Sources of economic growth in Thailand, 1970 - 89

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To my parents and family

Declaration

Except where otherwise indicated this thesis is my own work.

Paitoon Kaipornsak

February 1995

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Abstract

During the past three decades the Thai economy has experienced annual average real growth of 7.1 per cent. In the late 1980s and early 1990s, growth accelerated. Thailand became one of the fastest growing economies in the world. Economic growth is reflected in rising per capita income and in health and education indicators of standard of living. Economic policies have played a key role in growth, in particular, making recent high growth possible.

In this study, two major sources of growth, input growth and total factor productivity (TFP) growth, are analyzed. Production function analysis is the main methodology. Total factor productivity is estimated in three forms: TFP growth (per cent per annum), share of TFP contribution to output growth and a TFP level index.

Input growth was the dominant source of growth in the long-run period (1970 - 89), but TFP growth was a major source of the recent rapid acceleration of the economic growth. Input growth is constrained by the need to curtail population growth for economic and social reasons and by limits to the expansion of cultivatable land. The emphasis needs to be on increasing productivity to sustain growth in the long run.

Factors affecting TFP growth are examined. Technological advance and a competitive environment are found to be two major factors on productivity. Research and development has been significant in improving technology while foreign direct investment has contributed to the transfer of advanced technology. Policies such as protection and offsets to it to increase exports, market structure and organization and management all had important influences on the competitive environment and affected TFP growth. In the early years, protection not only caused an inefficient allocation of resources, but also led to inefficient resource utilization, notably as a disincentive to improving production technology. Exports, on the other hand, promoted international competitiveness. Market structure, measured in this study by an industrial concentration ratio of large-scale firms, also affected TFP growth since high concentration ratios meant that large scale firms had monopoly power. Organization and management, proxied by dummy variables, is used to explain the different timing of the diffusion, as well as the rate of adoption, of technology.

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Abbreviations

ADF - Augmented Dickey-Fuller test
Adj-R^2 - Adjusted coefficient of determination
BLUE - Best linear unbiased estimator
CES - Constant elasticity of substitution
CRS-CD - Constant return to scale, Cobb-Douglas production function
CRS-T - Constant return to scale, Translog production function
DRC - Domestic resource cost
DW - Durbin-Watson statistics
EC - European Community
ERP - Effective rate of protection
FDI - Foreign direct investment
FE - Fixed effect
GATT - General Agreement on Tariff and Trade
GDP - Gross domestic product
GLS - Generalized least square
GNP - Gross national product
IBRD - International Bank for Reconstruction and Development
ISIC - International standard Industry classification
NESDB - National Economic and Social Development Board
NRP - Nominal rate of protection
OLS - Ordinary least square
PIM - Perpetual inventory method
R&D - Research and development
RE - Random effect
TFP - Total factor productivity
VES - Variable elasticity of substitution

1 Total factor productivity growth as a source of growth

At the end of the second World War, the Thai economy was stagnant. Trade, except with Japan, had been cut off for over three years. There was therefore an acute shortage of all types of manufactured goods. Rice, the major export, was the only major crop that was not in short supply.

Economic and Social Development Plans were introduced in the early 1960s to modernize the economy and to raise living standards. The government played a dominant role both in infrastructural investment (transportation, communication, irrigation, electricity and other public utilities) and industrialization which were seen as key to development during the period of the First National Economic and Social Development Plan (1961 - 66). GDP grew at an average real rate of 8 per cent per annum, albeit from a negligible base. During subsequent plan periods the responsibility for development in manufacturing and services was devolved to the private sector, but the government continued to expand the social and physical infrastructure and to refine the policies that gave essential price signals to producers and consumers. A planning network was maintained to express the government's views and to indicate broad directions of government policy and targets for the growth of the economy. Policies were developed to give appropriate signals to the principal actors in the economy. From the 1980s, policy liberalization began to move the style of government from detailed regulation and intervention to promotion and broad policy signals.

Average annual growth rates remained high and accelerated in the late 1980s making Thailand one of a select group of rapidly growing East Asian economies (World Bank 1993).

Economic growth has led to improved standards of living. Average real per capita income (at 1985 prices) rose four times from 1961 to 1990, health and education became widespread and life expectancy increased substantially (Chapter 2).

Table 1.1

Economic growth in Thailand, 1961 - 93

Period	Real GDP growth (per cent per annum)
First development plan (1961 - 66)	8.0
Second development plan (1967 - 71)	7.5
Third development plan (1972 - 76)	6.2
Fourth development plan (1977 - 81)	7.1
Fifth development plan (1982 - 86)	5.3
Sixth development plan (1987 - 91)	10.6
1987	9.5
1988	13.2
1989	12.0
1990	11.6
1991	8.1
1992[p]	7.6
1993[p]	7.9

Note p = preliminary figures

Source National Economic and Social Development Board, various issues, *National Income of Thailand*, Bangkok.

Two major sources of growth: input growth and total factor productivity growth

If it is assumed that the production function is linearly homogeneous, then output will increase in the same proportion as the rise in factor inputs. Such trends have clearly been evident in many developing economies. But output growth can also be obtained from growth in total factor productivity (TFP), that is, an increase in output without an increase in the quantity of inputs.

Time series studies of Hong Kong, Japan, the Republic of Korea and Malaysia indicate (Table 1.2) that TFP growth has been a crucial source of growth. Cross-country studies confirm that TFP growth makes a significant contribution to growth in many economies (Table 1.3).

In Thailand, TFP growth was expected to play a major role as a source of growth in recent years. There are signs of overheating of input growth in the economy such as labour shortages. TFP growth is therefore important and should be encouraged to sustain growth and to raise the ability to compete in the world market in the future.

Table 1.2

TFP growth and growth of GDP in selected countries

Year	Average growth of GDP	Share of TFP growth in GDP growth	Share of total inputs growth in GDP growth
Hong Kong			
1970-75	6.9	8	92
1975-80	12.3	29	71
Japan			
1955-71	2.9	25	75
1952-71	3.8	38	62
1960-73	4.5	41	59
1952-64	5.1	53	47
1955-70	5.6	55	45
1953-71	5.9	58	42
Korea			
1955-60	4.3	34	66
1960-65	6.3	39	61
1965-68	11.6	52	48
Malaysia			
1970-75	7.1	20	80
1975-80	8.6	21	78

Sources for Hong Kong and Malaysia; Ikemoto, Yukio, 1986. "Technical progress and level of technology in Asian countries, 1970-80: A translog index approach", *The Developing Economies*, XXIV (4): 368-390. for Japan 1960-73, 1955-71; Perkins, F., 1991. *The Impact of Economic reform on productivity growth in Chinese industry: A case of Xiamen special economic zone*, China Paper No 91/6, Economics Division, Research School of Pacific Studies, The Australian National University, Canberra. for 1953-71; Denison, Edward F. and Chung, William K., 1976. *How Japan's economy grew so fast: the sources of postwar expansion*, Washington, D.C.: The Brookings Institute. for 1955-70; Nishimizu, Mieko and Hulten, Charles R., 1978. "The sources of Japanese economic growth: 1955-71", *Review of Economics and Statistics*, LX (3): 351-361. for 1952-64; Watanabe, Tsunehiko, 1972. "Improvement of labour quality and economic growth: Japan's postwar experience", *Economic Development and Cultural Change*, 21: 33-35. for 1952-71; Jorgenson, Dale W. and Ezaki, Mitsuo, 1973. "The measurement of macroeconomic performance in Japan: 1951-1968", in Ohkawa, Kazushi and Hayami, Yujiro (eds.), *Economic Growth: The Japanese Experience since the Meiji Era*, vol 1, Tokyo: The Japan Economic Research Centre. for Korea; Han, Chun Kee, 1971. *Sources of Growth Rates in Japan and Korea: A Comparative Study*, Productivity Series No 1, prepared for The Asian Productivity Organization and Technology and Development Institute, The East-West Center, University of Hawaii.

Table 1.3

TFP growth and growth of GDP - cross-country comparison

Country	Average growth of GDP (per cent per annum)	Share of TFP growth in GDP growth (per cent)	Share of total inputs growth in GDP growth (per cent)
Brazil, 1960-74	7.3	22	78
Chile, 1960-74	4.4	27	73
Colombia, 1960-74	5.6	37	62
Hong Kong, 1960-70	9.1	47	53
Korea, Republic of, 1960-73	9.7	42	58
Mexico, 1960-74	5.6	37	62
Peru, 1960-70	5.3	28	72
Turkey, 1963-75	6.4	35	65

Source World Bank, 1987. *World Development Report*, Washington DC.: Oxford University Press.

For Thailand, the studies were undertaken on sectoral and industrial sources of growth (Table 1.4 - 1.6). The results showed that the contribution of TFP growth was rather small, except in some periods and some sectors. TFP growth of manufacturing and industries was found to be relatively large but fluctuated over time.

Table 1.4

Sectoral sources of growth in Thailand, 1961 - 85

per cent

	GDP growth	Contribution of capital	Contribution of labour	TFP growth
Economy wide				
1961 - 65	7.0(100.0)	4.4(62.5)	1.4(20.5)	1.2(17.0)
1965 - 70	8.1(100.0)	4.7(57.4)	1.1(13.4)	2.4(29.2)
1970 - 75	6.0(100.0)	4.3(72.4)	1.8(30.6)	0.1(2.2)
1975 - 80	7.2(100.0)	4.0(55.8)	1.8(24.3)	1.4(19.9)
1980 - 85	5.1(100.0)	3.9(76.5)	1.5(29.2)	0.3(5.6)
Mining and manufacturing				
1971 - 75	8.3(100.0)	4.4(53.1)	4.5(54.0)	-0.6(-7.0)
1975 - 80	9.4(100.0)	3.1(33.3)	0.4(3.9)	5.9(62.8)
1980 - 85	4.9(100.0)	3.8(78.5)	1.29(26.5)	-0.24(-4.9)
Services (other than agriculture, mining and manufacturing)				
1971 - 75	5.9(100.0)	4.6(77.9)	2.3(39.3)	-1.0(-17.0)
1975 - 80	8.4(100.0)	5.3(63.3)	0.8(9.1)	2.3(27.6)
1980 - 85	6.2(100.0)	4.9(79.5)	1.8(28.6)	-0.5(-1.9)
Services (trade, Banking and Finance, and services)				
1971 - 75	6.4(100.0)	5.0(79.0)	2.4(37.5)	-1.0(-16.4)
1975 - 80	7.7(100.0)	6.4(83.7)	0.7(8.7)	0.6(7.5)
1980 - 85	6.3(100.0)	4.8(75.9)	1.9(29.9)	-0.4(-5.6)

Source Kitti Limskul, 1988. "The sectoral capital stock, employment and sources of economic growth in Thailand 1960 - 1986", *International Economic Conflict Discussion Paper, No. 40*, Economic Research Center, Nagoya University.

Table 1.5

Sources of growth of industries in Thailand, 1963 - 70 and 1970 - 76

per cent

	Contribution of capital		Contribution of intermediate input		Contribution of labour		TFP growth	
Year	63 - 70	70 - 76	63 - 70	70 - 76	63 - 70	70 - 76	63 - 70	70 - 76
Food processing	13.2	6.3	10.5	21.1	72.4	68.6	3.9	4.1
Food processing, rice	-0.5	28.7	9.6	9.1	81.0	54.4	9.9	7.9
Beverages	-7.3	64.7	63.1	6.5	39.0	23.8	5.2	5.0
Tobacco	4.7	78.7	33.5	16.2	62.9	0.02	-1.1	5.1
Textiles	8.0	10.2	35.6	35.2	51.7	43.2	4.7	11.4
Weaving apparel	18.0	-18.7	20.3	29.7	51.5	84.8	10.2	4.2
Leathers and leather products	21.0	40.2	6.3	40.3	69.0	11.8	3.6	7.7
Footwear	1.6	15.9	10.9	10.0	70.1	56.9	17.5	17.2
Wood and wood products	-0.9	11.4	12.4	36.9	79.9	39.0	8.7	12.7
Furniture and fixtures	18.1	-179.6	17.6	82.0	58.0	198.5	6.3	-0.9
Papers and paper products	7.5	12.7	14.2	20.5	71.3	57.7	7.0	9.1
Printing and publishing	20.7	36.0	16.7	29.9	57.7	25.2	5.0	8.9
Basic chemicals	-9.4	-4.6	34.1	36.1	62.3	57.7	13.1	10.8
Chemical products	35.7	-13.3	6.1	36.1	55.6	68.4	2.6	8.8
Rubber and rubber products	-0.4	19.8	26.2	26.0	66.7	50.1	4.5	4.1
Non-metallic mineral products	0.4	-19.3	23.2	16.8	54.5	72.9	21.9	29.7
Glass and glass products	-12.1	-31.9	58.6	55.0	40.0	68.8	13.5	8.1
Other non-metallic mineral products	-13.8	7.5	36.2	20.1	73.7	70.4	3.9	2.0
Iron and steel	1.4	-5.4	19.2	27.6	72.1	71.5	6.6	6.3
Non-ferous metal	11.1	-8.7	20.7	33.1	63.1	69.1	5.1	6.4
Metal products	8.6	-128.9	18.9	137.5	64.2	100.9	8.3	-9.5
Non-electrical machinery	0.8	-32.1	26.5	67.7	68.0	59.1	4.7	5.2
Electrical machinery	12.3	16.1	21.4	17.8	60.0	60.6	6.5	5.5
Transport equipment	-2.3	-7.8	14.1	17.0	84.7	83.2	3.5	7.6

Source Paitoon Wiboonchutikula,1982. "The total factor productivity growth of the manufacturing industries in Thailand, 1963 - 1976", Ph.D. thesis, University of Minnesota, Minnesota (Unpublished).

Table 1.6

Sources of growth of some industries in Thailand, 1975 - 83

per cent

	Output growth	Contribution of capital	contribution of labour	Contribution of intermediate input	TFP growth
Spinning weaving and knitting	8.4(100.0)	0.8(9.7)	-0.1(-0.7)	3.8(45.7)	3.8(45.3)
Synthetic fibre	8.0(100.0)	0.6(8.0)	-0.2(-2.4)	2.6(32.0)	5.0(62.3)
Garments and other textiles	6.4(100.0)	0.4(6.0)	0.1(1.9)	4.5(7.0)	1.4(21.9)
Electrical goods	27.4(100.0)	1.8(6.6)	0.5(1.7)	18.2(66.4)	6.9(25.3)
Paper and pulp	9.0(100.0)	2.6(29.0)	0.3(3.6)	4.6(51.4)	1.5(16.2)
Rubber products	2.7(100.0)	0.9(34.1)	0.1(2.2)	2.3(86.1)	-0.6(-22.9)
Automotive parts	11.5(100.0)	1.0(9.0)	0.3(2.3)	2.6(22.6)	7.6(66.1)

Source Brimble, Peter, 1987. "Total factor productivity growth at the firm level in Thailand: a challenge for the future", Faculty of Economics, Thammasat University, Bangkok (Unpublished).

The studies of TFP growth and sources of growth in Thailand, however, employed different set of data, different level of aggregation or sectors, and different period of data and methodology. These differences make the results hard to analyze and compare. It is therefore interesting for a study to estimate TFP growth and sources of growth of major sectors and detailed industries and crops under the same methodology employed and consistent data set so as to compare and analyze.

Furthermore, the study of TFP growth will have less meaning without the analysis of factors affecting TFP growth. Since the analysis of factors affecting TFP growth is a highly sophisticated field of study, by taking into account of time and data constraints, this study is focused at investigating relationship between TFP growth and those factors concerning trade liberalization and competition.

Purpose and scope of the study

This study estimates the major sources of economic growth in Thailand. Initially, growth may be encouraged by increasing growth of inputs employed in the economy. Natural resources and populations, however, are limited. Productivity improvements offer a continuing source of growth.

For the whole economy, sources of growth are estimated for eight major sectors: agriculture; mining and quarrying; manufacturing; construction; electricity and water; telecommunication and transportation; commerce and finance; and services. Sources of growth are also analyzed at more disaggregated levels in thirteen industries in manufacturing and five major crops in agriculture. The thirteen industries include food; beverage and tobacco; textiles, leather and footwear; wood, paper and furniture; printing and publishing; industrial chemicals and other chemicals; petroleum refineries and miscellaneous petrochemical products; rubber and plastic products; non-metallic products; metallic products; machinery; electrical machinery and supplies and transport equipment and vehicles. The five crops are paddy; cassava; sugar cane; maize and soya beans.

Apart from decomposing the sources of growth, the study also analyzes the sources of input and TFP growth and factors affecting these sources. Input growth is dominated by capital, labour and land. Factors contributing to TFP growth analyzed include domestic competitiveness, openness to international trade policy, foreign direct investment and research and development.

Outline of the study

Chapter 2 reviews the development of Thailand from a largely agrarian economy to a much more diversified and industrialized one. Possible factors and policies concerning input and TFP growth are briefly discussed in this chapter.

Chapter 3 considers the theoretical framework of TFP in relation to economic growth.

The two major sources of economic growth are estimated and analyzed in Chapters 4 to 6. Chapter 4 is concerned with the analysis of sources of growth in eight major sectors of the economy. This provides a perspective on the sources of growth in the whole economy. In Chapters 5 and 6, manufacturing (thirteen industries) and agriculture (five crops) are studied at more disaggregated levels to deepen the analysis of productivity and input growth.

Factors affecting TFP growth are investigated and analyzed in Chapter 7. They include factors affecting competitiveness or monopoly, protection and exports, research and development, foreign direct investment and its impact on improving domestic access to technology or technology transfer.

The conclusions are summarized in Chapter 8.

2 Economic background

Thai economic histories mostly date back to around 1782 when Bangkok became the capital city. The history of modern Thailand began in 1851 when King Mongkut became the King (Ingram 1971). By 1855, restrictions on foreign trade had been reduced and a treaty which established new conditions of trade with Britain had been concluded, opening the country to external influences (Muscat 1966). But the Thai economy remained very small and rice was the only major product. In 1919, there were only seven factories in Bangkok (Ingram 1971) and some rice milling in the provinces. Annual average per capita income growth was barely perceptable.

In the 1950s, with recovery from the Japanese occupation, the pace of development accelerated markedly. From 1951 to 1956 average annual real GDP (at constant 1952 prices) grew at 4.1 per cent (Bundhit 1959). The government began to accept responsibility for a major role in modernization and catching up with higher income countries. Economy wide National Economic and Social Development Plans became the vehicles by which the government sought to affect change. While national policy was directed to all sectors, industrialization, as in many other developing economies, was seen as the key economic strategy.

Economic growth and change in production structures

The Thai economy has changed substantially, agriculture declining and industrial production and services increasing as a proportion of GDP (Table 2.1). The proportion of people employed in the agriculture also declined from 83 per cent to 67 per cent from 1960 - 89 (Table 2.2). However, agriculture has continued to grow and remains the main source of employment.

Table 2.1

GDP by sectors at constant prices (1962 price for 1960 and 1972 price for the others), 1960 - 89

per cent

	1960	1970	1980	1985	1989
Agriculture	38	27	21	20	16
Industry	19	25	31	30	34
(of which manufacturing)	(13)	(16)	(22)	(21)	(24)
Services	43	48	49	50	50
GDP	100	100	100	100	100

Note 1 The new national income series of Thailand was taken back to 1970. GDP shares for 1960 were calculated from the old series.

2 Industry includes mining and quarrying, manufacturing, construction, electricity and water.

3 Services includes communication and transportation, trade and banking, dwellings, public administration and other services.

Source Calculated from National Economic and Social Development Board, *National Income Account*, various issues.

Table 2.2

Employment by sectors, 1960 - 89

per cent

	1960	1970	1980	1985	1989
Agriculture	84	80	71	68	67
Industry	4	6	10	11	12
(of which manufacturing)	(3)	(4)	(8)	(8)	(9)
Services	12	14	19	21	21
Total	100	100	100	100	100

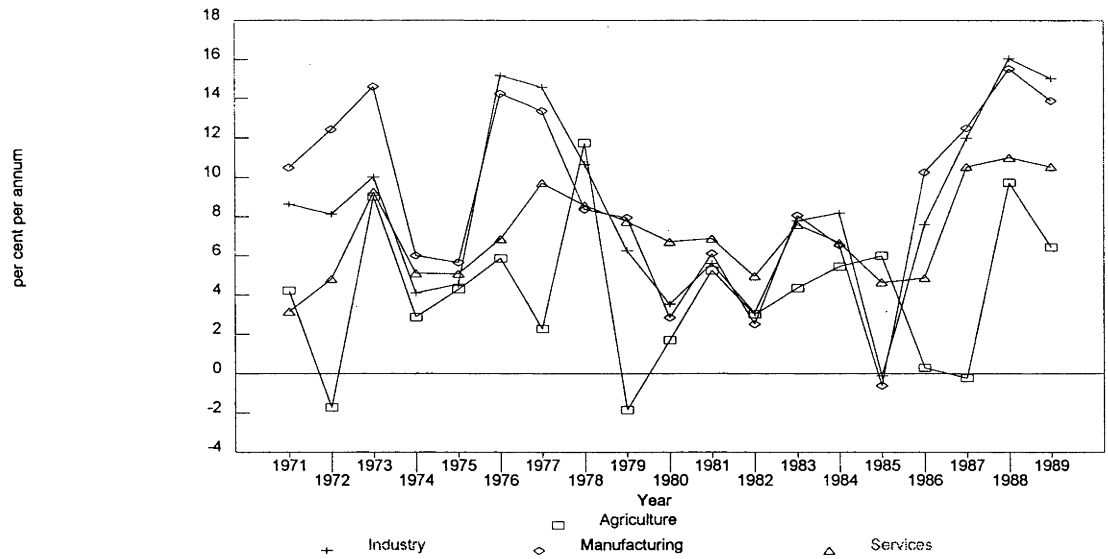
Source National Statistical Office, *Labour Force Survey*, round 2 (round 3 for 1985 and 1989), various issues.

The growth rate of agriculture has been lower than that of the other sectors and overall GDP growth (Figure 2.1). The growth of agriculture value-added was lower than that of GDP and other sectors in every year except 1985 when industry was in recession following the industrial countries' measures to reduce inflation in the early 1980s. From 1986, however, industry recovered rapidly.

Figure 2.1

Growth of value-added at 1972 constant prices by sectors, 1961 - 89

per cent per annum



Source National Economic and Social Development Board, *National Income of Thailand*, various issues

Both agriculture and manufacturing have diversified their outputs in the past 30 years (Tables 2.3 and 2.4).

Table 2.3

Value-added by main crops at 1972 constant prices, 1960 - 89

per cent

	1960	1970	1980	1985	1989
Paddy	50.9	47.8	37.7	35.2	31.3
Cassava	2.3	3.5	8.4	7.9	8.2
Maize	2.3	4.8	4.9	6.3	5.0
Sugar	3.0	1.8	1.4	3.9	5.5
Rubber	6.9	5.1	5.8	6.6	9.5
Soya beans	0.2	0.4	0.4	1.2	2.2
Other	34.4	36.6	41.1	38.9	38.3
Total agriculture	100.0	100.0	100.0	100.0	100.0

Note 'Other' includes cotton, kenaf, jute, kapok, tobacco, sorghum, mungbean, etc.

Source National Economic and Social Development Board, *National Income of Thailand*, various issues.

Table 2.4
Value-added by major industries at 1972 constant prices, 1960 - 89

per cent

	1960	1970	1980	1985	1989
Food	34.2	16.5	14.1	16.4	14.1
Beverages and tobacco	23.1	20.3	16.3	15.5	12.8
Textiles, leather and footwear	13.1	20.7	25.3	26.6	27.6
Wood paper and furniture	5.4	7.4	5.2	4.4	3.5
Transport equipment and vehicles	4.9	5.5	7.8	3.9	7.1
Non-metallic products	4.0	4.0	3.6	4.1	4.5
Petroleum refineries and products	0.03	5.7	5.2	4.8	3.8
Electrical machinery and supplies	0.6	1.9	2.9	3.0	3.5
Other	14.7	18.0	19.6	21.3	23.1
Total industry	100.0	100.0	100.0	100.0	100.0

Note The data for 1960 are in current prices as no data at constant prices were reported for industry level.
'Other' includes printing and publishing, chemicals, rubber and plastic products, metallic products and machinery.
Source National Economic and Social Development Board, *National Income of Thailand*, various issues.

Agricultural expansion in Thailand has become natural resource constrained. Land for agriculture can no longer be expanded at low cost. Policy biases in favour of industry result in relatively little capital being attracted to agriculture. Ammar, Suthad and Direk (1989) argue that the growth of agriculture will be even more constrained in the future. They estimate that the amount of land per agricultural worker will decline at the rate of 1 per cent per annum and that the capital stock per worker will increase by only 1 per cent per annum during the next ten years.

The Thai government has in the past adopted conflicting policies toward agriculture. Trade restrictions (export taxes, licensing of exports, and quotas) have, on the one hand, lowered domestic prices of exportable agricultural goods. On the other hand, agricultural product price supports or guarantees have been used to raise farmers' income. These measures contradict each other. Unfortunately, the price support measures have been generally ineffective, while the trade restrictions have been quite effective in terms of lowering the domestic prices of agricultural products. The negative net

effect of these two contradictory sets of measures thus contributed to the relative decline of agriculture.

Government intervention in non-agricultural sectors has also affected the relative prices of agricultural products. Trade protection through import licensing and import tariffs leads to the overvaluation of the Thai baht, reducing the export prices of agricultural products when converted into local currency. The Thai baht overvalued by about 10 per cent as a result of trade policies during 1960 - 84 (Ammar and Suthad 1991). Export taxes on rice and other agricultural crops reinforced the depressing effect of overvaluation on agricultural sector profitability. Macroeconomic policies caused maladjustment in the real exchange rate, increasing it from 3.4 per cent in 1960 - 64 to 14.7 per cent in 1980 - 84. The combined effect of trade and macroeconomic policies resulted in a currency over-valuation of 15 to 20 per cent for tradable agricultural products. Ammar and Suthad (1991) estimated the effect of price intervention on relative producer prices by showing the proportionate change which would have occurred in the observed relative prices of four commodities if all interventions were removed. Intervention was found to have depressing effects on the producer prices of rice, maize and rubber but to inflate the producer price of sugar. The effects of the intervention on output and consumption were then also estimated by applying the estimated price elasticity (of supply and demand) coefficients to these results. The results of the effect of intervention on agricultural outputs showed a decline in outputs into rice, maize and rubber (those with export taxes) and an increase in sugar output. The effect of price intervention on consumption was found to lead to price increases in rice, maize and rubber, and a decrease in sugar.

Direct intervention has been used to stabilize domestic prices relative to world prices, for example, by fixing prices to a government - imposed ceiling to subsidize the cost of food. But price controls and subsidies have often not been sustainable due to subsequent balance of payments or government budget pressures.

Industrial sector growth is influenced by macroeconomic policy; sector-specific policy; and the efficiency of the administration of regulations, rules, and procedures related to trade and industry (Paitoon, Chongruk and Jeerasak 1991).

The government adopted restrictive macroeconomic fiscal policies, particularly in the first half of the 1980s, to balance budgets by raising public saving and restraining public investment. As a consequence government expenditure as a percentage of GDP fell from 18.4 per cent in 1980 to 14.7 per cent in 1989. Government revenue as a percentage of GDP increased from 14.5 per cent in 1980 to 18.3 per cent in 1989.

