The Sources of East Asian Economic Growth Revisited

Lawrence J. Lau and Jungsoo Park

Stanford University and the State University of New York at Buffalo

Economic Development and International Economics Seminar
Department of Economics
Stanford University
May 19, 2004

Phone: 1-650-723-3708; Fax: 1-650-723-7145
Email: LJLAU@STANFORD.EDU; WebPages: WWW.STANFORD.EDU/~LJLAU

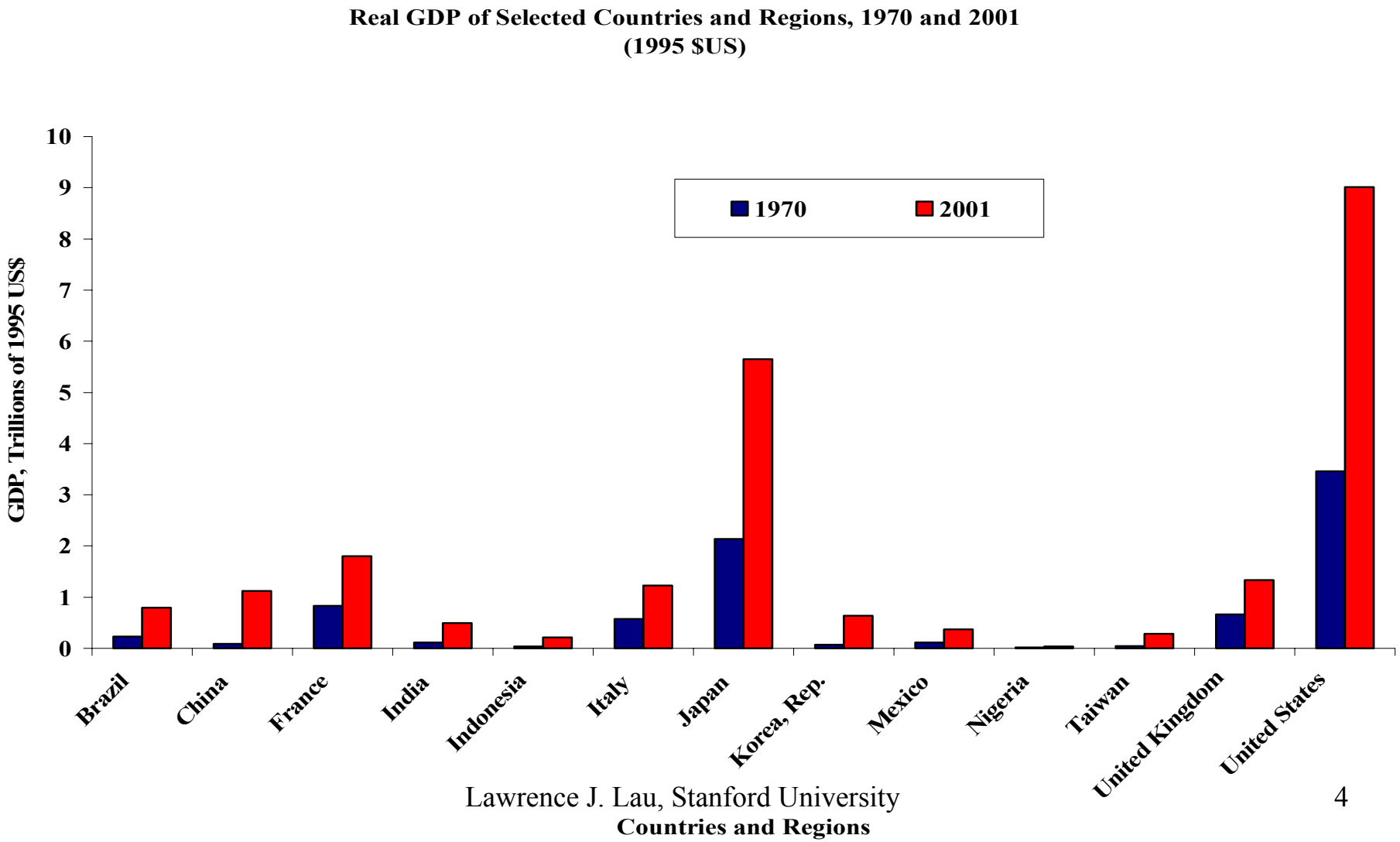
Preview

- Accounting for Growth in the Real Output of an Economy
- The Methodology
- The Empirical Experience of East Asian and Other Economies
  - Tangible Input (in particular tangible capital) -Driven Growth in the Early Stage of Economic Development
  - Intangible Input- or Technical Progress-Driven Growth in the Mature Stage of Economic Development
- Prospects of Future Economic Growth for East Asian Developing Economies

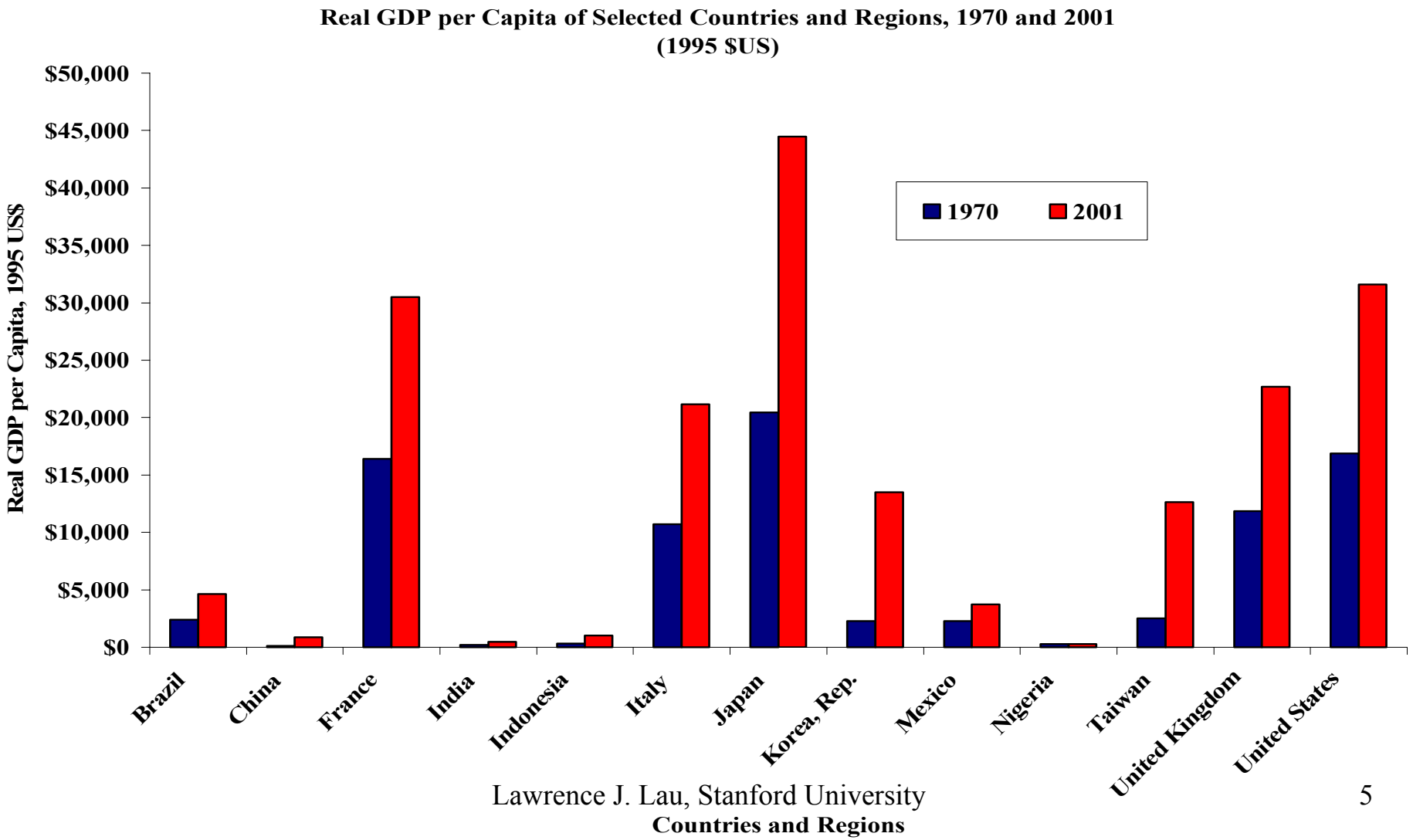
What Are the Sources of Long-Term Economic Growth?

- Great dispersion in the levels and rates of growth of real GDP and real GDP per capita across economies
- What are the causes of these differences? Can the differences be explained by the differences in the levels and rates of growth in measured inputs such as tangible or physical capital (structure and equipment), labor hours, and land?
- How important is technical progress, or equivalently improvements in productive efficiency, or growth in total factor productivity, in explaining these differences?
- What are the sources of growth of real aggregate output over time?

Real GDP of Selected Countries and Regions, 1970 and 2001



Real GDP per Capita of Selected Countries and Regions, 1970 and 2001



Accounting for Economic Growth

- Growth accounting is a methodology for decomposing the growth of output by its proximate sources:
  - How much of the growth of output can be attributed to the growth of measured inputs, tangible capital and labor (and land—the land input is not normally included as a source of growth of output because it is fixed in quantity)? and
  - How much of the growth of output can be attributed to technical progress (also known as growth in total factor productivity, multifactor productivity, "the residual," or "a measure of our ignorance") or improvements in productive efficiency over time.
- **TECHNICAL PROGRESS (GROWTH IN TOTAL FACTOR PRODUCTIVITY) = GROWTH IN OUTPUT HOLDING ALL <u>MEASURED</u> INPUTS CONSTANT**
- How much of the growth in real output is due to "working harder"? How much is due to "working smarter"?

Interpretation of Technical Progress (Growth of Total Factor Productivity)

- Not "Manna from Heaven"
- The effects of growth in unmeasured "Intangible Capital" (Human Capital, R&D Capital, Goodwill and Reputational Capital (Advertising, Branding and Market Development), Information System, Software, Business Methods, etc.)
- The effects of growth or degradation and depletion in other omitted and unmeasured inputs (Land, Natural Resources, Water Resources, Environment, etc.)
- The effects of improvements in technical and allocative efficiency over time, e.g., learning-by-doing
- "Residual" or "Measure of Our Ignorance"

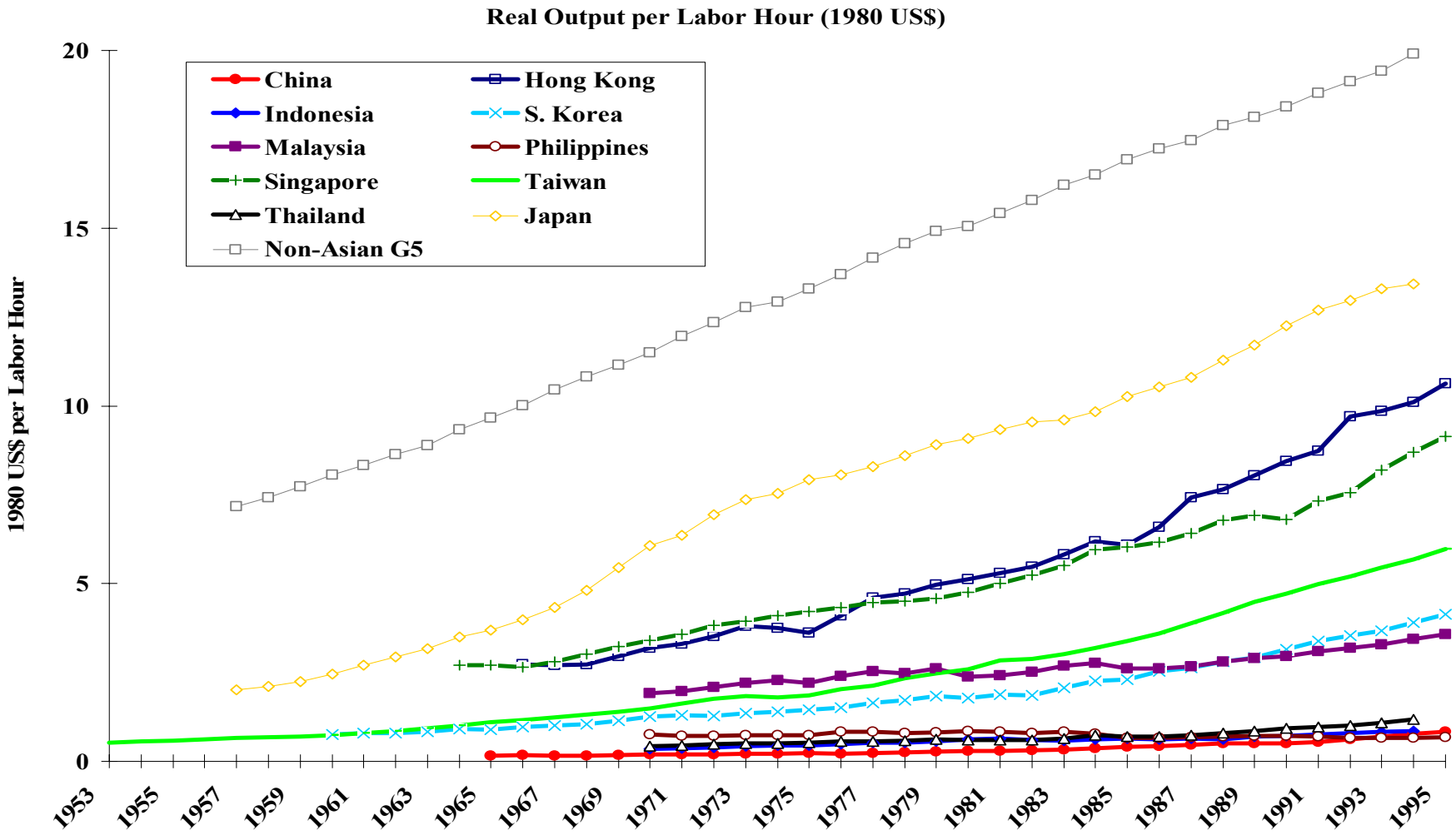
Rates of Growth of Inputs & Outputs of the East Asian Developing & the G-7 Countries

