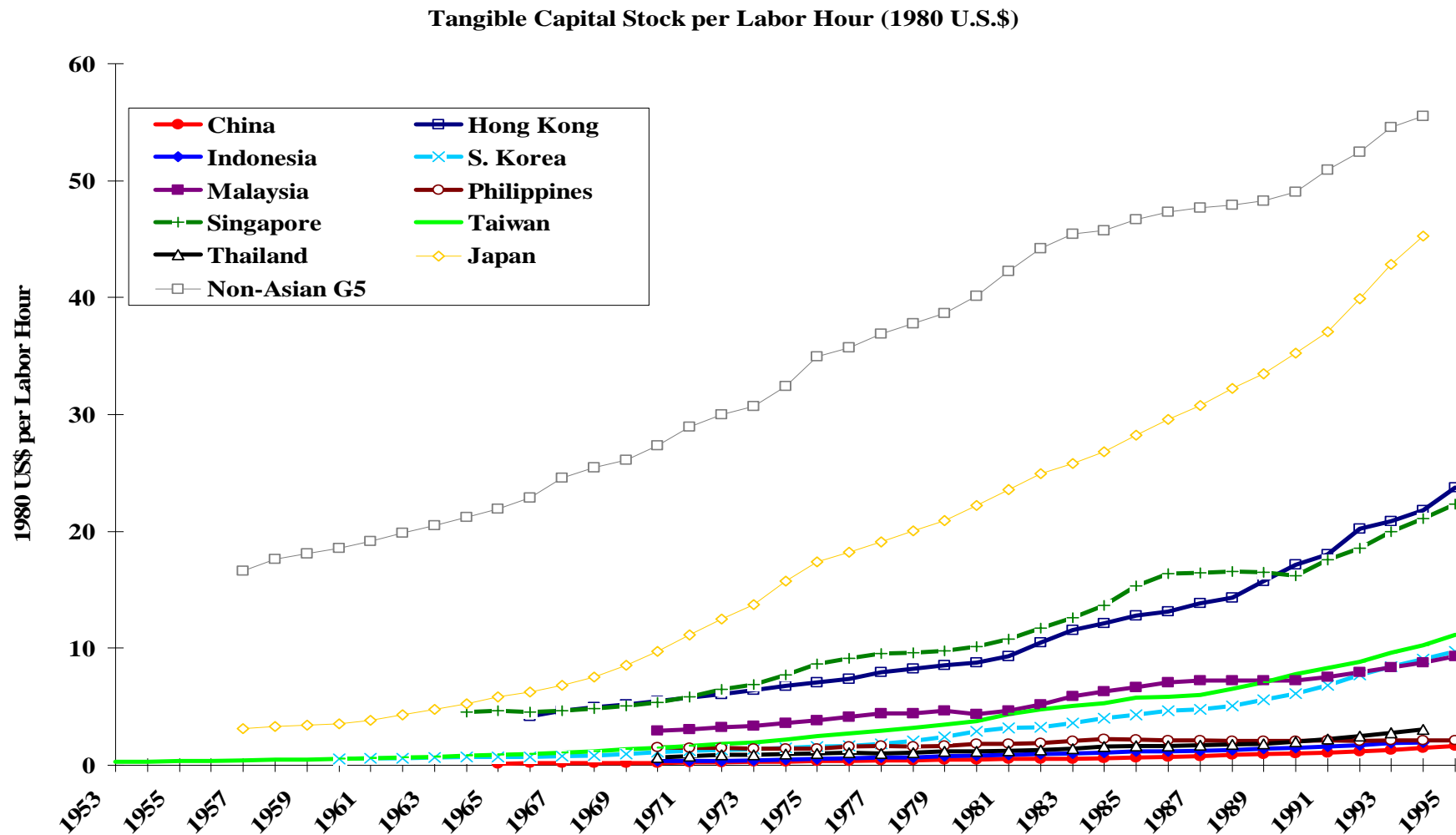
	Sample Period	Output (Real GDP)	Tangible Capital Stock	Utilized Tangible Capital	Employment	Total Labor Hours	Average Years of Education of the Working-Age Population <sup>1</sup>	Total Years of Education of the Working-Age Population <sup>1</sup>	Average Share of Labor Earnings to GDP
Hong Kong	66-95	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.

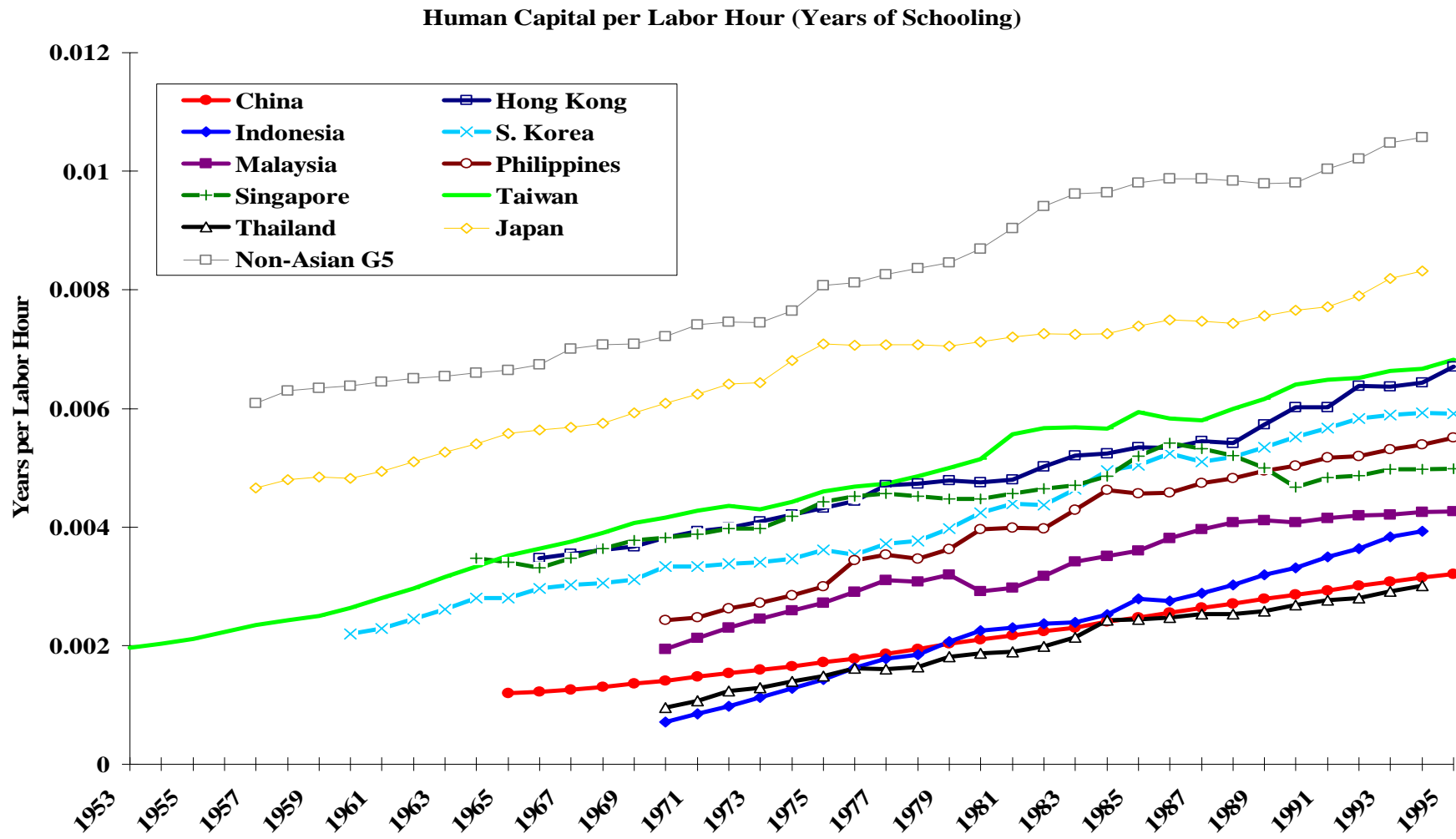
# Real Output per Labor Hour (1980 US\$)