Sector-specific policies affecting the size and structure of industrial production included such fiscal measures as business taxes, corporate income tax, excise taxes and import duties. Export credits, industrial long term credit and special credit for small scale industries were also used to promote industry. Additional incentives by the Board of Investment consisted of exemptions from tariffs and income taxes and subsidies for export processing zones.

Protection and subsidies for industry have been reduced in recent years. The Board of Investment revised the criteria regarding promotion for industries by reducing the size of the export industry which could request privileges and enabling more small and medium scale industries to obtain benefits. The Board of Investment also encouraged sub-contracting by large scale firms to encourage small industries producing equipment and parts for large industries to have a greater role in the economy. Measures to promote small scale industry included low interest credit from the Bank of Thailand, a credit fund for small scale industry, and technical and loan assistance for small scale industry by the Ministry of Industry.

Administrative efficiency also affects industrial development. The government applied industrial regulations for two major purposes: to regulate and to promote industry. Over time the emphasis varied.

Industries operate under various statutes, Royal Decrees and Ministerial regulations. Ministries can implement procedures by issuing Announcements. Government officials have wide discretion in applying laws and regulations. Most are more concerned with regulation rather than promotion.

The range of controls and regulations concerns the licensing of new operations, the size of enterprises, environmental standards, building regulations, location, machinery standards, quality of output and many other aspects of the operation of specific

industries. Regulations create many problems for manufacturers. Barriers to entry for potential new competitors are common. The large number of rules and regulations that manufacturers have to follow causes confusion and hence reduces efficiency. Some rules and regulations are so impractical that they cannot be enforced although attempts to enforce them create delay for industry. Some laws are old and no longer relevant.

The overall effects of the regulatory framework stifle competition and thus enable inefficiency to flourish. The government has recognized the costs of excessive regulations. Many have been revised to shorten bureaucratic processes and to gradually promote more competition. Factory Act B.E. 2512 was revised to reduce delays and unnecessary processes and make the bureaucracy more promotional. The number of machines and workers of factory establishments covered by the Act is to be increased to allow more competition from small factories which will then be able to be established without controls or licenses.

Three industrialization strategies

State ownership

State capitalism had been adopted as a national policy in Thailand in 1932. The government established several state-owned factories though private enterprises also began to operate. The importance of state enterprises was emphasized after World War II because it was argued that Thailand lacked private entrepreneurs and capital. By 1957, there were 141 state enterprises (Pranee 1988). But these state enterprises were highly inefficient and thus failed to encourage industrial development and overall growth (IBRD 1959).

Thailand hence began to seek a new direction for the economy (Juanjai, Supote and Sorrayuth 1986). The Promotion of Industrial Investment Act in 1954 adopted protection as the key industrialization strategy. Import controls were supplemented by tariffs on imported goods. In addition to establishing a National Economic and Social Development Board to oversee development as a whole, the Board of Investment was created to promote private investment, mainly in manufacturing.

Private enterprise promotion and import substitution

The promotion of private enterprises was officially launched in 1954 (Pranee 1988) but by 1958 only six enterprises were established as a result of government incentive (Ukrit 1983). The Board of Investment was strengthened in 1960 by a new Promotion of Industrial Investment Act (B.E. 2503) which granted tariff concessions on imported inputs into industrial production, regulated the entry of new firms and the expansion of productive capacity of existing ones, encouraged the imposition of import and export controls, made provision for credit assistance and gave income tax holidays to firms that qualified for promotion. The Promotion of Industrial Investment Act was amended again in 1962, 1965 and 1972, in each case extending privileges for industrial firms. Foreign direct investment was encouraged.

After sluggish growth during the 1950s, from 1960 to 1972, the manufacturing sector grew by almost 11 per cent per annum. The strong growth of agriculture, in particular of rice exports in spite of high taxes on rice exports from the 1950s, brought prosperity and encouraged manufacturing. Tourism grew together with other service industries. Protectionist industrial policies encouraged manufacturing in the 1960s, but they also had severely distorting effects.

The government guaranteed that it would not compete with private enterprises and that it would not nationalize promoted industries. Tariffs were not only high but also became widely dispersed as manufacturers argued for special tariff privileges. High tariffs were imposed on most manufactured imports and import of goods competing with domestic production was prohibited. Tariffs were reduced or exempted on machinery and raw material inputs into manufacturing. Promoted firms were given privileged access to finance and such funding was subsidized. New entry into manufacturing and expansion of existing production were restricted as additional protective measures. Income and corporate taxes were waived or reduced for promoted firms for varying periods.

Foreign investors were permitted to bring some skilled workers, technicians and managers and their families from abroad and to repatriate dividends and capital.

These measures encouraged entry into, and expansion of, manufacturing and facilitated foreign investment, but they also had negative impacts.

Manufacturing became excessively capital and technology-intensive limiting employment opportunities and thus misallocating resources as well as using them inefficiently. High protection against imports and the encouragement of domestic monopolies and oligopolies also contributed to gross inefficiency and high costs.

The high cost of manufacturing created biases against traditional agricultural exports and prevented the emergence of manufactured exports. Highly protected import substitution was very import-intensive. Balance of payments difficulties began to emerge in the late 1960s. They were exacerbated by the rise in petroleum prices and ensuing instability in world markets in the 1970s.

Export promotion

The Third Economic and Social Development Plan (1972 - 76) restated the importance of the private sector and began to emphasize the promotion of exports. Export promotion was to be achieved by further investment incentives, particularly in the form of tax and other concessions to domestic and foreign-owned firms. The government established industrial investment zones to encourage investment in export industries including fisheries, livestock and manufacturing.

Despite its good intentions, the Third Development Plan failed to reverse or even halt the negative effects of highly protectionist policies (Table 2.5). The bias against exports remained until the 1980s. Protection for production for the domestic market peaked in the early 1970s and remained high into the 1980s. Only recently have tariff levels and tariff dispersion been reduced. The barrage of additional incentives (fiscal and financial) was probably largely redundant in Thailand, that is, as in other countries it failed to encourage additional investment. The incentives, however, supported the distorting effects of the other protectionist measures.

Table 2.5

Manufacturing effective rates of protection (ERP), 1969 - 87

	1969	1974	1984	1987
Exports [a]	-0.43	-0.35	0.02	0.04
Import-competing	0.54	0.63	0.21	0.39
Non-import competing	1.87	0.77	0.53	0.55

a Products are classified as exports if their export level was greater than 10 per cent of domestic production and their net exports were positive

Source Warr, Peter G., 1994. "The Thai economy in perspective", in Peter G. Warr (ed), *The Thai Economy in Transition*, Cambridge: Cambridge University Press.

In the early 1980s, there was an attempt to lower nominal tariffs to a maximum of 60 per cent and reduce the dispersion of the rates across industries. The attempt met with limited success, however, due to conflict with other objectives of the National Plan, such as enhancement of government revenue. By 1987, the weighted average effective rate of protection had actually doubled compared to levels of 1981 (Paitoon, Rachain and Nattapong 1989, Ministry of Finance 1984). Non-durable consumer goods and transport equipment continued to have higher nominal and effective protection rates than inputs such as machinery and chemical products. The effective rate of protection for import substitution industries remained much higher than that of exporting industries. There has, however, recently been a substantial decline in tariffs on capital goods. For example, on September 1990, the import duty on 419 categories of machinery and capital equipment was lowered from between 30 - 60 per cent to 5 per cent across the board. During 1991 - 92, import duties on various types of vehicles were also drastically reduced from 100 to 200 per cent to between 42 - 68 per cent. Tariffs on all types of car parts are now 20 per cent. Duties on computers and parts were cut from 20 - 40 per cent to 5 per cent and tariffs on parts imported for assembly were also reduced from 10 to 1 per cent. Hence, effective rates of protection are likely to be lower than the rates estimated in 1987.

Since the begining of the 1989, Thai trade policy has therefore moved increasingly to reduce protection, lower average tariff levels and reduce tariff dispersion. This has made an important contribution towards greater trade policy neutrality. If the dispersion of tariffs had not been reduced as the average tariff level was lowered, the tariff structure may not have become more neutral. For example, a reform that reduces tariffs on intermediate and capital goods but leaves those on final outputs high can in-

crease effective protection on such goods, although the average level of tariffs has been reduced (World Bank 1987).

International trade and its effects on sources of growth

The expansion of exports introduces competition and thus leads to more efficient resource allocation and utilization and higher productivity. International trade also widens markets with benefits from scale economies and gains from international specialization. The need to compete internationally exerts pressure on non-traded services such as transport and banking.

A rapid growth of exports and imports indicates an increased openness of the Thai economy. The share of merchandised exports (fob) plus merchandised imports (cif) to GDP (at current prices) increased from 26 per cent in 1970 to 65 per cent in 1990 (World Bank 1992).

The composition of trade has changed. Traditionally, agricultural products formed the bulk of Thailand's exports and in 1989, Thailand was still a major agricultural exporter. For example, rice exports from Thailand accounted for 42 per cent of the volume and 36 per cent of the value of world rice exports in that year. However, although the total value of agricultural exports has been increasing, the share of agricultural products in total exports declined from 83 per cent in 1961 to 15 per cent in 1991 (Table 2.6). The share of manufactured exports grew rapidly, from 2 per cent in 1960 to 76 per cent in 1991.

Table 2.6
Export values by sectors, 1961 - 91

per cent

	1961	1970	1980	1991
Agriculture	83	68	47	15
Manufacturing	2	6	32	76
Others	15	26	21	9
Total	100	100	100	100

Source Bank of Thailand, *Monthly Bulletin*, various issues.

Chessada and Nattapol (1988) classify Thailand's export manufactures into four groups: agriculturally based or agro-industries; new export industries; transnational corporation labour-intensive industries; and local labour-intensive industries. The agriculturally based industries consist mostly of food industries and furniture. Originally, these industries served domestic consumption but over time they have become export-oriented. They include canned fruits, vegetables and seafood. The new export industries include textiles, jewelry, plastic products, leather products and paper products.

Labour-intensive transnational corporation industries (mostly Japanese-owned) use local labour to assemble imported intermediate goods. They include the production of integrated circuits, other electronics and ball bearings.

The local labour-intensive industries are mostly light industries that also have lower capital-labour ratios than the transnational corporation industries. The investors in this group are mostly local, though some are from Taiwan and Hong Kong. Some local labour-intensive industries have developed from domestic consumption industries into export industries. These include clothing, tiles and rubber products. The remaining labour-intensive local industries were established mainly as export industries, such as those producing plastic flowers, toys and footwear.

The expansion of export industries during the initial period of rapid export growth of manufactures in 1984 - 86 relied on rubber products, leather products, furniture, engineering and computer parts and equipment. For example, during 1983 to 1986, export growth was 46 per cent per annum for ball bearings and computer parts and equipment, 33 per cent per annum for leather products and 34 per cent per annum for furniture.

Several high growth export-oriented industries have been promoted by the Board of Investment. As discussed in the following section, there was high foreign direct investment in these industries. In 1987 for instance, 60 per cent of promoted industries were classified as export industries, the majority being owned by Japan and Taiwan. The highest investment in promoted industries was found in yarn and fabric textiles, electricity and equipment, computer parts, printers, floppy disk drives, micro-

waves, toys, rubber products, furniture and plastics. Many of these industries had high TFP growth (Chapter 5).

Imports have of course grown with exports and the rapid expansion of investment that was associated with rapid growth in the 1980s. The composition of imports has moved increasingly away from consumer goods towards capital, intermediate and raw material goods (Table 2.7)

Table 2.7
Distribution of imports, 1960 - 91

per cent of value

	1960	1970	1980	1991
Consumer goods	35	20	10	9
Intermediate and raw material	18	25	24	34
Capital goods	25	35	25	40
Other imports	22	20	41	17
Grand total	100	100	100	100

Source Bank of Thailand, *Monthly Bulletin*, various issues.

Foreign direct investment

Foreign direct investment has been an important source of growth in the Thai economy, particularly in the late 1980s. Foreign direct investment assisted the dramatic shift of Thai industry from import substitution toward export orientation (Jeerasak, Wisarn, Somjai, Pipat and Duangmanee 1989). The share of new export-oriented projects in total foreign direct investment projects increased from about 10 per cent in 1984 to more than 80 per cent in 1988. In the late 1980s, this trend had a significant impact on production efficiency due to benefits derived from technology transfer and training.

The share of foreign investment in gross domestic investment in Thailand grew from 0.7 per cent in 1979 to nearly 9 per cent in 1990 (Table 2.8).

Table 2.8

Net foreign direct investment inflows and their share in gross domestic investment, 1979 - 90

	1979	1982	1985	1988	1989	1990
Foreign direct investment (million baht)	1,127.5	4,331.4	4,441.8	28,243.8	45,697.6	64,695.0
Per cent of gross domestic investment	0.7	2.3	1.8	6.5	8.2	8.6

Source Foreign direct investment, Bank of Thailand, *Quarterly Bulletin*, various issues; gross domestic investment World Bank, *World Tables 1992*, Baltimore: The Johns Hopkins University Press.

As protection grew foreign direct investment was attracted to Thailand in the 1960s to defend markets established by exports. Protectionist and associated policies made investment in import-substitution rewarding in private profit terms to foreign investors, although the smallness of production runs, excessively capital-intensive technique, low capital utilization and the ensuing bias against agriculture and exports had high social costs.

Positive social returns from foreign direct investment were greatly increased when international circumstances of production began to change in the 1970s making Thailand attractive as an export base. Wages were rising rapidly in newly industrializing countries such as Hong Kong and Taiwan. Thailand was not yet bound by clothing and textile limitations under the Multifibre Arrangement. Above all, Thailand had a proven record of fiscal and monetary responsibility leading to low inflation and realistic and stable exchange rates. The many incentives to exports demonstrated the governments emphasis on export policy. Thailand had a complex bureaucratic environment but so did other low-labour cost countries. In several of these countries, rent seeking by public officials was on a greater scale than in Thailand (Fulkus 1992, Suphat 1992 and Sutiphan 1992). Some foreign investors even moved from the domestic to export markets in the changing circumstances of the 1980s.

Japan and the United States have been the most important source countries of foreign direct investment. Hong Kong, Taiwan and Singapore have also contributed large net flows (Table 2.9). In industry, foreign direct investment was mostly concentrated in electrical appliances, metallic and non-metallic products, food, textiles and chemicals (for example, in 1988, it represented 77 per cent of foreign direct investment

in this sector). These industries also had high TFP growth (Chapter 5). There was a dramatic change from net outflow to net inflow of foreign direct investment into financial institutions (Table 2.10) after the government signalled its interest in liberalizing financial markets in the late 1980s.

Table 2.9
Foreign direct investment net flows into Thailand by countries of origin, 1979 - 90

million baht

	1979	1982	1985	1987	1988	1989	1990
Japan	245.9	1,037.3	1,534.0	3,268.7	14,591.3	18,761.6	27,931.0
USA	226.5	857.3	2,387.5	1,815.7	3,178.6	5,220.3	6,154.0
Hong Kong	284.9	593.4	649.0	796.2	3,161.4	5,715.7	7,027.4
Taiwan	1.9	2.0	170.6	687.3	3,161.4	5,062.3	7,159.9
Singapore	-24.2	-387.5	-1,121.9	535.3	1,520.7	2,748.0	6,135.8
UK	103.7	182.2	166.3	448.1	621.4	222.3	1,130.5
Fed. Republic of Germany	184.7	182.2	166.3	448.1	621.4	817.6	1,150.0
France	-9.8	17.3	143.1	132.9	282.9	392.6	682.0
Netherlands	-11.4	1,066.8	-42.1	74.4	289.3	1,629.4	649.8
Others	125.3	780.5	433.7	956.2	659.4	5,127.8	6,674.6
Total	1,127.5	4,331.8	4,441.8	9,043.7	2,8243.8	45,697.6	64,695.0

Source Bank of Thailand, *Quarterly Bulletin*, various issues.

The changing structure of foreign direct investment is evident in Table 2.10. The bulk of investment flowed to manufacturing where, as indicated, there has been a shift from domestically to export-oriented investment.

Table 2.10
Foreign direct investment net flow by sectors, 1979 - 90

per cent

	1979	1982	1985	1988	1989	1990
Industry	64.2	28.4	30.9	57.9	47.8	47.9
Financial institutions	-48.5	-11.1	-29.1	9.6	6.2	7.0
Trade	30.3	16.1	24.6	13.9	14.9	20.0
Construction	26.1	17.0	36.0	6.9	8.6	5.1
Mining & quarrying	13.7	38.8	11.7	1.7	1.3	1.8
Agriculture	0.4	0.4	1.8	1.1	1.3	1.2
Services	13.8	10.3	24.2	8.9	19.9	17.0
Total	100.0	100.0	100.00	100.0	100.0	100.0

Source Bank of Thailand, *Quarterly Bulletin*, various issues.

Research and development

The government passed the National Research Council Act in 1956, to encourage scientific research to sustain development. The National Applied Science Research Institute Establishment Act followed in 1963. The Ministry of Science, Technology and Energy was established in 1979. The Fifth National Economic and Social Development Plan (1982 - 86) contained a section on the application of science and technology to development. During the later phase of the Sixth Plan (1987 - 92), the Thai and United States government agreed on cooperation in 'the Science and Technology Development Program'. A seven year agreement (1985 - 92) had a budget of $US 49 million to support biological, material and applied electronic technology, to promote technology in the industrial sector and to formulate policies and create the linkage mechanism between the public and private sectors regarding science and technology. But Thailand, like most economies in early stages of development and most small countries, naturally remains highly dependent on the international 'shelf' of available technology. The principal research and development efforts, at least, remain adaptive.

Importing technology is a cheap way of obtaining it, particularly as adaptive skills develop. Whether such skills have been developed on an adequate scale in Thailand is not clear. A recent study of the technological capability of 119 producers in three types of industries, biotechnology, materials technology and electronic technology, found that firms with a comparatively high technology capability were foreign firms or joint ventures (Thailand Development Research Institute 1991). Even large scale Thai firms still required turn-key technology transfers and factories. The study concluded that private firms show little interest in research and development. In practical terms, however, it is clear that a great deal of adaptation has occurred.

As the Thai economy has grown rapidly from the second half of the 1980s, the demand for skilled and particularly for technical and managerial workers has increased rapidly. A study by the Thailand Development Research Institute (1991) found that an excess demand for science and technology skills is still likely to exist during the Seventh National Economic and Social Development Plan (1992 - 96) in categories such as mechanical, chemical, industrial and mining engineering. Technical workers have moved from government to private enterprises as private salaries have become signifi-

cantly higher than government salaries. A study by the Office of the Civil Service Commission found that during 1985 - 87, of the 4,740 persons who resigned from jobs, 70 per cent had a higher degree in science and technology. The government had 756 vacant science and technology positions which could not be filled. This situation is typical for a rapidly growing country. Returns to high level technicians and managers are likely to be higher, in social as well as financial terms, in the private rather than in the public sector.

The lack of labour skilled and experienced in science and technology and the lack of funds to develop such a capacity will continue to hamper the development of an indigenous technological research and development capacity for some time.

The government is emphasising increased funding to science and particularly technology or engineering departments of universities to increase the number of undergraduate places available in these disciplines. However, the cost of funding science and engineering study is much higher than that for other disciplines. Recently, the government has encouraged private universities to expand teaching in technology and engineering. Thai economic growth cannot be sustained in future years unless technology training increases because of the importance of research and development to TFP growth and hence overall GNP growth.

Human capital development

The principal human capital factors that affect productivity are education and health.

Education

Education plays a role in increasing the productivity of labour. In agriculture this will be essential as the growth of factor inputs declines. In other sectors it is already important.

Primary school enrolments have improved so that in 1992, the proportion of students in the school age population was 93 per cent. Primary school standards were, however, uneven.

The enrolment of students in lower secondary schools, (the first three years of high school) rose from 29 per cent of the population aged 13 to 15 years in 1980, to 35 in 1985 and 40 per cent in 1990. Compared with other East Asian countries, this ratio was low. The percentage of children in high school was 48 per cent in Indonesia, 57 per cent in Malaysia, 69 per cent in Singapore, 74 per cent in Hong Kong and 87 per cent in the Republic of Korea in 1988 (World Bank 1991).

The enrolment of secondary school students is quite high in urban areas, especially in Bangkok. The transitional rate of students from the final year of primary school to the first year of lower secondary school was 95 per cent in Bangkok, 90 per cent in Nonthaburi (near Bangkok) and 82 per cent in Phuket (regarded as a rich province), but it was only 24 per cent in Udon Thani, Nongkhai, Si Sa ket and Ubon Ratchathani, and 22 per cent in Buri Rum, all poorer provinces (National Economic and Social Development Board 1989).

Thailand also lags in technical education. Skilled trades and technical workers are therefore in short supply.

In 1985 the amount spent per student on primary education was 3,423.2 baht. Nearly the same amount (3,894.0 baht per students) was spent on secondary (including both lower and higher) education in the past (Mathana and Mason 1988). The number of primary students decreased by around 400,000 during 1980 to 1990, but the number of lower secondary students did not increase by as much during the same period (Table 2.11). In part this was because the cost of lower secondary places was rising with the free services provided by the government to encourage families to allow their children to study at the lower secondary school level. The cost of secondary school places under the new scheme is not yet available. Government policy to extend compulsory education from 6 years to 9 years was announced in March 1991 (Cabinet resolution) and increases in lower secondary school attendance may be expected.

The government has placed high priority on education with education expenditure at around 3 per cent of GDP. The annual educational budget increased on average by 4.8 per cent per annum between 1980 and 1990 (in constant 1987 prices, Table

2.12). The total number of students increased by an average of 1 per cent per annum, implying a rapid increase in the cost of education per student.

Table 2.11

Total number of students, 1980 and 1990

per cent of school aged population in bracket

	1980	1990
Pre primary	349,827(8.6)	1,292,593(36.0)
Primary	7,370,846(97.0)	6,955,492(93.8)
Lower secondary	1,346,637(29.4)	1,394,129(37.2)
Higher secondary	565,984(18.4)	833,862(20.5)
Tertiary education [a]	207,390(3.6)	417,826(8.6)
Total	9,840,684(41.4)	10,893,902(46.6)

a including undergraduate and post graduate degree

Source Office of the Permanent Secretary, Ministry of Education, 1980 and 1990. *Education Statistics in Brief*, Bangkok.

Table 2.12

Government expenditure on education, 1980 and 1990

million baht

	1980	1990	per cent increase	per cent growth per annum
Current prices	25,264.1	59,962.1	-	-
1987 prices	31,818.8	51,425.5	48.0	4.8

Note GDP deflator is used to deflate current price.

Source Budget Bureau, in National Statistical Office, 1980 and 1990. *Statistical Yearbook Thailand*, Bangkok.

The increase in the cost per student place resulted from attempts to improve the quality of education. The ratio of students (at all levels) per teacher declined from an average of 21 in 1980 to 19 in 1990. The ratios fell from 23 in 1980 to 20 in 1990 for primary education and from 18 in 1980 to 17 in 1990 for secondary education (Office of the Permanent Secretary, Minister of Education 1980 and 1990). The qualifications of teachers rose. The quality of students and therefore of the labour force should have improved as a result. However, if the quality of graduates does not improve this increase in costs may merely indicate inefficiency in the school education system. It would therefore be important to evaluate changes in the quality of the education and students, but such information is not available.

Health

The health of the Thai population has improved substantially since the 1950s. Life expectancy has increased from 52 years in 1960 to 66 years in 1987. Mortality for children under five years of age dropped from 149 to 49 per thousand people between 1960 and 1988. First born deaths have been reduced from 84 per thousand in 1965 to 39 per thousand people in 1987. Malnutrition of children 0 to 5 years of age fell, from 51 per cent in 1981 to 25 per cent in 1986. The distribution of services and health personnel to rural areas is given priority by the Ministry of Public Health (Sirilaksana 1992). The standard of medical care is one of the highest in South East Asia.

Rapid economic growth, however, also has some negative aspects. Traffic congestion has led to heavy pollution in the Bangkok area as has rapid industrial expansion without concern for environmental impact. Over 50 per cent of the 52,000 factories and 23 industrial estates in Thailand are in Bangkok and surrounding areas. Health indicators nevertheless show improvement (United Nation Development Programme 1990). Remedial policies are necessary to ensure that positive environmental outcomes accompany growth.

Population and rural - urban movement

The Thai population increased from only 8 million people in 1911 (first national census) to 56 million in 1990 with peak population growth rates of 3.5 per cent a year during 1970 - 73. The rate of population growth has fallen to 1.5 per cent per annum in 1990 and 1991 (National Statistical Office 1992). Immigration fell from 490,000 persons in 1960 to 350,000 in 1970 and 270,000 persons in 1980 (National Statistical Office 1960, 1970 and 1980) contributing to low growth. The slower growth of population indicates that labour-input growth is not likely to be an important source of growth in the future. The productivity of labour will therefore become crucial.

The change in the distribution of employment between agriculture and other sectors has been quite slow relative to the change in the production structure. The considerable movement of population from rural to urban areas (Thienchay and Suwanee 1985) was driven by income differentials. Over the last 30 years rural earnings

have remained relatively low and have even been negative in some years. It seems that in the 1980s in particular, real income growth of rural households (mainly farmers) was negative in all regions except in the rural parts of Bangkok (Medhi 1992). Low rural incomes reflect relatively low productivity.

Land

Although agricultural output has continued to expand in Thailand, its growth has been limited by low land productivity. For example, the land productivity of rice, measured by output per agricultural land area, was on average 331 kilograms per rai (1 rai = 0.395 acre) during 1985 - 89 for Thailand. It was on average 460, 649, 858, 1,000 and 1,109 kilograms per rai for Vietnam, Indonesia, China, the United States and Australia (Office of Agricultural Economics 1990/91).

Much of the growth of agricultural output has resulted from the expansion of the area under cultivation through incursions into forested areas. A rising agricultural population led to the cultivation of land with inherently low productivity (National Economic and Social Development Board 1990). A 1990 survey by the Department of Land Development on the misuse of agricultural land in Thailand found that 22 per cent of the land used by rice farmers was inappropriate for rice growing (Kosit 1991).

The total area of land in Thailand is 321 million rai. The area of farming land increased from 20 per cent in 1961 to 46 per cent in 1988. Twenty eight per cent was forest land, the rest being used for industrial and community uses (Office of Agricultural Economics 1991).

Government land policies cover economic benefits, social benefits, conservation and national security (Tongroj 1990a and 1990b). Land policy differs between forest and other land. Until the 1980s land policy was relatively neglected, but policies announced in 1985 reflected the fear of environmental damage as a result of deforestation. The economic and environmental objective was to convert some of the unproductive deforested lands back to forest. Forty per cent of Thailand's total land area was to be reserved as forest land, with 25 per cent of this area designated as commercial forest land. Sound environmental practices were to protect social outcome as well as profit-

ability. The participation of the private sector was to be encouraged in the development of commercial forests.

Maximum efficiency in the use of land was to be encouraged more generally. The policies put emphasis on land outside the forest including land rights (such as title deeds to landowners), land taxes (such as the introduction of a progressive land tax), agricultural zoning, farm development strategies, soil conservation and urban land use.

The limited availability of land for agriculture was to be offset by increasing agricultural efficiency and productivity. This would also increase farmers' incomes (National Economic and Social Development Board 1991). Measures to increase agricultural productivity have focused on improving productivity of all the factors of production - capital, labour and land - particularly in the major export crops. Other measures included intervention in the pricing of crops during low agricultural price periods to protect farmers' incomes. The government has attempted to improve efficiency and productivity of farming by the promotion and development of improved seed and new techniques using fertilizers and pest controls, irrigation and land development. The measures employed have varied depending on the crop involved and agricultural conditions but overall involve a great deal of bureaucratic intervention.