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

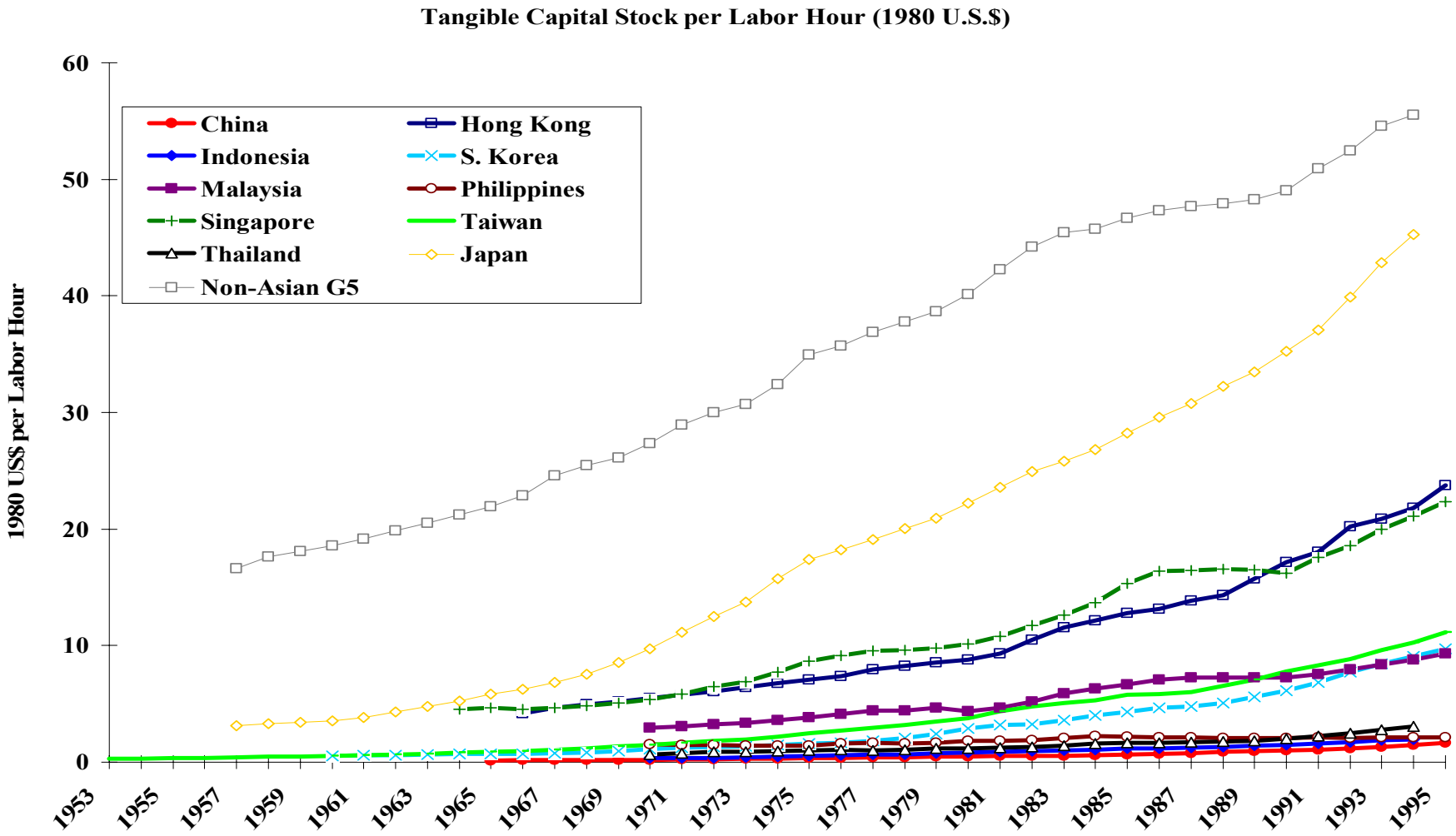
	Sample Period	Output (Real GDP)	Tangible Capital Stock	Utilized Tangible Capital	Employment	Total Labor Hours	Average Years of Education of the Working-Age Population[1]	Total Years of Education of the Working-Age Population[1]	Average Share of Labor Earnings to GDP
Hong Kong	66-95	7.36	8.79	8.79	2.56	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.

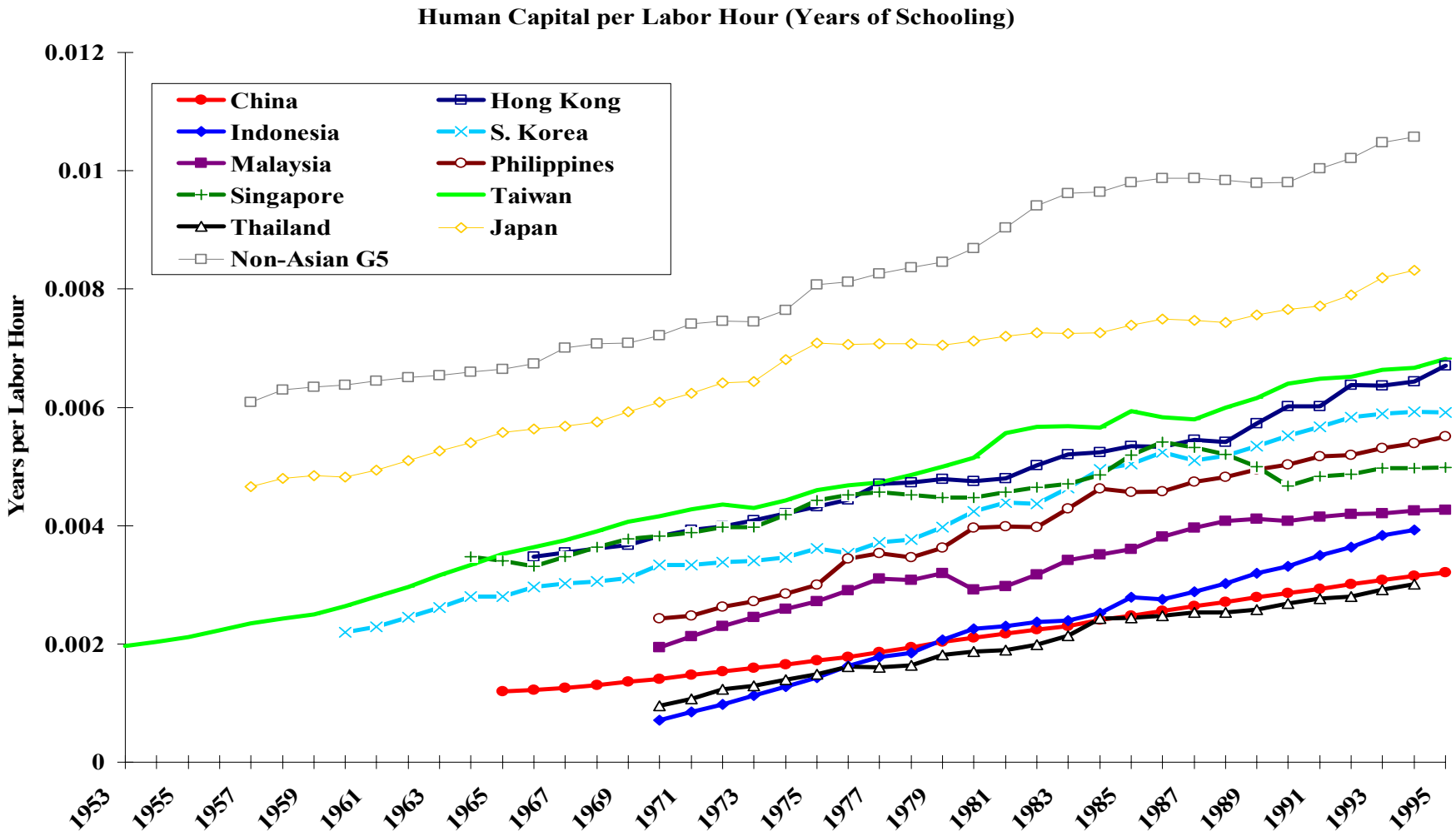
Real Output per Labor Hour (1980 US$)



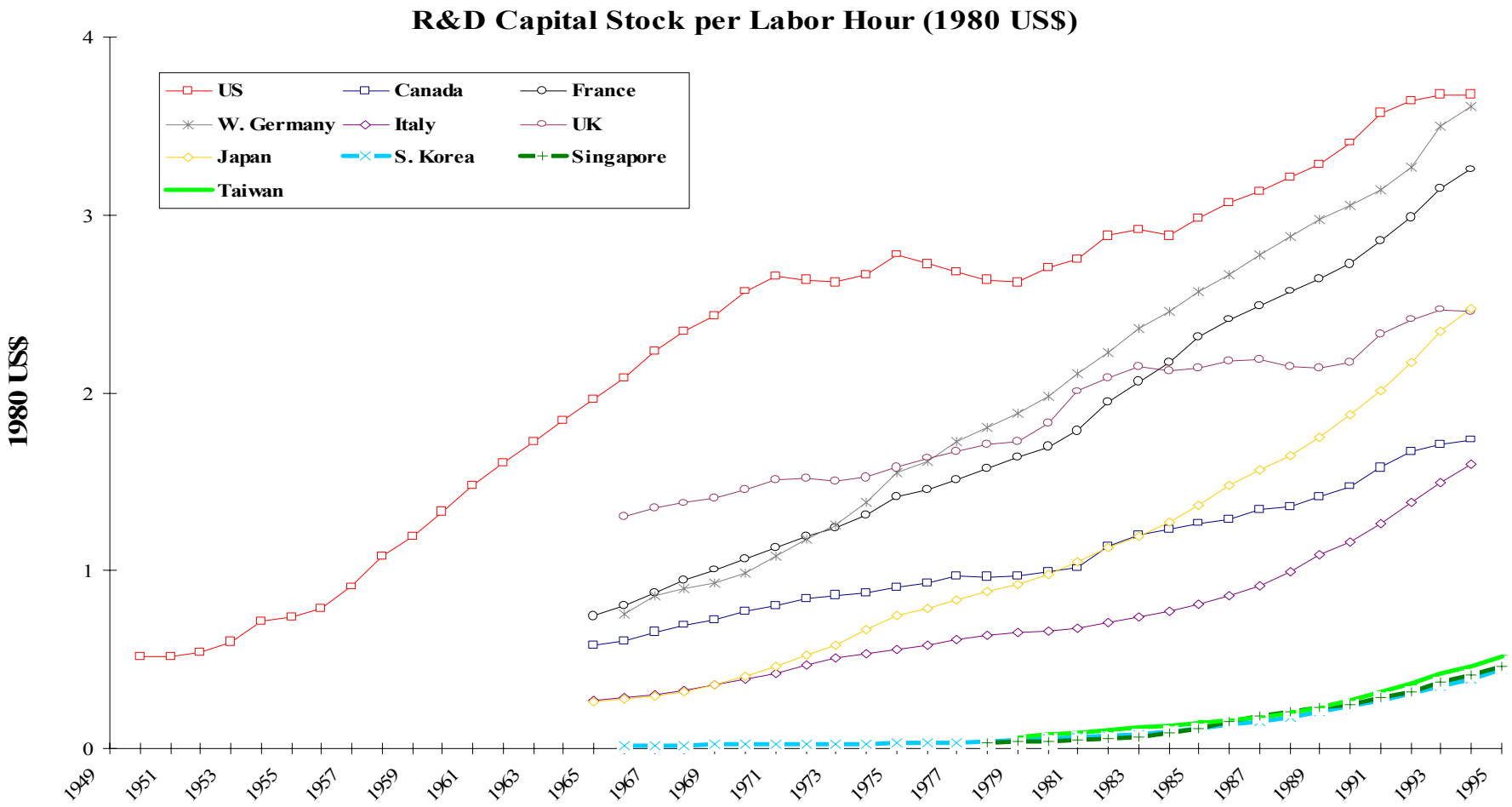
Tangible Capital Stock per Labor Hour (1980 US$): Selected Economies