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



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



# The Commodity-Augmenting Representation of Technical Progress

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One specialization of

$$Y = F(K, L, t) \text{ is}$$

$$Y^* = F(K^*, L^*), \text{ where}$$

$Y^*$ ,  $K^*$ , and  $L^*$  are efficiency-equivalent quantities. Thus, in terms of measured quantities,

$$Y = A_0(t) F(A_K(t)K, A_L(t)L).$$

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# The Different Kinds of Purely Commodity-Augmenting Technical Progress

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

=  $A_0(t)F(A_K K, A_L L)$ , purely output-augmenting (Hicks-neutral)

=  $A_0 F(A_K(t)K, A_L L)$ , purely capital-augmenting (Solow-neutral)

=  $A_0 F(A_K K, A_L(t)L)$ , purely labor-augmenting (Harrod-neutral)

# Accounts of Growth (Early 1950s-Late 1980s): Kim & Lau (1992, 1994a, 1994b)

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<b>Table 2.2: Relative Contributions of the Sources of Economic Growth (percent)</b>				
<b>Economy</b>	<b>Tangible Capital</b>	<b>Labor</b>	<b>Technical Progress</b>	
<b>Hong Kong</b>	<b>74</b>	<b>26</b>	<b>0</b>	
<b>Singapore</b>	<b>68</b>	<b>32</b>	<b>0</b>	
<b>S. Korea</b>	<b>80</b>	<b>20</b>	<b>0</b>	
<b>Taiwan</b>	<b>85</b>	<b>15</b>	<b>0</b>	
<b>Japan</b>	<b>56</b>	<b>5</b>	<b>39</b>	
<b>Non-Asian G-5</b>	<b>36</b>	<b>6</b>	<b>59</b>	

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

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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 Hypothesis of No Technical Progress: Selected Economies—Augmented Sample

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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 and Western Economies

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

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

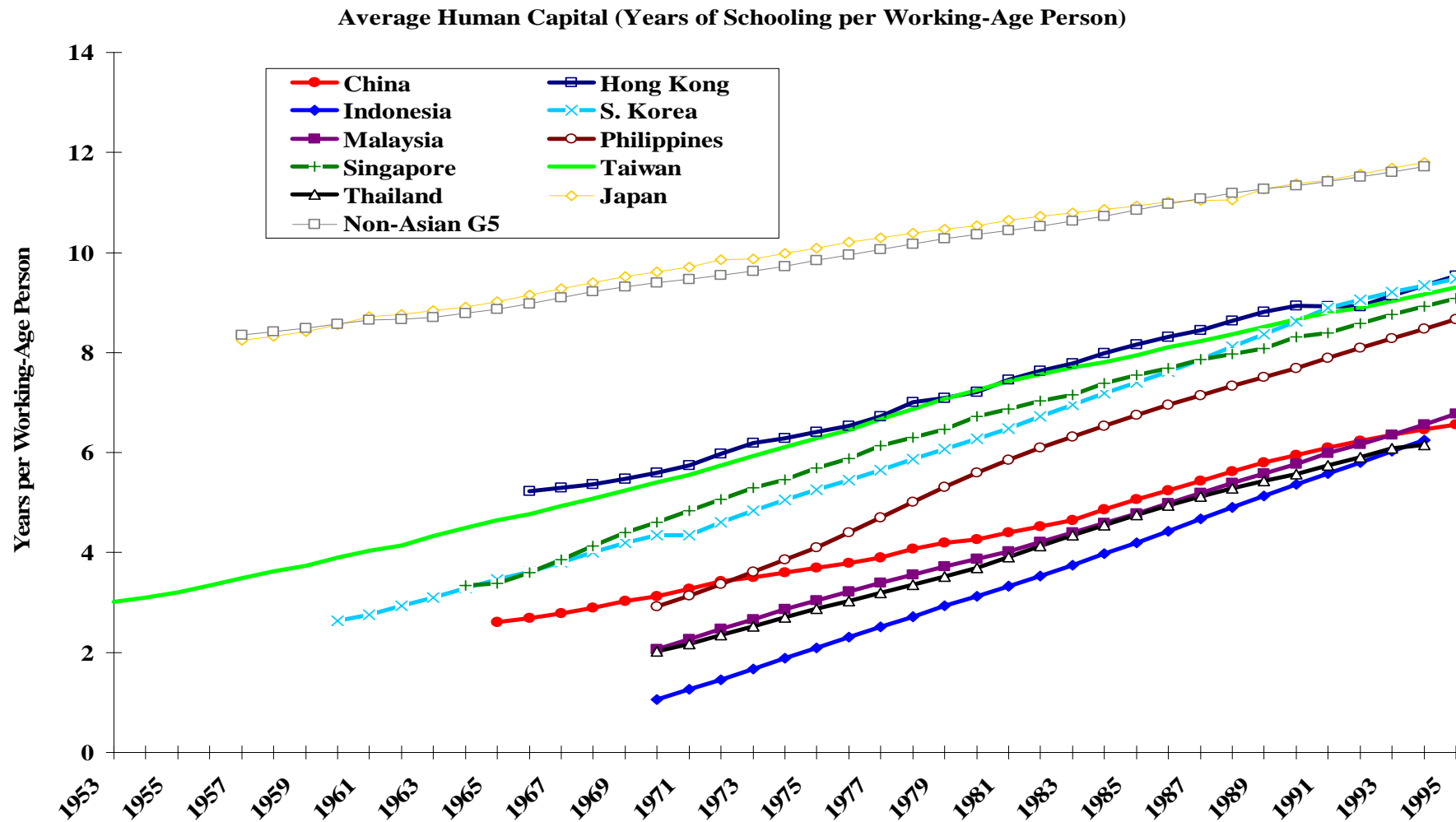
	Tangible Capital	Labor	Technical Progress
Hong Kong	74.46	25.54	0.00
South Korea	78.20	21.80	0.00
Singapore	64.80	35.20	0.00
Taiwan	84.04	15.96	0.00
Japan	49.90	4.84	45.26
Non-Asian G-5 Countries	38.71	2.77	58.52