Measures to increase and stabilize farm incomes have not been clearly effective. Thailand's agricultural market is quite competitive and most of the agricultural products are exported at prices closely linked to world markets. Prices hence fluctuate according to world demand and supply conditions. In Thailand, it has not been feasible for prices to be set differently from world market prices. Price support schemes put intolerable pressures on the government budget if they extend beyond the very short run. Agricultural policy has hence been receding from price stabilization.

The government support infrastructural facilities, although difficult to measure, has been important in raising production. Irrigation, though still not sufficient for some regions, has made farmers less dependent on the weather. Transportation improvements have led the way by making it possible to bring inputs to farms and get products to markets. Bringing power to rural areas has obvious high returns. An improving telecommunications network has brought price signals from world market to farmers.

Agricultural productivity has improved over the past 20 years, but the extent to which this has resulted from government as distinct from farmer initiatives is not clear. The expansion of land and other inputs has, in any case, contributed more to growth (Chapter 4 and 6).

Financial markets

The operation of financial markets affects the availability of capital and its use in production. The structure of commercial banks and interest rate policies are major concerns in the allocation of financial resources and movement of funds. In general, financial policy in Thailand favoured capital-intensive techniques and large-scale industries and was biased against agriculture.

Commercial banks dominated business finance until the recent emergence of nonbank financial enterprises. The Hong Kong and Shanghai Bank was the first bank established in Thailand in 1888. The Siam Commercial Bank, the first Thai bank, was established in 1906. Initially, permission to establish a commercial bank was required from the Ministry of Finance. Banks could freely set up branches throughout the country until 1962, when the Commercial Banking Act was enacted. In 1990, there were 29 commercial banks. They accounted for 71 per cent of total financial sector assets.

A branch banking system network has evolved, aided by controls over number of commercial banks. Most bank offices are in Bangkok and the metropolitan area. The banking sector is highly concentrated with the five largest domestic banks accounting for 66 per cent of total bank assets (Naris 1992). Provincial bank managers have little authority to provide credit. These conditions have led to a bias of credit provision against provincial and rural areas. Credit was mainly provided for large industries in the Bangkok metropolitan area. In 1987, the credit - deposit ratio of commercial banks in Bangkok was 99, compared to 70 in other provinces.

The interest rate ceilings set by the Bank of Thailand since 1962 led to distortion in the allocation of financial resources by favouring capital-intensive techniques. The interest rate ceilings changed over time, but the changes were few and slow to adjust to changes in market rates (Chesada 1990). The rate was normally set below the market

rate, so that, typically of repressed financial systems (McKinnon 1973), there was a shortage of domestic funds. Large projects, particularly in highly protected manufacturing sectors, were given priority for loans.

Since the 1980s, financial policy has been gradually liberalized to promote financial flexibility and to attract saving and inflows of foreign capital. At present, the interest rate is floating.

To promote Thailand as a regional financial centre, to encourage regional trade and investment and to improve the international competitiveness of Thai financial institutions, the government announced the establishment of the Bangkok International Banking Facility in 1992. Under this facility banks will be able to take deposits and raise loans from banks. They will also be able to engage in loan syndications.

Financial liberalization is expected to improve the mobilization of domestic savings. The Ministry of Finance and the Bank of Thailand project that, given present rates of growth in the economy, domestic saving will rise only 25 per cent, while investment demand will rise by 32 per cent during the five years of the Seventh Economic and Social Development Plan. This implies a deficiency in domestic savings by more than 800 billion baht. Financial reforms are expected to assist in attracting additional inflows, particularly of foreign direct investment. Competition in the financial market should lead to interest rates at market clearing levels. The foreign commercial banks should increase access to capital funds in the Thai economy at international interest rates.

A large increase in capital mobility might be expected as a result of the reform. Inflows of portfolio and of short term and long term capital in fact increased more than 130 per cent within 2 years from 107.2 billion baht in 1989 to 247.0 billion baht in 1991. The inflow of short term private borrowings also increased from 4.1 billion baht in 1987 to 157.7 billion baht in 1991. Financial liberalization and reforms can therefore be expected to mobilize domestic and foreign capital inflows to finance development efforts in Thailand.

3 Theoretical framework and the measurement of TFP

The methodology of TFP growth measurement using parameters estimated from production functions is examined in this chapter. Production functions and their properties are briefly discussed. Input and output data used are then explained.

TFP growth measurement

Productivity is measured as a ratio of output to inputs, normally in real terms (Nadiri 1970, 1972, Nelson 1973, 1980). There are two main types of productivity measures, partial productivity indices and multi-factor or total factor productivity (TFP). The partial indices of labour and capital productivity are the average products of labour and capital. TFP is defined as total output per unit of weighted factor inputs, where weights are factor output elasticities or factor shares, if perfect competition is assumed.

TFP growth occurs when an advance in technology and/or a change in the environment (competitiveness, market structure and organization) result in greater productivity and efficiency (Chapter 7). An advance in technological change that is not embodied in factor inputs is called disembodied technological progress (Intriligator 1965, 1978, 1992, McCarthy 1965). The rate of growth of TFP is defined as the difference between the rate of growth of real output (at constant prices) and the rate of growth of real factor inputs (at constant prices). The rate of growth of factor inputs is defined as a weighted average of the rate of growth of individual inputs. If a production function has constant returns to scale and all marginal rates of substitution between inputs are equal to the corresponding relative price ratios (at producer equilibrium), a change in TFP may be identified with a shift in the production function (Jorgenson and Griliches 1967).

There are many ways of measuring TFP growth. In practice, the two indices used most often in empirical research are Kendrick's arithmetic measure (Kendrick 1961, Kendrick and Sato 1963) and Solow's geometric index (Solow 1957). Kendrick measures TFP growth using a distribution equation derived from a homogeneous production function and the use of Euler's theorem (Equation 3.1). Solow's measure is

based on the Cobb-Douglas production function, with constant returns to scale and neutral technological change in a perfect competition framework (Equation 3.2) (Solow 1956, 1957). The Solow TFP growth is equivalent to that measured by Kendrick for small changes in the quantities of inputs and outputs (Levhari, Kleiman and Halevi 1966).

$$\dot{TFP} = \frac{y_1/y_0}{(wL_1 + rK_1)/(wL_0 + rK_0)} \tag{3.1}$$

$$\dot{TFP} = \frac{\dot{y}}{y} - (\beta_k \frac{\dot{K}}{K} + \beta_L \frac{\dot{L}}{L}) \tag{3.2}$$

where

$\dot{TFP}$, $\dot{K}$, and $\dot{L}$ are growth of TFP, capital and labour respectively

y = real output (at constant price) = f(K, L)

K = capital

L = labour

β_k = output elasticity of capital

β_L = output elasticity of labour

$\beta_k + \beta_L = 1$

0 and 1 are the initial period and the next period respectively

w and r are the prices of labour and capital

This study uses the Solow measure to calculate TFP growth. Mathematically, real output (y) is a function of capital (K) and labour (L) (Equation 3.3).

$$y_t = f(K_t, L_t, t) \tag{3.3}$$

where t is time.

The growth in output over time is given by taking a natural logarithmic then total differentiating Equation (3.3) with respect to t.

$$\frac{d\ln y}{dt} = \frac{\partial \ln y}{\partial \ln K}\frac{\partial \ln K}{\partial t} + \frac{\partial \ln y}{\partial \ln L}\frac{\partial \ln L}{\partial t} + \frac{\partial \ln y}{\partial t}$$

$$\frac{dy}{dt}\frac{1}{y} = \frac{\partial \ln y}{\partial \ln K}\left(\frac{1}{K}\frac{\partial K}{\partial t}\right) + \frac{\partial \ln y}{\partial \ln L}\left(\frac{1}{L}\frac{\partial L}{\partial t}\right) + \left(\frac{\partial y}{\partial t}\right)\frac{1}{y} \tag{3.4}$$

$$\text{Or, } \frac{\dot{y}}{y} = \beta_k \frac{\dot{K}}{K} + \beta_L \frac{\dot{L}}{L} + m \tag{3.5}$$

where

$\cdot$ means $\frac{\partial}{\partial t}$

$\beta_k = \frac{\partial \ln y}{\partial \ln K}$ = output elasticity of capital

$\beta_L = \frac{\partial \ln y}{\partial \ln L}$ = output elasticity of labour

$m = \frac{\partial y}{\partial t}\frac{1}{y} = \dot{TFP}$

According to the definition, m is the rate of growth of output over time (while other input growth is controlled) and is referred to as TFP growth since, from Equation (3.5)

$$m = \dot{TFP} = \frac{\dot{y}}{y} - \beta_k \frac{\dot{K}}{K} - \beta_L \frac{\dot{L}}{L} \tag{3.6}$$

Two terms of Equation (3.5) ($\beta_k \frac{\dot{K}}{K}$ and $\beta_L \frac{\dot{L}}{L}$) indicate the change in output owing to an increase in total inputs of both capital and labour or a movement along the production function. The last term (equals m) on the right side indicates the change in output owing to disembodied technological progress or a shift in the production function. Output therefore increases or decreases due to two factors: increases in inputs (input growth) and shifts in the production function (TFP growth) (Solow 1957).

It should be noted that productivity growth may be either positive or negative. The growth of output or value-added at constant prices ($\frac{\dot{y}}{y}$) can be either less or more than the growth of the weighted average of inputs used (in real terms or constant prices

($\beta_K \frac{\dot{K}}{K}$ and $\beta_L \frac{\dot{L}}{L}$) as shown in Equation (3.6), depending on whether these last two terms exceed the first one.

In general, let $y_i(t)$ be the quantity of the i^{th} variety of output, produced in period t. $K_i(t)$ is the quantity of capital input used in the production of the i^{th} output in period t. $L_i(t)$ is the quantity of labour input used in the production of the i^{th} output in period t. A Tornqvist index of total factor productivity growth or TFP(t) (Tornqvist 1936, Diewert 1976 and 1979, Hulten 1973 and Lawrence and McKay 1980) can be written as:

$$\ln y_i(t) - \ln y_i(t-1) = \bar{V}_k^i [\ln K_i(t) - \ln K_i(t-1)]$$

$$+ \bar{V}_L^i [\ln L_i(t) - \ln L_i(t-1)] + \bar{V}_T^i \qquad (3.7)$$

where the weights are given by

$$\bar{V}_k^i = \frac{1}{2}[V_k^i(t) + v_K^i(t-1)]$$

$$\bar{V}_L^i = \frac{1}{2}[V_L^i(t) + V_L^i(t-1)]$$

The average rate of productivity growth ($\bar{V}_T^i = \dot{TFP}$) is therefore given by the translog rate of productivity growth

$$\bar{V}_T^i = \frac{1}{2}[V_T^i(t) + V_T^i(t-1)]$$

TFP growth or the shift of the production function is sometimes called residual growth or multifactor productivity growth: output growth due to factors other than input growth. It is impossible in practice to include all factors in a production function estimation due to limits on the availability of data on all factors concerned. Omission of minor production factors will not, however, have a significant effect on the results of the TFP growth estimation, as long as major input variables are included. TFP growth of the agricultural sector is estimated both with and without fertilizer as a factor and TFP estimates varied very little (Chapter 4). The reason for the small change in the estimated TFP growth might be due to the imposition of constant return to scale which implies that all weights sum to one. The added fertilizer variable in the model of agri-

cultural TFP growth estimation affects changing in the contribution of closely related input such as land. The main purpose of this study is not merely to estimate the absolute size of TFP growth, but to compare the size and indicators of TFP growth in sectors, industries and crops, and so to explain the major sources of growth in Thailand and draw policy implications.

The framework of input variables included in the TFP estimation follows the framework adopted by Gollop (1983). The alternatives of the aggregate productivity studies is based on the measures of value added versus on deliveries to final demand. While the final products included in national products should be the objective of production, the sum of sectoral deliveries to final demand should therefore be the appropriate measure. Gollop (1983) shows that existence of imported intermediate inputs may cause TFP studies based on value added measures to yield upward bias in their estimation of productivity growth (Appendix CH 3 Section 3.1).

Sectoral deliveries to intermediate demand could be excluded from the aggregated productivity estimation if they are viewed as self-cancelling transactions. The self-cancelling property in fact follows the assumption that the economy is closed to trade in foreign - produced inputs. Once trade in foreign - supplied inputs is introduced, however, domestic deliveries to intermediate demand and intermediate input purchases are not offsetting transfer.

Since the data on domestically produced and imported intermediate inputs is unavailable, the study will include only primary capital and labour inputs in the estimation. This, however,could make a little upward bias of TFP growth estimation.

TFP estimation methodology adopted in the study

There are studies estimating TFP growth in Thailand, however, most of them using non-parametric approach; i.e. they used factor shares as the weight of each input factor in calculation of TFP growth (Equation 3.6). This study will directly employ output elasticity of each input factor estimated from production function to be the weights. An advantage of this method is that the data on wage and rent (factor returns) normally are not much reliable.

The main task in estimating TFP growth is to determine the factor weights to be used in the TFP growth estimation equation, β_K and β_L in Equation (3.6). In equilibrium and with perfect competition, factor shares (wage shares and rent shares for labour and capital) are equal to the output elasticity of that factor, and these factor shares can be used to estimate Equation (3.6) (as used in some papers including Denison 1967, 1976). Nevertheless, the most direct method of TFP estimation is to estimate the production function and use the estimated values of output elasticities of factors as the weights in calculating Equation (3.6). In addition, since the cost function has a duality property with respect to the production function, the cost function can also be used to calculate TFP growth. These two methods of TFP calculation will be equal under the constant return to scale condition (Equation 3.12).

Production functions can be of the form

$$y(t) = F(X_{1t}, X_{2t}, ..., X_{nt}, t) \tag{3.8}$$

Alternatively, the cost function, according to microeconomic theory, may be chosen as a dual of the production function

$$C = C[y(t), P_{1t}, P_{2t}, ..., P_{nt}, t] \tag{3.9}$$

where

X_{it} = factor input

P_{it} = the i^{th} factor input price

i = 1, 2, ..., n

Assuming that F and C satisfy differentiability and curvature characteristics, the growth of total factor productivity can be measured by:

$$\dot{TFP} = \gamma = \frac{\partial \ln y(t)}{\partial t} = \frac{\partial y}{\partial t}\frac{1}{y} \tag{3.10}$$

where

y(t) is the output of the production function

$y(t) = F(X_{1t}, X_{2t}, ... X_{nt}, t)$

X_i is the i^{th} input

Therefore γ indicates how the maximum output changes over time, under the given inputs used.

Or using the duality property

$$\dot{TFP} = \Gamma = -\frac{\partial \ln C}{\partial t} = -\frac{\partial C}{\partial t}\frac{1}{C} \tag{3.11}$$

where

C(t) is the minimum total cost of producing output Y(t)

Therefore Γ is the change over time in the minimum cost of producing a given level of output, at given input prices.

γ is related to Γ by

$$\gamma = \frac{\Gamma}{\theta} \tag{3.12}$$

where

θ = lnC/lny = an index of returns to scale (Ohta 1974).

When constant returns to scale are imposed, $\gamma = \Gamma$ since $\theta = 1$. The cost function can be obtained by the solution of the cost minimization condition for competitive producers who face given input prices. Therefore Γ, which is estimated from the cost function, must give the same result as γ which is estimated from its primal production function under conditions of constant returns to scale.

TFP growth estimates are based on the production function to obtain elasticities of output which are then used as the weights of the factor inputs in TFP growth estimation. The prime reason for choosing the production function to estimate TFP growth is that some time-series data on input prices are unavailable and unreliable. In this study, TFP growth will be estimated by Equation (3.5).

Functional forms of the production function

Several forms of the production function could be used for econometric estimation. Two important forms of production function, Cobb-Douglas and Transcendental logarithmic (Translog), will be used in this study. Their properties are discussed briefly below.

The Cobb-Douglas production function

$$y = A K^{\alpha} L^{\beta} \tag{3.13}$$

In this case, $\sigma = 1$ and return to scale $(\mu) = \alpha + \beta >, <$ or $=1$

A simple Cobb Douglas production function is

$$y_t = A e_t^{mt} K_t^{\alpha} L_t^{(1-\alpha)} \tag{3.14}$$

wheree

A is a constant

m is the rate of Hicks neutral technological progress

α is parameter which applies to capital input

The marginal products of labour and capital will be:

$$\frac{\partial y}{\partial K} = r = \frac{\alpha y}{K}$$

$$\frac{\partial y}{\partial L} = w = (1-\alpha)\frac{y}{L} \tag{3.15}$$

Or

$$\alpha = \frac{\partial y}{\partial K}\frac{K}{L} = \frac{rK}{y}$$

$$(1-\alpha) = \frac{\partial y}{\partial L}\frac{L}{y} = \frac{wL}{y} \tag{3.16}$$

Equation (3.15) shows that the parameter α is in fact the output elasticity of capital. The labour exponential parameter (1-α) is also in fact the output elasticity of labour. Equation (3.15) is a constant returns to scale production function, hence output is entirely accounted for by the sum of the share of inputs.

The elasticity of substitution between labour and capital, σ, is be defined as

$$\sigma = \frac{d(\frac{K}{L})/(\frac{K}{L})}{d(\frac{w}{r})/(\frac{w}{r})} \tag{3.17}$$

From Equations (3.15),

$$\frac{w}{r} = \frac{(1-\alpha)K}{\alpha L} \tag{3.18}$$

Substituting Equation (3.18) into Equation (3.17)

$$\sigma = \frac{d(\frac{K}{L})/(\frac{K}{L})}{[\frac{(1-\alpha)}{\alpha} d(\frac{K}{L})]/[\frac{(1-\alpha)}{\alpha}\frac{K}{L}]} = 1$$

This means that the relative prices of the two factors of production always change in exactly the same proportions (but move in the opposite direction) to their relative quantities. This implies that their equilibrium shares of the national income, α and 1 - α can not change for given constant returns to scale Cobb-Douglas production function.

Transcendental logarithmic (Translog) production function

Translog production function is an interesting and commonly used form of non-homothetic production functions (Christensen, Jorgenson and Lau 1973). The returns to scale and equilibrium input ratios (input combination used) of the non-homothetic production function are not constant. They have more flexible functional forms and do not impose *a priori* restrictive constraints, such as homotheticity, constancy of the elastic-

ity of substitution, and additivity. They also enable the inclusion of multiple products and/or multiple inputs.

In the general case, let the translog production possibility frontier be

$$F(y_1, y_2, \ldots, y_n, A) = 0 \tag{3.19}$$

where

y_i is net output (output - input) of the i^{th} commodity; i = 1, 2, ... , n.

A is an index of the rate of technological progress

By adding unity and taking logarithms Equation (3.19) becomes

$$\ln(F+1) = \alpha_0 + \sum_i^n \alpha_i \ln y_i + \frac{1}{2}\sum_i^n \sum_j^n \alpha_{ij} \ln y_i \ln y_j$$

$$+ \sum_i^n \beta_i \ln A \ln y_i + \beta_A \ln A \tag{3.20}$$

In the case of two inputs, K and L, and one output y, the translog production function can be approximated as

$$\ln y_t = \gamma_0 + \gamma_k \ln K_t + \gamma_L \ln L_t + \frac{1}{2}\gamma_{kk}(\ln K_t)^2 + \frac{1}{2}\gamma_{LL}(\ln L_t)^2$$

$$+ \gamma_{kL} \ln K_t \ln L_t + \gamma_{kt} T \ln K_t + \gamma_{Lt} T \ln L_t + \gamma_t T \tag{3.21}$$

The output elasticities of capital and labour take varied values depending on levels of K, L and T and are given by

$$\frac{\partial \ln y_t}{\partial \ln K_t} = \frac{\partial y_t}{\partial K_t}\frac{K_t}{y_t} = \gamma_k + \gamma_{kk} \ln K_t + \gamma_{kL} \ln L_t + \gamma_{kt} T$$

$$\frac{\partial \ln y_t}{\partial \ln L_t} = \frac{\partial y_t}{\partial L_t}\frac{L_t}{y_t} = \gamma_L + \gamma_{LL} \ln L_t + \gamma_{kL} \ln K_t + \gamma_{Lt} T \tag{3.22}$$

If constant returns to scale are imposed, the following restrictions on the parameters of the production function Equation (3.22) hold.

$$\gamma_k + \gamma_L = 1$$

$$\gamma_{kk} + \gamma_{kL} + \gamma_{kt} = 0$$

$$\gamma_{LL} + \gamma_{kL} + \gamma_{Lt} = 0$$

$$\gamma_{kL} = \gamma_{Lk}, \quad \text{(Young's Theorem)} \tag{3.23}$$

Output and inputs used

Aggregated sectoral value-added at constant prices is used to measure output in the sectoral level analyses. For factor inputs, sectoral net capital stock and sectoral employed labour are used. Only the agricultural sector requires two additional variables in estimation (Chapter 4), agricultural planted area (Office of Agricultural Economics) and fertilizer per planted area (FAO).

Capital stock

There are no official capital stock series data for Thailand. Some capital stock series are available for some periods, but such estimated series are not continuous. The first series of capital stock was estimated by Trescott in 1968 in order to analyze economic growth in Thailand (1946 - 65). Other series have been estimated including those by the Bank of Thailand (1960 - 79), the National Economic and Social Development Board (NESDB) (1970 - 80), Kitti (1988) for 1960 - 86 and Direk and Chaiyudht (1989) for 1972 - 87. A new capital stock series was estimated by the NESDB (1970 - 89).

This study uses the net capital stock data estimated by the NESDB for 1970-89, because its time coverage is appropriate and it contains more disaggregated data than any of the other series. In the new National Accounts, some of the concepts, as well as the coverage, grouping and classifications of data were changed, but the NESDB data is estimated using consistent net capital stock series data. Data variables required are not available beyond 1989.

Most of the capital stock series were estimated using the Perpetual Inventory Method (PIM) (Christensen and Jorgenson 1970). Gross fixed capital formation minus depreciation is added to capital stock from the previous year. The only differences among the estimations are the rates of depreciation adopted in the estimation and the capital stock in the bench mark years.

Employed labour

Sectoral employment data are from the annual labour force survey conducted by the National Statistical Office. Two labour force surveys are conducted each year. The first is held from January to March, the non-agricultural season. Agricultural employment drops but employment in industry and services rises. Seasonal migration temporarily occurs during this period. The second is from July to September corresponding with the agricultural season. Since 1984, another round of the survey has been conducted in May. Therefore, the new sequences of the survey have three rounds; February (first round), May (second round) and August (third round).

The number of employed workers is averaged over a year since this study is concerned with annual changes in production and productivity in the whole economy and different sectors.

Appendix CH 3

3.1 Growth accounting and aggregate factor productivity [1]

This section is to show that the existence of imported intermediate inputs may cause TFP estimation based on value added measures to yield upward bias. Nevertheless, the data on domestically produced and imported intermediate inputs is unavailable, the study, therefore, includes only primary capital and labour inputs in the estimation along the line with the value added model.

Let the aggregate economy be a collection of interdependent sectors. Each sector uses labour, capital and intermediate inputs to produce products delivered to meet final and/or intermediate demands. For an economy closed to foreign trade to supply material inputs. Under these conditions, deliveries to final demand and value-added models can be shown later to produce equivalent measures of aggregate productivity growth. Given this characterization of economic activity, deliveries to meet final demand can be shown to equal national net output or aggregate value-added. Labour and capital are therefore the only primary inputs in the production accounting according to Equation (3).

In general, sectoral accounting identities relate the value of gross output to payments to all factors of production, including intermediate inputs.

$$q_j Y_j = \sum_k p_{kj} K_j + \sum_l p_{lj} L_{lj} + \sum_i p_i X_{ij} \qquad (1)$$

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1 Details of this section are based on Gollop (1983 and 1987), and Syrquin (1987).

where

Y_j = gross output of the jth sector

q_j = price of gross output of the jth sector

p_{lj}, p_{kj} = price of labour and capital employed by the jth sector respectively

p_i = price of the ith intermediate input

X_{ij} = ith intermediate input used in the jth sector

i = 1, 2, ..., h intermediate inputs used

j = 1, 2, ..., n sectors

k = 1, 2, ..., s capital inputs used

l = 1, 2, ..., r labour inputs used

The value of sectoral value-added ($q_j^V V_j$) is equal to the value of gross output less the value of intermediate input purchases:

$$q_j^V V_j = q_j^Y Y_j - \sum_i p_i X_{ij} \tag{2}$$

Substituting (1) into (2) and summing over all n sectors yields

$$\sum_j q_j^V V_j = \sum_j \sum_k p_{jk} K_{kj} + \sum_j \sum_l p_{lj} L_{lj} \tag{3}$$

Equations (1) and (3) show that final output is represented as a function of intermediate input and value-added. Value-added in turn is represented as a function of the capital, labour inputs.

Aggregate productivity growth estimation: closed economy

The production possibility frontier for the economy can be defined as

$$F(V_1, V_2, \ldots, V_n, K_{11}, K_{12}, \ldots, K_{sn}, L_{11}, L_{12}, \ldots L_{rn}, t)$$

In general, the maximum value of aggregate value-added (Φ) is expressed as a function of all quantities of sectoral value-added (V), aggregate labour (L), capital input (K) and time (t).

$$\Phi = F(V_1, V_2, \ldots, V_n, K_{11}, K_{12}, \ldots, K_{sn}, L_{11}, L_{12}, \ldots L_{rn}, t) \quad (4)$$

Given this production frontier and in a competitive economy, producer equilibrium requires that each factor's elasticity of output equal its value share in aggregate value-added.

Following the definition of elasticity by taking logarithmic Equation (4) and taking partial differentiation with respect to lnV, lnK and lnL, using Equation (3) and rearranging

$$\frac{\partial \ln F}{\partial \ln V_j} = -\frac{q_j^V V_j^V}{\sum_j q_j^V V_j^V}$$

$$\frac{\partial ln F}{\partial ln K_{kj}} = \frac{p_{kj} K_{kj}}{\sum_j q_j^V V_j^V}$$

$$\frac{\partial ln F}{\partial ln L_{lj}} = \frac{p_{lj} L_{lj}}{\sum_j q_j^V V_j^V} \qquad (5)$$

j = 1, 2, ..., n

k = 1, 2, ..., s

l = 1, 2, ..., r

Taking total logarithmic differentiation Equation (4) with respect to time t

$$\sum_j \left(\frac{\partial \ln F}{\partial \ln V_j}\right)\left(\frac{d \ln V_j}{dt}\right) + \sum_j \sum_k \left(\frac{\partial \ln F}{\partial \ln K_{kj}}\right)\left(\frac{d \ln K_{kj}}{dt}\right)$$

$$+ \sum_j \sum_l \left(\frac{\partial \ln F}{\partial \ln L_{lj}}\right)\left(\frac{d \ln L_{lj}}{dt}\right) + \frac{\partial \ln F}{\partial t} = 0 \qquad (6)$$

where

$\frac{\partial \ln F}{\partial t}$ is the aggregate total factor productivity growth

Substituting (5) into (6), the aggregate rate of productivity growth (F_V^C) can be expressed as

$$F_V^C = \frac{\partial \ln F}{\partial t} = \sum_j \left(\frac{q_j^V V_j}{\sum_j q_j^V V_j}\right)\left(\frac{d \ln V_j}{dt}\right) - \sum_j \sum_k \left(\frac{p_{kj} K_{kj}}{\sum_j q_j^V V_j}\right)\left(\frac{d \ln K_{kj}}{dt}\right)$$

$$- \sum_j \sum_l \left(\frac{p_{lj} L_{lj}}{\sum_j q_j^V V_j}\right)\left(\frac{d \ln L_{lj}}{dt}\right) \qquad (7)$$

Equation (7) shows that for aggregate productivity growth for a closed economy, maximizing net output (value-added) can be defined as the weighted average of growth rates of sectoral value-added less the weighted average of growth rates of primary inputs (labour and capital). Both weights of capital and labour sum to unity.