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



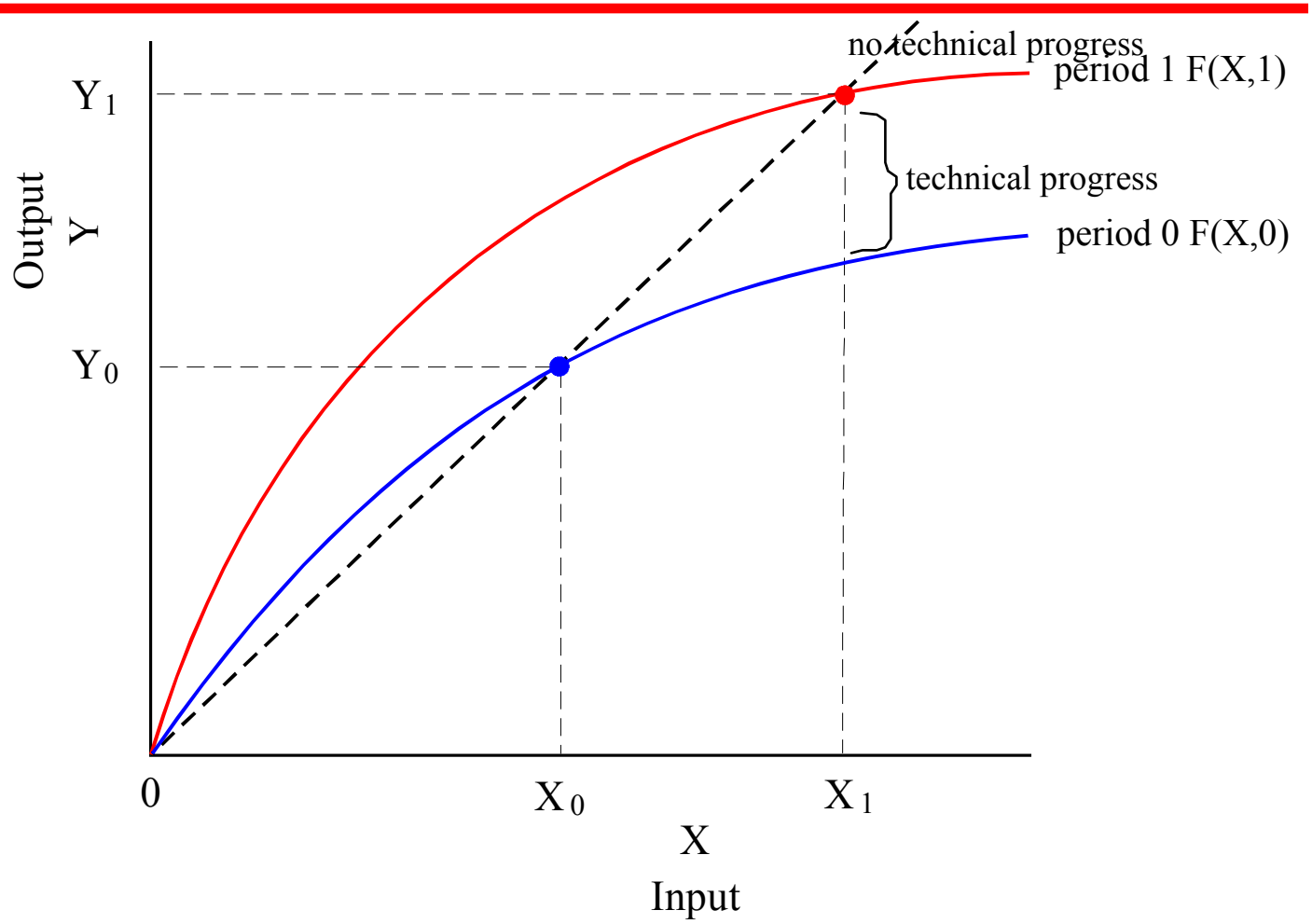
R&D Capital Stock per Unit Labor



Difficulties in the Measurement of Technical Progress (Total Factor Productivity)

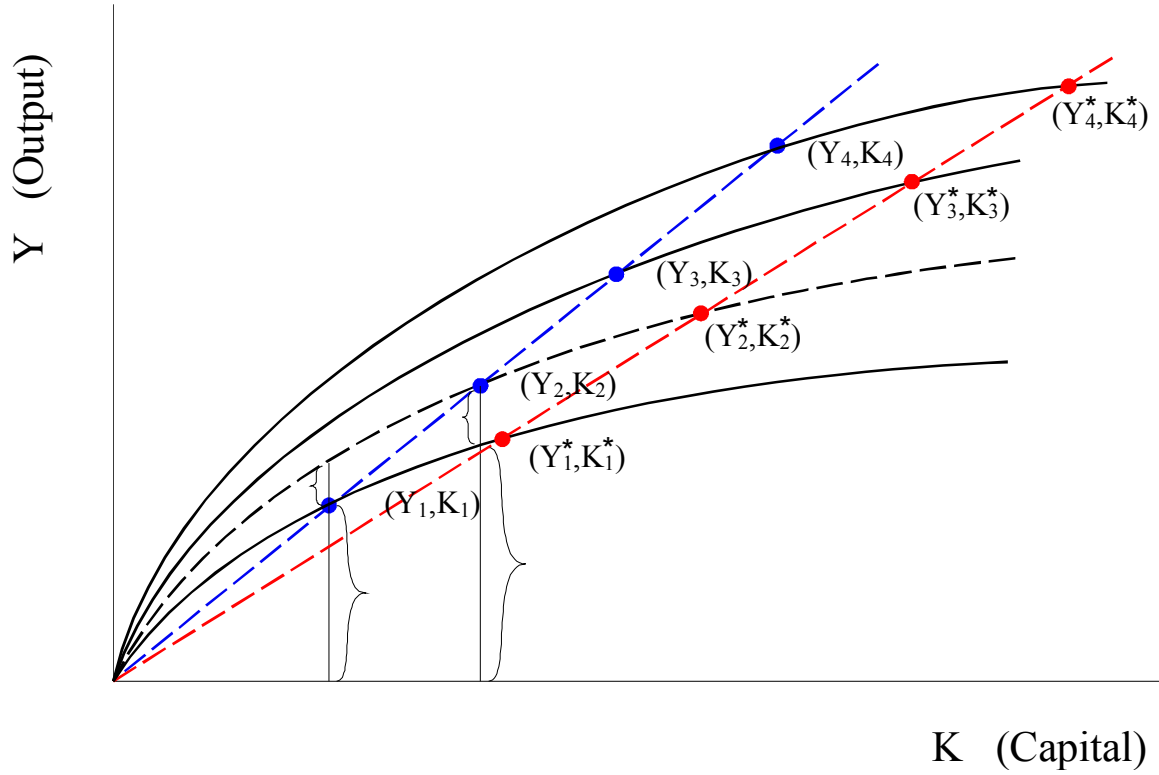
- (1) The confounding of economies of scale and technical progress
  - Solution: pooling time-series data across different countries--at any given time there are different scales in operation; the same scale can be observed at different times
- (2) The under-identification of the biases of scale effects and technical progress
  - Bias in scale effects--as output is expanded under conditions of constant prices of inputs, the demands for different inputs are increased at differential rates
  - Bias in technical progress--over time, again under constant prices, the demands of different inputs per unit output decreases at different rates
  - Solution: econometric estimation with flexible functional forms

Under-Identification of Technical Progress from a Single Time-Series of Empirical Data



Identification of Scale Effects and Technical Progress through Pooling Across Countries

Identification through Pooling



Two Leading Alternative Approaches to Growth Accounting

- (1) Econometric Estimation of the Aggregate Production Function, E.g., the Cobb-Douglas production function

$$Y_t = A_0 e^{\gamma t} K_t^{\alpha} L_t^{\beta}$$

$$\text{or, taking natural logarithms}$$

$$\ln Y_t = \ln A_0 + \alpha \ln K_t + \beta \ln L_t + \gamma t$$

- (2) Traditional Growth-Accounting Formula
- **Are Differences in Empirical Results Due to Differences in Methodologies or Assumptions or Both?**

Pitfalls of Traditional Growth Accounting (1)

- (1) If returns to scale are increasing, technical progress is over-estimated and the contribution of the inputs is underestimated (and vice versa);
- (2) Nonneutrality prevents simple cumulation over time;
- (3) Constraints to instantaneous adjustments and/or monopolistic or monopsonistic influences may cause production elasticities to deviate from the factor shares, and hence the estimates of technical progress as well as the contributions of inputs using the factor shares may be biased;

Pitfalls of Traditional Growth Accounting (2)

- (4) With more than two fixed or quasi-fixed inputs, their output elasticities cannot be separately identified even under constant returns.

The Meta-Production Function Approach as an Alternative

- Introduced by Hayami (1969) and Hayami & Ruttan (1970, 1985)
- Haymai & Ruttan assume that $F_i(.) = F(.)$:
  - $Y_{it} = F(K_{it}, L_{it}, t)$, $i = 1, \ldots, n$; $t = 0, \ldots, T$
- Which implies that all countries have identical production functions in terms of measured inputs
- Thus pooling of data across multiple countries is justified

Extension by Boskin, Lau & Yotopoulos

- Extended by Lau & Yotopoulos (1989) and Boskin & Lau (1990) to allow time-varying, country- and commodity-specific differences in efficiency
- Applied by Boskin, Kim, Lau, & Park to the G-5 countries, G-7 countries, the East Asian Newly Industrialized Economies (NIEs) and developing economies in the Asia/Pacific region

The Extended Meta-Production Function Approach: The Basic Assumptions (1)

(1) All countries have the same underlying aggregate production function F(.) in terms of standardized, or "**efficiency-equivalent**", quantities of outputs and inputs, i.e.

(1) $$Y^*_{it} = F(K^*_{it}, L^*_{it}) \ , \ i = 1,...,n.$$

The Extended Meta-Production Function Approach: The Basic Assumptions (2)

(2) The measured quantities of outputs and inputs of the different countries may be converted into the unobservable standardized, or "efficiency-equivalent", units of outputs and inputs by multiplicative country- and output- and input-specific time-varying **augmentation factors**, $A_{ij}(t)$'s, i = 1,...,n; j = output (0), capital (K), and labor (L):

(2) $$Y^*_{it} = A_{i0}(t)Y_{it} \ ;$$

(3) $$K^*_{it} = A_{iK}(t)K_{it} \ ;$$

(4) $$L^*_{it} = A_{iL}(t)L_{it} \ ; \ i = 1, \ldots, n.$$

The Commodity-Augmenting Representation of Technical Progress

One specialization of

$Y = F(K, L, t)$ is

$Y^* = F(K^*, L^*)$, where

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

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

The Extended Meta-Production Function Approach: The Basic Assumptions (2)

- In the empirical implementation, the commodity augmentation factors are assumed to have the constant geometric form with respect to time. Thus:

(5) $Y^*_{it} = A_{i0}\,(1+c_{i0})^t Y_{it}$;

(6) $K^*_{it} = A_{iK}\,(1+c_{iK})^t K_{it}$;

(7) $L^*_{it} = A_{iL}\,(1+c_{iL})^t L_{it}$; $i = 1,\ldots,n.$

A_{i0}'s, A_{ij}'s = augmentation level parameters

c_{i0}'s, c_{ij}'s = augmentation rate parameters

The Extended Meta-Production Function Approach: The Basic Assumptions (2)

- For at least one country, say the ith, the constants A_{i0} and A_{ij}'s can be set identically at unity, reflecting the fact that "efficiency-equivalent" outputs and inputs can be measured only relative to some standard.
- The A_{i0} and A_{ij}'s for the U.S. are taken to be identically unity.
- Subject to such a normalization, the commodity augmentation level and rate parameters can be estimated simultaneously with the parameters of the aggregate production function.