(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 Lau, Stanford University. They 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)



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

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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

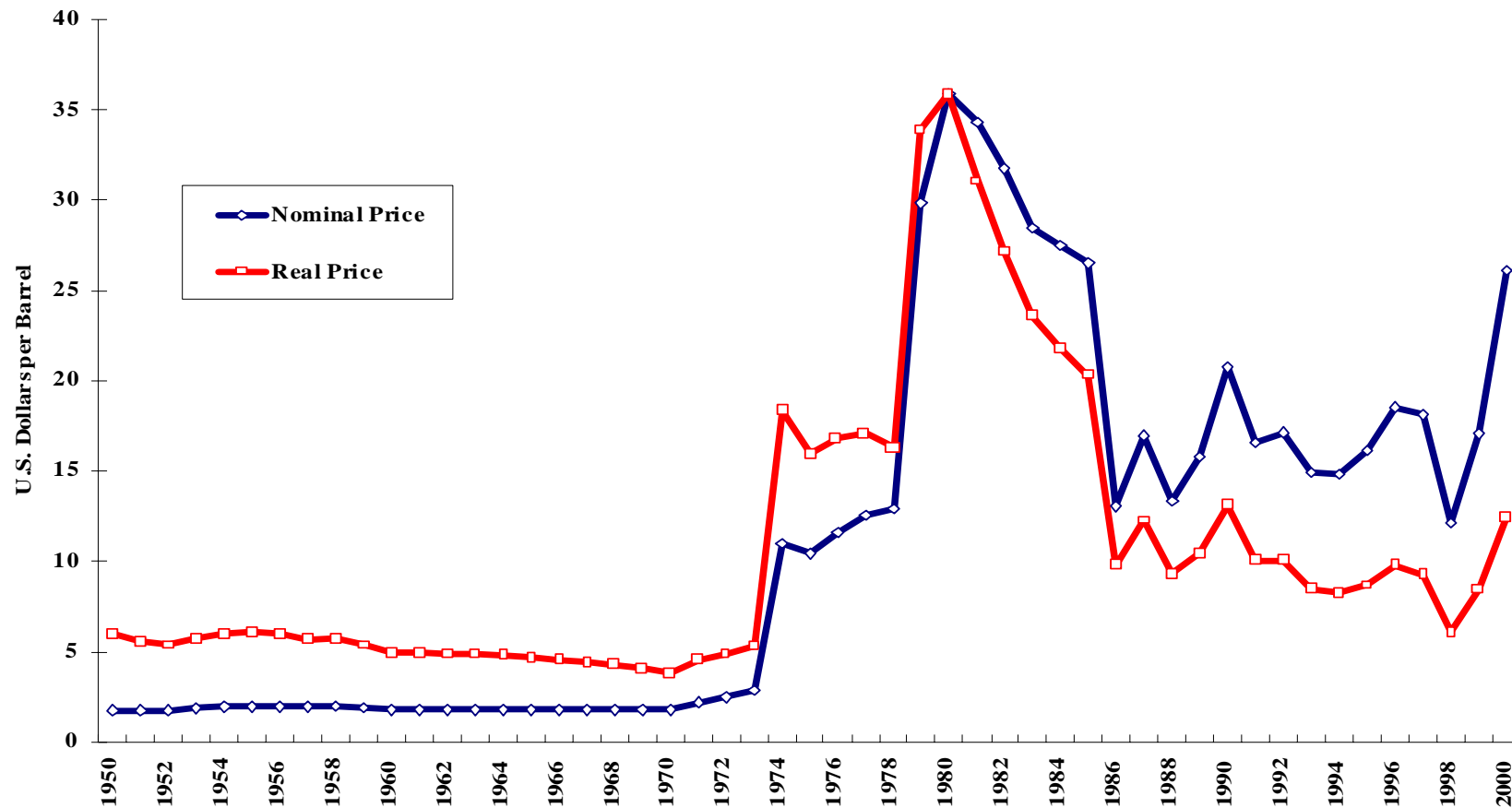
	Tangible Capital	Labor	Human Capital	Technical Progress
Hong Kong	69.37	29.08	1.55	0.00
South Korea	75.44	22.33	2.23	0.00
Singapore	59.36	38.82	1.82	0.00
Taiwan	80.83	17.37	1.80	0.00
Indonesia	77.49	17.36	5.15	0.00
Malaysia	59.48	37.68	2.83	0.00
Philippines	54.60	41.24	4.16	0.00
Thailand	73.91	22.66	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, Stanford University, estimated under the restrictions of  $c_{iK}=0$  for all East Asian developing economies.