Consider the other case of a model of aggregate productivity growth stated in terms of deliveries to final demand (the economy's objective is assumed to be to maximize aggregate output defined as delivery to final demand). It will now be constrained by aggregate production functions of gross output, not aggregate value-added functions. In the case of a closed economy, with aggregate output defined as deliveries to final demand (Y_j), the maximum value of all quantities of sectoral deliveries to final demand Y_j, all primary inputs and time are shown in (8) below.

$$\Phi = G(Y_1, Y_2, \ldots, Y_n, K_{11}, K_{12}, \ldots, K_{sn}, L_{11}, L_{12}, \ldots L_{rn}, t) \qquad (8)$$

The model here excludes intermediate inputs and sectoral deliveries to intermediate demand because all domestic purchases and sells of intermediate inputs are self-cancelling transactions.

Therefore, the linearly homogeneous sectoral production functions are

$$Z_i = g^j(K_{1j}, K_{2j}, \ldots, K_{sj}, L_{1j}, L_{2j}, \ldots, L_{rj}, X_{1j}, X_{2j}, \ldots, X_{nj}, t) \qquad (9)$$

Following the steps in Equations (5) to (7) in the case of an aggregate value-added function, and because $\Sigma\Sigma p_j X_{ji} = \Sigma\Sigma p_i X_{ij}$, the aggregate productivity growth can be expressed as the weighted average of the growth of sectoral deliveries to final demand less a weighted average of growth of labour and capital inputs as in Equation (10).

$$F_Y^C = \frac{\partial \ln G}{\partial t} = \Sigma_j \left(\frac{q_j^Y Y_j}{\Sigma_j q_j^Y Y_j}\right)\left(\frac{d \ln Y_j}{dt}\right) - \Sigma\Sigma_{j\,k}\left(\frac{p_{kj} K_{kj}}{\Sigma_j q_j^Y Y_j}\right)\left(\frac{d \ln K_{kj}}{dt}\right)$$

$$-\sum_j \sum_l \left(\frac{p_{lj} L_{lj}}{\sum_j q_j^Y Y_j}\right)\left(\frac{d \ln L_{lj}}{dt}\right) \qquad (10)$$

Equation (10) shows that the growth of aggregate productivity for a model stated in terms of deliveries to final demand can be expressed as the weighted average of growth of sectoral deliveries to final demand less a weighted average of growth of primary inputs (labour and capital).

The relationship between F_V^C and F_Y^C can be shown as

$$F_V^C = \frac{\sum_j q_j^Y Y_j}{\sum_j q_j^V V_j} F_Y^C$$

Summing over all sectors gives $\sum_j q_j^V V_j = \sum_j q_j^Y Y_j$

For an economy closed to trade in foreign produced inputs, it can be concluded that value-added and delivery to final demand models of production leads to identical aggregate productivity growth measurement.

Aggregate productivity growth: open economy

In the case of an open economy with foreign-produced intermediate inputs, the only difference will be that imported inputs must enter the aggregate production possibility frontier. Therefore the aggregate production possibility frontier will be

$$\Phi = H(Y_1, Y_2, \ldots, Y_n, K_{11}, K_{12}, \ldots, K_{sn}, L_{11}, L_{12}, \ldots L_{rn}, M_{11}, M_{12}, \ldots, M_{un}, t) \qquad (11)$$

The linearly homogeneous sectoral production functions are

$$Z_j = h^j(K_{1j}, K_{2j}, \ldots, K_{sj}, L_{1j}, L_{2j}, \ldots L_{rj}, X_{1j}, X_{2j}, \ldots, X_{nj}, M_{1j}, M_{2j}, \ldots, M_{uj}, t) \quad (12)$$

The derived aggregate productivity growth, following similar steps as outlined in Equations (5) to (7), will give Equation (13) below. The aggregate productivity growth in a model incorporating trade and foreign produced inputs from delivery to final demand (Y) is smaller than the closed economy model of aggregate productivity in Equation (10) due to the inclusion of terms for imported inputs as in Equation (13).

$$F_Y^O = \frac{\partial \ln F}{\partial t} = \sum_j \left(\frac{q_j^Y Y_j}{\sum_j q_j^Y Y_j}\right)\left(\frac{d \ln Y_j}{dt}\right) - \sum_j \sum_k \left(\frac{p_{kj} K_{kj}}{\sum_j q_j^Y Y_j}\right)\left(\frac{d \ln K_{kj}}{dt}\right)$$

$$- \sum_j \sum_l \left(\frac{p_{lj} L_{lj}}{\sum_j q_j^Y Y_j}\right)\left(\frac{d \ln L_{lj}}{dt}\right) - \sum_j \sum_m \left(\frac{p_m M_{mj}}{\sum_j q_j^Y Y_j}\right)\left(\frac{d \ln M_{mj}}{dt}\right) \qquad (13)$$

where

F_Y^O = the aggregate productivity growth derived from a delivery to final demand model for an economy open to trade in foreign produced inputs

M_{mj} = the imported inputs of sector j^{th}

In the case of an economy open to trade in foreign produced inputs, the aggregate productivity growth derived from a value-added model of aggregate production function will be derived similarly to the steps in Equations (1) to (7) for the closed-to-trade model. The only difference is that the model for an open economy will have the term of the value of the economy's imported inputs in Equations (1) and (2). Now Equations (2) will be

$$q_j^V V_j = q_j^Y Y_j - \sum_i p_i X_{ij} - \sum_m p_m M_{mj} \quad \text{, and}$$

$$\frac{d\ln V_j}{dt} = \frac{q_j Z_j}{q_j^v V_j}\frac{d\ln Z_j}{dt} - \sum_i \frac{p_i X_j}{q_j^v V_j}\frac{d\ln X_{ij}}{dt} - \sum_m \frac{p_m M_{mj}}{q_j^v V_j}\frac{d\ln M_{mj}}{dt} \qquad (14)$$

Following similar steps from Equations (1) to (7), the aggregate productivity growth in the model open to trade in imported input (F_V^O) will be

$$F_V^O = \sum_j \left(\frac{q_j^V V_j}{\sum_j q_j^V V_j}\right)\left(\frac{d\ln V_j}{dt}\right) - \sum_j \sum_k \left(\frac{p_{kj} K_{kj}}{\sum_j q_j^V V_j}\right)\left(\frac{d\ln K_{kj}}{dt}\right)$$

$$-\sum_j \sum_l \left(\frac{p_{lj} L_{lj}}{\sum_j q_j^V V_j}\right)\left(\frac{d\ln L_{lj}}{dt}\right) - \sum_j \sum_m \frac{p_m M_{mj}}{\sum_j q_j^v V_j}\frac{d\ln M_{mj}}{dt} \qquad (15)$$

The relationship between F_V^O and F_V^C can be shown as

$$F_V^O = \frac{\sum_j q_j^Y Y_j}{\sum_j q_j^V V_j} F_Y^O \qquad (16)$$

where

$\frac{\sum_j q_j^Y Y_j}{\sum_j q_j^V V_j}$ equals unity for a closed economy but it is greater than unity for an open economy.

For aggregate productivity growth for the open economy maximizing aggregate final output (deliveries to final demand) can be defined as the weighted average of growth of sectoral deliveries to final output less the weighted average of growth of primary inputs (capital and labour) and imported inputs (Equation 13). The aggregate productivity growth derived from a value-added model is hence greater than the productivity growth derived from deliveries to final demand, as shown in Equation (16).

Sectoral productivity growth estimation

Neither foreign produced inputs nor domestically produced intermediate inputs enter the description of sectoral value-added productivity growth as shown in Equation (17) below. But in the deliveries to final demand model, sectoral productivity growth now depends on both intersectoral and international transactions as shown in Equation (18).

$$f_{V_j}^O = \frac{\partial ln V^j}{\partial t} = \frac{d\, ln V_j}{dt} - \sum_k \left(\frac{p_{kj} K_{kj}}{q_j^V V_j}\right)\left(\frac{d\, ln K_{kj}}{dt}\right) - \sum_l \left(\frac{p_{lj} L_{lj}}{q_j^V V_j}\right)\left(\frac{d \ln L_{lj}}{dt}\right) \qquad (17)$$

$$f_{Y_j}^{O} = \frac{\partial \ln Y^j}{\partial t} = \frac{d \ln Y_j}{dt} - \sum_k \left(\frac{p_{kj} K_{kj}}{q_j^Y Y_j}\right)\left(\frac{d \ln K_{kj}}{dt}\right) - \sum_l \left(\frac{p_{lj} L_{lj}}{q_j^Y Y_j}\right)\left(\frac{d \ln L_{lj}}{dt}\right)$$

$$-\sum_i \left(\frac{p_i X_{ij}}{q_j^Y Y_j}\right)\left(\frac{d \ln X_{ij}}{dt}\right) - \sum_m \left(\frac{p_m M_{mj}}{q_j^Y Y_j}\right)\left(\frac{d \ln M_{mj}}{dt}\right) \quad (18)$$

where

$$V_j = V^j(L_{1j}, L_{2j}, \ldots, L_{rj}, K_{1j}, K_{2j}, \ldots, K_{sj}, t)$$

V_j is sectoral (j) value-added function

$$Y_j = Y^j[V^j(.), X_{1j}, X_{2j}, \ldots, X_{nj}, M_{1j}, M_{2j}, \ldots, M_{uj}, t]$$

Y_j is sectoral (j) production of gross output

X_{ij} is i^{th} intermediate input used in the j^{th} sector

M^{mj} is m^{th} imported input used in the j^{th} sector

4 Estimation of TFP growth of eight major sectors

The major task of the analysis in Chapters 4, 5, and 6 will be to identify the two major sources of growth in the Thai economy during the past 20 years: input growth and TFP growth. The study will estimate the size of these sources of growth and compare the results for the various sectors studied. This study deals with eight major sectors into which the economy is divided: agriculture; mining and quarrying; manufacturing; construction; electricity and water; communication and transportation; commerce and finance; and services. The grouping of these eight sectors is determined by the availability of data. The manufacturing and agricultural sectors are analyzed in more detail with thirteen industries and five crops respectively in Chapters 5 and 6.

First, production functions for each major sector in the economy are estimated to calculate the weights employed in the estimation of their TFP growth. To compare and analyze TFP growth consistently, the form of production function commonly used, the constant returns to scale Cobb-Douglas production function (CRS-CD), is chosen. As the study uses aggregated data, the aggregation bias is also a reason to choose CRS-CD. The constant returns to scale Cobb-Douglas production function is linearly homogeneous with the properties of additivity and separability *a priori* which is important for the analysis of production functions, in terms of the existence and consistency of aggregation of variables (Zellner 1962, Green 1964, Walters 1968, Bridge 1971, Berndt and Christensen 1973, Yuhn 1991). Nevertheless, constant and non-constant returns to scale of Cobb-Douglas and Translog production functions are also estimated and reported. The results of the estimation will finally be compared across sectors in terms of both TFP growth and an index of TFP levels.

Production function and TFP growth estimation

Two factor inputs, capital (K) and labour (L), are considered in the production functions estimated for all sectors studied, except in agriculture which has an additional important input factor in land, that is, the planted area (PA). The constant returns to scale Cobb-Douglas (CRS-CD) production function used in the study is described as follows

For non-agriculture

$$\ln y_t = \beta_0 + \beta_k \ln K_t + (1 - \beta_k) \ln L_t \quad (4.1)$$

Or $[\ln y_t - \ln L_t] = \beta_0 + \beta_k [\ln K_t - \ln L_t]$;

And for agriculture

$$\ln y_t = \beta_0 + \beta_k \ln K_t + \beta_p \ln PA_t + (1 - \beta_k - \beta_p) \ln L_t$$

Or ; $[\ln y_t - \ln L_t] = \beta_0 + \beta_k [\ln K_t - \ln L_t] + \beta_p [\ln PA_t - \ln L_t]$; (4.2)

where

$\beta_L = 1 - \beta_k$ for non-agriculture

$\beta_L = 1 - \beta_k - \beta_p$ for agriculture

For agriculture, another equation, including fertilizer per planted area (F), is estimated, as it could be argued that fertilizer is another important factor of production. TFP growth is examined and compared with and without the fertilizer variable. In the estimation of TFP growth in the production of five crops in Chapter 6, the study includes only the first three inputs (capital, labour and planted area) as data is not available on fertilizer utilization for each crop in each area for time series. For a consistent comparison of TFP growth in the overall agricultural sector and the separate five crops, it is necessary to use agricultural TFP growth estimated from a common model, hence without fertilizer. A comparison of the results between the two models, with and without fertilizer, is given to show the impact of the inclusion of fertilizer.

The CRS-CD production function for agriculture including fertilizer is

$$\ln y_t = \beta_0 + \beta_k \ln K_t + \beta_p \ln PA_t + \beta_f \ln F_t + (1 - \beta_k - \beta_p - \beta_f) \ln L_t$$

Or $[\ln y_t - \ln L_t] = \beta_0 + \beta_k [\ln K_t - \ln L_t] + \beta_p [\ln PA_t - \ln L_t]$

$$+ \beta_f [\ln F_t - \ln L_t] \quad (4.3)$$

The translog production function for non-agriculture is

$$\ln y_t = \beta_0 + \beta_k \ln K_t + \beta_L \ln L_t + \frac{1}{2}\beta_{kk}(\ln K_t)^2 + \frac{1}{2}\beta_{LL}(\ln L_t)^2$$

$$+ \beta_{kL} \ln K_t \ln L_t \qquad (4.4)$$

If a constant returns to scale condition is imposed, this implies the following restrictions on the parameters of the production function Equation (4.4)

$$\beta_k + \beta_L = 1$$

$$\beta_{kk} + \beta_{kL} = 0$$

$$\beta_{LL} + \beta_{kL} = 0$$

and $\beta_{kL} = \beta_{Lk}$, by Young's Theorem (4.5)

Imposing these restrictions, the constant return to scale translog production function (CRS-T) that is estimated (detail in Section 4.1 Appendix CH 4) becomes:-

For non-agriculture

$$\ln y_t - \ln L_t = \beta_0 + \beta_k(\ln K_t - \ln L_t) - \frac{1}{2}\beta_{kL}(\ln K_t - \ln L_t)^2$$

For agriculture

$$\ln y_t - \ln L_t = \beta_0 + \beta_k(\ln K_t - \ln L_t) + \beta_p(\ln PA_t - \ln L_t)$$

$$-\frac{1}{2}\beta_{kL}(lnK_t - \ln L_t)^2 - \frac{1}{2}\beta_{kp}(lnK_t - \ln PA_t)^2 - \frac{1}{2}\beta_{Lp}(lnL_t - \ln PA_t)^2$$

(4.6)

Given the low number of observations (annual time series data,1970 - 89), the study does not estimate the CRS-T production functions for agriculture including fertilizer. However, the agricultural production function including fertilizer is estimated and compared using the CRS-CD function.

The output elasticities of capital and labour of the translog production function are not constant and do not depend only on the coefficients of capital and labour, as is the case with Cobb-Douglas. The value of the coefficients vary depending on levels of K and L as in Equation (4.7). This makes a difference between β_K and β_L in Cobb-Douglas and also in translog production functions.

$$\frac{\partial \ln y_t}{\partial \ln K_t} = \frac{\partial y_t}{\partial K_t}\frac{K_t}{y_t} = \beta_k + \beta_{kk} \ln K_t + \beta_{kL} \ln L_t$$

$$\frac{\partial \ln y_t}{\partial \ln L_t} = \frac{\partial y_t}{\partial L_t}\frac{L_t}{y_t} = \beta_L + \beta_{LL} \ln L_t + \beta_{kL} \ln K_t \qquad (4.7)$$

Testing for stationary and cointegration of data

For many economic relationships, the theory identifies the long run relationship rather than the short run fluctuations. Many macroeconomic variables show strong persistence; that is, long-memory and are thus integrated series, which are non-stationary. For integrated variables, cointegration analysis is used to detect stable long-run relationships around which there are all manner of possible short-run fluctuations.

Under classical assumptions, the errors, μ_t, have zero mean and finite variance and are known as covariance stationary or stationary (Maddala 1989). Many economic time series are clearly non-stationary since the mean and variance depend on time. However, if a series is stationary around some deterministic time polynomial, the series is known as trend stationary. Given their persistence, non-stationary variables are highly autocorrelated and hence linear functions of them tend also to be highly autocorrelated. Thus, in a regression involving non-stationary variables, the error term is liable to be non-stationary and highly autocorrelated. As a result, the estimates of the coefficients' standard errors are biased, although the estimated coefficients are unbiased; the result is overstated and the F-ratios give an incorrect inference (Hargreaves 1992).

Since statistical inference is no longer applicable, a different methodology is used to test for relationships between integrated variables. If two or more variables are all integrated, each showing strong persistence, then normally linear functions are also

integrated. However, occasionally a linear function of the variables that is not integrated can be found. In this case, the stochastic trends are in some sense cancelling each other out. This leaves a function that is stationary, with constant moments and mean reverting. Therefore, this appears like an equilibrium error and it can be seen that there appears to be some sort of long-run equilibrium relationship between the variables according to the linear function. Whenever a variable stays away it must be drawn back so that the linear function remains stationary. Therefore, to determine whether such a relationship exists, rather than use t and/or F-tests, it is preferable to test whether the linear function is stationary. Given two variables, y and X, the regression, $y = \alpha + \beta X + \mu$, is performed and then tested to see whether μ is stationary. Then the function $y - \alpha - \beta X$ is said to be 'cointegrating' (Engle and Granger 1987, 1991, Maddala 1989).

The test of stationarity used in this study is the Augmented Dickey-Fuller test (ADF) which has the null hypothesis that $\rho = 1$ where ρ is coefficient parameter of time lag variable (Dickey and Fuller 1979). If the test cannot reject the null hypothesis, this indicates that the variable is nonstationary (it is not I(0)). The first difference is then tested, the second difference and so on until stationarity is found. A variable is known as integrated if order k, I(k), if k differences are required to create stationarity.

The cointegration test is a unit root test applied to the residuals. If the series are not cointegrated then there must be a unit root in the residuals, under the null hypothesis of non-cointegration.

The stationarity of variables is tested in this thesis. The null hypothesis of non-stationarity cannot be rejected and hence the variables appear to be non-stationary (results are shown in Table A4.1 Appendix). In addition, the tests for cointegration also cannot reject the null hypothesis and hence the variables appear to be not cointegrated (results are shown in Table A4.2 Appendix). The obvious problem here is the small sample size when estimating long-run effects. The null hypothesis automatically tends to be accepted given the lack of power. However, *a priori*, variables, such as y, K and L, would be expected to be integrated in Thailand as they are found to be for other economies where more data are available.

Since the variables are found to be non-stationary, the estimation of production function in levels terms may produce spuriously high values of $\overline{R}^2$ and of the t-ratios. The estimation of coefficients by Ordinary Least Square (OLS) for Equations (4.1), (4.2), (4.3), (4.5) and (4.6) may be unreliable.

As the test for cointegration is very weak given the small sample size, it is uncertain whether the true long-run relationship between the variables has been obtained. However, it is possible to proceed by estimating the coefficients of the production functions, in terms of difference equations, as shown in Equations (4.8) to (4.12) below. Mathematically, by taking the first difference on Equations (4.1), (4.2), (4.3) and (4.6), there is no intercept term included in the difference equations. However, to make estimated equations more flexible, the study includes an intercept term in the difference equations; possibly, in general, these may reflect other factors not included in the specification. The assumption is that these have a constant effect which is marginally better than assuming that they do not exist. If the constant really should not be there, the estimation may still lead to a zero or insignificant near-zero value. However, if this coefficient is constrained to zero, it can have drastic effects on the results. Moreover, in adding intercept terms, the estimated coefficients are still unbiased. In case of production function, the interpretation of the constant term in the difference equation is as an estimate of average TFP for the sector under the assumption that this is constant over the period[1]. Therefore, when these estimates are compared to the Tornqvist time series estimates of TFP growth on average (1970 - 89 in Table 4.2 below), both sources are found to give the same results. The first difference method is used to eliminate the stochastic trend under the assumption that the variables are I(1). It is, normally, considered *a priori* impossible for these variables to be I(2) or higher.

For CRS-CD Equations (4.8) to (4.10)

For non-agriculture

$$\Delta[\ln y_t - \ln L_t] = \beta_0 + \beta_k \Delta[\ln K_t - \ln L_t]; \qquad (4.8)$$

1 The constant term in the difference equation is identical to the coefficient of time trend in the level data estimation.

For agriculture without fertilizer

$$\Delta[\ln y_t - \ln L_t] = \beta_0 + \beta_k \Delta[\ln K_t - \ln L_t] + \beta_p \Delta[\ln PA_t - \ln L_t] \quad (4.9)$$

For agriculture with fertilizer

$$\Delta[\ln y_t - \ln L_t] = \beta_0 + \beta_k \Delta[\ln K_t - \ln L_t] + \beta_p \Delta[\ln PA_t - \ln L_t]$$

$$+ \beta_f \Delta[\ln F_t - \ln L_t] \quad (4.10)$$

For CRS-T in Equations (4.11) and (4.12)

For non-agriculture

$$\Delta(\ln y_t - \ln L_t) = \beta_0 + \beta_k \Delta(\ln K_t - \ln L_t) - \frac{1}{2}\beta_{kL} \Delta(\ln K_t - \ln L_t)^2 \quad (4.11)$$

For agriculture

$$\Delta(\ln y_t - \ln L_t) = \beta_0 + \beta_k \Delta(\ln K_t - \ln L_t) + \beta_p \Delta(\ln PA_t - \ln L_t)$$

$$-\frac{1}{2}\beta_{kL}\Delta(\ln K_t - \ln L_t)^2 - \frac{1}{2}\beta_{kp}\Delta(\ln K_t - \ln PA_t)^2 - \frac{1}{2}\beta_{Lp}\Delta(\ln L_t - \ln PA_t)^2 \quad (4.12)$$

Production function estimation results

The estimation results for the CRS-CD production function using difference equation are presented in Table 4.1 below and for the CRS-T production function in Table A4.3 (Appendix CH 4). The CRS-CD is the main function discussed as the results are generally satisfactory. Compared with CRS-T, $\overline{R}^2$ and the t-ratios are rather similar. Since the CRS-CD is part a linear restricted CRS-T; that is, the quadratic terms have new coefficients, simple F-tests can be used to tell whether the CRS-T function is necessary. F-tests of the linear restrictions (tests of the comparison between Equations [(4.11) or (4.12)] and [(4.8) or (4.9)], show that in general the CRS-CD cannot be rejected (Table A4.3 Appendix CH 4). In addition, the CRS-CD is a homothetic functional form, with the property of additivity and separability necessary for consistency of aggregation. Selection of the CRS-CD to be used to calculate TFP growth for *all* sectors is also

essential for consistency of comparison of estimated TFP results. Different functional forms could give different estimates of TFP growth.

The estimation results for the non-constant returns to scale (NCRS) of the Cobb-Douglas and Translog production functions are also presented in Table A4.5 and A4.6.

There are two possible reasons why estimation results of CRS-T in Table A4.3 (Appendix CH 4) have high $\overline{R}^2$ and yet t-values are not significant in many sectors. First, chronic autocorrelation still exists; DW value are quite low. Second, there is strong multicollinearity between some variables in CRS-T such as (lnK-lnL) and $(\text{lnK-lnL})^2$.

The estimation results for the CRS-CD function in levels, Equations (4.1), (4.2) and (4.3) are shown in Table A4.4 (Appendix CH 4). The results show rather high autocorrelation, as discussed earlier.

The estimation results for the CRS-CD production functions, Equations (4.8) to (4.10), (Table 4.1), show that most capital coefficients (β_K) are significant except for agriculture. For non-agriculture, β_K is generally around one and hence β_L (= 1 - β_K) is around zero and therefore insignificant. For agriculture, $\beta_L + \beta_D$, is around one and so β_K is near zero and insignificant. In non-agriculture, β_L appears definitely greater than zero for communication and transportation.

The low output elasticities with respect to labour (β_L) in many sectors may be explained by several factors. An increase in labour inputs may not significantly increase output if the production techniques used are inefficient as they employ too much labour relative to other inputs under the existing techniques of production which are biased toward highly capital-intensive techniques. This may be possibly the case for a developing economy like Thailand where there is abundant cheap, unskilled labour. As part of explanation, an evidence can be showed that there have been a rapid employment growth in some sectors, especially manufacturing and others where the elasticity of labour is insignificant (Table A4.7 Appendix CH 4). Another possible explanation might be owing to the reliability of the data as the contribution of factor input is sensitive to the magnitude of weights estimated from the production functions. When the output elasticities are compared to factor shares derived directly from the national ac-

counts, it is likely to reflect the upward bias of the estimated capital contribution (Table A4.8 Appendix CH 4).

Table 4.1
Estimation results of CRS-CD using difference equation

	$\hat{\beta}_0$	$\hat{\beta}_k$	$\hat{\beta}_L$	$\hat{\beta}_p$	$\hat{\beta}_f$	R^2
Agriculture (excluding F)	0.0135	0.0488	0.2566	0.6946		0.8707
t-ratio	1.2781	0.2351	2.6043*	4.6556*		
Agriculture (including F)	.00945	0.0289	0.2478	0.6406	0.0827	0.8807
t-ratio	0.9070	0.1446	2.6123*	4.3381*	1.5262**	
Mining quarrying	-0.0183	0.9647	0.0353			0.9617
t-ratio	-0.7806	21.2859*	0.7792			
Manufacturing	0.0050	1.0083	-0.0083			0.9274
t-ratio	0.4627	15.1982*	-0.0083			
Construction	-0.0153	0.9228	0.0772			0.6196
t-ratio	-0.6652	5.5062*	0.4606			
Electricity and water	0.0319	1.0110	-0.0110			0.9484
t-ratio	2.8778*	18.2256*	-0.1983			
Communication and transportation	0.0101	0.9075	0.0925			0.9315
t-ratio	1.0718	15.6773*	1.5979**			
Commerce and finance	0.0017	1.0358	-0.0358			0.7430
t-ratio	0.1316	7.2819*	-0.2517			
Services	-0.0128	1.0079	-0.0079			0.9509
t-ratio	-2.5990*	18.7045*	-0.1466			

Remarks The t-ratio of $\hat{\beta}_L$ is calculated by

$t\,\hat{\beta}_L = \frac{\hat{\beta}_L}{SE\,\hat{\beta}_L}$ where $Var(\hat{\beta}_L) = Var(\hat{\beta}_k) + Var(\hat{\beta}_p) + 2Cov(\hat{\beta}_k\,\hat{\beta}_p)$ for agriculture excluding F,

where $Var(\hat{\beta}_L) = Var(\hat{\beta}_k) + Var(\hat{\beta}_p) + Var(\hat{\beta}_f) + 2\,Cov(\hat{\beta}_k\,\hat{\beta}_p) + 2\,Cov(\hat{\beta}_p\,\hat{\beta}_f) + 2\,Cov(\hat{\beta}_k\,\hat{\beta}_f)$ for agriculture including F, $Var(\hat{\beta}_L) = Var(\hat{\beta}_k)$ for non-agriculture

* means statistically significant at 5 per cent (one tailed test) and ** means statistically significant at 10 per cent (one tailed test)

Source author's calculations

The only sector, agriculture, in which the labour coefficients are significant is a relatively competitive sector and production techniques are labour-intensive. This sector consists of many small farmers, has low government protection, and entry and exit is quite simple. Except for land, factors in this sector are relatively mobile; labour migrates either temporarily or permanently from this sector to the manufacturing sector. Fertilizer levels can be changed easily. There is little capital input. Finally, land is relatively easily taken in and out to grow other crops. These factors probably explain the significant labour coefficients obtained for agriculture.