The Extended Meta-Production Function Approach: The Basic Assumptions (2)

- It is important to understand that the meta-production function approach assumes that the production function is identical for all countries only in terms of the efficiency-equivalent quantities of outputs and inputs; it is not identical in terms of measured quantities of outputs and inputs.
- A useful way to think about what is the same across countries is the following—the isoquants remain the same for all countries and over time with a suitable, possibly time-varying, renumbering of the isoquants and a suitable, possibly time-varying, re-scaling of the input axes.

The Extended Meta-Production Function Approach: The Basic Assumptions (3)

(3) The aggregate meta-production function is assumed to have a flexible functional form, e.g. the transcendental logarithmic functional form of Christensen, Jorgenson & Lau (1973).

The Extended Meta-Production Function Approach: The Basic Assumptions (3)

- The translog production function, in terms of "efficiency-equivalent" output and inputs, takes the form:

$$(8)\ \ln Y^*_{it} = \ln Y_0 + a_K \ln K^*_{it} + a_L \ln L^*_{it} + B_{KK}(\ln K^*_{it})^2/2 + B_{LL}(\ln L^*_{it})^2/2 + B_{KL}(\ln K^*_{it})(\ln L^*_{it}),\ i = 1,\ldots,n.$$

- By substituting equations (5) through (7) into equation (8), and simplifying, we obtain equation (9), which is written entirely in terms of **observable** variables:

The Estimating Equation

(9) $$\ln Y_{it} = \ln Y_0 + \ln A^*_{i0} + a^*_{Ki} \ln K_{it} + a^*_{Li} \ln L_{it}$$
$$+ c^*_{i0} t + B_{KK}(\ln K_{it})^2/2 + B_{LL}(\ln L_{it})^2/2 + B_{KL}(\ln K_{it})$$
$$(\ln L_{it}) + (B_{KK} \ln(1+c_{iK}) + B_{KL} \ln(1+c_{iL}))(\ln K_{it})t$$
$$+ (B_{KL} \ln(1+c_{iK}) + B_{LL} \ln(1+c_{iL}))(\ln L_{it})t$$
$$+ (B_{KK}(\ln(1+c_{iK}))^2 + B_{LL}(\ln(1+c_{iL}))^2$$
$$+ 2B_{KL} \ln(1+c_{iK}) \ln(1+c_{iL}))t^2/2,$$

$i = 1,...,n$, where A^*_{i0}, a^*_{Ki}, a^*_{Li}, c^*_{i0} and c_{ij}'s, $j = K, L$ are country-specific constants.

Tests of the Maintained Hypotheses of the Meta-Production Function Approach

- The parameters B_{KK}, B_{KL}, and B_{LL} are independent of i, i.e., of the particular individual country. This provides a basis for testing the maintained hypothesis that there is a single aggregate meta-production function for all the countries.
- The parameter corresponding to the $t^2/2$ term for each country is not independent but is completely determined given B_{KK}, B_{KL}, B_{LL} , c_{iK}, and c_{iL}. This provides a basis for testing the hypothesis that technical progress may be represented in the constant geometric commodity-augmentation form.

The Labor Share Equation and the Hypothesis of Instantaneous Profit Maximization

- In addition, we also consider the behavior of the share of labor costs in the value of output:

  (10) $w_{it}L_{it}/p_{it}Y_{it}$
  $= a^*_{Lii} + B_{KLi}(\ln K_{it}) + B_{LLi}(\ln L_{it}) + B_{Lti}t,\ i = 1,...,n.$

- Under the assumption of instantaneous profit maximization under competitive output and labor markets, the share of labor costs in the value of output should be equal to the elasticity of output with respect to labor:

  (11) $w_{it}L_{it}/p_{it}Y_{it}$
  $= a^*_{Li} + B_{KL}(\ln K_{it}) + B_{LL}(\ln L_{it})$
  $+(B_{KL}\ln(1+c_{iK}) + B_{LL}\ln(1+c_{iL}))t, \qquad i = 1,...,n.$

- This provides a basis for testing the hypothesis of profit maximization with respect to labor.

Test of Hypotheses: The Meta-Production Function Approach

- The maintained hypotheses of the meta-production function approach
  - "Identical Meta-Production Functions" and
  - "Commodity-Augmentation Representation of Technical Progress"
- Hypotheses on the nature of the production technology
  - Identical augmentation level parameters across economies
  - The three different kinds of purely commodity-augmenting technical progress
- The hypothesis of no technical progress

Tests of the Maintained Hypotheses of Traditional Growth Accounting

- **Homogeneity**

  $B_{KK} + B_{KL} = 0;$

  $B_{KL} + B_{LL} = 0.$

- **Constant returns to scale**

  $a^*_{Ki} + a^*_{Li} = 1.$

- **Neutrality of technical progress**

  $c_{iK} = 0;\ c_{iL} = 0.$

The Three Different Kinds of Purely Commodity-Augmenting Technical Progress

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

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

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

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

The Sources of Economic Growth: Findings of Kim & Lau As Reported by Krugman (1994)

- Using data from the early 1950s to the late 1980s, Kim and Lau (1992, 1994a, 1994b) find, by estimating a meta-production function for the G-5 and the 4 Newly Industrialized Economies (NIEs—Hong Kong, South Korea, Singapore and Taiwan) that:
- (1) No technical progress in the East Asian NIEs but significant technical progress in the industrialized economies (IEs)
- (2) East Asian economic growth has been tangible inputs-driven, with tangible capital accumulation as the most important source of economic growth (the latter applying also to Japan)
  - Working harder as opposed to working smarter
- (3) Technical progress is the most important source of economic growth for the IEs, followed by tangible capital, accounting for over 50% and 30% respectively, with the exception of Japan
  - NOTE THE UNIQUE POSITION OF JAPAN!
- (4) Despite their high rates of economic growth and rapid capital accumulation, the East Asian Newly Industrialized Economies actually experienced a significant decline in productive efficiency relative to the industrialized countries as a group

The Findings of Kim & Lau (1992, 1994a, 1994b)

- (5) Technical progress is purely tangible capital-augmenting and hence complementary to tangible capital, confirming the earlier findings of Boskin and Lau for the Group-of-Five (G-5) Countries
- (6) Technical progress being purely tangible capital-augmenting implies that it is less likely to cause technological unemployment than if it were purely labor-augmenting
- (7) Similar results are obtained when China and the ASEAN countries of Indonesia, Malaysia, Philippines and Thailand are included in the sample.

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

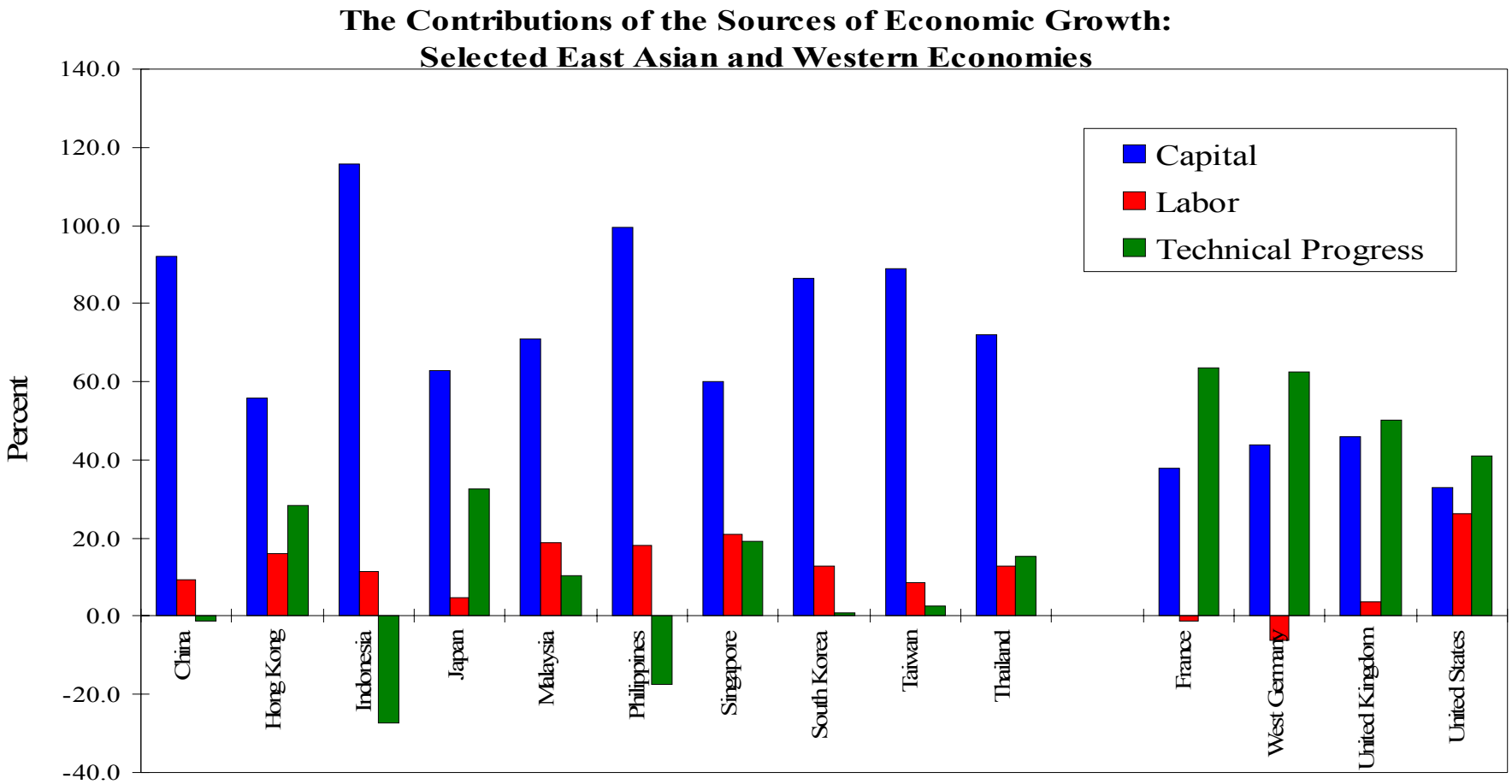
Table 2.2: Relative Contributions of the Sources of Economic Growth (percent)				
Economy	Tangible Capital	Labor	Technical Progress	
Hong Kong	74	26	0	
Singapore	68	32	0	
S. Korea	80	20	0	
Taiwan	85	15	0	
Japan	56	5	39	
Non-Asian G-5	36	6	59	

Accounts of Growth: Selected East Asian and Western Economies (Kim & Lau, 1996)

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

Accounts of Growth: Selected East Asian and Western Economies (Kim & Lau, 1996)



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) and Iwata, Khan and Murao (2002)
- Credibility of such studies undermined by restrictive maintained hypotheses such as
  - CONSTANT RETURNS TO SCALE
  - NEUTRALITY OF TECHNICAL PROGRESS &
  - INSTANTANEOUS COMPETITIVE PROFIT MAXIMIZATION
- And sometimes by the additional assumption of a Cobb-Douglas production function with identical production elasticities across all economies

Tests of Hypotheses on Augmented Sample

Tested Hypothesis	Maintained Hypothesis	Assigned Level of Significance	Degrees of Freedom Number of Restrictions	Test Statistics chi-sq/degrees of freedom chi-sq	p-value
I. Single Meta Production Function	Unrestricted	0.01	24	1.11	0.3331
II. Factor Augmentation	I	0.01	9	0.67	0.7369
III. Traditional Maintained Hypotheses					
(1) Homogeneity	I+II	0.005	2	19.97	0.0000
(2) Constant Returns to Scale	I+II	0.005	3	16.02	0.0000
(3) Neutrality	I+II	0.01	18	4.3	0.0000
(4) Profit Maximazation	I+II	0.01	27	1.96	0.0020
IV. Identical Augmentation Levels of					
(1) Capital	I+II	0.01	8	1.83	0.0665
(2) Labor	I+II	0.01	8	1.16	0.3192
V. Zero Technical Progress					
(1) G-5 Countries	I+II	0.01	15	18.1	0.0000
(2) East Asian NIEs	I+II	0.01	12	1.23	0.2548
VI. Purely Capital-Augmenting Tech. Pro.	I+II	0.01	18	1.8	0.0197

Test Results: The Meta-Production Function Approach

- The Maintained Hypotheses of the Meta-Production Function Approach
  - "Identical Meta-Production Functions" and
  - "Factor-Augmentation Representation of Technical Progress"
- Cannot be rejected.