# Nominal and Real Price of Oil

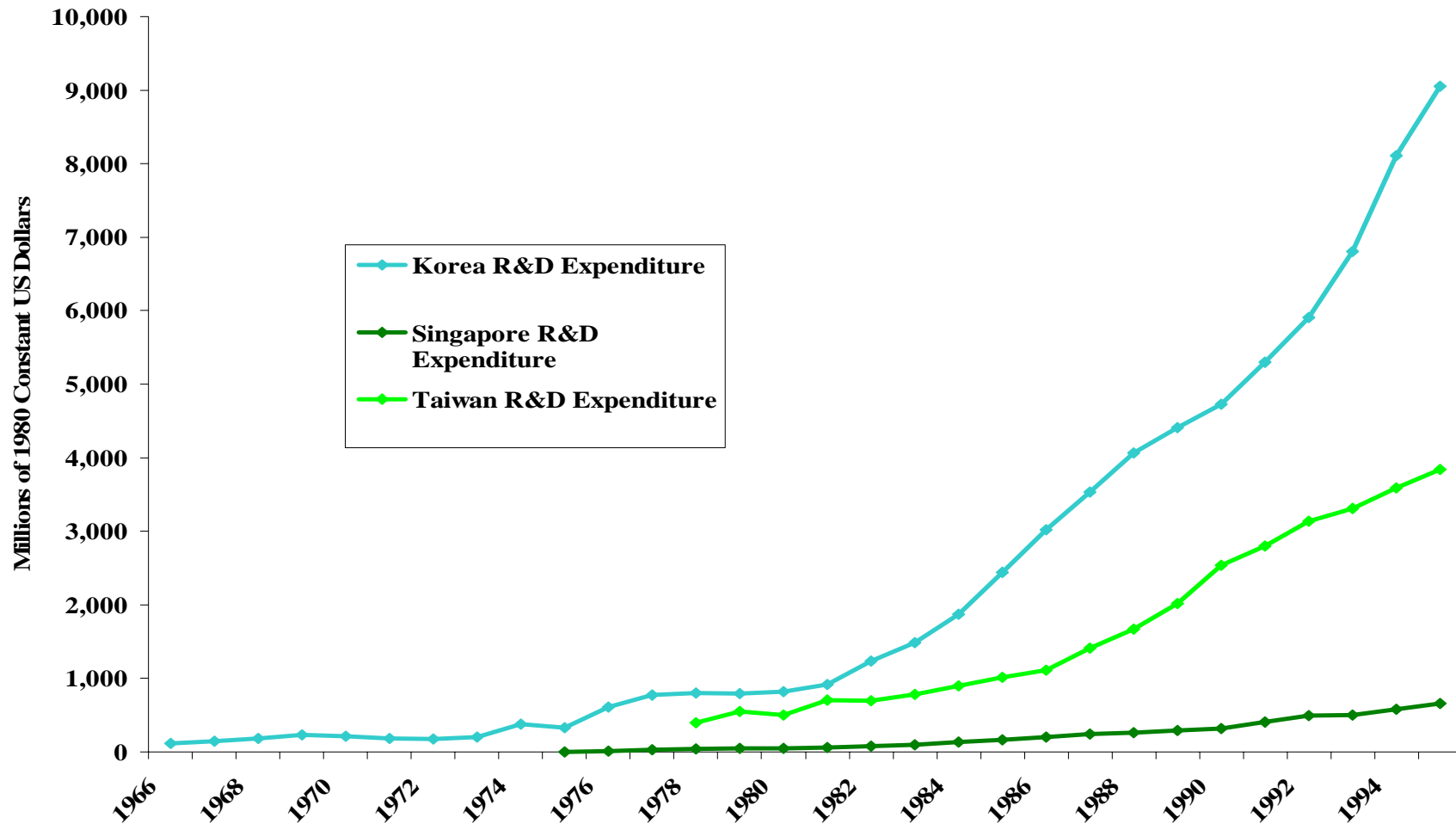
Figure 7.1: Nominal and Real Prices of Oil\*



\*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).

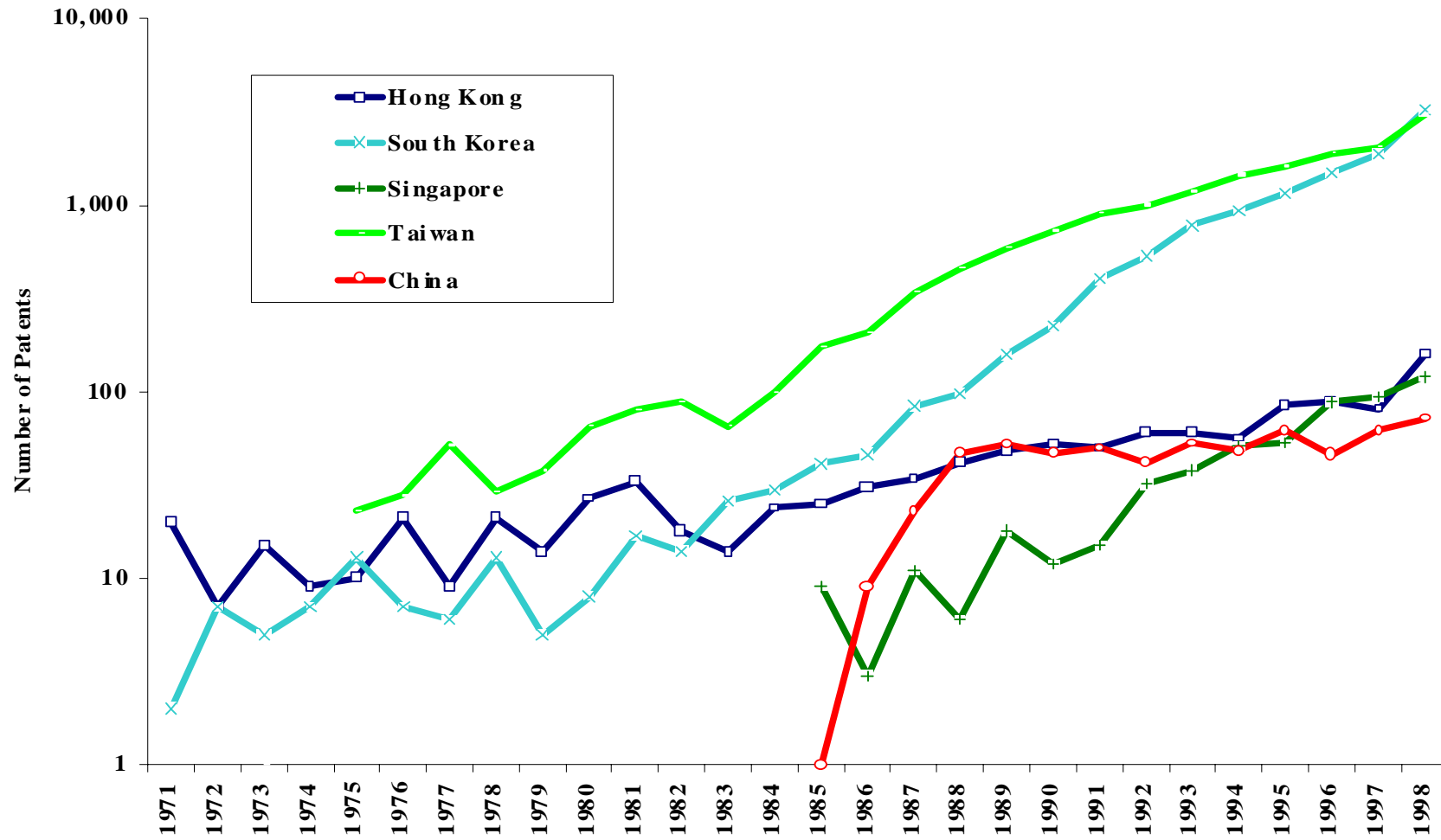
# R&D Expenditures: 3 East Asian Newly Industrialized Economies