Using the coefficients of the estimated production functions, estimates of TFP growth of each sector can be calculated. The elasticities of output with respect to capital (β_K) and to labour (β_L) in each sector will be used to weight the growth of capital and growth of labour in the Tornqvist indices of TFP growth.

Estimated TFP growth and input growth contribution

Table A4.9 (Appendix CH 4) shows the average TFP growth of each sector as well as the contributions from the growth of the major factor inputs: capital, labour, fertilizer and planted area. The results in Table A4.9 are presented in a more consolidated form in Table 4.2 below. Capital inputs clearly made the highest contribution to output growth in every period under study, except in agriculture where increase in land made for the highest contribution to growth. However, if the average contribution of capital growth to output growth is considered between the first half (1971 - 80) and the second half (1981 - 89) of the study, the trend in all sectors has clearly declined, except for electricity and water and services. The relatively small influence of capital on agricultural output growth, compared with the other sectors, may be because this sector is a traditional sector where capital has not been an important factor of production. The contribution of land to growth has declined. While agricultural production previously used land extensively, access to land has become more limited over time. Though it is essential to do so, the government's attempts to preserve forests have added to land limitations. Since the expansion of agricultural land will make little contribution to growth in the future, it is important that improvement in agricultural land productivity be encouraged.

The estimates of TFP growth in the agricultural sector derived from both models (excluding and including fertilizer as an input) are quite similar (Table A4.9 Appendix CH 4). TFP growth estimated from the model including fertilizer is higher than that estimated from the model excluding fertilizer, during 1971 - 75, but lower for the other periods. There are clear differences, however, between the results of these models in the contribution of related input factors mentioned in Chapter 3. The apparent contribution of capital is reduced and that of agricultural land is reduced a little when fertilizer is included in the model. This may because capital and land pick up some of the effects of fertilizer when the latter is omitted.

In general, by examining the estimated intercepts in Table 4.1, TFP growth in most sectors is insignificant and the highest is 3.2 per cent on average for the electricity and water. With the exception of services, electricity and water, most sectors show improvement in TFP growth over time (Figure A4.1 Appendix CH 4). The trend in TFP growth (whether positive or negative) tends to be marked by large year-to-year fluctuations. The improvement in TFP growth and the relative decline in the capital input contribution to output growth has meant that capital is no longer the most influential factor creating growth in every sector. TFP has replaced capital growth as the largest single source of growth in some sectors such as construction, communications and transportation, and commerce and finance, especially towards the end of the 1980s (1986 - 89). During the highest growth period, TFP growth is relatively rapid in all sectors except services.

Labour has been important in agricultural growth but it has not had a significant impact on output growth in other sectors. There has been less bias toward capital in agriculture than in manufacturing. Agricultural production uses relatively labour-intensive techniques, so that an increase in labour input increases output significantly. In manufacturing production policies encouraged use of highly capital-intensive techniques. Therefore an increase in labour employed may have resulted in the marginal output of labour being zero.

Table 4.2

Sources of growth in eight sectors, 1971 - 89

average per cent per annum

	Year	Capital growth	Labour growth	Land growth	TFP growth
Agriculture	1971 - 80	0.3	0.7	2.4	0.5
	1981 - 89	0.3	0.8	1.1	2.3
	1986 - 89	0.2	0.7	0.8	2.4
	1971 - 89	0.3	0.8	1.8	1.4
Mining and	1971 - 80	10.0	-0.1	na	-4.1
quarrying	1981 -89	6.6	-0.1	na	0.7
	1986 - 89	6.1	-0.7	na	5.1
	1971 - 89	8.4	-0.1	na	-1.8
Manufacturing	1971 - 80	10.0	-0.1	na	-0.3
	1981 - 89	6.9	-0.0	na	1.4
	1986 - 89	7.2	-0.1	na	5.9
	1971 - 89	8.5	-0.1	na	0.5
Construction	1971 - 80	8.5	0.9	na	-4.5
	1981 - 89	5.5	0.5	na	1.7
	1986 - 89	5.4	0.7	na	6.0
	1971 - 89	7.1	0.7	na	-1.5
Electricity and	1971 - 80	8.7	-0.1	na	4.4
water	1981 - 89	9.7	-0.1	na	1.8
	1986 - 89	6.6	-0.0	na	6.2
	1971 - 89	9.1	-0.1	na	3.2
Communication	1971 -80	6.9	0.4	na	-0.4
and transportation	1981 - 89	4.9	0.4	na	2.6
	1986 - 89	3.8	0.5	na	5.0
	1971 - 89	5.9	0.4	na	1.0
Commerce and	1971 - 80	9.0	-0.2	na	-2.3
finance	1981 -89	5.7	-0.2	na	2.9
	1986 -89	5.8	-0.2	na	7.1
	1971 - 89	7.4	-0.3	na	0.2
Services	1971 - 80	7.9	-0.0	na	-1.0
	1981 - 89	8.1	-0.0	na	-1.5
	1986 - 89	8.5	-0.0	na	-2.4
	1971 - 89	8.0	-0.0	na	-1.3

Note na = not applicable

Source Author's calculations

To study the role of TFP growth in the Thai economy in more detail, this study examines two further aspects of the estimated TFP results. Firstly, TFP growth in each sector is analyzed, with particular attention to the high growth sectors. Secondly, the study considers the contribution of TFP growth to output growth in each sector.

Relative contributions of input and TFP growth to output growth

The relative contribution of input and TFP growth to output growth is shown in a more disaggregated form (Table A4.10 Appendix CH 4). A more consolidated version for the same periods as Table 4.2 is shown in Table 4.3 below.

TFP growth shows the growth of output without an increase in any input. From the results of the TFP estimation (Table A4.9 and Figure A4.1 Appendix CH 4 and summary Table 4.2 earlier), the average TFP growth per annum during 1971 - 89 of all sectors ranged between 3.2 and -1.3 per cent per annum. The average annual TFP growth for each sector is: electricity and water 3.2, agriculture 1.4, communication and transportation 1.0, manufacturing 0.5, commerce and finance 0.2, construction -1.5, mining and quarrying -1.8 and services -1.3. In comparing TFP growth between the two periods of the study, however, (between 1971 - 80 and 1981 - 89) the estimated results confirm that the average TFP growth, except for services, was higher in the 1980s than in the 1970s.

Six sectors (mining and quarrying, manufacturing, construction, communication and transportation, commerce and finance and services) had negative TFP growth between 1971 - 80, but the rates were all positive in 1981 - 89. The contribution of TFP growth in agriculture has improved steadily, although the rate of TFP growth has been rather slow compared with other sectors. TFP growth in manufacturing was positive between 1971 - 89, increased very strongly in 1986 - 89 (5.3 per cent) but fluctuated more than agriculture. TFP growth has been increasing during the recent high growth period in the late 1980s in most sectors. The commerce and finance sector show a very clear increase in TFP growth during 1986 - 89. This may reflect the introduction of computers into banking. Construction is another sector which shows TFP growth in 1986 - 89, possibly because TFP growth was much low in previous period.

The TFP share in output growth for the whole period of the study (1971 - 89), ranged between 32.5 per cent and -28.5 per cent (Table 4.3). During 1981 - 89, the share of TFP growth in output growth rose, ranging between 52.4 per cent and -23.6 per cent. The share of TFP growth in output growth is again greater in the period of highest growth (1986 - 89), ranging between 60.2 per cent to -40.0 per cent.

TFP growth was important to output growth in all sectors, except services, but the output of services grew at an average of 6 - 7 per cent per annum from 1971 to 1989 (Table A4.9 Appendix CH 4). The major source of growth in this sector is capital input growth. The low contribution of TFP growth in the service sector may explain why service sector growth is limited at 6 - 7 per cent and is lower than that of other sectors, particularly in the period of high growth in the late 1980s. A possible reason for the low TFP growth in services is the grouping of government services and public administration and defence in this sector. The lack of competition in government services and defence and the difficulty of accurate measurement of value of output in the government services and public administration (some social value or benefit might possibly be omitted) may be responsible for low TFP growth.

The growth of output in agriculture is low compared with the other sectors, (Table A4.9 Appendix CH 4) but it is very steady. The share of capital, labour and land input growth in agricultural output growth declined during 1971 - 89 (Table A4.10 Appendix CH 4) as the share of TFP growth in output growth increased. Capital input growth has been small, only 1 - 2 per cent per annum, compared with the other sectors where it was 3 - 9 per cent per annum during 1970 - 89. TFP growth of agriculture has therefore become a major factor increasing growth in this sector.

Commerce and finance, communication and transportation, construction, and manufacturing are the sectors where TFP growth played the greatest role in output growth in the late 1980s.

Table 4.3

Share of contribution to growth, 1971 - 89

per cent

	Year	Capital growth	Labour growth	Land growth	TFP growth
Agriculture	1971 - 80	8.4	17.8	62.1	11.7
	1981 - 89	5.6	18.6	23.4	52.4
	1986 - 89	4.3	16.0	19.5	60.2
	1971 - 89	7.0	18.2	42.3	32.5
Mining and quarrying	1971 - 80	173.1	-1.7	na	-71.5
	1981 - 89	91.4	-1.2	na	9.8
	1986 - 89	57.4	-5.4	na	48.0
	1971 - 89	129.9	-1.4	na	-28.5
Manufacturing	1971 - 80	103.8	-0.6	na	-3.2
	1981 - 89	83.6	-0.5	na	16.9
	1986 - 89	55.0	-0.5	na	45.5
	1971 - 89	95.0	-0.6	na	5.6
Construction	1971 - 80	171.9	18.8	na	-90.7
	1981 - 89	71.5	5.9	na	22.6
	1986 - 89	44.8	5.7	na	49.5
	1971 - 89	113.2	11.3	na	-24.5
Electricity and water	1971 - 80	66.9	-1.2	na	34.3
	1981 - 89	84.8	-0.7	na	15.9
	1986 - 89	51.8	-0.2	na	48.4
	1971 - 89	74.8	-1.0	na	26.1
Communication and transportation	1971 - 80	99.7	6.0	na	-5.6
	1981 - 89	61.9	5.5	na	32.6
	1986 - 89	41.0	4.9	na	54.1
	1971 - 89	80.6	5.8	na	13.7
Commerce and finance	1971 - 80	139.1	-3.5	na	-35.6
	1981 - 89	67.8	-2.2	na	34.4
	1986 - 89	45.6	-1.2	na	55.6
	1971 - 89	100.5	-2.8	na	2.3
Services	1971 - 80	115.9	-0.6	na	-15.2
	1981 - 89	124.1	-0.5	na	-23.6
	1986 - 89	140.6	-0.6	na	-40.0
	1971 - 89	119.7	-0.6	na	-19.1

Note na means not applicable

Source Author's calculations

Sectoral TFP level index comparisons

It may be misleading to focus only on TFP growth as it shows only the percentage of growth or the speed of growth. It does not show the level of TFP. The TFP level index in a year (t_m) may be lower than the TFP level index in the initial year (t_0) of the study even if TFP growth at the considered year (t_m) may be positive, since TFP growth in an earlier period may have been very low (or highly negative). An index of TFP level has therefore been estimated.

The last column of Table A4.11 (Appendix CH 4) and Figure A4.2 show the TFP level index of each sector annually. The TFP growth in the column to the left of the TFP level index shows the incremental increase in output in that year due to TFP growth. The starting value of TFP is set at 100 in the first year (1970) and the TFP level index is calculated by adding or subtracting estimated TFP growth (increase) in each year, as shown in the last column in Table A4.11 Appendix CH 4. The third column (output growth) in the table is the compound growth rate as the output in column two is calculated by applying the growth rate figure of output year by year. The growth in column three is therefore the same concept of compound interest rate and it is larger than the annual figure of growth rate. For instance, for agriculture, the growth rate figure of output are 4.22 per cent in 1971 and -1.71 per cent in 1972, the output growth in column three are found to be 4.22 per cent in 1971 and -1.78 per cent in 1972. The figures of output growth due to input growth and TFP growth are then derived proportionally from the compound output growth (column three). The difference of TFP level indices between any two years such as this year and last year in Table A4.11 (Appendix CH 4) is not identical to the figure of TFP growth but lager size. The TFP level index in a particular year shows how much it grows from 1970 therefore the fluctuation of TFP level can be obviously seen high compared to the annual TFP growth figures. The summarized TFP level is presented in Table 4.4.

For the whole period of the study (1970 - 89), five out of eight sectors had a TFP level index higher than 100 in the last year (1989). They are: electricity and water (300.3); communication and transportation (169.4); commerce and finance (146.1); manufacturing (143.6); and agriculture (141.2). The three sectors which have a TFP level index lower than 100 in 1989 are: construction (88.1); mining and quarrying

(76.3); and services (47.6). Every sector, however, shows an increase in TFP level index during 1986 - 89, except for the services.

Comparing later years with the output levels of each sector (where the output in 1970 is also given to be 100), again shows the importance of TFP growth to output growth. In 1989, four of the five sectors where the TFP level index is higher than 100 also had the highest output level in 1989. Agriculture is the exception. Although its TFP level index is higher than 100 in 1989, the output level is not very high compared with the other sectors (the lowest output level among the eight sectors in 1989). TFP growth is the major source of growth in agriculture in the period 1981 - 89 in Table 4.3 but input growth declined.

Table 4.4
TFP level of eight sectors, 1970 - 89

1970 = 100

	AG	MQ	MF	CON	EW	CT	COMF	SV
1970	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1971	95.5	98.0	99.0	88.5	109.4	96.3	91.5	96.0
1972	95.4	81.7	101.5	72.5	116.2	87.1	85.4	94.1
1973	102.3	63.3	104.2	60.8	128.5	88.2	89.8	93.0
1974	103.8	58.6	95.6	45.3	132.5	88.5	86.7	89.4
1975	104.6	40.2	89.8	43.8	144.9	85.9	80.7	91.0
1976	103.7	47.7	98.7	54.2	150.6	85.9	81.3	89.4
1977	103.0	60.2	110.5	65.1	158.0	89.4	86.3	91.1
1978	107.5	73.8	106.5	74.5	171.5	86.5	85.9	89.3
1979	101.8	60.8	104.7	56.6	175.6	95.1	74.4	92.2
1980	104.8	51.2	90.4	51.2	166.1	101.0	70.7	87.6
1981	107.9	31.7	89.5	50.0	150.6	98.8	73.7	87.4
1982	110.0	28.5	80.0	40.5	167.1	104.2	64.7	87.1
1983	111.4	16.4	81.8	48.7	145.2	109.4	66.9	88.3
1984	114.5	29.1	78.0	53.8	130.4	113.6	70.0	79.7
1985	123.1	27.6	57.8	34.7	132.0	107.1	66.0	77.4
1986	119.4	20.7	77.4	24.1	146.4	111.5	67.8	70.4
1987	121.5	23.9	98.7	35.3	176.4	121.9	92.3	71.1
1988	139.1	51.5	127.9	61.4	220.3	144.3	119.0	66.1
1989	141.2	76.3	143.6	88.1	300.3	169.4	146.2	47.6

Note AG = agriculture, MQ = mining and quarrying, MF = manufacturing, CON = construction, EW = electricity and water, CT = communication and transportation, COMF = commerce and finance and SV = services.
Source Author's calculations

The results of the estimated TFP level index at the end period depend on the base year selected. An example is in the construction sector where the TFP growth is largely negative during the first five years of the study and varied in the last three years of the study. The TFP level index of construction is still below 100 in 1989. Had the study chosen 1981 as the base year, when the TFP level index was equal to 100, the TFP level index in 1989 would have been higher than 100, since the TFP level index in 1981 (54.1) was lower than in 1989 (90.5). In electricity and water, where TFP growth was high in the 1970s, even negative TFP growth during 1981- 85 was not strong enough to pull the TFP level index below 100. The longest time series available, including years before the major oil price increases, provide a more stable period of prices and structural change. The TFP level index in the last year (1989) will be comparable among all sectors so the indices at least show in which sector the TFP level index accelerated most during 1970 to 1989.

Appendix CH 4

4.1 CRS-T production function

The general Translog production function can be written as Equation (1) below.

$$ln\,y = \beta_o + \beta_k\, ln\,K + \beta_L\, ln\,L + \beta_{kL}\, ln\,K\, ln\,L$$

$$+\frac{1}{2}\beta_{kk}(ln\,K)^2 + \frac{1}{2}\beta_{LL}(ln\,L)^2 \qquad (1)$$

Impose restriction of constant return to scale;

$$\sum_i \beta_i = \mathbf{1}, i = K, L$$

$$\sum_i \beta_{ij} = \mathbf{0}; i, j = K, L$$

$$\beta_{ij} = \beta_{ji}; \forall i, j$$

Substitute restriction into Equation (1) and rearrange, Equation (2) is CRS-T for non-agriculture

$$ln\,y = \beta_o + \beta_k\, ln\,K + (\mathbf{1} - \beta_k)\, ln\,L + \beta_{kL}\, ln\,K\, ln\,L$$

$$-\frac{1}{2}\beta_{kL}(ln\,K)^2 - \frac{1}{2}\beta_{kL}(ln\,L)^2$$

Or,

$$ln\,y - ln\,L = \beta_o + \beta_k(ln\,K - ln\,L) - \frac{1}{2}\beta_{kL}(ln\,K - ln\,L)^2 \qquad (2)$$

Agriculture

The general Translog production function can be written as Equation (3) below.

$$ln\,y = \beta_o + \beta_k\, ln\,K + \beta_L\, ln\,L + \beta_p\, ln\,PA + \beta_{kL}\, ln\,K\, ln\,L + \beta_{kp}\, ln\,K\, ln\,PA$$

$$+\beta_{Lp}\, ln\,L\, ln\,PA + \frac{1}{2}\beta_{kk}(ln\,K)^2 + \frac{1}{2}\beta_{LL}(ln\,L)^2 + \frac{1}{2}\beta_{pp}(ln\,PA)^2 \qquad (3)$$

Impose restriction of constant return to scale

$$\sum_i \beta_i = \mathbf{1}, i = K, L, PA$$

$$\sum_i \beta_{ij} = \mathbf{0}; i, j = K, L, PA$$

$$\beta_{ij} = \beta_{ji}; \forall i, j$$

Substitute restrictions into Equation (3) and rearrange, Equation (4) is CRS-T for agriculture

$$ln\,y = \beta_o + \beta_k\, ln\,K + (\mathbf{1} - \beta_k - \beta_p)\, ln\,L + \beta_p\, ln\,PA + \beta_{kL}\, ln\,K\, ln\,L$$

$$+\beta_{kp}\, ln\,K\, ln\,PA + \beta_{Lp}\, ln\,L\, ln\,PA - \frac{1}{2}(\beta_{kL} + \beta_{kp})(ln\,K)^2$$

$$-\frac{1}{2}(\beta_{kL} + \beta_{Lp})(ln\,L)^2 - \frac{1}{2}(\beta_{kp} + \beta_{Lp})(ln\,PA)^2$$

$$ln\,y - ln\,L = \beta_o + \beta_k(ln\,K - ln\,L) + \beta_p(ln\,PA - ln\,L) - \frac{1}{2}\beta_{kL}(ln\,K - ln\,L)^2$$

$$-\frac{1}{2}\beta_{kp}(ln\,K - ln\,PA)^2 - \frac{1}{2}\beta_{Lp}(ln\,L - ln\,PA)^2 \qquad (4)$$

Table A4.1
Results of stationarity test (ADF) of variables

(lny-lnL)

	Lags	Without trend		Lags	With trend	
		Estimated value	Critical value		Estimated value	Critical value
Agriculture	3	-1.8737	-3.0294	2	-3.3134	-3.6749
Mining and quarrying	0	-2.0216	-3.0294	0	-2.9856	-3.6746
Manufacturing	4	-1.7689	-3.0296	0	-3.6159	-3.6746
Construction	4	-3.8264	-3.0294	3	-3.4084	-3.6746
Electricity and water	1	-1.6424	-3.0294	0	-2.5734	-3.6746
Communication and transportation	0	-1.1800	-3.0294	0	-2.9019	-3.6746
Commerce and finance	0	-1.8402	-3.0294	0	-2.5852	-3.6746
Services	0	-1.4134	-3.0294	0	-3.4157	-3.6746

(lnK-lnL)

	Lags	Without trend		Lags	With trend	
		Estimated value	Critical value		Estimated value	Critical value
Agriculture	1	-1.2576	-3.0294	1	-2.8006	-3.6746
Mining and quarrying	0	-2.0187	-3.0294	0	-3.1573	-3.6746
Manufacturing	4	-1.8539	-3.0294	4	-3.6517	-3.6746
Construction	0	-2.7329	-3.0294	0	-2.9207	-3.6746
Electricity and water	0	-2.9351	-3.0294	0	-2.9061	-3.6746
Communication and transportation	0	-2.2222	-3.0294	0	-3.1143	-3.6746
Commerce and finance	0	-1.3940	-3.0294	0	-2.3766	-3.6746
Services	0	-0.7310	-3.0294	0	-3.0530	-3.6746

(lnPA-lnL) and (lnF-lnL) of agriculture

Section	Lags	Without trend		Lags	With trend	
		Estimated value	Critical value		Estimated value	Critical value
lnPA-lnL	0	-3.0661	-3.0294	0	-2.9744	-3.6746
lnF-lnL	0	-0.34703	-3.0294	1	-2.9177	-3.6746

Note The null hypothesis cannot reject when the absolute term of estimated values are lower than critical values

Lags = the maximun order of lags of the difference terms of ADF being added (augmented) until stationary is found.

Source Author's calculations

Table A4.2

Results of cointegration test (unit root of residual), CRS-CD

Sector	Without time trend		With time trend	
	Estimated value	Critical value	Estimated value	Critical value
Agriculture (without fertilizer)	-2.1457	-4.2196	-3.5838	-4.7885
Agriculture (with fertilizer)	-3.3951	-4.7253	-3.9817	-5.2467
Mining and quarrying	-2.1617	-3.6765	-1.5700	-4.3185
Manufacturing	-1.2942	-3.6765	-1.3762	-4.3185
Construction	-3.0704	-3.6765	-2.5965	-4.3185
Electricity and water	-1.0418	-3.6765	-1.6924	-4.3185
Communication and transportation	-1.1040	-3.6765	-2.0697	-4.3185
Commerce and finance	-0.8879	-3.6765	-1.4064	-4.3185
Services	-3.3544	-3.6765	-2.1662	-4.3185

Remark 95 per cent critical value

Source Author's calculations

Table A4.3 (a)

Results of CRS-T estimation by difference equations, agriculture

	β_0	β_k	β_L	β_{kL}	β_{Lp}	β_{kp}	Adj R^2
Agriculture	0.0159	-2.0684	-2.1023	0.5205	0.3872	-1.9237	0.9091
t-ratio	1.7335**	-0.6420	-0.48385	0.8920	0.4442	-2.8025*	
F-test of restriction; F(3, 14) = 3.2538							

Table A4.3 (b)

Results of CRS-T estimation by difference equations, non-agriculture

	β_0	β_k	β_{kL}	Adj R^2	F-test of restriction
Mining and quarrying	-0.0170	0.9077	0.0304	0.9596	0.10646
t-ratio	-0.6981	5.0370*	0.3274		
Manufacturing	0.0058	0.3946	0.2332	0.9240	0.2432
t-ratio	0.5172	0.3165	0.4930		
Construction	-0.0142	-2.3110	1.1132	0.6064	0.4306
t-ratio	-0.6056	-0.4682	0.6556		
Electricity and water	0.0292	0.7882	0.3571	0.9502	1.6004
t-ratio	2.6375*	4.2770*	1.2650		
Communication and transportation	0.0101	0.8707	0.0198	0.9272	0.0023
t-ratio	1.0408	1.0981	0.0465		
Commerce and finance	0.0014	2.9878	-0.6446	0.7601	0.1927
t-ratio	0.1044	0.6719	-0.4392		
Services	-0.0090	-1.1023	0.8646	0.9685	10.4817*
t-ratio	-2.1986*	-1.6874**	3.2372*		

Remark F-test of restriction is tested whether the restriction (CRS-CD) is accepted; i.e., $\beta_{kL} = 0$ for non-agriculture and $\beta_{kL} = \beta_{Lp} = \beta_{kp} = 0$ for agriculture

For non-agriculture, the F-test gives the same result as the t-ratio of β_{kL} since there is only one variable to be tested.