The Maintained Hypotheses of Traditional Growth Accounting

- The Maintained Hypotheses of Traditional Growth Accounting, viz.:
  - Constant Returns to Scale
    - Homogeneity of the production function is implied by constant returns to scale--a production function F(K, L) is homogeneous of degree k if:

      $$F(\kappa K, \kappa L) = \kappa^k F(K, L)$$

    - Constant returns to scale imply k=1; Increasing returns to scale imply k>1; decreasing returns to scale imply k<1
  - Neutrality of Technical Progress
  - Instantaneous Profit Maximization under Competitive Output and Input Markets
- Are all rejected.

The Hypothesis of No Technical Progress

- $c_{i0} = 0$; $c_{iK} = 0$; $c_{iL} = 0$.
- This hypothesis is rejected for the Group-of-Five Countries.
- This hypothesis cannot be rejected for the East Asian NIEs.

Purely Capital-Augmenting Technical Progress

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

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

$$= A_0 F(A_K(1+c_{iK})^t K,\, A_L L)$$

The production function can also be written as:

$$= A_0 F(A_K e^{c_{iK} \cdot t} K,\, A_L L)$$

Implications of the Hypothesis of Purely Capital-Augmenting Technical Progress

- Technical progress is not labor-augmenting, i.e., not simply equivalent to more labor (One thousand janitors are not equivalent to a Kenneth Arrow); instead, it is equivalent to more capital.
- Capital-augmenting technical progress implies the complementarity between tangible capital and technical progress (intangible capital).
- The existence of a steady state can no longer be assured.

The Estimated Parameters of the Aggregate Meta-Production Function

Table 6.2	Estimated Parameters of the Aggregate Production Function					
Parameter	I+II+IV+V(2)+VI		I+II+IV+VI	
Y_0	0.293	(399.295)	0.331	(318.414)
a_K	0.256	(8.103)	0.245	(7.929)
a_L	0.63	(6.666)	0.524	(5.077)
B_{KK}	-0.074	(-7.445)	-0.058	(-4.919)
B_{LL}	-0.073	(-1.101)	-0.012	(-0.178)
B_{KL}	0.032	(1.324)	0.025	(1.103)
C_{iK}				
Hong Kong	0		0.062	(2.443)
Singapore	0		0.045	(1.702)
South Korea	0		0.026	(1.197)
Taiwan	0		0.024	(1.523)
France	0.083	(8.735)	0.1	(6.394)
West Germany	0.074	(6.761)	0.089	(5.465)
Japan	0.072	(3.927)	0.098	(3.483)
UK	0.046	(5.749)	0.056	(5.045)
United States	0.061	(7.592)	0.067	(6.321)
R-sq	0.753		0.753	
D.W.	1.448		1.473	

The Hypothesis of No Technical Progress: 2 Inputs, Augmented Sample, No Breaks

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	
	$c_{iK}=0$	Level of Significance	$c_{iK}=0$	Level of Significance
4 NIEs	0.06243	0.01	0.01907	0.005
4 ASEAN + China	N.A.		0.21692	0.005
9 Developing Economies	N.A.		0.07782	
G-5	0.00000	0.01	0.00000	0.01
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

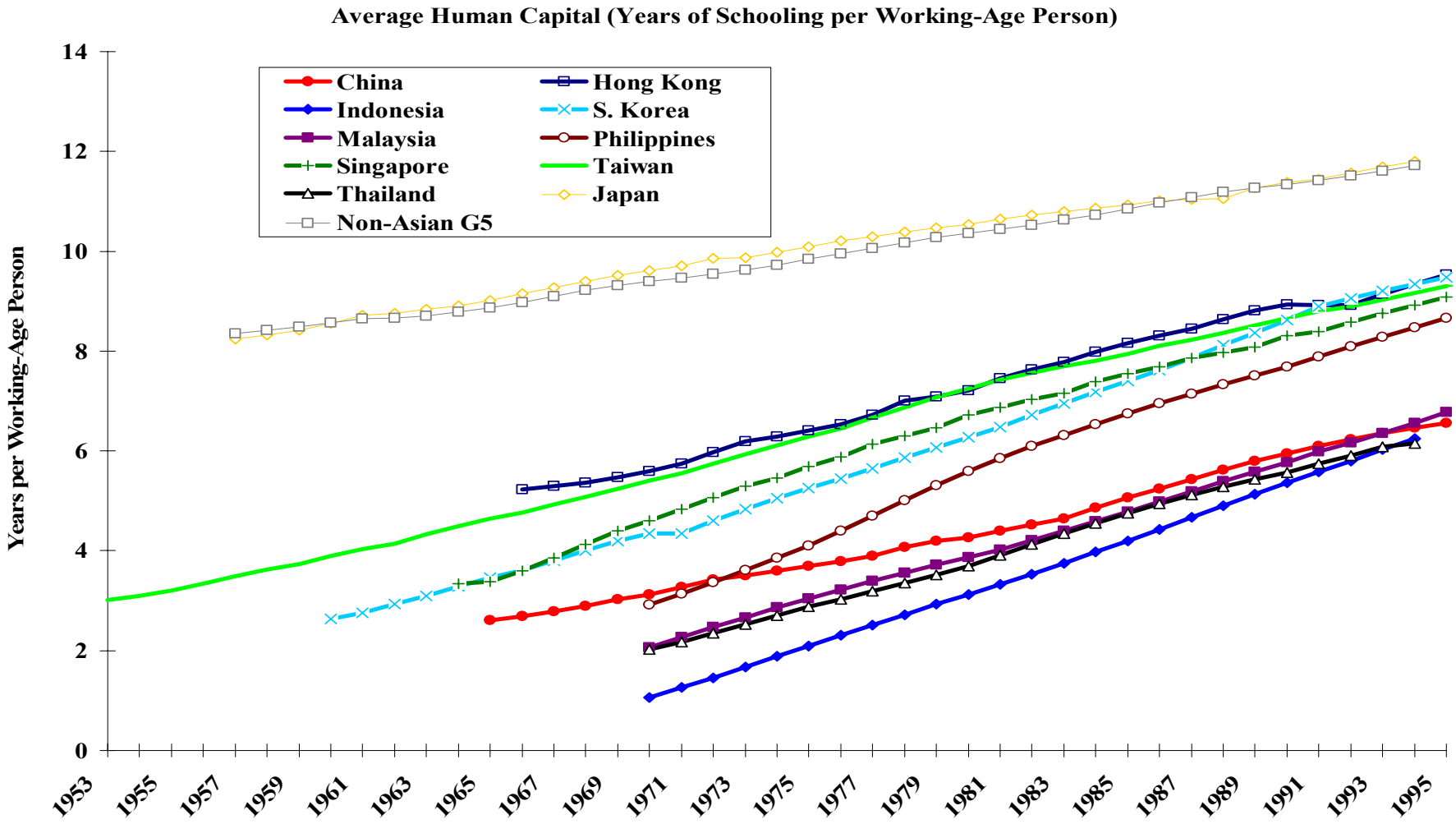
	Tangible Capital	Labor	Technical Progress
Hong Kong	74.46	25.54	0.00
South Korea	78.20	21.80	0.00
Singapore	64.80	35.20	0.00
Taiwan	84.04	15.96	0.00
Japan	49.90	4.84	45.26
Non-Asian G-5 Countries	38.71	2.77	58.52

(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 Table 5.3. 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)



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: 3 Inputs, Augmented Sample, 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	
	$c_{iK}=0$	Level of Significance	$c_{iK}=0$	Level of Significance
4 NIEs	0.12332	0.01	0.02546	0.005
4 ASEAN + China	N.A.		0.08986	0.005
9 Developing Economies	N.A.		0.02954	
G-5	0.00000	0.01	0.00000	0.01
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

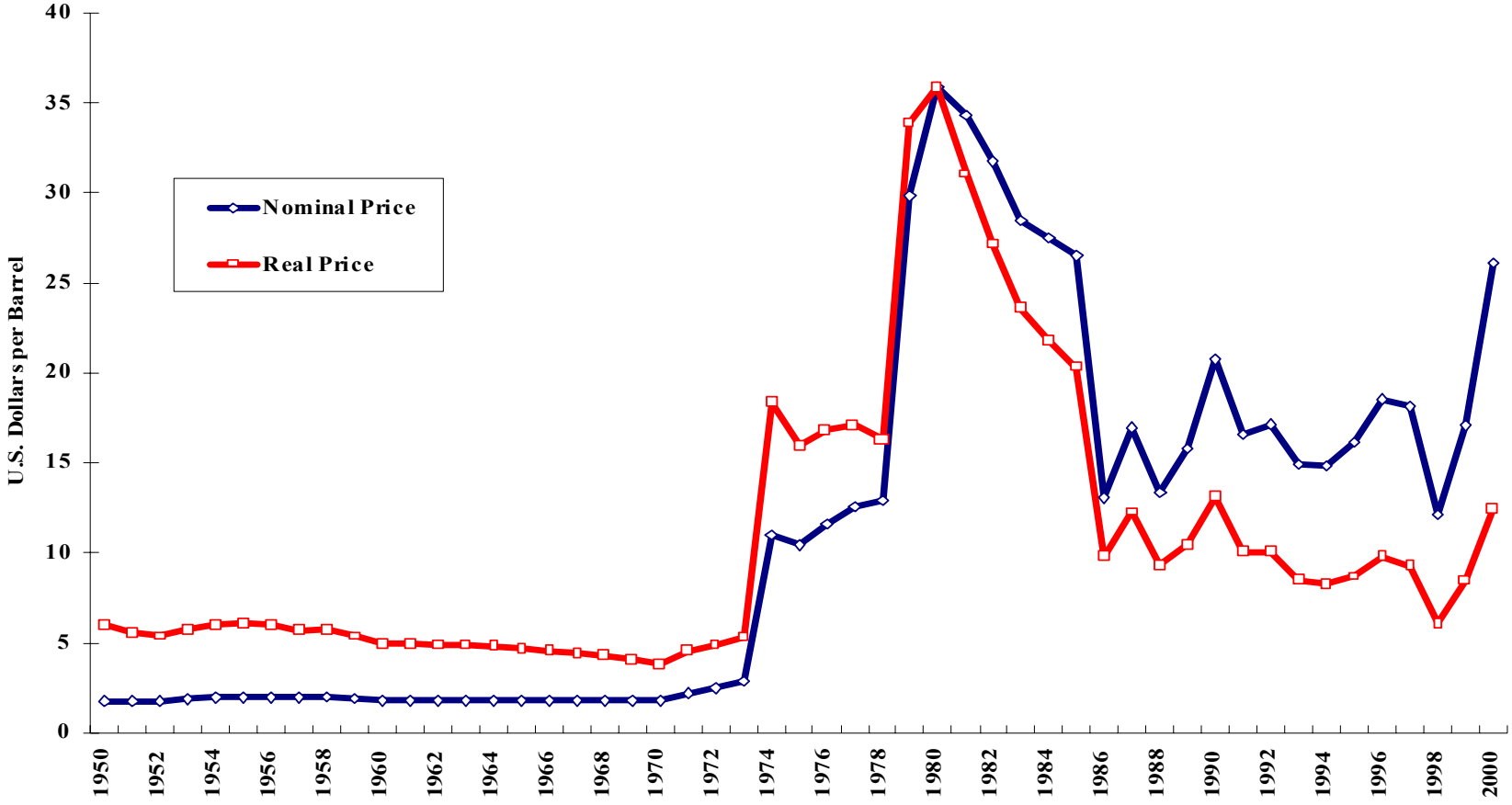
(2) Full Sample: 4 NIEs, 4 ASEAN, China and G-5

	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, Chapter 6, and estimated under the restrictions of $c_{iK}=0$ for all East Asian developing economies.