Real R&D Expenditures (3 NIEs)



# Patents Granted in the United States— Selected East Asian Economies

Figure 7.2: Number of Patents Granted Annually in the United States, Four East Asian NIEs and China



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# 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 (2.70)	18.42 (5.57)	4.68 (1.36)	55.81

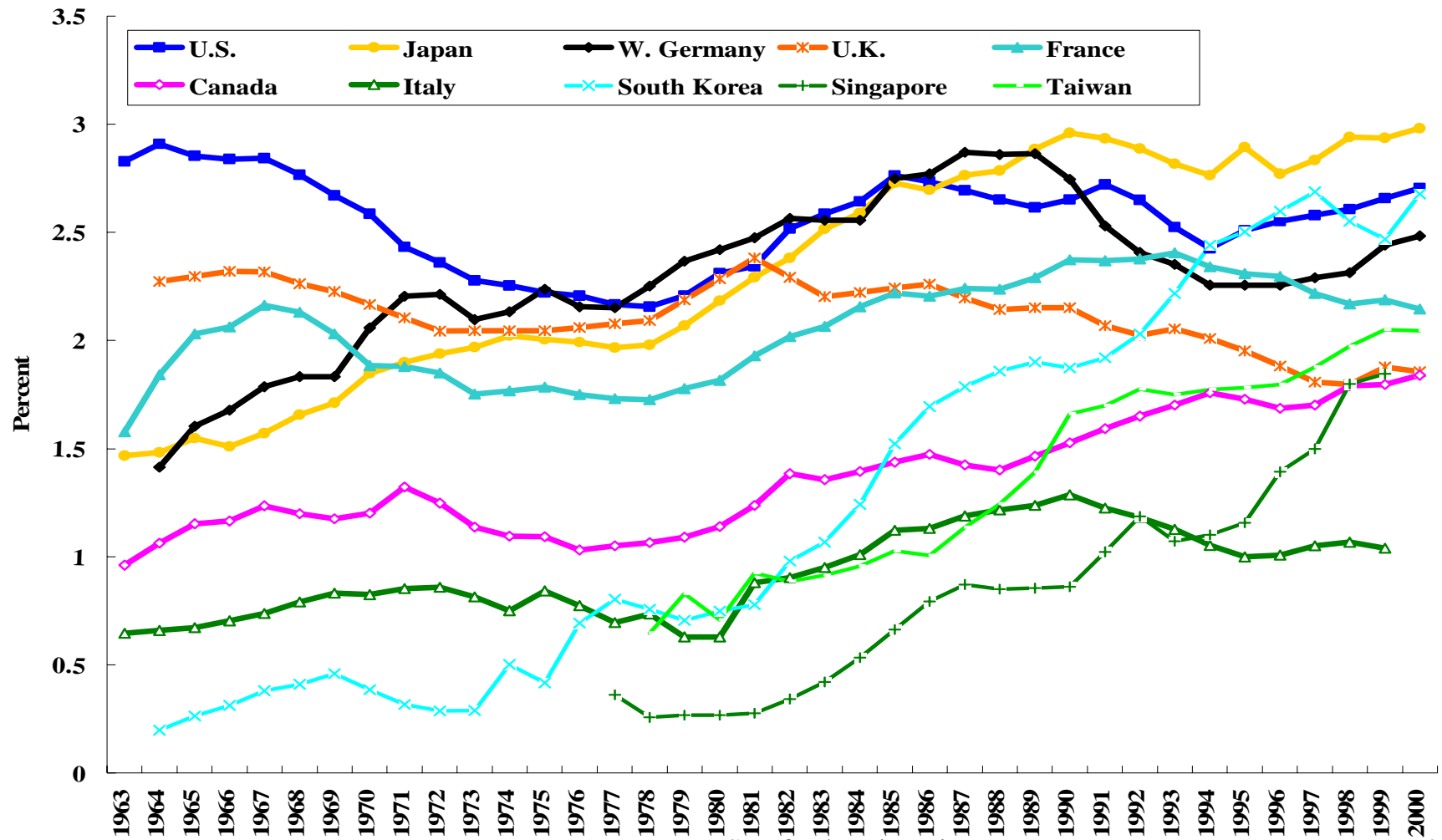
# Simultaneous Capital- and Human Capital- Augmenting Technical Progress

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$$\begin{aligned} Y &= A_0(t) F(A_K(t)K, A_H(t)H, A_L(t)L) \\ &= A_0 F(A_K(t)K, A_H H, A_L L) \\ &= A_0 F(A_K K, A_H(t)H, A_L L) \\ &= A_0 F(A(t)K^\alpha H^\beta, A_L L) \end{aligned}$$