* means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Note β_k and β_L in CRS-T here is not the same as β_k and β_L in CRS-CD (discussed in text)

Source Author's calculations

Table A4.4 (a)

Estimation results of CRS-CD by level data (non-stationary long-run relationship), agriculture

	β_0	β_k	β_L	β_p	β_f	Adj R^2
Agriculture (without F)	-1.2517	0.3937	0.2005	0.4058		0.8754
t-ratio	-2.8107*	9.1170*	2.4605*	4.4693*		
DW statistics = 0.9416						
Agriculture (with F)	-0.0560	0.1400	0.2376	0.4513	0.1711	0.9309
t-ratio	-0.1228	1.9021*	3.5384*	6.5738*	3.8291*	
DW statistics = 1.5661						

Table A4.4 (b)

Estimation results of CRS-CD by level data (non-stationary long-run relationship), non-agriculture

	β_0	β_K	β_L	Adj R^2	DW statistics
Mining and quarrying	-0.9954	0.8070	0.1930	0.9223	0.7057
t-ratio	-11.6947*	15.0552*	3.6013*		
Manufacturing	-1.0624	0.9593	0.0407	0.9222	0.6447
t-ratio	-6.7391*	15.0429*	0.6382		
Construction	-0.6369	0.9780	0.0220	0.3978	0.4043
t-ratio	-0.7955	3.6814*	0.0828		
Electricity and water	-2.0001	0.8466	0.1534	0.6342	0.2073
t-ratio	-25.7117*	5.8260*	1.0557		
Communication and transportation	-1.1300	1.1603	-0.1603	0.8867	0.5713
t-ratio	-6.6473*	12.2335*	-1.6900**		
Commerce and finance	-1.1044	0.8074	0.1926	0.6471	0.5064
t-ratio	-2.7227*	5.9870*	1.4281**		
Services	-1.7129	0.7237	0.2763	0.9500	1.3449
t-ratio	-18.8343*	19.0290*	7.2649*		

Remark $t_{\beta_L} = \frac{\beta_L}{SE_{\beta_L}}$; $where SE_{\beta_L} = SE_{\beta_K}$ for non-agriculture; and

$SE_{\beta_L} = \sqrt{V(\beta_k) + V(\beta_p) + 2Cov(\beta_k \beta_p)}$, for agriculture without F

$SE_{\beta_L} = \sqrt{V(\beta_k) + V(\beta_p) + V(\beta_f) + 2Cov(\beta_k \beta_p) + 2Cov(\beta_k \beta_f) + 2Cov(\beta_p \beta_f)}$ for agriculture with F

* means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Source Author's calculations

Table A4.5 (a)

Estimation results of NCRS-CD by level data, agriculture

	β_0	β_k	β_L	β_p	β_f	Adj R^2
Agriculture (without F)	1.0871	0.5114	0.1087	0.2190		0.9724
t-ratio	0.3140	2.8680*	0.6697	0.7571		
DW statistics = 1.0790						
Agriculture (with F)	2.3854	0.2622	0.1420	0.2566	0.1716	0.9851
t-ratio	0.9302	1.7931*	1.1878	1.2069	3.8312*	
DW statistics = 1.7561						

Table A4.5 (b)

Estimation results of NCRS-CD by level data, non-agriculture

	β_0	β_k	β_L	Adj R^2	DW statistics
Mining and quarrying	1.6509	0.7073	0.0400	0.8820	0.5676
t-ratio	1.6831**	11.9821*	0.5482		
Manufacturing	-1.1071	0.9570	0.0457	0.9844	0.6490
t-ratio	-1.3386**	12.2272*	0.4058		
Construction	0.5924	0.4118	0.3629	0.8878	0.6788
t-ratio	0.7539	1.4087**	1.4536**		
Electricity and water	-4.0022	1.0227	0.1669	0.9818	0.5154
t-ratio	-10.1205	10.2176*	1.7760*		
Communication and transportation	-3.2196	1.0808	0.0686	0.9787	0.4266
t-ratio	-4.1305*	12.5013*	0.5872		
Commerce and finance	-1.2756	0.7938	0.2152	0.9600	0.5212
t-ratio	-0.8556	4.4259*	0.9178		
Services	-0.1037	0.8568	0.0541	0.9971	0.8948
t-ratio	-0.2137	17.1434*	0.7425		

Remark * means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Source Author's calculations

Table A4.6 (a)

Estimation results of NCRS-T by level data, agriculture

$$lny = \beta_o + \beta_k lnK + \beta_L lnL + \beta_p lnPA + \beta_{kL}\, lnKlnL + \beta_{kp}\, lnKlnPA + \beta_{Lp}\, lnLlnPA + (1/2)\beta_{kk}(lnK)^2 + (1/2)\beta_{LL}(lnL)^2 + (1/2)\beta_{pp}(lnPA)^2$$

	Coefficients	t-statistic
β_o	-1019.2	-0.7152
β_k	-102.9128	-0.7514
β_L	80.1688	0.6597
β_p	163.1851	0.7741
β_{kL}	5.0759	0.8443
β_{kp}	5.3935	0.5423
β_{Lp}	-6.5578	-0.6886
β_{kk}	3.7988	-0.5716
β_{LL}	3.7020	-0.7493
β_{pp}	10.0312	-0.6608
Adj R^2 = 0.9888		
DW-statistics =2.3026		

Table A4.6 (b)
Estimation results of NCRS-T by level data, non-agriculture

$$\ln y = \beta_o + \beta_k \ln K + \beta_L \ln L + \beta_{kL} \ln K \ln L + (1/2)\beta_{kk}(\ln K)^2 + (1/2)\beta_{LL}(\ln L)^2$$

	β_0	β_k	β_L	β_{kL}	β_{kk}	β_{LL}
Mining and quarrying	12.5264	-5.0244	3.0342	-0.0691	0.6812	-0.2640
t-ratio	0.4884	-1.7341**	0.9141	-0.5055	2.9851*	-0.7428
Adj R^2 = 0.9216, DW statistics = 1.0419						
Manufacturing	21.0219	-4.3476	1.2448	1.3872	-1.2455	-1.2132
t-ratio	0.6220	-0.7595	0.1418	1.5139**	-1.5937**	-0.9782
Adj R^2 = 0.9859, DW statistics = 1.2407						
Construction	48.6496	-9.0087	0.2083	3.4457	-3.5120	-2.6496
t-ratio	2.5064*	-1.1163	0.0263	1.0969	-0.9068	-0.9851
Adj R^2 = 0.9275, DW statistics = 0.9372						
Electricity and water	-37.9981	0.1994	7.2300	-0.4635	0.6066	-0.2440
t-ratio	-3.7794*	0.0967	4.9586*	-0.8719	1.2050	-0.5132
Adj R^2 = 0.9941, DW statistics = 1.1080						
Communication and transportation	63.1136	-6.6631	-3.4914	0.3447	0.2847	-0.0170
t-ratio	4.1815*	-2.3097*	-0.8683	0.6659	0.5283	-0.0276
Adj R^2 = 0.9938, DW statistics = 0.9757						
Commerce and finance	113.2926	4.6847	-18.6459	-1.9037	2.0842	2.7940
t-ratio	1.5413**	0.2768	-0.8120	-0.5917	0.7597	0.6952
Adj R^2 = 0.9768, DW statistics = 0.7198						
Services	-13.8951	-6.6268	8.1698	1.7684	-1.5033	-2.0312
t-ratio	-0.4373	-1.4020**	1.0049	2.6194*	-3.3856*	-1.8547*
Adj R^2 = 0.9986, DW statistics = 1.5126						

Remark * means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Note β_k and β_L in CRS-T here is not the same as β_k and β_L in CRS-CD (discussed in text)

Source Author's calculations

Table A4.7

Employment growth and capital growth in major sectors, 1971 - 89

per cent per annum

	Employment growth	Capital growth
Agriculture	2.94	5.90
Mining and quarrying	-2.61	8.66
Manufacturing	6.22	8.46
Construction	9.12	7.65
Electricity and water	10.56	9.04
Communication and transportation	4.57	6.53
Commerce and finnance	5.74	7.18
Services	4.95	7.94

Source Author's calculation

Remark AG = Agriculture, MQ = mining and quarrying, MF = Manufacturing, CON = Construction, EW = Electricity and water, TC = Transport and communication, COMF = Commerce and finace, SV = Services

Table A4.8

Estimated output elasticity of capital and value share of capital return, 1971 - 89

Points

	Value share of capital return							
	AG	MQ	MF	CON	EW	TC	COMF	SV
1970	0.8586	0.8581	0.8314	0.7145	0.7451	0.7484	0.8848	0.6299
1971	0.8433	0.8438	0.8263	0.7255	0.7438	0.7446	0.8738	0.6274
1972	0.8366	0.8304	0.8207	0.7221	0.7509	0.7462	0.8683	0.6189
1973	0.8279	0.8258	0.8204	0.7577	0.7472	0.7529	0.8858	0.6112
1974	0.8449	0.8614	0.8168	0.7986	0.7008	0.7461	0.8977	0.5909
1975	0.8478	0.8541	0.7877	0.6983	0.6807	0.7220	0.8907	0.5751
1976	0.8497	0.8650	0.7801	0.6588	0.6731	0.7266	0.8786	0.5763
1977	0.8472	0.8944	0.7682	0.6899	0.7062	0.6951	0.8804	0.5932
1978	0.8559	0.8961	0.7635	0.6535	0.6914	0.7078	0.8847	0.5752
1979	0.8399	0.8689	0.7581	0.6735	0.6233	0.6899	0.8750	0.5665
1980	0.8225	0.8632	0.7470	0.6504	0.5328	0.6811	0.8570	0.5400
1981	0.8171	0.8369	0.7460	0.6348	0.6556	0.7030	0.8541	0.5458
1982	0.8056	0.8454	0.7209	0.6022	0.7057	0.7148	0.8445	0.5284
1983	0.8110	0.8471	0.7148	0.5757	0.6948	0.7051	0.8322	0.5284
1984	0.8118	0.8677	0.7197	0.5601	0.6908	0.7234	0.8277	0.5424
1985	0.8177	0.8997	0.7206	0.5397	0.7268	0.7281	0.8116	0.5458
1986	0.8177	0.9135	0.7271	0.5517	0.7383	0.7311	0.8210	0.5500
1987	0.8130	0.9244	0.7169	0.5884	0.7481	0.7318	0.8269	0.5693
1988	0.8164	0.9342	0.7197	0.6203	0.7515	0.7392	0.8361	0.5834
1989	0.8139	0.9439	0.7089	0.6549	0.7572	0.7384	0.8310	0.5878
Elasticity (β_K)	0.0488	0.9647	1.0083	0.9228	1.0110	0.9075	1.0358	1.0079

Source Author's calculations

Table A4.9
Sources of growth in eight sectors, 1971 - 89

contribution to output growth per cent per annum

Agriculture (excluding fertilizer per acre)

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1971 - 75	3.74	0.27	0.52	2.11	0.83
1976 - 80	3.95	0.37	0.85	2.67	0.07
1971 - 80	**3.84**	**0.32**	**0.69**	**2.39**	**0.45**
1981 - 85	4.80	0.31	0.98	1.25	2.26
1986 - 89	4.06	0.17	0.65	0.79	2.44
1981 - 89	**4.47**	**0.25**	**0.83**	**1.05**	**2.34**
1971 - 89	**4.14**	**0.29**	**0.75**	**1.75**	**1.35**

Agriculture (including fertilizer per acre)

	Output growth	Capital growth	Labour growth	Land growth	Fertilizer growth	TFP growth
1971 - 75	3.74	0.16	0.50	1.94	0.27	0.86
1976 - 80	3.95	0.22	0.82	2.46	0.66	-0.20
1971 - 80	**3.84**	**0.19**	**0.66**	**2.20**	**0.46**	**0.33**
1981 - 85	4.80	0.18	0.95	1.16	0.43	2.09
1986 - 89	4.06	0.10	0.63	0.73	6.68	1.07
1981 - 89	**4.47**	**0.15**	**0.80**	**0.97**	**3.21**	**1.64**
1971 - 89	**4.14**	**0.17**	**0.73**	**1.62**	**1.76**	**0.95**

Mining and quarrying

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	-0.86	11.05	-0.63	-11.28
1976 - 80	12.38	8.88	0.44	3.05
1971 - 80	**5.76**	**9.97**	**-0.10**	**-4.12**
1981 - 85	4.47	6.96	0.29	-2.78
1986 - 89	10.55	6.05	-0.56	5.07
1981 - 89	**7.18**	**6.56**	**-0.09**	**0.71**
1971 - 89	**6.43**	**8.35**	**-0.09**	**-1.83**

Manufacturing

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	9.84	11.21	-0.09	-1.28
1976 - 80	9.35	8.71	-0.03	0.67
1971 - 80	**9.60**	**9.96**	**-0.06**	**-0.31**
1981 - 85	4.52	6.76	-0.03	-2.21
1986 - 89	13.05	7.18	-0.06	5.93
1981 - 89	**8.31**	**6.94**	**-0.04**	**1.41**
1971 - 89	**8.99**	**8.53**	**-0.05**	**0.50**

Construction

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	-1.54	9.46	0.51	-11.50
1976 - 80	11.39	7.48	1.35	2.56
1971 - 80	**4.93**	**8.47**	**0.93**	**-4.47**
1981 - 85	4.21	5.58	0.27	-1.64
1986 - 89	12.04	5.39	0.69	5.96
1981 - 89	**7.69**	**5.49**	**0.46**	**1.74**
1971 - 89	**6.24**	**7.06**	**0.70**	**-1.53**

Electricity and water

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	13.97	7.39	-0.21	6.79
1976 - 80	11.87	9.90	-0.09	2.06
1971 - 80	**12.92**	**8.65**	**-0.15**	**4.43**
1981 - 85	10.39	12.17	-0.12	-1.65
1986 - 89	12.71	6.59	-0.02	6.15
1981 - 89	**11.42**	**9.69**	**-0.08**	**1.81**
1971 - 89	**12.21**	**9.14**	**-0.12**	**3.19**

Communication and transportation

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	4.27	6.41	0.57	-2.71
1976 - 80	9.53	7.35	0.25	1.93
1971 - 80	**6.90**	**6.88**	**0.41**	**-0.39**
1981 - 85	6.81	5.74	0.42	0.64
1986 - 89	9.17	3.76	0.45	4.96
1981 - 89	**7.85**	**4.86**	**0.43**	**2.56**
1971 - 89	**7.35**	**5.92**	**0.42**	**1.01**

Commerce and finance

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	5.23	9.05	-0.26	-3.56
1976 - 80	7.68	8.90	-0.19	-1.03
1971 - 80	**6.46**	**8.98**	**-0.22**	**-2.30**
1981 - 85	5.06	5.69	-0.21	-0.42
1986 - 89	12.69	5.78	-0.15	7.06
1981 - 89	**8.45**	**5.73**	**-0.18**	**2.90**
1971 - 89	**7.40**	**7.44**	**-0.21**	**0.17**

Services

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	6.04	7.78	-0.04	-1.69
1976 - 80	7.67	8.11	-0.04	-0.39
1971 - 80	**6.86**	**7.94**	**-0.04**	**-1.04**
1981 - 85	6.85	7.71	-0.03	-0.82
1986 - 89	6.06	8.52	-0.04	-2.42
1981 - 89	**6.50**	**8.07**	**-0.03**	**-1.53**
1971 - 89	**6.69**	**8.00**	**-0.04**	**-1.28**

Source Author's calculations

Table A4.10
Share of contribution to output growth, 1971 - 89

Agriculture

	Output	Capital	Labour	Land	TFP
1971 - 75	100.00	7.33	13.97	56.41	22.25
1976 - 80	100.00	9.34	21.47	67.49	1.69
1971 - 80	**100.00**	**8.36**	**17.83**	**62.10**	**11.69**
1981 - 85	100.00	6.48	20.38	26.08	47.06
1986 - 89	100.00	4.30	15.98	19.53	60.19
1981 - 89	**100.00**	**5.60**	**18.60**	**23.43**	**52.36**
1971 - 89	**100.00**	**6.95**	**18.22**	**42.32**	**32.50**

Mining and quarrying

	Output	Capital	Labour	TFP
1971 - 75	-100.00	1284.05	-73.37	-1310.94
1976 - 80	100.00	71.77	3.55	24.66
1971 - 80	**100.00**	**173.09**	**-1.66**	**-71.46**
1981 - 85	100.00	155.70	6.56	-62.24
1986 - 89	100.00	57.35	-5.35	48.00
1981 - 89	**100.00**	**91.40**	**-1.23**	**9.83**
1971 - 89	**100.00**	**129.91**	**-1.43**	**-28.49**

Manufacturing

	Output	Capital	Labour	TFP
1971 - 75	100.00	113.96	-0.93	-13.04
1976 - 80	100.00	93.15	-0.30	7.15
1971 - 80	**100.00**	**103.82**	**-0.62**	**-3.20**
1981 - 85	100.00	149.46	-0.55	-48.95
1986 - 89	100.00	55.01	-0.49	45.47
1981 - 89	**100.00**	**83.56**	**-0.51**	**16.92**
1971 - 89	**100.00**	**94.95**	**-0.57**	**5.61**

Construction

	Output	Capital	Labour	TFP
1971 - 75	-100.00	615.93	33.15	-748.97
1976 - 80	100.00	65.68	11.82	22.50
1971 - 80	**100.00**	**171.91**	**18.83**	**-90.72**
1981 - 85	100.00	132.54	6.42	-38.96
1986 - 89	100.00	44.75	5.70	49.54
1981 - 89	**100.00**	**71.45**	**5.92**	**22.63**
1971 - 89	**100.00**	**113.23**	**11.29**	**-24.51**

Electricity and water

	Output	Capital	Labour	TFP
1971 - 75	100.00	52.90	-1.49	48.58
1976 - 80	100.00	83.40	-0.78	17.39
1971 - 80	**100.00**	**66.91**	**-1.16**	**34.25**
1981 - 85	100.00	117.06	-1.17	-15.89
1986 - 89	100.00	51.84	-0.19	48.36
1981 - 89	**100.00**	**84.81**	**-0.68**	**15.88**
1971 - 89	**100.00**	**74.84**	**-0.95**	**26.11**

Communication and transportation

	Output	Capital	Labour	TFP
1971 - 75	100.00	150.06	13.34	-63.43
1976 - 80	100.00	77.08	2.67	20.27
1971 - 80	**100.00**	**99.66**	**5.97**	**-5.64**
1981 - 85	100.00	84.39	6.17	9.44
1986 - 89	100.00	41.02	4.94	54.08
1981 - 89	**100.00**	**61.90**	**5.53**	**32.59**
1971 - 89	**100.00**	**80.56**	**5.75**	**13.70**

Commerce and finance

	Output	Capital	Labour	TFP
1971 - 75	100.00	173.03	-4.94	-68.07
1976 - 80	100.00	115.92	-2.49	-13.45
1971 - 80	**100.00**	**139.06**	**-3.48**	**-35.58**
1981 - 85	100.00	112.49	-4.18	-8.31
1986 - 89	100.00	45.56	-1.18	55.61
1981 - 89	**100.00**	**67.82**	**-2.18**	**34.35**
1971 - 89	**100.00**	**100.52**	**-2.78**	**2.25**

Services

	Output	Capital	Labour	TFP
1971 - 75	100.00	128.78	-0.72	-28.05
1976 - 80	100.00	105.70	-0.58	-5.12
1971 - 80	**100.00**	**115.87**	**-0.64**	**-15.22**
1981 - 85	100.00	112.50	-0.46	-12.02
1986 - 89	100.00	140.59	-0.60	-39.98
1981 - 89	**100.00**	**124.14**	**-0.52**	**-23.61**
1971 - 89	**100.00**	**119.68**	**-0.59**	**-19.09**

Source Author's calculations

Table A4.11
TFP level index, 1970 - 89

points of output given in 1970 = 100

Agriculture

	Output	Output growth	Output increases due to				TFP indices
			Capital growth	Labour growth	Land growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1971	104.22	4.22	0.50	6.91	1.33	-4.53	95.47
1972	102.44	-1.78	0.34	-3.57	1.49	-0.04	95.43
1973	111.68	9.24	0.26	1.21	0.86	6.91	102.34
1974	114.88	3.21	-0.05	-7.00	8.85	1.42	103.76
1975	119.80	4.92	0.38	4.85	-1.14	0.82	104.57
1976	126.83	7.03	0.56	1.45	5.86	-0.84	103.73
1977	129.71	2.88	0.98	2.82	-0.20	-0.73	103.00
1978	144.95	15.24	0.30	2.41	8.04	4.49	107.49
1979	142.29	-2.67	0.24	-2.60	5.39	-5.70	101.80
1980	144.70	2.42	0.29	1.05	-1.88	2.96	104.76
1981	152.29	7.58	0.69	1.97	1.74	3.19	107.94
1982	156.87	4.58	0.59	-0.32	2.28	2.04	109.98
1983	163.69	6.82	0.47	3.40	1.57	1.38	111.37
1984	172.60	8.90	0.28	2.41	3.08	3.13	114.49
1985	182.92	10.32	0.39	0.18	1.18	8.58	123.07
1986	183.47	0.55	0.31	2.05	1.87	-3.67	119.40
1987	183.06	-0.41	0.30	-1.22	-1.60	2.11	121.51
1988	200.88	17.81	0.40	2.94	-3.08	17.55	139.05
1989	213.79	12.92	0.30	1.07	9.45	2.11	141.16
1971 - 75	110.60	3.96	0.29	0.48	2.28	0.91	100.31
1976 - 80	137.70	4.98	0.47	1.03	3.44	0.04	104.16
1971 - 80	**124.15**	**4.47**	**0.38**	**0.75**	**2.86**	**0.48**	**102.24**
1981 - 85	165.67	7.64	0.48	1.53	1.97	3.66	113.37
1986 - 89	195.30	7.72	0.33	1.21	1.66	4.52	130.28
1981 - 89	**178.84**	**7.68**	**0.41**	**1.39**	**1.83**	**4.04**	**120.89**
1971 - 89	**150.06**	**5.99**	**0.40**	**1.05**	**2.37**	**2.17**	**111.07**

Mining and quarrying

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	107.34	7.34	11.71	-2.37	-2.00	98.00
1972	107.25	-0.09	11.58	4.64	-16.30	81.70
1973	101.38	-5.87	12.78	-0.23	-18.42	63.28
1974	105.38	3.99	11.99	-3.32	-4.68	58.60
1975	94.81	-10.57	9.50	-1.70	-18.37	40.22
1976	110.93	16.12	7.92	0.75	7.44	47.66
1977	133.09	22.16	8.11	1.49	12.56	60.22
1978	157.87	24.78	13.25	-2.06	13.59	73.81
1979	163.22	5.35	15.42	2.90	-12.98	60.83
1980	167.96	4.73	14.73	-0.38	-9.62	51.21
1981	161.93	-6.03	12.60	0.88	-19.50	31.71
1982	170.98	9.05	11.03	1.20	-3.18	28.53
1983	169.08	-1.90	12.26	-2.00	-12.15	16.38
1984	199.01	29.93	12.70	4.57	12.67	29.05
1985	206.51	7.50	11.58	-2.64	-1.45	27.60
1986	204.69	-1.82	7.99	-2.91	-6.90	20.70
1987	219.40	14.72	11.66	-0.18	3.25	23.94
1988	261.73	42.32	14.34	0.45	27.53	51.48
1989	305.23	43.50	21.23	-2.53	24.79	76.27
1971 - 75	103.23	-1.04	11.51	-0.60	-11.96	68.36
1976 - 80	146.61	14.63	11.89	0.54	2.20	58.75
1971 - 80	**124.92**	**6.80**	**11.70**	**-0.03**	**-4.88**	**63.55**
1981 - 85	181.50	7.71	12.03	0.40	-4.72	26.65
1986 - 89	247.76	24.68	13.80	-1.29	12.17	43.10
1981 - 89	**210.95**	**15.25**	**12.82**	**-0.35**	**2.78**	**33.96**
1971 - 89	**165.67**	**10.80**	**12.23**	**-0.18**	**-1.25**	**49.54**

Manufacturing

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	110.50	10.50	11.40	0.09	-0.99	99.01
1972	124.25	13.75	11.74	-0.46	2.46	101.48
1973	142.40	18.15	15.36	0.04	2.75	104.23
1974	150.94	8.54	17.62	-0.41	-8.68	95.55
1975	159.46	8.51	14.03	0.18	-5.70	89.85
1976	182.18	22.72	13.62	0.29	8.81	98.66
1977	206.52	24.34	12.79	-0.26	11.82	110.48
1978	223.80	17.29	21.32	-0.03	-4.01	106.47
1979	241.59	17.79	19.87	-0.35	-1.73	104.74
1980	248.46	6.86	21.26	-0.01	-14.38	90.35
1981	263.61	15.16	15.98	0.05	-0.88	89.47
1982	270.23	6.62	16.42	-0.31	-9.50	79.98
1983	292.04	21.81	19.94	0.02	1.84	81.82
1984	311.14	19.10	22.94	0.00	-3.84	77.98
1985	309.24	-1.90	18.36	-0.11	-20.16	57.82
1986	340.96	31.73	12.20	-0.02	19.54	77.37
1987	383.62	42.65	21.83	-0.50	21.31	98.68
1988	443.15	59.54	30.34	-0.04	29.25	127.92
1989	504.71	61.55	46.30	-0.41	15.65	143.57
1971 - 75	137.51	11.89	14.03	-0.11	-2.03	98.02
1976 - 80	220.51	17.80	17.77	-0.07	0.10	102.14
1971 - 80	**179.01**	**14.85**	**15.90**	**-0.09**	**-0.96**	**100.08**
1981 - 85	289.25	12.16	18.73	-0.07	-6.51	77.41
1986 - 89	418.11	48.87	27.67	-0.24	21.44	111.89
1981 - 89	**346.52**	**28.47**	**22.70**	**-0.15**	**5.91**	**92.74**
1971 - 89	**258.36**	**21.30**	**19.12**	**-0.12**	**2.29**	**96.60**

Construction

	Output	Output growth	Change of Output due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	101.29	1.29	10.51	2.30	-11.52	88.48
1972	96.65	-4.64	9.70	1.68	-16.02	72.46
1973	94.51	-2.14	9.64	-0.16	-11.62	60.84
1974	88.71	-5.80	9.07	0.69	-15.56	45.28
1975	92.22	3.51	6.77	-1.75	-1.51	43.77
1976	111.08	18.85	6.65	1.74	10.46	54.24
1977	130.69	19.52	6.61	2.18	10.84	65.07
1978	151.00	20.31	11.59	-0.67	9.38	74.46
1979	148.87	-2.13	11.98	3.75	-17.85	56.60
1980	155.91	7.04	11.09	1.38	-5.42	51.18
1981	165.13	9.21	9.08	1.35	-1.21	49.97
1982	164.02	-1.11	8.32	0.06	-9.49	40.48
1983	181.37	17.35	9.05	0.05	8.25	48.73
1984	200.54	19.17	12.95	1.13	5.09	53.82
1985	189.83	-10.71	8.77	-0.40	-19.08	34.74
1986	184.32	-5.51	4.83	0.31	-10.65	24.10
1987	207.33	23.00	9.17	2.66	11.17	35.27
1988	247.36	40.04	12.39	1.51	26.12	61.39
1989	295.03	47.67	19.93	1.01	26.73	88.12
1971 - 75	94.68	-1.56	9.14	0.55	-11.25	62.17
1976 - 80	139.51	12.74	9.58	1.67	1.48	60.31
1971 - 80	**117.09**	**5.59**	**9.36**	**1.11**	**-4.88**	**61.24**
1981 - 85	180.18	6.78	9.63	0.44	-3.29	45.55
1986 - 89	233.51	26.30	11.58	1.37	13.35	52.22
1981 - 89	**203.88**	**15.46**	**10.50**	**0.085**	**4.10**	**48.51**
1971 - 89	**158.20**	**10.26**	**9.90**	**0.99**	**-0.63**	**65.21**

Electricity and water

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	118.71	18.71	9.61	-0.30	9.40	109.40
1972	137.26	18.55	12.02	-0.24	6.78	116.18
1973	158.51	21.25	9.82	-0.91	12.33	128.51
1974	169.13	10.62	7.19	-0.53	3.96	132.47
1975	191.66	22.53	9.34	0.78	12.41	144.88
1976	213.88	22.21	16.76	-0.30	5.76	150.64
1977	244.99	31.12	23.84	-0.08	7.37	158.01
1978	279.24	34.25	21.10	-0.36	13.52	171.52
1979	306.61	27.37	23.17	0.14	4.06	175.58
1980	335.55	28.94	38.95	-0.52	-9.49	166.09
1981	372.26	36.71	52.82	-0.60	-15.51	150.58
1982	422.74	50.48	33.89	0.07	16.51	167.08
1983	460.49	37.75	61.53	-1.88	-21.90	145.18
1984	501.57	41.08	56.17	-0.32	-14.77	130.41
1985	549.82	48.25	46.32	0.33	1.60	132.01
1986	605.85	56.03	42.08	-0.45	14.42	146.42
1987	675.52	69.67	40.00	-0.27	29.96	176.39
1988	761.11	85.59	41.59	0.13	43.87	220.26
1989	886.46	125.35	45.19	0.10	80.08	300.33
1971 - 75	155.06	18.33	9.60	-0.24	8.98	126.29
1976 - 80	276.06	28.78	24.76	-0.22	4.24	164.37
1971 - 80	**215.56**	**23.56**	**17.18**	**-0.23**	**6.61**	**145.33**
1981 - 85	461.38	42.85	50.15	-0.48	-6.82	145.05
1986 - 89	732.24	84.16	42.21	-0.12	42.08	210.85
1981 - 89	**581.76**	**61.21**	**46.62**	**-0.32**	**14.92**	**174.30**
1971 - 89	**389.02**	**41.39**	**31.13**	**-0.27**	**10.54**	**159.05**