Nominal and Real Price of Oil

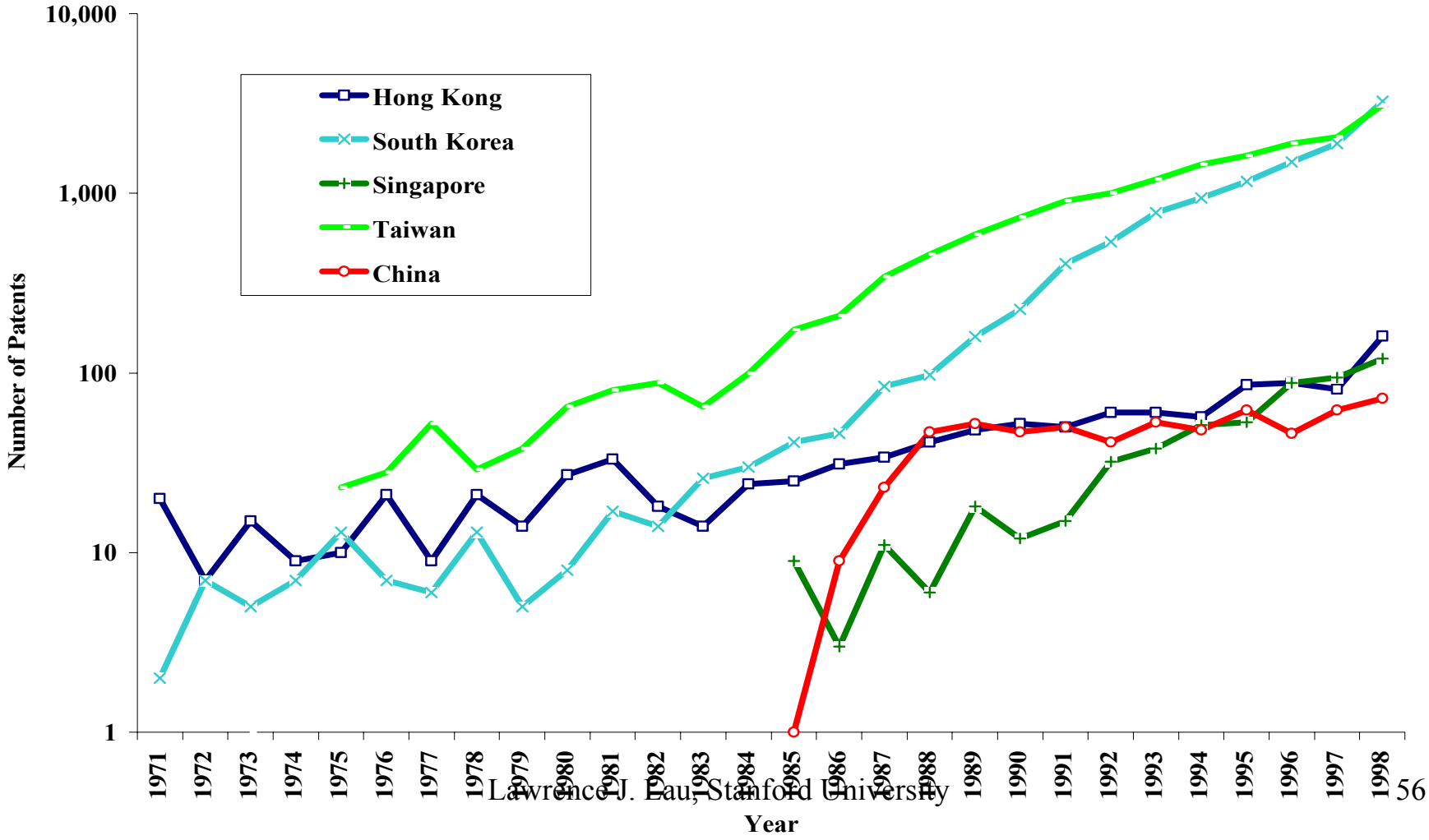
Figure 7.1: Nominal and Real Prices of Oil*



*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)

	Pre-1973 $c_{iK0}=0$[1]	1974-1985 $c_{iK1}=0$[1]	Post-1986 $c_{iK2}=0$[1]
(1) Full Sample : 4 NIEs and G-5			
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 7.4: Growth Accounts: Contributions of the Sources of Growth (Entire Sample Period)
(Three-Input Model with Human Capital and Shifts in the Rates of Capital-Augmentation)

	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
(1) Full Sample : 4 NIEs and G-5					
Hong Kong	66-95	48.41 (8.79)	27.57 (2.44)	8.16 (4.80)	15.86
South Korea	60-95	51.23 (12.28)	24.78 (3.35)	11.59 (6.31)	12.40
Singapore	64-95	46.73(10.23)	32.43 (4.70)	10.86 (5.92)	9.99
Taiwan	53-95	58.26 (11.76)	21.61 (2.33)	9.87 (5.40)	10.27
Japan	57-94	38.89 (7.98)	9.17 (0.56)	3.24 (2.15)	48.70
Non-Asian G-5 Countries	57-94	30.13 (3.52)	7.09 (0.17)	5.21 (1.68)	57.57
(2) Full Sample : 4 NIEs, 4 ASEAN, China and G-5					
Hong Kong	66-95	56.89 (8.79)	23.65 (2.44)	2.51 (4.80)	16.94
South Korea	60-95	65.45 (12.28)	18.62 (3.35)	3.84 (6.31)	12.08
Singapore	64-95	53.10 (10.23)	33.94 (4.70)	3.23 (5.92)	9.73
Taiwan	53-95	71.26 (11.76)	15.61 (2.33)	3.15 (5.40)	9.99
Indonesia	70-94	71.20 (10.88)	14.59 (2.72)	9.38 (10.34)	4.83
Malaysia	70-95	54.22 (9.65)	32.47 (4.68)	5.12 (8.02)	8.19
Philippines	70-95	54.05 (5.40)	37.81 (3.94)	8.15 (7.41)	-0.01
Thailand	70-94	60.84 (9.68)	18.06 (2.93)	5.65 (8.00)	15.44
China	65-95	83.87 (11.63)	11.92 (2.55)	4.21 (5.99)	0.00
Japan	57-94	49.04 (7.98)	5.23 (0.56)	1.08 (2.15)	44.65
Non-Asian G-5 Countries	57-94	37.44 (3.52)	3.36 (0.17)	1.70 (1.68)	57.49

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 and G-5

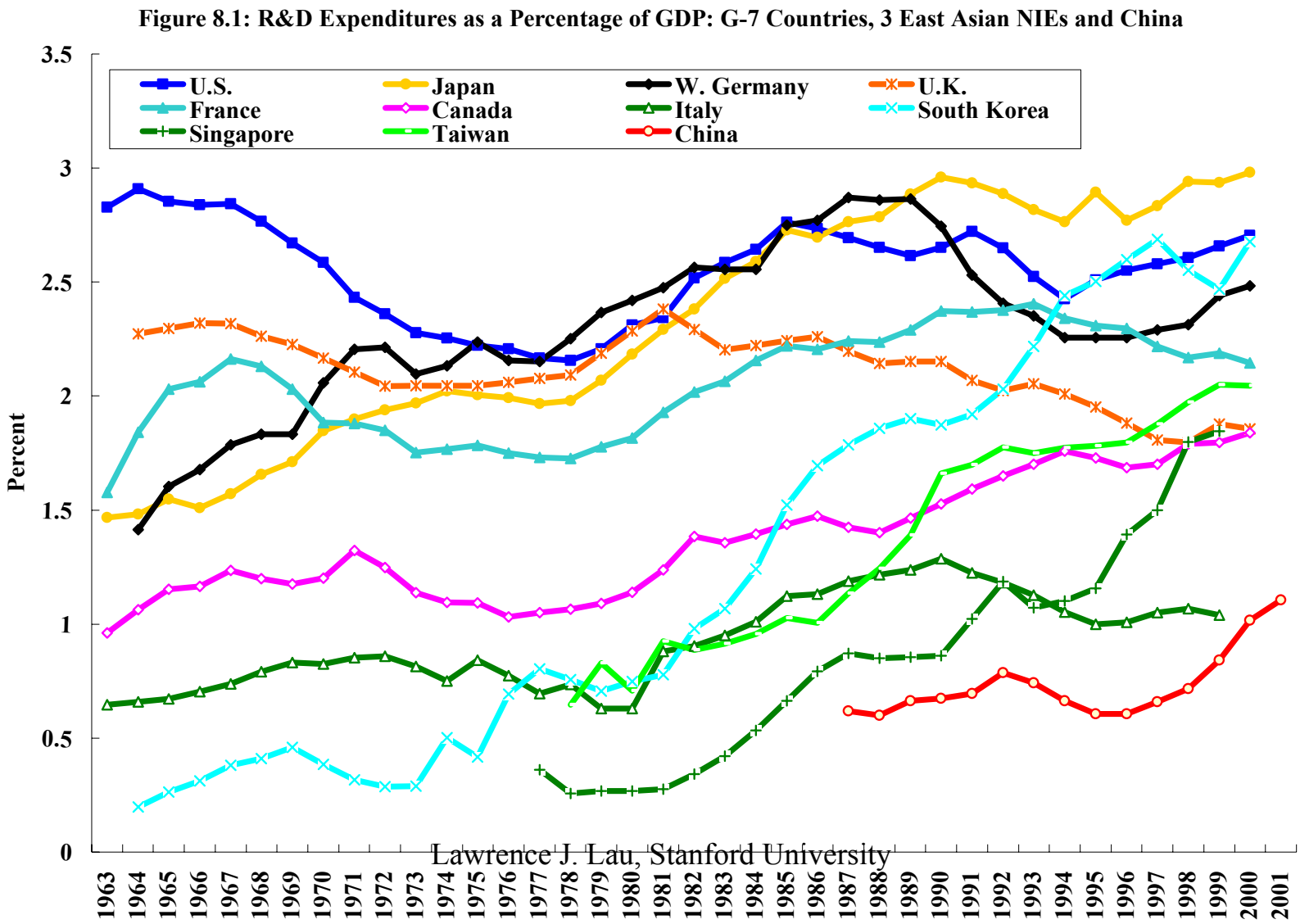
	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
(1) Pre-1973					
Hong Kong	66-73	57.58 (9.67)	32.35 (3.10)	10.07 (5.57)	0.00
South Korea	60-73	55.66 (11.58)	27.99 (4.14)	16.35 (7.70)	0.00
Singapore	64-73	48.87 (12.73)	36.87 (7.56)	14.26 (9.17)	0.00
Taiwan	53-73	65.56 (13.21)	22.20 (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					
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					
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 (4.88)	4.09 (0.31)	3.42 (1.44)	62.05
Non-Asian G-5 Countries	86-94	21.08 (2.70)	18.42 (5.37)	4.68 (1.36)	55.81

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

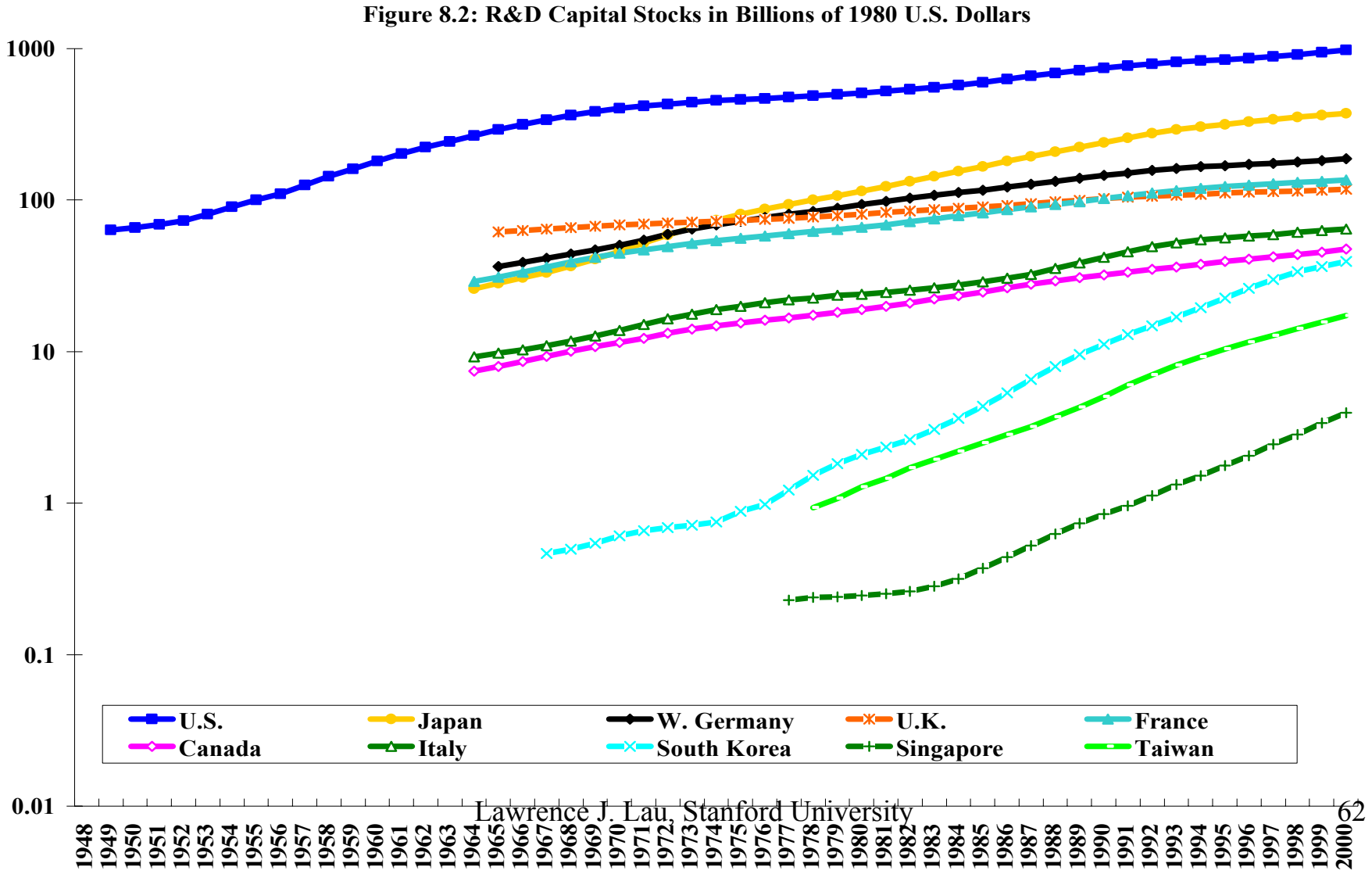
Table 7.5b: Growth Accounts: Contributions of the Sources of Growth (3 Sub-Periods)
(Three-Input Model with Human Capital and Shifts in the Rates of Capital-Augmentation)
Full Sample for 4 NIEs, 4 ASEAN, China and G-5