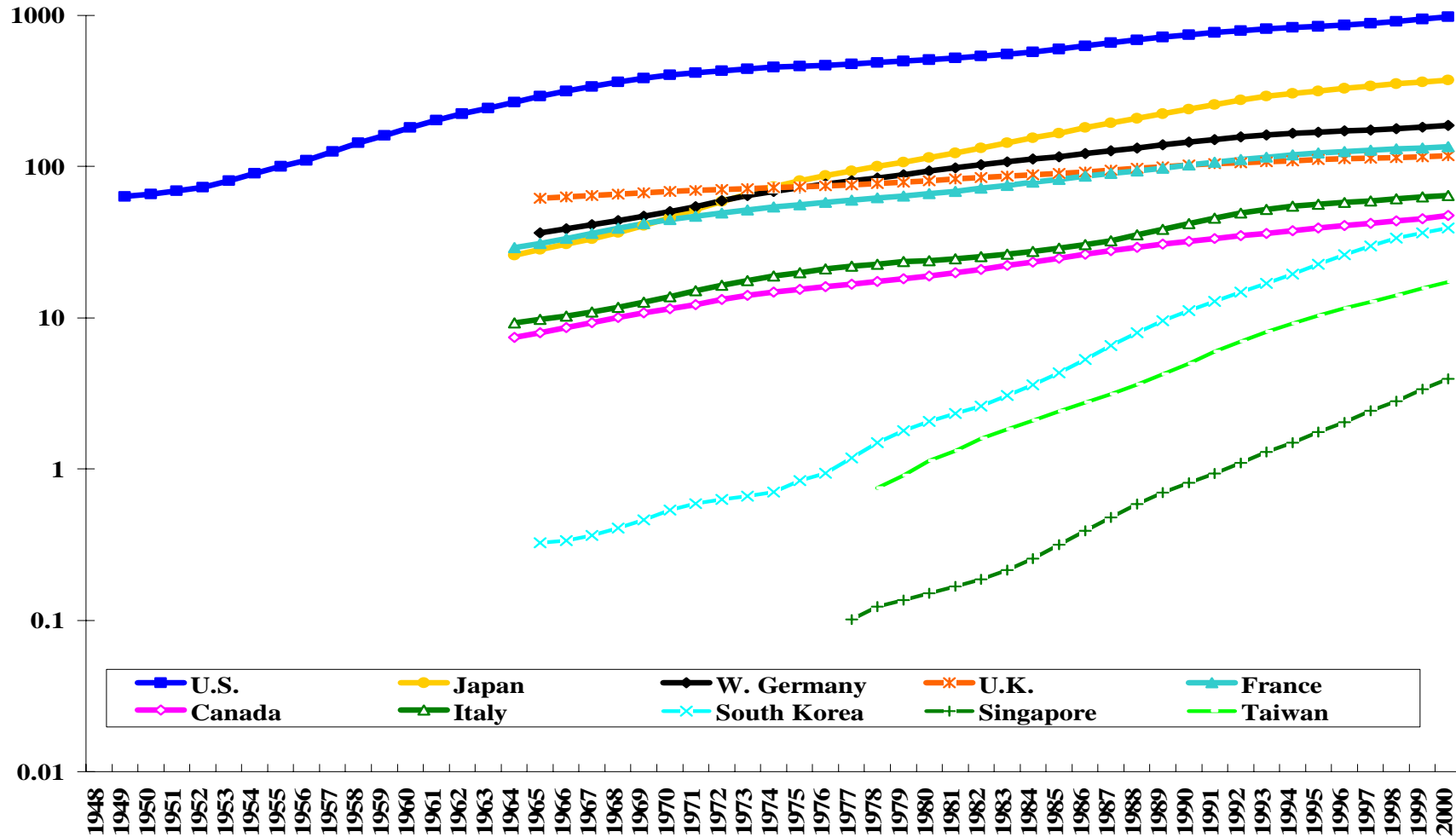
# R&D Expenditures as a Ratio of GDP: G-7 Countries and 3 East Asian NIES

Figure 8.1: R&D Expenditures as a Percentage of GDP: G-7 Countries and 3 East Asian NIES



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

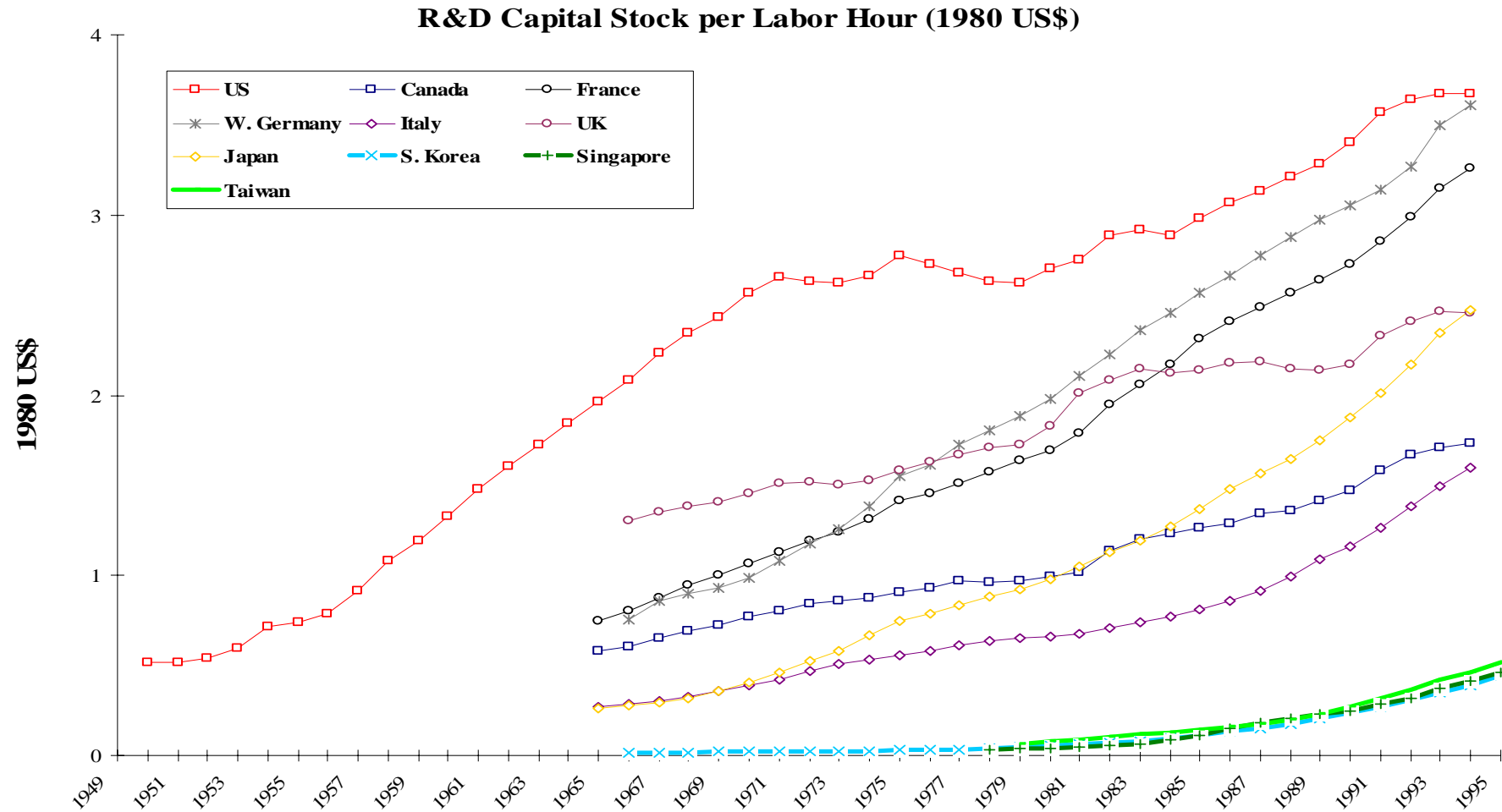
Figure 8.2: R&D Capital Stocks in Billions of 1980 U.S. Dollars