Communication and transportation

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	102.10	2.10	8.16	-2.37	-3.69	96.31
1972	106.44	4.34	9.21	4.35	-9.22	87.09
1973	115.50	9.06	6.70	1.21	1.15	88.24
1974	122.88	7.38	5.05	2.10	0.22	88.46
1975	123.02	0.14	5.17	-2.45	-2.58	85.88
1976	130.31	7.29	9.05	-1.77	0.02	85.89
1977	143.43	13.12	7.68	1.91	3.53	89.43
1978	153.96	10.53	13.17	0.28	-2.91	86.51
1979	174.25	20.29	10.26	1.40	8.63	95.14
1980	193.66	19.41	13.31	0.25	5.86	101.00
1981	199.34	5.67	9.46	-1.62	-2.16	98.84
1982	218.40	19.06	9.61	4.11	5.33	104.17
1983	235.28	16.88	9.63	1.99	5.26	109.43
1984	258.43	23.15	19.64	-0.66	4.17	113.61
1985	268.69	10.26	16.17	0.63	-6.54	107.07
1986	287.28	18.59	13.55	0.62	4.43	111.50
1987	310.21	22.93	8.95	3.60	10.38	121.88
1988	341.82	31.61	9.08	0.12	22.42	144.30
1989	381.37	39.55	13.51	0.99	25.07	169.37
1971 - 75	113.99	4.60	6.86	0.57	-2.82	89.19
1976 - 80	159.12	14.13	10.69	0.41	3.02	91.59
1971 - 80	**136.56**	**9.37**	**8.78**	**0.49**	**0.10**	**90.39**
1981 - 85	236.03	15.00	12.90	0.89	1.21	106.62
1986 - 89	330.17	28.17	11.27	1.33	15.58	136.76
1981 - 89	**277.87**	**20.86**	**12.18**	**1.09**	**7.60**	**120.02**
1971 - 89	**203.49**	**14.81**	**10.39**	**0.77**	**3.65**	**104.43**

Commerce and finance

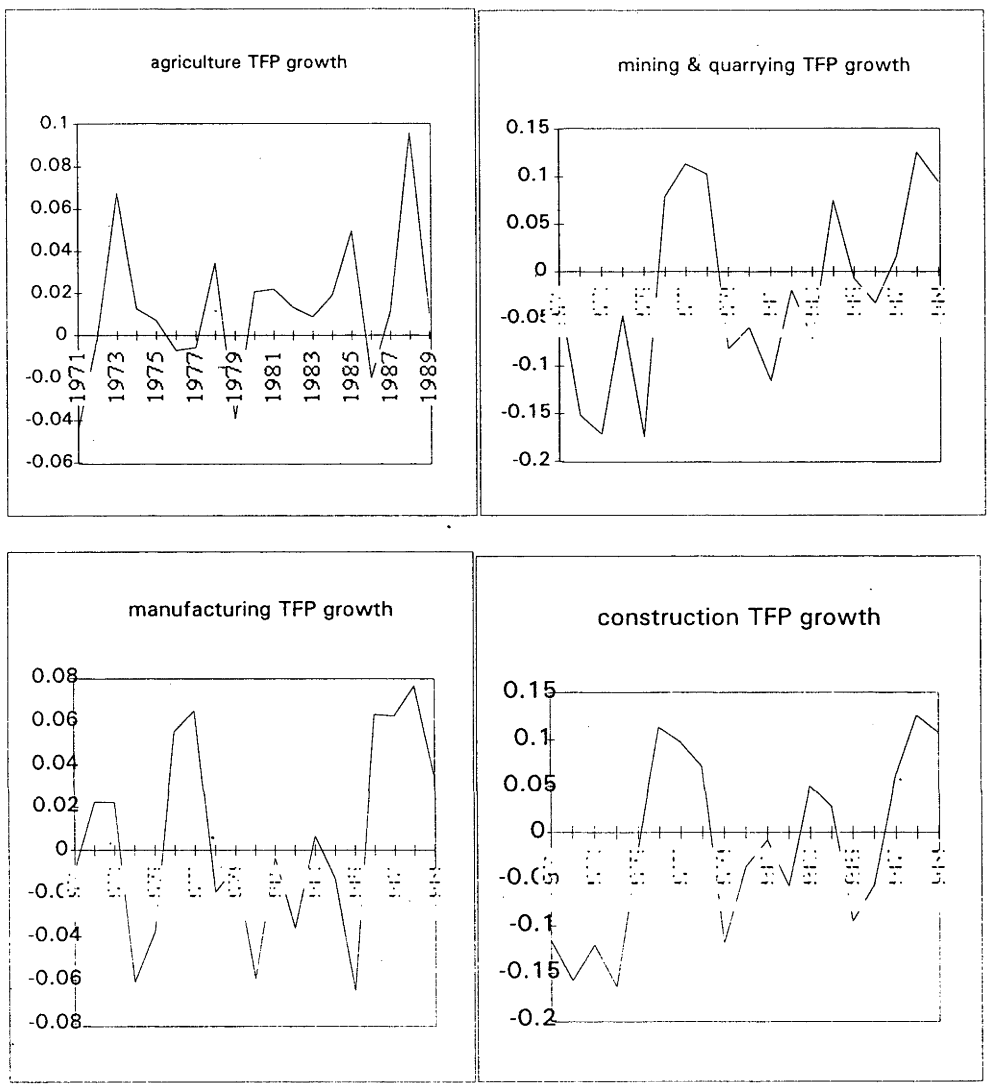
	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	100.90	0.90	10.11	-0.73	-8.48	91.52
1972	103.46	2.56	8.86	-0.21	-6.09	85.43
1973	116.50	13.04	9.06	-0.40	4.38	89.81
1974	123.82	7.32	10.82	-0.43	-3.07	86.74
1975	128.56	4.74	10.29	0.50	-6.05	80.69
1976	138.86	10.30	9.30	0.44	0.56	81.25
1977	153.27	14.41	10.55	-1.17	5.03	86.28
1978	167.77	14.50	14.86	0.03	-0.40	85.88
1979	173.52	5.75	17.65	-0.43	-11.47	74.41
1980	185.88	12.35	16.43	-0.40	-3.68	70.73
1981	199.50	13.62	11.02	-0.33	2.98	73.65
1982	200.19	0.68	10.75	-1.07	-9.01	64.65
1983	213.78	13.59	11.20	0.15	2.25	66.89
1984	230.28	16.50	13.61	-0.17	3.06	69.95
1985	237.44	7.16	11.90	-0.79	-3.95	66.00
1986	248.53	11.09	9.71	-0.37	1.74	67.75
1987	285.02	36.48	13.14	-1.17	24.51	92.26
1988	328.85	43.84	17.02	0.09	26.74	119.00
1989	381.57	52.71	25.59	-0.02	27.13	146.13
1971 - 75	114.65	5.71	9.83	-0.25	-3.86	86.84
1976 - 80	163.86	11.46	13.76	-0.30	-1.99	79.71
1971 - 80	**139.25**	**8.59**	**11.79**	**-0.28**	**-2.93**	**83.27**
1981 - 85	216.24	10.31	11.70	-0.44	-0.94	68.23
1986 - 89	310.99	36.03	16.36	-0.37	20.03	106.28
1981 - 89	**258.35**	**21.74**	**13.77**	**-0.41**	**8.38**	**85.14**
1971 - 89	**195.67**	**14.82**	**12.73**	**-0.34**	**2.43**	**84.16**

Services

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP growth	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	105.48	5.48	9.50	-0.03	-3.99	96.01
1972	112.79	7.31	9.25	-0.07	-1.87	94.14
1973	120.19	7.40	8.55	-0.03	-1.13	93.01
1974	124.55	4.36	8.24	-0.25	-3.64	89.37
1975	134.03	9.48	7.71	0.13	1.64	91.01
1976	142.18	8.15	9.63	0.10	-1.58	89.43
1977	154.98	12.80	11.30	-0.15	1.65	91.08
1978	167.51	12.54	14.49	-0.13	-1.81	89.26
1979	184.48	16.97	14.05	-0.03	2.94	92.20
1980	193.78	9.30	14.11	-0.17	-4.65	87.55
1981	208.53	14.75	15.07	-0.19	-0.13	87.42
1982	224.25	15.72	16.13	-0.08	-0.33	87.09
1983	242.62	18.37	17.21	-0.09	1.25	88.33
1984	254.31	11.69	20.23	0.10	-8.63	79.70
1985	269.80	15.49	17.81	-0.06	-2.26	77.44
1986	281.64	11.84	19.04	-0.13	-7.09	70.35
1987	303.75	22.11	21.62	-0.25	0.75	71.10
1988	325.86	22.11	27.12	-0.03	-4.96	66.13
1989	341.28	15.41	34.00	0.00	-18.57	47.56
1971 - 75	119.41	6.81	8.65	-0.05	-1.80	92.71
1976 - 80	168.59	11.95	12.72	-0.08	-0.69	89.90
1971 - 80	**144.00**	**9.38**	**10.68**	**-0.06**	**-1.25**	**91.31**
1981 - 85	239.90	15.20	17.29	-0.06	-2.02	84.00
1986 - 89	313.13	17.87	25.44	-0.10	-7.47	63.79
1981 - 89	**272.45**	**16.39**	**20.91**	**-0.08**	**-4.44**	**75.01**
1971 - 89	**204.84**	**12.70**	**15.53**	**-0.07**	**-2.76**	**83.59**

Source Author's calculations

Figure A4.1
TFP growth of eight major sectors



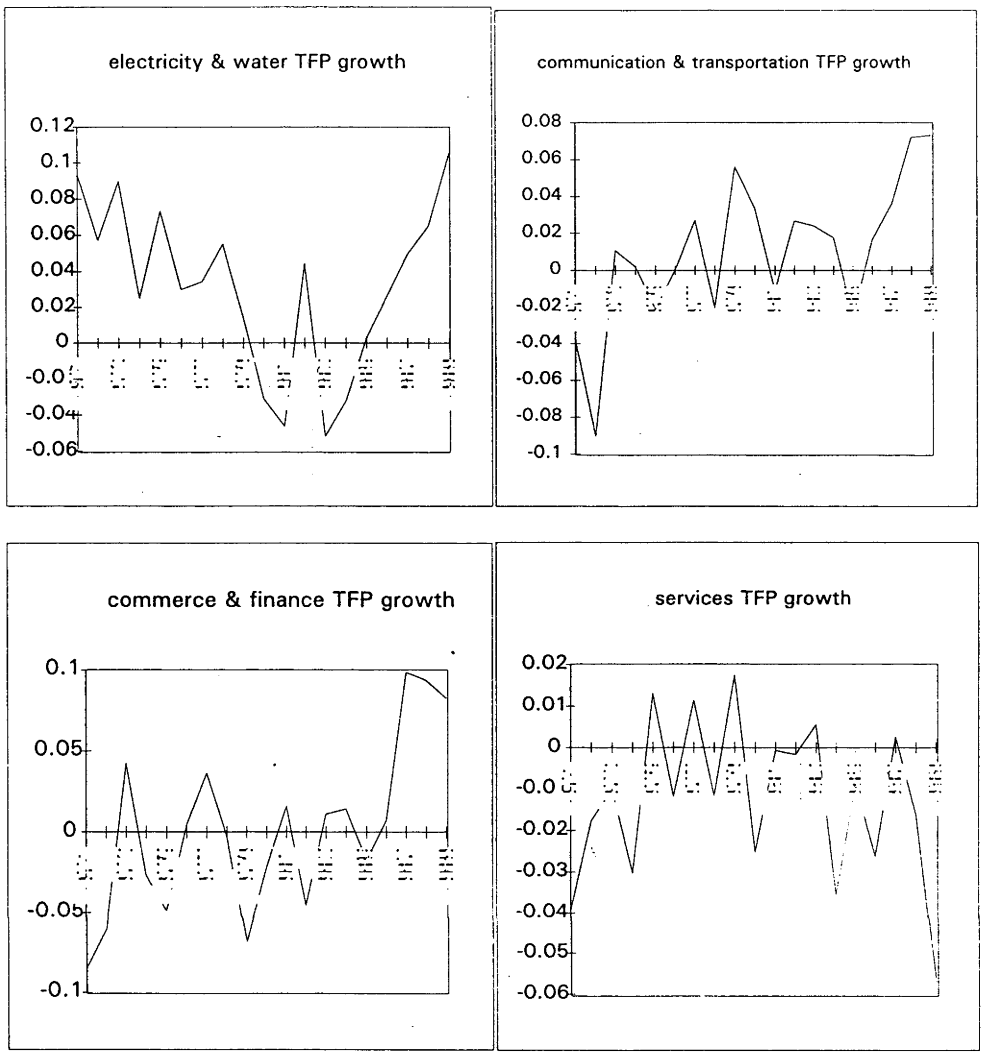
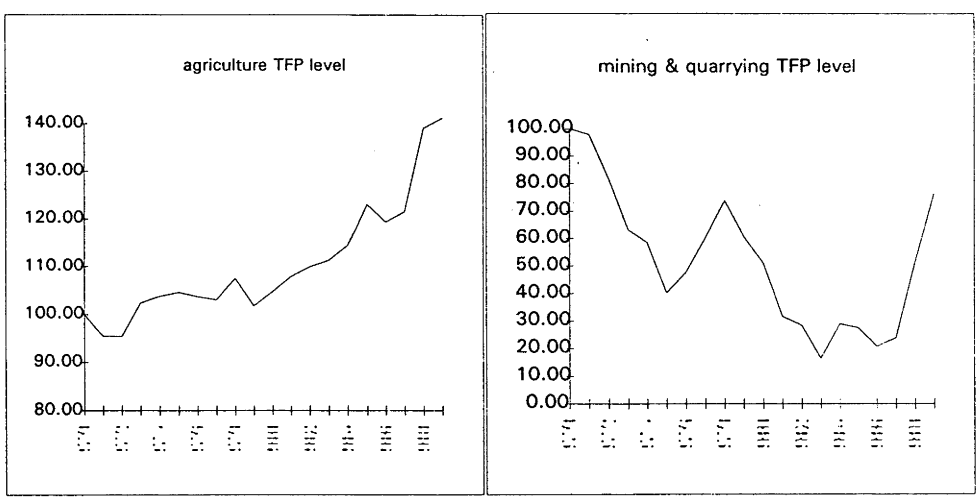
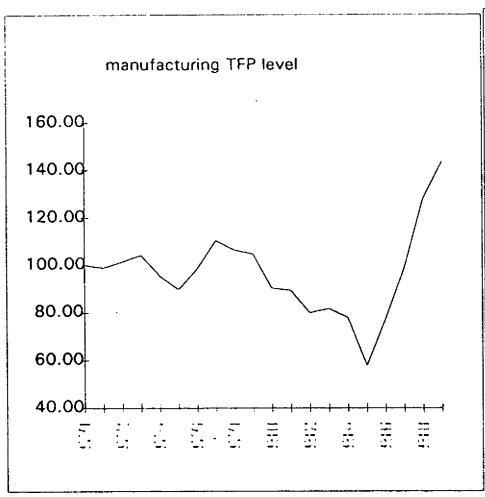
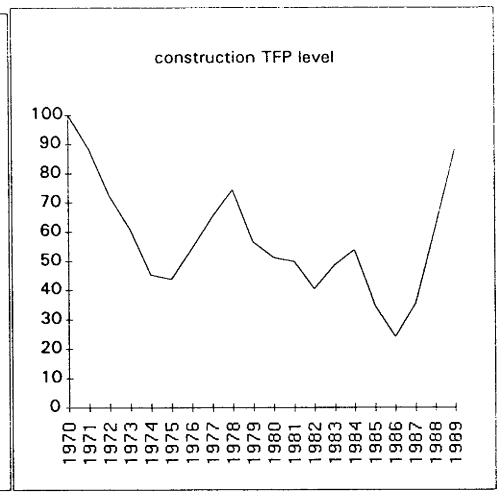
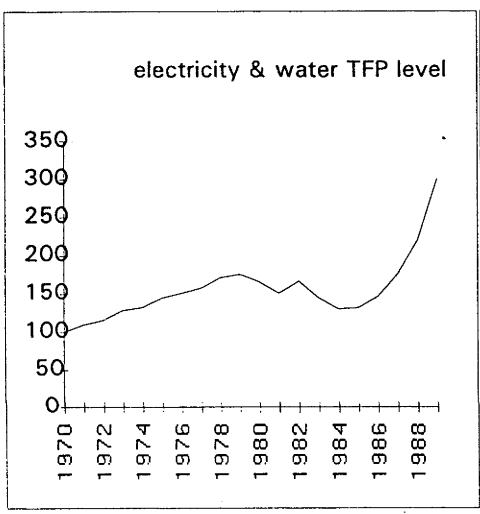


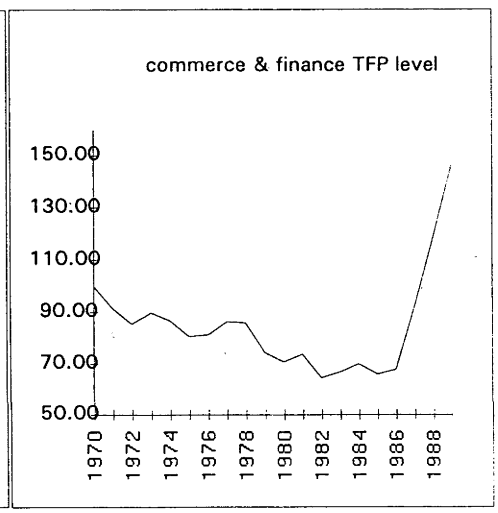
Figure A4.2
TFP level of eight major sectors

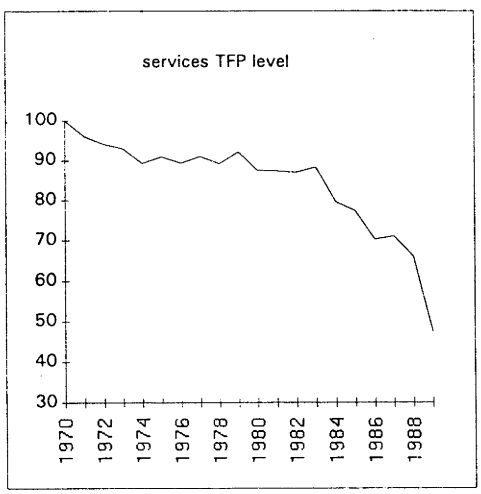



manufacturing TFP level
160.00
140.00
120.00
100.00
80.00
60.00
40.00


construction TFP level
100
90
80
70
60
50
40
30
20
10
0
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989


electricity & water TFP level
350
300
250
200
150
100
50
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


commerce & finance TFP level
150.00
130.00
110.00
90.00
70.00
50.00
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


services TFP level
100
90
80
70
60
50
40
30
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988

5 Estimation of TFP growth in thirteen manufacturing industries

The manufacturing sector is disaggregated into thirteen industries and TFP estimates for each sector are given in this chapter. The TFP estimation results are analyzed and compared in terms of both growth rates and the TFP level for the thirteen industries. Some characteristics of the industries are also examined to make comparisons between different roles of TFP growth among industries.

The estimation of TFP growth is undertaken, using the three digit level of International Standard Industry Classification (ISIC) as this is the most disaggregated level at which the required data on all the variables in the estimation are available. The industries examined were food (FD); beverage and tobacco (BVT); textiles leather and footwear (TXLF); wood, paper and furniture (WD); printing and publishing (PP); industrial chemicals and other chemicals (CHM); petroleum refineries and miscellaneous petrochemical products (PETR); rubber and plastic products (RUBP); non-metallic products (NMET); metallic products (MET); machinery (MACH); electrical machinery and supplies (ELCM); and transport equipment and vehicles (VEC).

Estimation of the thirteen industry production functions

As in Chapter 4, a two-factor approach to the industrial production function is adopted with capital (K) and labour (L) as the two major inputs producing net output. Data are described in Chapter 3. The employed labour data are taken from the UNIDO data time series of industry from 1970 - 89 (International Economic Data Bank, The Australian National University).

The CRS-CD production function used in this study is described as Equation (5.1). A CRS-T production function is also estimated as Equation (5.2).

$$(\ln y_t - \ln L_t) = \beta_0 + \beta_k (\ln K_t - \ln L_t) \tag{5.1}$$

$$(\ln y_t - \ln L_t) = \beta_0 + \beta_k (\ln K_t - \ln L_t) - \frac{1}{2}\beta_{kL} (\ln K_t - \ln L_t)^2 \tag{5.2}$$

Testing for stationarity and cointegration of data

As described in Chapter 4, ADF tests are performed and they do not reject the null hypothesis implying that the variables are non-stationary (Table A5.1 Appendix CH 5). However, tests of cointegration do not reject the null hypothesis either, implying that the variables are not cointegrated (results in Table A5.2 Appendix CH 5).

Since the variables are non-stationary, the first difference equation is estimated instead.

The estimated equation of the CRS-CD production function is Equation (5.3) and CRS-T is as Equation (5.4) below[1].

$$\Delta(\ln y_t - \ln L_t) = \beta_0 + \beta_k \Delta(\ln K_t - \ln L_t) \tag{5.3}$$

$$\Delta(\ln y_t - \ln L_t) = \beta_0 + \beta_k \Delta(\ln K_t - \ln L_t) - \frac{1}{2}\beta_{kL}\Delta(\ln K_t - \ln L_t)^2 \tag{5.4}$$

Estimation results of production functions

The results of the estimated CRS-CD production function using difference equation are presented in Table 5.1 and those of CRS-T are shown in Table A5.3 Appendix CH 5. As in Chapter 4, the CRS-CD production function is used since it is essential for consistency of TFP estimation throughout the study. In addition, the CRS-CD is a homothetic functional form, which has a *priori* property of additivity and separability that is necessary for consistency of aggregation. When the results for the CRS-T function are compared with those for the CRS-CD function, the extra variables are insignificant in all sectors except petroleum refineries and miscellaneous petrochemical products (PETR) and metallic products (MET). Given the lack of extra explanatory power and possible multicollinearity between (lnK-lnL) and $(\text{lnK-lnL})^2$, the CRS-CD results are analyzed further.

1 The reason for adding the intercept term in the estimated equations and its meaning are mentioned in Chapter 4.

The results for the CRS-CD production function estimation Equation (5.3) are showed in Table 5.1. The estimation results for the non-constant returns to scale (NCRS) of the Cobb-Douglas and Translog production functions are also presented in Table A5.5 and A5.6.

Generally, in all industries except transport equipment and vehicles, the elasticity of output with respect to capital (β_K) is statistically significant. The β_K's had rather significant high values (more than 0.7) in all but six industries: beverage and tobacco (0.1313); transport equipment and vehicles (0.1768); industrial chemicals and other chemicals (0.2936); wood paper and furniture (0.4999); electrical machinery and supplies (0.6104); and petroleum refineries and miscellaneous petrochemical products (0.6606). Only the first two of these were statistically insignificant. Since $\beta_L = 1-\beta_K$ the estimates of the output elasticity of labour (β_L), on the other hand, were insignificant in all industries, except for beverage and tobacco (0.8687), transport equipment and vehicles (0.8232), industrial chemicals and other chemicals (0.7067), wood paper and furniture (0.5001), electrical machinery and supplies (0.3896) and metallic products (0.2327).

Overall, these results imply that a 1 per cent increase in capital increases output by more than a 1 per cent increase in labour, except where β_L was larger than 0.5 in a few industries: beverage and tobacco; transport equipment and vehicles; industrial chemical and other chemicals; and wood paper and furniture. The high output elasticity of capital probably reflect high effective protection and subsidies for capital. The highly capital-intensive techniques of production adopted caused an inefficiency. The estimation of output elasticity of capital is also likely to give an upward biased result discussed in Chapter 4.

Table 5.1

Estimation results of the CRS-CD production function using difference equation for thirteen industries

$$\ln Y_t = \beta_0 + \sum_j \beta_j \ln X_{jt} + \mu_t \; ; \; \text{where} \sum_j \beta_j = 1; j = K, L$$

Sector	$\hat{\beta}_0$	$\hat{\beta}_K$	$\hat{\beta}_L$	R^2
Food	0.01661	1.1238	-0.1238	0.6030
t-ratio	1.2243	5.3237*	-0.5865	
Beverage and tobacco	0.0232	0.1313	0.8687	0.0076
t-ratio	0.8157	0.3620	2.3947*	
Textile, leather and footwear	0.0205	0.9330	0.0670	0.7060
t-ratio	1.7066**	6.6493*	0.4775	
Wood, paper and furniture	-0.0056	0.4999	0.5001	0.4742
t-ratio	-0.2918	4.1514*	4.1530*	
Printing and publishing	-0.0034	1.0496	-0.0496	0.7956
t-ratio	-0.2018	8.4297	-0.3983	
Industrial chemicals and other chemicals	0.0591	0.2936	0.7064	0.1492
t-ratio	2.9567*	2.0385*	4.9049*	
Petroleum refineries and miscellaneous petrochemical products	-0.0266	0.6606	0.3394	0.3196
t-ratio	-0.8207	3.0747*	1.5800**	
Rubber and plastic products	0.0048	1.0402	-0.0402	0.3982
t-ratio	0.1706	3.5927*	-0.1388	
Non-metallic products	0.0395	0.7772	0.2228	0.5069
t-ratio	2.0738*	4.4162*	1.2661	
Metallic products	0.0102	0.7673	0.2327	0.7310
t-ratio	0.7025	7.0655*	2.1427*	
Machinery	0.0158	0.7117	0.2883	0.4682
t-ratio	0.6512	4.1046*	1.6627**	
Electrical machinery & supplies	0.0282	0.6104	0.3896	0.6037
t-ratio	1.1052	5.3305*	3.4020*	
Transport equipment & vehicles	0.0391	0.1768	0.8232	0.0164
t-ratio	0.7613	0.5326	2.4801*	

Remark t-ratio of $\hat{\beta}_L$ is calculated by $t\,\hat{\beta}_L = \frac{\hat{\beta}_L}{SE\hat{\beta}_L}$, $Var(\hat{\beta}_L) = Var(\hat{\beta}_K)$

* means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Source Author's calculations

Estimated TFP growth and input growth contribution

The TFP growth of each industry is calculated by using the estimated output elasticities of capital and labour from the CRS-CD production function as weights in the index calculation as discussed in the model presented in Chapter 3. The results for TFP growth and the contributions to growth are shown in Tables A5.7 and A5.8 Appendix CH 5. Table 5.2 (a consolidated version of Table A5.8 Appendix CH 5) shows the percentage contribution to output growth of inputs and TFP growth over the whole period.

In general, by examining the estimated intercepts in Table 5.1, TFP growth in most sectors is insignificant and the highest is 5.9 per cent on average for the whole period for the industrial chemicals and other chemicals. However, during the late 1980s, TFP growth was clearly higher in most industries than in the 1970s. It ranged from a low of -10.0 per cent per annum in petroleum refineries and petrochemical products during 1986 - 89 to the highest growth of 24.0 per cent per annum in transport equipment and vehicles during 1986 - 89. The range of TFP growth in all thirteen industries for the whole period of the study (1971 - 89) is shown in Table A5.7 Appendix CH 5. TFP growth in petroleum refineries and petrochemical products, a highly concentrated industry and which has very low export shares in value-added (Chapter 7), was negative. Both high concentration and low exports suggest low competitiveness were causes of low or negative TFP growth.