	Sample period	Tangible Capital	Labor	Human Capital	Technical Progress
(1) Pre—1973					
Hong Kong	66-73	68.37 (9.67)	28.50 (3.10)	3.13 (5.57)	0.00
South Korea	60-73	72.60 (11.58)	21.87 (4.14)	5.53 (7.70)	0.00
Singapore	64-73	55.59 (12.73)	40.18 (7.56)	4.22 (9.17)	0.00
Taiwan	53-73	80.63 (13.21)	15.45 (2.63)	3.91 (6.73)	0.00
Indonesia	70-73	73.09 (11.90)	9.37 (2.15)	17.54 (19.50)	0.00
Malaysia	70-73	59.97 (9.56)	29.99 (4.32)	10.05 (12.64)	0.00
Philippines	70-73	39.79 (5.12)	49.97 (7.36)	10.24 (11.51)	0.00
Thailand	70-73	82.11 (10.96)	7.67 (0.57)	10.22 (11.44)	0.00
China	65-73	85.29 (13.51)	10.36 (3.19)	4.35 (7.01)	0.00
Japan	57-73	55.01 (11.43)	4.85 (0.82)	1.06 (2.87))	39.09
Non-Asian G-5 Countries	57-73	41.50 (4.62)	6.00 (4.24)	1.43 (1.70)	51.07
(2) 1974—1985					
Hong Kong	74-85	64.31 (9.58)	32.73 (3.40)	2.96 (5.67)	0.00
South Korea	74-85	78.08 (13.28)	18.10 (2.83)	3.81 (6.41)	0.00
Singapore	74-85	64.68 (9.94)	31.72 (3.42)	3.60 (5.48)	0.00
Taiwan	74-85	78.91 (11.89)	18.12 (2.23)	2.97 (4.98)	0.00
Indonesia	74-85	77.69 (12.22)	13.55 (2.65)	8.76 (10.20)	0.00
Malaysia	74-85	61.39 (10.76)	33.61 (4.94)	5.00 (8.15)	0.00
Philippines	74-85	62.59 (7.29)	29.28 (3.53)	8.13 (8.07)	0.00
Thailand	74-85	67.53 (8.69)	25.02 (3.55)	7.46 (8.96)	0.00
China	74-85	80.46 (9.44)	14.64 (2.53)	4.90 (6.37)	0.00
Japan	74-85	40.65 (6.73)	10.22 (0.93)	0.96 (1.69)	48.17
Non-Asian G-5 Countries	74-85	36.29 (2.65)	-14.55 (-0.42)	2.53 (1.90)	75.73
(3) Post-1986					
Hong Kong	86-95	41.81 (7.56)	6.46 (0.53)	1.58 (3.10)	50.14
South Korea	86-95	44.54 (11.90)	14.98 (2.76)	1.75 (4.15)	38.73
Singapore	86-95	37.01 (8.50)	31.30 (4.32)	1.52 (3.38)	30.17
Taiwan	86-95	43.00 (9.01)	10.46 (1.34)	1.38 (3.13)	45.16
Indonesia	86-94	62.79 (8.88)	15.91 (2.31)	5.69 (6.94)	15.61
Malaysia	86-95	42.87 (8.53)	33.41 (4.83)	3.25 (6.15)	20.47
Philippines	86-95	52.18 (3.77)	41.63 (2.96)	6.23 (5.09)	-0.03
Thailand	86-94	51.01 (11.27)	13.32 (2.72)	2.36 (5.25)	33.31
China	86-95	56.38 (12.53)	10.24 (3.01)	3.27 (4.54)	0.00
Japan	86-94	38.21 (4.86)	2.47 (0.11)	1.17 (1.44)	58.14
Non-Asian G-5 Countries	86-94	27.14 (2.70)	13.83 (5.37)	1.58 (1.36)	57.45

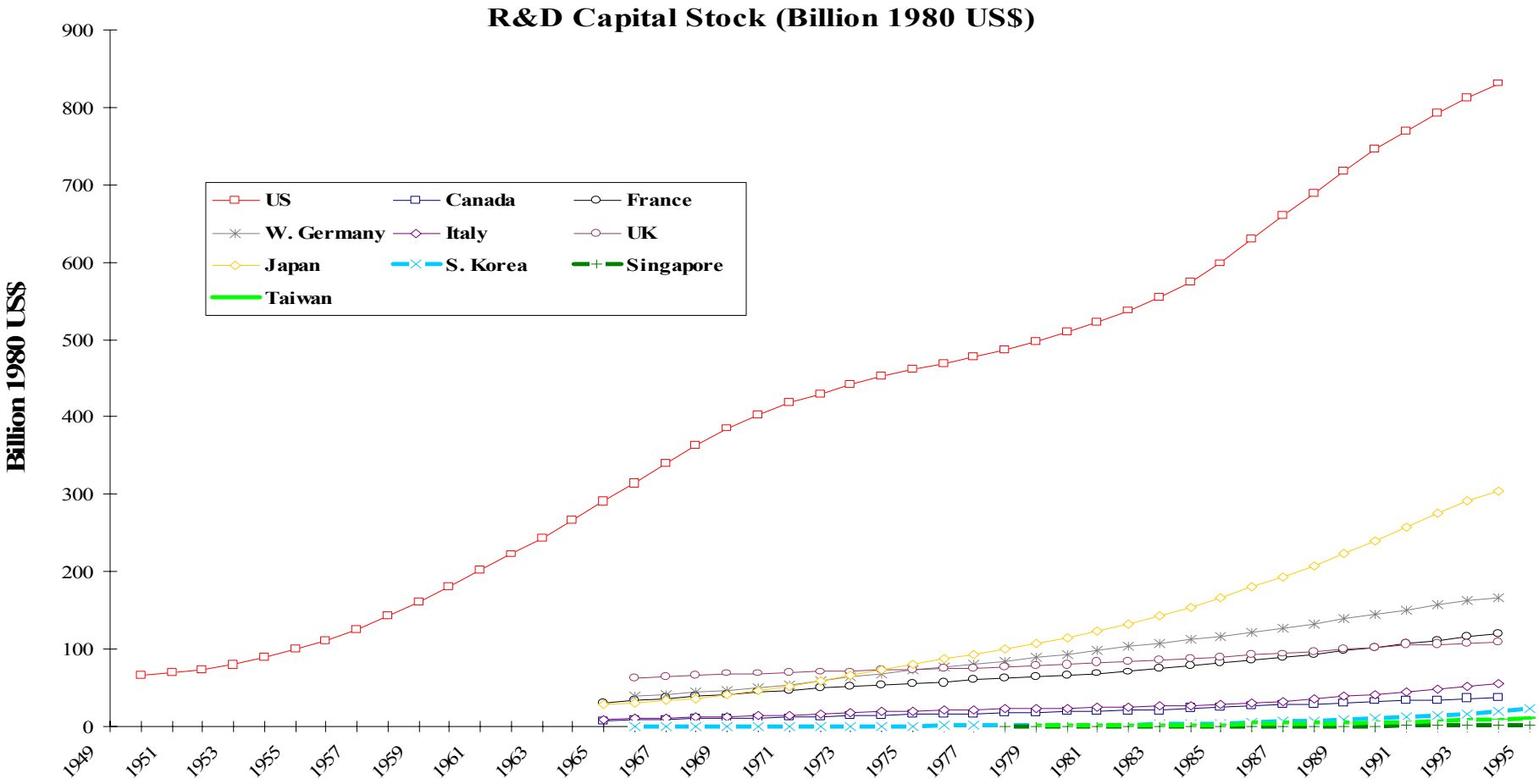
R&D Expenditures as a Ratio of GDP: G-7 Countries, 3 East Asian NIES & China



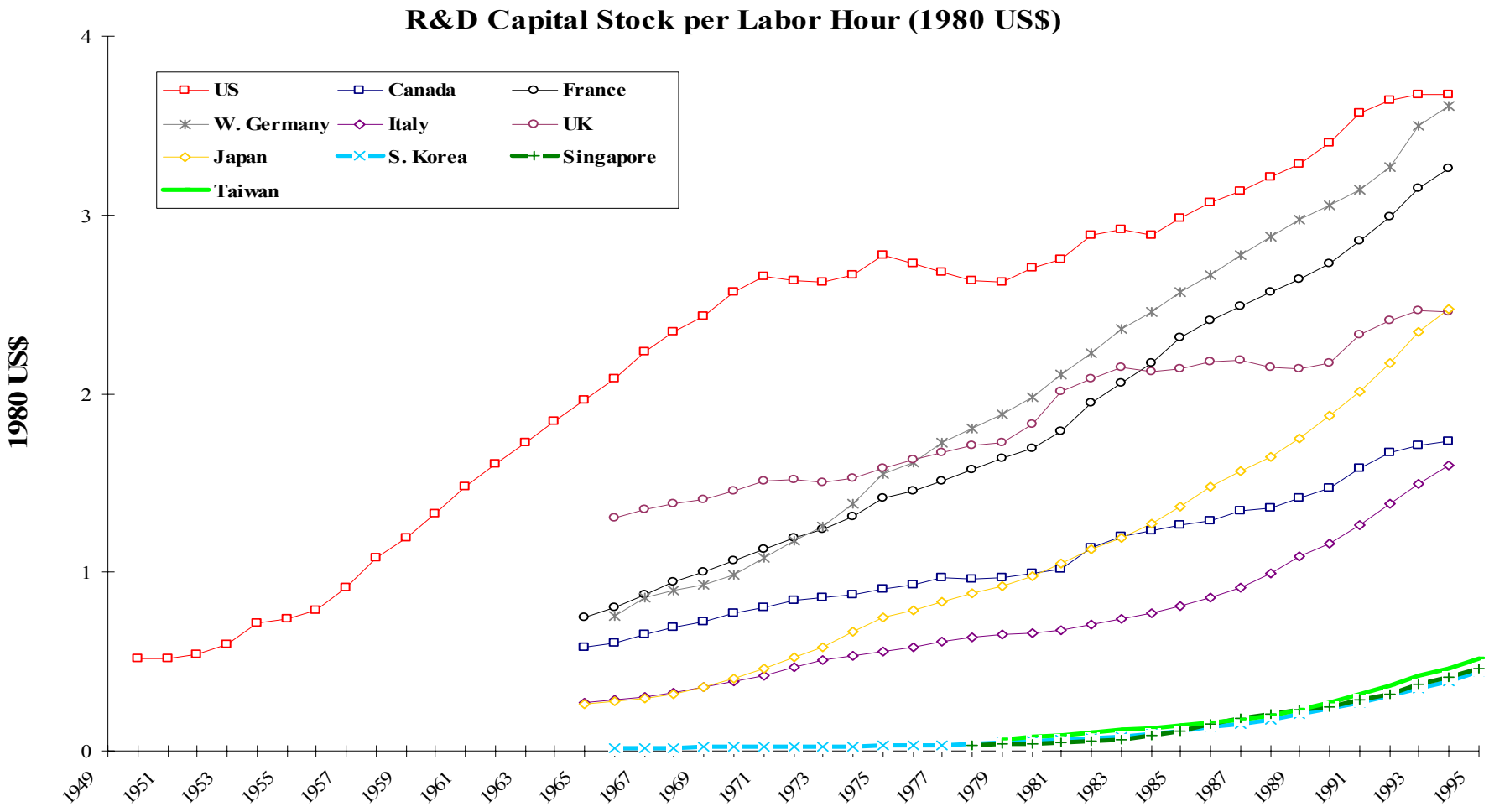
R&D Capital Stocks: G-7 Countries and 3 East Asian NIEs