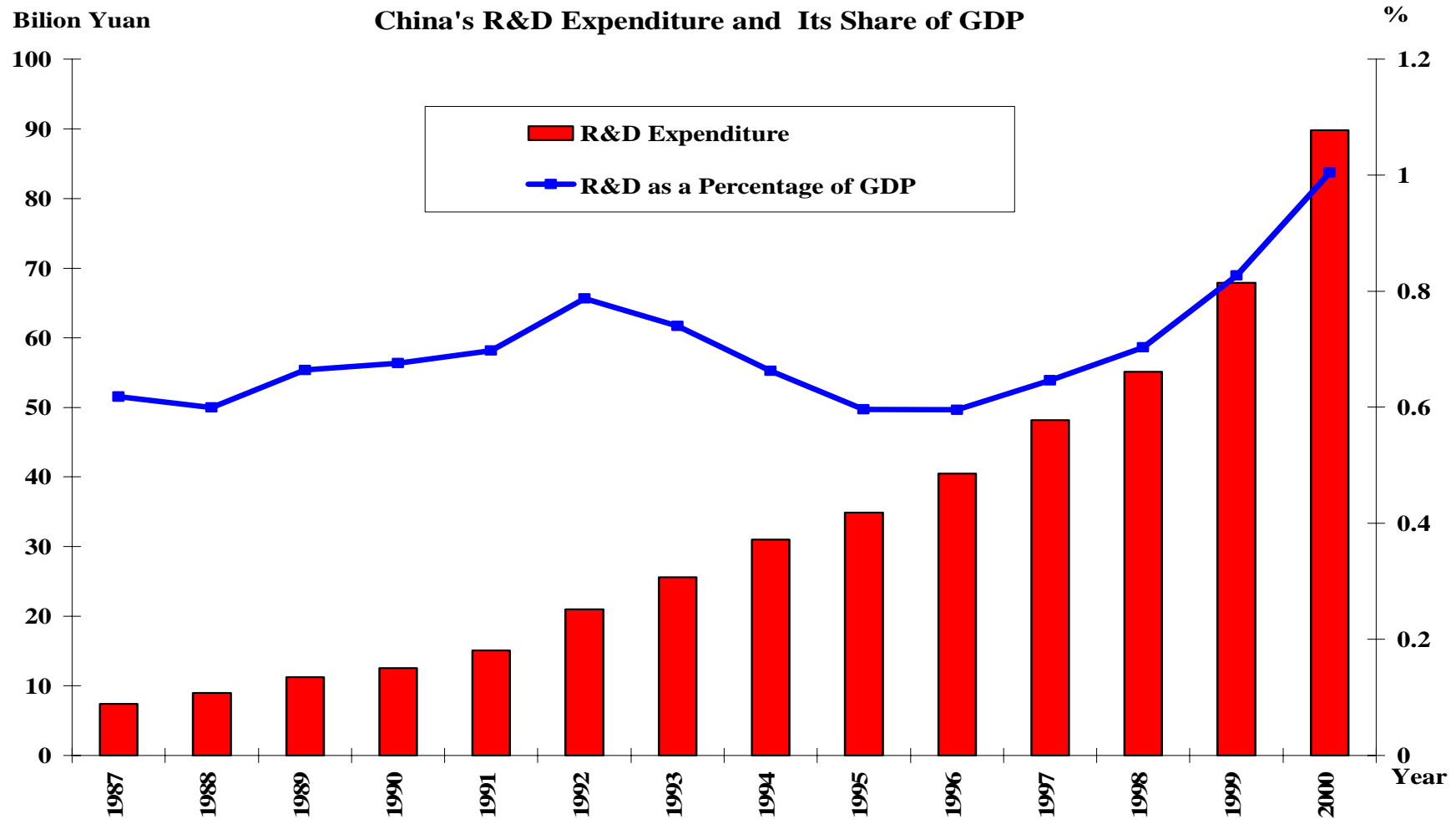
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# R&D Capital Stock per Unit Labor