R&D Capital

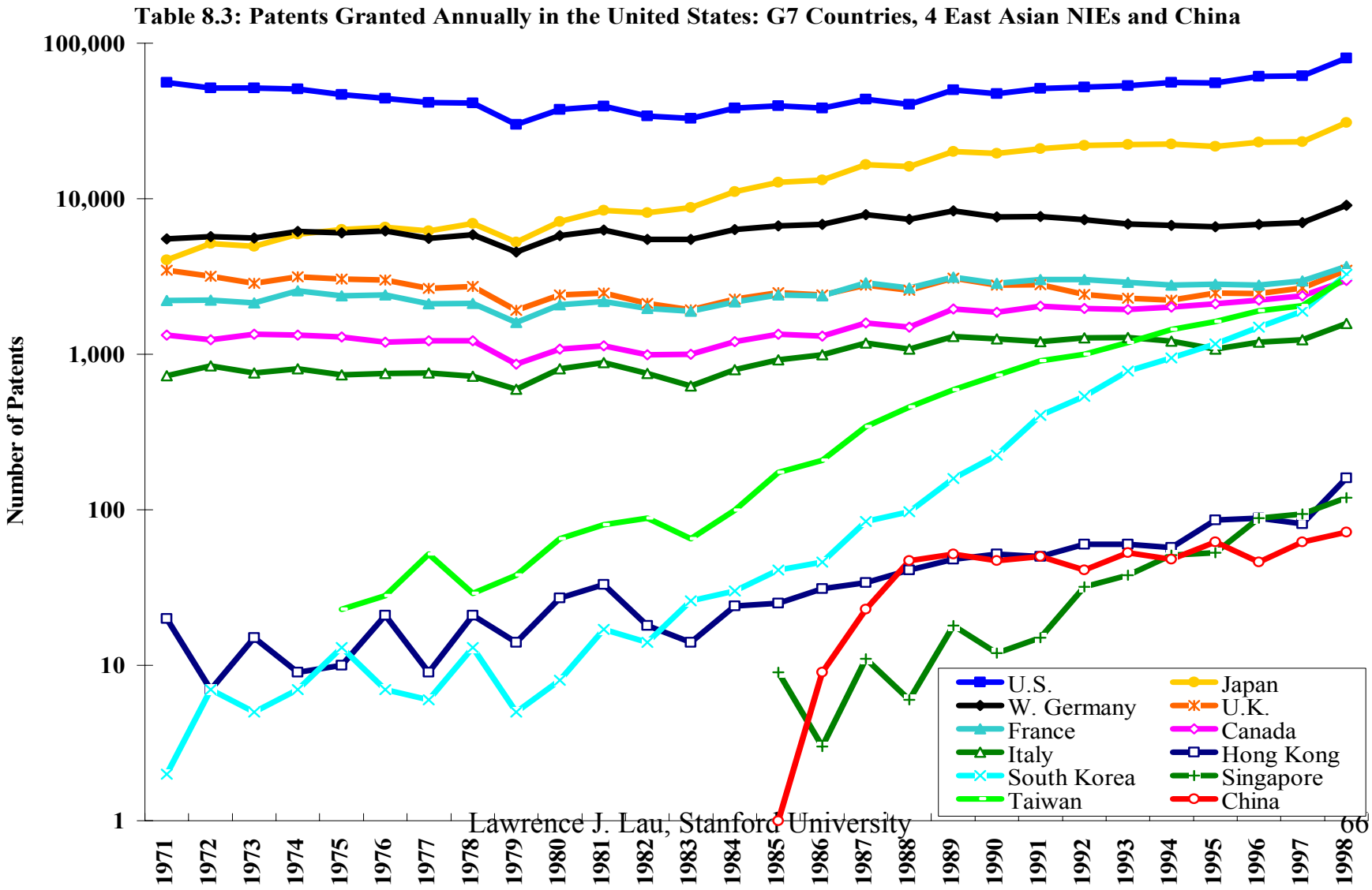

R&D Capital Stock (Billion 1980 US$)
Billion 1980 US$
900
800
700
600
500
400
300
200
100
0
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
US
Canada
France
W. Germany
Italy
UK
Japan
S. Korea
Singapore
Taiwan

R&D Capital Stock per Unit Labor



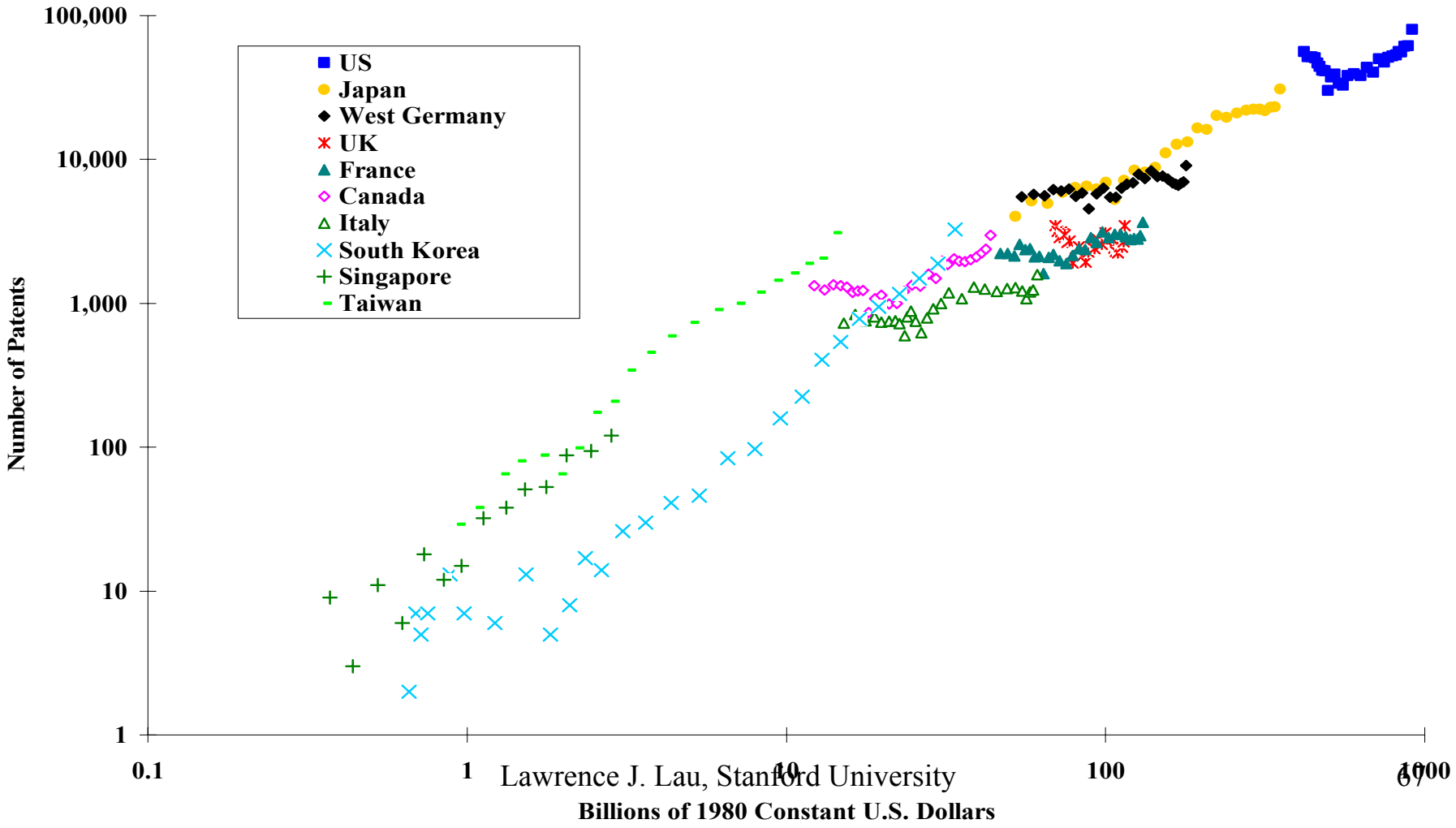
R&D Expenditures: China

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

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



Real Outputs and Inputs—4-Inputs (Tangible Capital, Labor, Human & R&D Capital) Case

Table 8.1: Average Annual Rates of Growth of Real Output and Inputs (R&D 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]	R&D Capital Stock	Average Share of Labor Earnings to GDP
South Korea	67-95	8.81	13.12	13.35	3.12	3.42	3.32	5.93	14.90	0.39
Singapore	77-95	7.82	8.62	8.88	3.24	3.60	2.20	4.11	12.03	0.42
Taiwan	78-95	7.40	9.39	9.43	2.22	1.63	1.80	3.68	15.21	0.50
Japan	64-94	5.06	7.95	7.66	1.09	0.45	0.94	1.92	8.55	0.62
Canada	64-94	3.64	4.64	4.57	2.35	1.74	0.96	2.85	5.56	0.60
France	64-94	2.93	3.92	3.97	0.39	-0.40	1.30	2.09	4.82	0.64
West Germany	65-94	2.65	2.89	2.67	-0.02	-0.42	1.03	1.59	5.37	0.66
Italy	64-94	3.15	4.57	4.73	0.02	-0.31	1.34	1.87	6.10	0.72
United Kingdom	65-94	2.14	3.65	3.46	0.07	-0.30	0.89	1.15	2.00	0.66
United States	49-94	3.13	3.03	3.30	1.71	1.31	0.81	2.06	5.89	0.66

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

Table 8.2: p-Values for the Tests of Hypothesis of No Technical Progress
(Four-Input Model with Human Capital and R&D Capital)

	Full Sample for G-7 + 3 NIEs[1] $c_{iK}=0$, all i
3 NIEs	0.01284
G-7	0.00385
All Economies	0.00004

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

Table 8.4 Growth Accounts: Contributions of the Sources of Growth (Percent)
(Four-Input Model with Human Capital and R&D Capital)

	Sample Period	Tangible Capital	Labor	Human Capital	R&D Capital	Technical Progress
South Korea	67-95	60.12	14.23	1.75	23.90	0.00
Singapore	77-95	50.44	23.90	1.30	24.35	0.00
Taiwan	78-95	55.85	11.25	1.14	31.76	0.00
Japan	64-94	42.40	5.24	0.72	17.08	34.56
Non-Asian G-7 Countries	65-94	32.52	3.72	1.16	14.90	47.69

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, 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.

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

- Thus, indigenously generated improvements in technology have been quite scarce in developing East Asian economies other than Japan.
- 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 if R&D capital is not explicitly taken into account as a factor input.
- 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, shoes.
- 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 developed 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 of the domestic market, e.g., real estate.

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 tangible inputs.
- Tostlebee (1956): The growth in U.S. agriculture in the 19th Century can be attributed to the growth of tangible inputs, with a negative rate of growth of total factor productivity (expansion of land under cultivation).
- Hayami and Ogasawara (1999): Japanese economic growth between the Meiji Restoration and the World War I can be largely attributed to the growth of tangible 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, Singapore and Taiwan, principally through R&D capital, accounting for between a quarter and a third of the growth in real output.

The Sources of Economic Growth--Developed Economies

- The most important source of economic growth for developed economies is Intangible capital, accounting for more than half of the growth of output.
  - Within intangible capital, technical progress (or unidentified tangible capital, is the most important, accounting for between one-third to one-half of the growth in real output, followed by R&D capital, accounting for between 15 and 20 percent.
- Tangible capital is the next important source of economic growth, accounting for almost a third.
- Technical progress reflects the effects of intangible capital that is not explicitly identified, i.e., other than human capital and R&D capital—e.g., knowledge capital, goodwill, software, etc.
- The United States is the world leader in human capital and R&D capital.

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 of non-productive accumulation of tangible capital.

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 tangible input-driven rather than intangible input or technical progress-driven--it is attributable to growth in tangible 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 East Asian Economic Growth Sustainable?

- East Asian economies, with the exception of Japan, still lag far behind developed economies in tangible capital per unit labor.
- There is therefore considerable room for the continuation of rapid tangible input-driven economic growth in the future before diminishing returns step in.
- Intangible capital per unit labor, e.g., R&D capital, lags even further behind, offering additional opportunities for investment.
- Investment in intangible capital, e.g., investments in R&D, has begun to increase in the East Asian NIEs.
- 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-technology 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.
- 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.

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