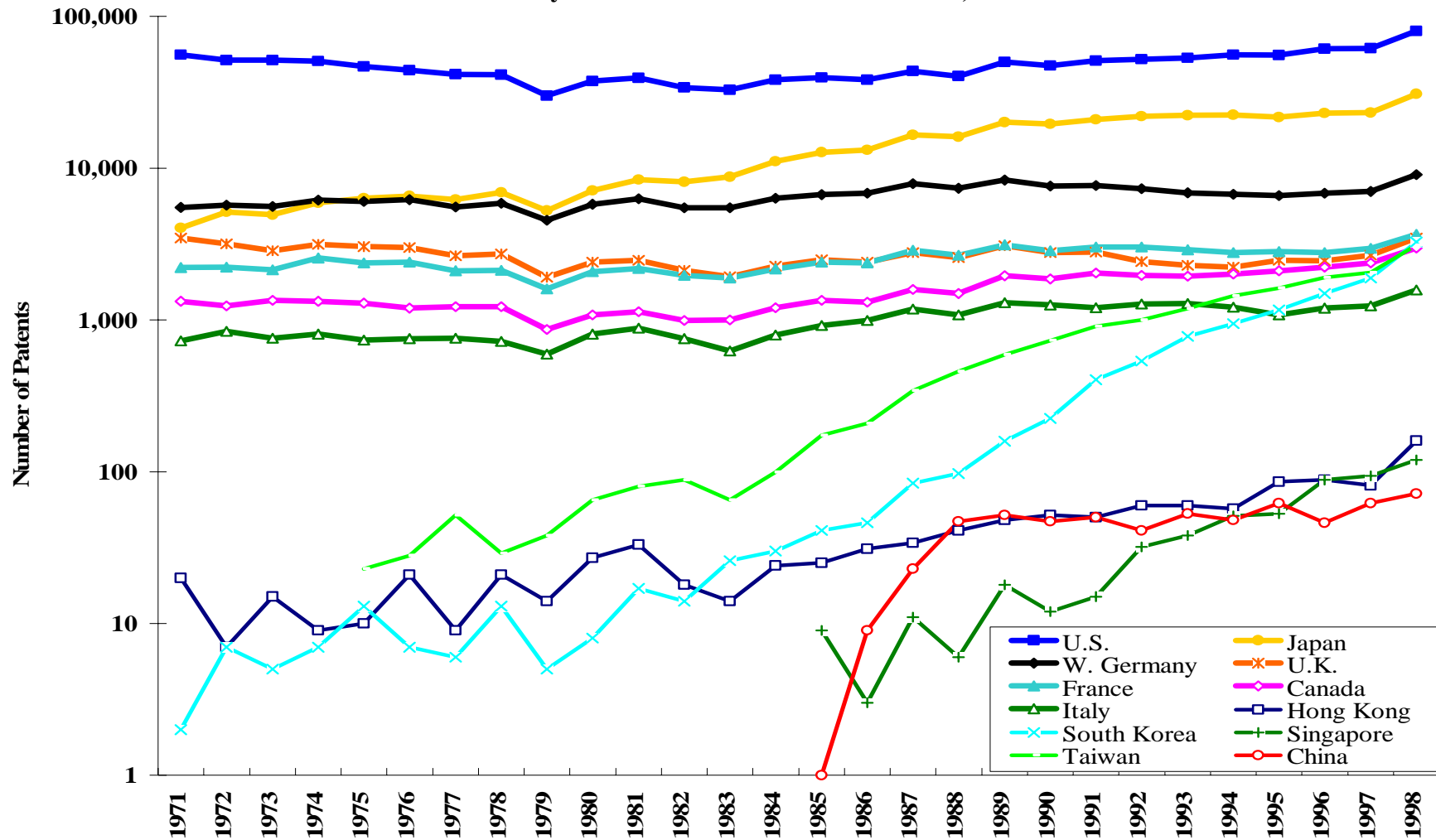


# R&D Expenditures: China



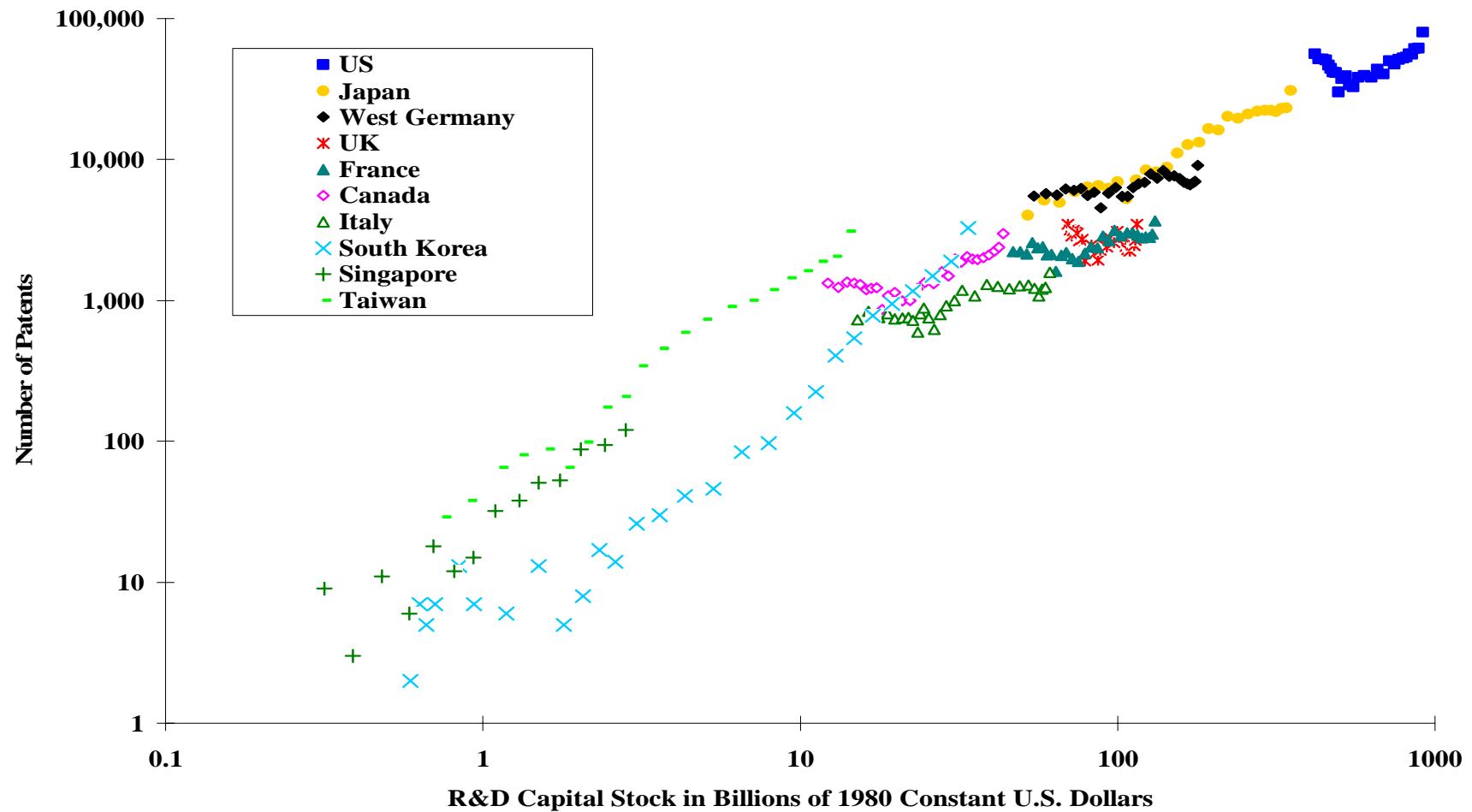
# Patents Granted in the United States: G-7 Countries and East Asian Developing Countries

Table 8.3: Patents Granted Annually in the United States: G7 Countries, 4 East Asian NIEs and China



# Patents Granted in the United States and R&D Capital Stock

Figure 8.4: The Number of U.S. Patents Granted Annually vs. R&D Capital Stocks



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

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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<sup>1</sup>

	$c_{iK}=0, \text{ all } i$
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