The trends in TFP growth in the thirteen industries over the period of 1970 - 89 are also shown in Figure A5.1 Appendix CH 5. TFP growth tended to rise in most industries (with large year-to-year fluctuations) except in the beverage and tobacco and petroleum refineries and miscellaneous petrochemical products industries.

Capital growth is the most influential source of growth in most industries (Table 5.7 Appendix CH 5), except beverage and tobacco, industrial chemicals and other chemicals, non-metallic products and transport equipment and vehicle. Its role has, however, declined from the first half (1971 - 80) to the second half (1981 - 89) of the periods of study, except petroleum refineries and miscellaneous petrochemical products and metallic products. Labour growth is the most influential on growth for the

period of study (1971 - 89) in beverage and tobacco and transport equipment and vehicle.

The relative contribution to output growth of capital, labour and TFP growth to total output growth is shown in Table A5.8 Appendix CH 5 (which summaries Table 5.2). Except in beverage and tobacco, industrial chemical and other chemicals, non-metallic products and transport equipment and vehicles, capital input growth was the most influential factor explaining growth.

Table 5.2
Share of contribution to growth, average during 1971 - 89

per cent

	capital growth	Labour growth	TFP growth
Food	**84.5**	-4.9	20.4
Beverage and tobacco	17.7	**47.1**	35.3
Textile, leather and footwear	**74.6**	5.9	19.5
Wood, paper and furniture	**90.2**	39.7	-11.2
Printing and publishing	**108.0**	-4.0	-4.1
Industrial chemicals and other chemicals	20.0	19.2	**60.9**
Petrochemical refineries and miscellaneous petrochemical products	**109.6**	29.4	-38.5
Rubber and plastic products	**95.6**	-0.9	5.3
Non-metallic products	**47.1**	11.5	41.4
Metallic products	**69.6**	12.2	18.2
Machinery	**73.9**	11.6	14.5
Electrical machinery and supplies	**48.2**	24.8	23.5
Transport equipment and vehicles	12.1	**49.9**	38.0

Source Author's calculation

TFP growth was the most influential factor generating growth in industrial chemicals and other chemicals (60.9 per cent), while labour input growth was the most influential factor stimulating growth in transport equipment and vehicles (49.9) and beverage and tobacco (47.1) (Table 5.2).

Table 5.3
Share of contribution to growth, 1971 - 89

per cent

	Year	Capital growth	Labour growth	TFP growth
Food	1971 - 80	93.9	-7.2	13.3
	1981 - 89	74.5	-2.5	28.0
Beverage and tobacco	1971 - 80	18.4	42.4	39.2
	1981 - 89	16.6	54.0	29.4
Textile, leather and	1971 - 80	79.8	7.1	13.1
footwear	1981 - 89	67.3	4.3	28.4
Wood, paper and	1971 - 80	119.6	31.0	-21.3
furniture	1981 - 89	38.0	55.1	6.91
Printing and publishing	1971 - 80	105.9	-2.4	-3.51
	1981 - 89	112.7	-7.4	-5.3
Industrial chemicals and	1971 - 80	29.8	27.8	42.4
other chemicals	1981 - 89	5.2	6.1	88.7
Petroleum refineries and	1971 - 80	66.6	40.2	-6.8
petrochemical products	1981 - 89	192.4	8.3	-100.7
Rubber and plastic	1971 - 80	94.1	-0.5	6.3
products	1981 - 89	97.8	-1.4	3.8
Non-metallic products	1971 - 80	55.4	11.3	33.3
	1981 - 89	39.8	11.7	48.6
Metallic products	1971 - 80	69.9	24.7	5.4
	1981 - 89	69.3	1.3	29.4
Machinery	1970 - 80	95.1	13.6	-8.7
	1981 - 89	52.8	9.5	37.8
Electrical machinery	1971 - 80	52.6	28.3	13.3
and supplies	1981 - 89	41.6	19.7	38.7
Transport equipment	1971 - 80	14.7	70.2	15.1
and vehicles	1981 - 89	7.0	9.4	83.6

Source Author's calculations

The total period has been split into two sub-periods to detect changes in the pattern of factor contribution over time (Table 5.3).

In many industries each source of increasing growth fluctuated so that there is no clear overall trend of factor contribution to growth. Some trends were, however, evident in some industry groups. Contribution to growth from capital growth decreased in most industries. In both sub-periods the increasing role of TFP growth is evident in food, textiles leather and footwear, wood paper and furniture, industrial chemicals and other chemicals, non-metallic products, metallic products, machinery, electrical machinery and supplies, and transport equipment and vehicles industries. The TFP growth contribution is lower in the beverage and tobacco, printing and publishing, petrochemical refineries and miscellaneous petrochemical products, and rubber and plastic products (Table A5.8 Appendix CH 5 and Table 5.3). Capital contribution to output growth is lower in most industries except in the printing and publishing, petroleum refineries and miscellaneous petrochemical products, and rubber and plastic products industries, in which capital makes a greater contribution to growth.

TFP level index

This section considers TFP levels over time for each industry (Table 5.4). The TFP level in 1970 is set equal to 100 and estimated compound TFP growth rate is added to this index each year as in Table A5.9 Appendix CH 5 (see Chapter 4 for more details). From Table 5.4 (summarizing Table A5.9 Appendix CH 5), it can be seen that most industries had a TFP level higher than 100 at the end of the study. This is consistent with the findings in Chapter 4 that the TFP level index for manufacturing sector is higher than 100. The trend of the TFP level can be seen in Figure A5.2 Appendix CH 5: the TFP level increased, except printing and publishing, petroleum refineries and petrochemical products.

Table 5.4

TFP level of thirteen industries, 1970 - 89

1970 =100

	CHM	ELCM	NMET	TXLF	MACH	VEC	FD
1970	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1971	106.9	91.2	107.3	102.5	105.8	112.8	106.9
1972	114.4	87.1	114.5	107.6	101.7	133.8	106.1
1973	119.6	82.2	122.0	114.5	86.6	120.8	108.7
1974	99.5	55.9	117.9	99.8	88.3	66.6	99.4
1975	87.3	82.7	120.9	102.2	101.3	14.6	101.3
1976	98.3	68.2	130.0	117.4	92.8	50.2	113.1
1977	111.7	99.4	150.1	135.3	96.1	117.3	122.1
1978	137.6	121.6	152.9	133.0	84.4	116.0	122.7
1979	159.6	162.6	139.3	130.1	81.0	89.1	116.9
1980	195.4	177.3	131.8	120.8	86.6	108.9	112.4
1981	221.9	206.2	139.4	123.43	143.6	121.3	118.3
1982	211.0	234.4	134.3	122.3	143.0	112.9	114.9
1983	236.2	240.2	155.7	123.4	130.5	140.5	100.4
1984	289.3	264.0	176.9	122.7	101.9	131.8	103.1
1985	306.2	269.4	123.3	104.1	59.1	-7.8	84.3
1986	330.2	337.2	165.9	147.1	79.0	40.3	113.3
1987	396.5	345.8	207.5	179.5	105.3	81.0	131.9
1988	446.5	263.5	259.0	213.2	142.5	168.0	160.0
1989	432.1	314.1	297.7	230.4	223.7	220.4	186.2

year	BVT	MET	RUBP	WD	PP	PETR
1970	100.0	100.0	100.0	100.0	100.0	100.0
1971	81.1	100.0	100.44	103.1	100.7	125.9
1972	84.4	103.0	102.0	95.8	100.4	151.6
1973	100.1	94.5	110.7	85.5	106.3	146.8
1974	107.8	82.2	96.4	68.9	102.3	118.1
1975	115.7	83.4	95.1	60.7	109.0	130.8
1976	121.2	91.8	103.9	73.5	117.9	149.9
1977	120.5	104.2	109.5	80.7	131.7	151.2
1978	123.0	104.8	101.2	84.9	128.7	104.2
1979	148.1	107.3	114.5	98.2	100.7	77.0
1980	138.9	102.1	108.5	88.7	76.8	33.6
1981	161.7	88.1	89.4	77.1	78.6	43.6
1982	159.2	86.7	67.9	68.7	92.1	57.7
1983	171.0	82.7	92.4	66.8	122.2	59.4
1984	163.5	83.3	25.2	67.2	73.2	29.7
1985	130.5	103.9	23.7	49.8	39.7	18.7
1986	127.3	118.3	56.9	58.7	74.6	11.7
1987	141.2	128.1	92.9	87.1	48.9	-7.3
1988	172.6	137.1	123.0	111.6	23.7	-71.8
1989	168.2	136.4	129.1	98.0	57.4	-93.5

Source Author's calculations

High TFP growth in industry may be due to a number of factors which are discussed in detail in Chapter 7. The effective protection in food, electrical machinery and supplies, textiles leather and footwear, rubber and plastic products, non-metallic products and metallic products was quite low (around 0 to 0.2), in contrast to in industrial chemicals and other chemicals and machinery (around 0.3). The industries with low protection would be expected to have high TFP levels than those with high protection.

Foreign direct investment was also a major factor promoting TFP growth through technology transfers. Foreign direct investment was concentrated in electrical appliances, metallic products, non-metallic products, chemicals, textiles, food and vehicles industries, particularly in the high growth period of the late 1980s. Although the

effective rate of protection of transport equipment and vehicles was relatively high, the TFP level in this industry is higher than 100 in 1989, possibly due to the high proportion of foreign direct investment during the late 1980s. The recent reduction in import duty on imported cars in 1991 (for example from 180 per cent to 60 per cent for small cars), and hence reduction in protection, should induce further TFP growth in this industry. The effect of this development on TFP growth could not be estimated due to limitations on data after 1989.

Exports and competitiveness are other factors promoting TFP growth in the high TFP level industries. Exports per value added were high during 1970 - 89 in metallic products (1.2), electrical machinery and supplies (1.0), food (0.7), textiles leather and footwear (0.4), and rubber and plastic products (0.4). On the other hand, the lower TFP level industries had rather low export shares (petroleum refineries and miscellaneous petrochemical products (0.04), printing and publishing (0.04) and wood paper and furniture (0.3)).

Industrial concentration of industries also explains differences in TFP. High industrial concentration leads to market domination by a few large firms. Industries were found to have quite low concentration ratios (Chapter 7), except for petroleum refineries and petrochemical products (50 per cent in 1970) and beverage and tobacco (31.0 per cent in 1970). The concentration ratios of the higher TFP level industries were found to be lower than 20 per cent in 1984, except beverage and tobacco. Although, beverage and tobacco had higher TFP levels from 1970 to 1989, TFP growth of this industry declined from 2.9 per cent during 1971-80 to 1.7 per cent during 1981-89, possibly because high concentration retarded TFP growth.

Three industries were found to have a declining trend in TFP levels: wood paper and furniture, printing and publishing and petroleum refineries and petrochemical products (Table 5.4). A number of reasons may explain their low TFP growth, including high industrial concentration. Petroleum refineries and miscellaneous petrochemical products had a high concentration ratio of 50.0 per cent in 1970 and 22.5 per cent in 1984. In printing and publishing, low exports (0.02) were likely to be the major explanation. Wood, paper and furniture had a medium degree of protection, concentration and export shares.

Electrical machineries and supplies had low TFP levels in the early 1970s, but in recent years the industry's performance improved. Electrical machineries and supplies firms were first established in Thailand more than 30 years ago mainly for import substitution for the domestic market. High protection is a major reason for the low TFP levels in this industry in the early 1970s (Table 5.4). In 1970, value-added was only 481 million baht and it had increased to 1,901 million baht in 1980 and 4,739 million baht in 1989 (all at constant 1972 prices). The industry changed its character in this period. From being import substituting it became export oriented as increasing wages in their home countries drove Japanese, Korean and Singaporian entrepreneurs to Thailand, particularly in the late 1980s.

Many factories in this industry are joint ventures. Although it is not a high technology industry, foreign direct investment is a major source of technology transfer, explaining high TFP growth in this industry. The net foreign direct investment in electrical appliances grew from 448.2 million baht in 1980 to 8,497.2 million baht in 1989, an average annual growth of 32.7 per cent per annum.

This industry consists of many small and some large manufacturers. Large manufacturers are normally those which have a large amount of investment and most of them are foreign companies operating for the export market (Bangkok Bank 1992). Many enjoy Board of Investment privileges. Thai firms tend to be small. Some are sub-contractors for the other manufacturers.

Although the concentration ratio of this industry was quite high in 1970 (29.7 per cent, Chapter 7), it decreased to only 13.4 per cent in 1984. The effective rate of protection was 0.1 during 1981 and 1987 (Chapter 7). The export ratio was high (Chapter 7).

The government promoted the industry, initially for import substitution. Protection to stimulate the local production of parts and accessories was unsuccessful and resulted in the slow growth of this industry. Goods were smuggled into the domestic market, forcing the government to respond by reducing import duties on electrical and electronic goods. This made exports possible in the 1980s. Board of Investment incentives included exemption of taxes and import duties on machinery, exemption of

business tax on raw materials used in manufacturing for exports for a period of five years, exemption of business taxes on exported products and on inputs into exports. The most important measure offset high protection by drawbacks of taxes paid on materials imported for export production. Firms received income tax holidays. The Bank of Thailand also provides support in the form of credits, establishment of a guarantee fund for export credit and rediscounted bills.

During 1981 - 85, the TFP level dropped with the decrease in output growth in almost all the thirteen industries following the overall fall indicated in Chapter 4. In nine out of the thirteen industries (food, beverage and tobacco, textiles, leather and footwear, wood, paper and furniture, printing and publishing, rubber and plastic products, non-metallic products, metallic products, and transport equipment and vehicles), average TFP growth declined to negative rates. TFP growth was significantly higher in the late 1980s in these thirteen industries.

The TFP level index for all industries, except beverage and tobacco, wood, paper and furniture, and non-metallic products, dropped in 1974. The TFP level index of the printing and publishing and petroleum refineries and miscellaneous petrochemical products industries dropped sharply after 1979.

Increases in petroleum prices were a factor in both years. It is not possible to analyze the precise impact of petroleum price increases in the short term. In 1973 - 74, the growth of value-added in petroleum refineries and miscellaneous petrochemical products industry dropped from 7.6 per cent in 1973 to -1.8 per cent in 1974. In the following year, value added growth recovered to 8.2 per cent. After the second petroleum price increase in 1978 - 79, the value-added of the petroleum refineries and miscellaneous petrochemical products industry again slumped. The growth of value-added declined in 1980 (-11.1 per cent) and growth levels were still low at about 4 - 6 per cent from 1981 to 1983, compared with 8 to 9 per cent and more in the previous years. In 1986, the output growth rate of this industry seemed to recover. The TFP level also showed a sharp reduction after the second petroleum price increase.

When the price of petroleum products increased, the domestic demand for fuel declined. The cost of importing fuel increased substantially and the government encouraged the population to reduce consumption. There were strict controls on the use

of petroleum and electricity in every government office. On the supply side, the government regulated ceiling retail prices to discourage the domestic supply of petroleum products. Net fuel import costs increased initially which 35 to 60 per cent, but then dropped as a result of fuel saving. Then petroleum prices dropped in the early 1980s. Between 1980 and 1985, value-added (at constant prices) in the petroleum refineries and miscellaneous petrochemical products industry dropped in some years between 1980 and 1985.

When the price of petroleum products increased, the petroleum refineries and miscellaneous petrochemical products industries could not adjust their output and production techniques fast enough to handle the change. The industry had large scale production with many fixed factors compared with other industries. The reduction in output, as a result of demand and supply factors, combined with the difficulty of reducing inputs caused a sharp reduction in TFP growth.

Petroleum price increases also changed the techniques of production of other industries, making production energy saving. This is why the TFP level in many industries improved.

Appendix CH 5

Table A5.1
Results of stationarity test (ADF) of variables

(lny-lnL)

	lags	Without trend		lags	With trend	
		Estimated value	Critical value		Estimated value	Critical value
FD	0	-.0351	-3.0294	0	-2.2432	-3.6746
BVT	0	-0.9716	-3.0924	0	-1.8639	-3.6746
TXLF	0	-1.1091	-3.0924	0	-2.9144	-3.6746
WD	0	-1.3568	-3.0924	0	-1.6918	-3.6746
PP	0	-2.1063	-3.0924	0	-1.6400	-3.6746
CHM	0	-0.3121	-3.0924	0	-1.5954	-3.6746
PETR	1	-2.3964	-3.0924	1	-2.6718	-3.6746
RUBP	0	-0.4501	-3.0924	0	-2.1927	-3.6746
NMET	0	-0.8482	-3.0924	0	-1.3385	-3.6746
MET	0	-0.2475	-3.0924	0	-1.9293	-3.6746
MACH	0	0.2539	-3.0924	0	-2.5994	-3.6746
ELCM	1	-1.1274	-3.0924	0	-2.7622	-3.6746
VEC	0	-1.2635	-3.0924	0	-2.7622	-3.6746

(lnK-lnL)

	lags	Without trend		lags	With trend	
		Estimated value	Critical value		Estimated value	Critical value
FD	0	-0.4368	-3.0924	0	-1.9275	-3.6746
BVT	0	-2.2160	-3.0924	0	-1.6683	-3.6746
TXLF	0	-2.8195	-3.0924	0	-2.9377	-3.6746
WD	0	-1.5344	-3.0924	0	-0.5736	-3.6746
PP	0	-2.0174	-3.0924	0	-1.6018	-3.6746
CHM	0	-5.7947	-3.0924	0	-5.2892	-3.6746
PETR	0	1.0342	-3.0924	0	-0.9521	-3.6746
RUBP	0	-0.6534	-3.0924	0	-1.5308	-3.6746
NMET	1	-2.0003	-3.0924	1	-2.0197	-3.6746
MET	2	-0.9085	-3.0924	1	-2.4810	-3.6746
MACH	0	-0.5575	-3.0924	0	-2.3515	-3.6746
ELCM	0	-2.6985	-3.0924	0	-3.2168	-3.6746
VEC	0	-0.9588	-3.0924	0	-1.2301	-3.6746

Note The null hypothesis cannot be rejected when the absolute term of estimated values are less than critical value.
Lags = the maximun order of lags of the (augmented) difference terms of ADF being added until we can reject hypothesis.

Source Author's calculations

Table A5.2

Results of cointegration test (unit root of residual), CRS-CD

	Without time trend		With time trend	
	Estimated value	Critical value	Estimated value	Critical value
FD	-1.2018	-3.6765	-1.7145	-4.3185
BVT	-2.7338	-3.6765	-2.7585	-4.3185
TXLF	-0.4828	-3.6765	-1.9658	-4.3185
WD	-1.9656	-3.6765	-1.9229	-4.3185
PP	-1.8619	-3.6765	-2.6498	-4.3185
CHM	-0.8649	-3.6765	-1.6904	-4.3185
PETR	-2.4054	-3.6765	-3.3534	-4.3185
RUBP	-2.1168	-3.6765	-2.1994	-4.3185
NMET	-0.5177	-3.6765	-2.4943	-4.3185
MET	-1.7008	-3.6765	-1.6529	-4.3185
MACH	-1.5904	-3.6765	-2.1879	-4.3185
ELCM	-1.1538	-3.6765	-2.6836	-4.3185
VEC	-1.7207	-3.6765	-2.1563	-4.3185

Remark 95 per cent critical values

Source Author's calculations

Table A5.3
Results of CRS-T production function estimation using diffence equations

	β_0	β_k	β_{kL}	Adj R^2	F-test of restriction
FD	0.0175	-1.0379	0.8460	0.5962	0.7115
t-ratio	1.2783	-0.4036	0.8436		
BVT	0.0254	3.8506	-1.0023	0.0926	1.4986
t-ratio	0.9028	1.2587	-1.2242		
TXLF	0.0188	-2.4678	1.7246	0.7008	0.7081
t-ratio	1.5316	-0.6102	0.8414		
WD	-0.0069	-1.3143	0.4839	0.5159	2.4652
t-ratio	-0.3747	-1.1318	1.5701**		
PP	-0.0058	0.1285	0.7493	0.8078	2.0780
t-ratio	-0.3510	0.1976	1.4416**		
CHM	0.0587	-0.2918	0.1442	0.0995	0.0624
t-ratio	2.8466*	-0.1243	0.2498		
PETR	-0.0064	0.8116	1.3412	0.5025	7.2500*
t-ratio	-0.2237	4.2252*	2.6927*		
RUBP	-0.0039	-0.3925	0.5492	0.3984	0.2233
t-ratio	0.1410	-0.2695	1.0038		
NMET	0.0398	-1.0042	1.3514	0.4952	-0.1900
t-ratio	2.0642*	-0.4376	0.7787		
MET	0.0073	0.7673	0.2547	0.8216	9.5614*
t-ratio	0.6177	8.6757*	3.1039*		
MACH	0.0167	0.5959	0.0916	0.4361	0.0366
t-ratio	0.6559	0.8903	0.1795		
ELCM	0.0293	3.7157	-1.0524	0.6266	2.0465
t-ratio	1.1828	1.7095**	-1.4306**		
VEC	0.0394	-0.9777	0.7331	0.0362	0.3285
t-ratio	0.7513	-0.4787	0.5732		

Remark F-test of restriction is tested whether the restriction (CRS-CD) is accepted; i.e., $\beta_{kL} = 0$. Here it gives the same result as t-ratio of β_{kL}

Note β_K and β_L in CRS-T here is not the same as β_K and β_L in CRS-CD (discussed in Chapter 4)

* means 5 per cent satistically significant (one tailed test), ** means 10 per cent statistically significant (one tailed test)

Source Author's calculations

Table A5.4

Estimation results of CRS-CD by level data (long-run relaionship of non-stationary variables)

	β_0	β_k	β_L	Adj R^2	DW statistics
FD	-0.6232	1.2950	-0.2950	0.9545	0.6204
t-ratio	-3.7953*	19.9988*	4.5558*		
BVT	0.3702	0.6560	0.3440	0.8441	1.0347
t-ratio	1.5807**	10.1921*	5.3450*		
TXLF	-1.7001	0.8279	0.1721	0.3144	0.2661
t-ratio	-3.2796*	3.1166*	0.6478		
WD	-1.9669	0.3881	0.6119	0.6728	0.6171
t-ratio	-8.9416*	6.3294*	9.9785*		
PP	-1.6037	1.0005	-0.0005	0.8610	0.6893
t-ratio	-14.1739*	10.8937*	-0.0054		
CHM	2.5594	1.4927	-0.4927	0.4600	0.3157
t-ratio	1.8663*	4.1452*	-1.3682		
PETR	0.2878	0.0275	0.9725	0.0033	0.8426
t-ratio	7.4227*	0.2457	8.6761*		
RUBP	-1.0296	0.9767	0.0233	0.9578	0.9054
t-ratio	-8.2850*	20.7803*	0.4942		
NMET	-0.7100	0.9046	0.0392	0.2440	0.2344
t-ratio	-1.6266**	2.6708*	0.1157		
MET	-0.4671	1.0246	-0.0246	0.8631	0.6473
t-ratio	-1.7758*	10.9892*	-0.2638		
MACH	-2.1695	0.8056	0.1944	0.9275	0.7993
t-ratio	-34.9414*	15.6179*	3.7685*		
ELCM	-3.3263	0.0356	0.9644	0.0008	0.7993
t-ratio	-3.8674*	0.1207	3.2725*		
VEC	-1.9030	0.3728	0.6272	0.1858	0.8543
t-ratio	-7.5574*	2.3098*	3.8862*		

Note * means 5 per cent satistically significant (one tailed test), ** means 10 per cent statistically significant (one tailed test)

Source Author's calculations

Table A5.5

Estimation results of NCRS-CD by level data

	β_0	β_k	β_L	Adj R^2	DW statistics
FD	-1.7349	1.2571	-0.1790	0.9780	0.6547
t-ratio	-1.1801	15.2836*	-1.0794		
BVT	2.2353	0.7300	0.1268	0.9454	1.0682
t-ratio	0.6719	4.9613*	0.3235		
TXLF	-3.7895	0.9754	0.2086	0.9872	0.8547
t-ratio	-8.1753*	6.1958*	1.3408		
WD	0.2039	0.4094	0.4063	0.8785	0.5780
t-ratio	0.1665	6.9366*	3.1738*		
PP	-0.3347	1.0816	-0.2031	0.9800	1.0077
t-ratio	-0.7630	13.2730*	-1.9756*		0.2314
CHM	-4.9735	1.1978	0.3922	0.6747	
t-ratio	-0.7625	2.7531*	0.4726		
PETR	2.9644	0.2041	0.4536	0.7575	0.7515
t-ratio	3.0975*	1.7843*	2.1752*		
RUBP	-1.5887	0.9788	0.0722	0.9597	0.9357
t-ratio	-0.7535	20.1708	0.3588		
NMET	-4.6447	1.4650	0.0190	0.9621	1.2641
t-ratio	-7.8297*	7.6845*	0.1091		
MET	-1.5132	1.0198	0.0736	0.9188	0.6006
t-ratio	-1.1271	10.8031*	0.4736		
MACH	-3.6440	0.7372	0.3937	0.9738	0.8434
t-ratio	-2.1185*	7.7441*	1.6531**		
ELCM	-6.6802	0.4220	0.9955	0.9171	0.7162
t-ratio	-6.4950*	1.8009*	4.6343*		
VEC	-3.1471	0.3839	0.7336	0.7370	0.8927
t-ratio	-1.9000*	2.3411*	3.4112*		

Note * means 5 per cent satistically significant (one tailed test), ** means 10 per cent statistically significant (one tailed test)

Source Author's calculations

Table A5.6
Estimation results of NCRS-T by level data

$$\ln y = \beta_0 + \beta_k \ln K + \beta_L \ln L + \beta_{kL} \ln K \ln L + (1/2)\,\beta_{kk}(\ln K)^2 + (1/2)\,\beta_{LL}(\ln L)^2$$

	β_0	β_k	β_L	β_{kL}	β_{kk}	β_{LL}
FD	82.3421	5.9478	-16.9406	-0.4414	0.1009	1.6479
t-ratio	0.4523	0.3687	-0.4354	-0.2480	0.1007	0.3910
Adj R^2 = 0.9737, DW statistics = 0.7365						
BVT	472.6838	51.4352	-118.9125	-6.0532	2.2000	14.8146
t-ratio	1.1935	1.3650**	-1.2504	-1.2851	1.0816	1.2812
Adj R^2 = 0.9473, DW statistics = 1.5841						
TXLF	3.9671	-8.7979	7.2902	4.5125	-4.4332	-4.3716
t-ratio	0.3791	-1.0822	0.9309	1.4091**	-1.3662**	-1.3617**
Adj R^2 = 0.9885, DW statistics = 1.1109						
WD	147.3033	-1.4098	24.2107	0.7155	-0.816	1.6696
t-ratio	2.2705*	-0.4379	-1.8423*	2.2152*	-2.9582*	1.2812
Adj R^2 = 0.9441, DW statistics = 1.7524						
PP	-16.7229	3.7838	0.8332	0.7246	-1.1664	-0.7263
t-ratio	-1.3038	1.1252	0.1606	1.0894	-2.2672*	-0.6910
Adj R^2 = 0.9878, DW statistics = 1.4195						
CHM	557.8692	-18.2850	-90.9629	-0.3950	3.5880	8.6032
t-ratio	0.9824	-0.2849	-0.6537	-0.0464	0.8467	0.4816
Adj R^2 = 0.7866, DW statistics = 0.9789						
PETR	-75.2098	-2.8556	23.7596	0.6430	-0.2393	-3.6640
t-ratio	-4.9466*	-0.5048	3.1690*	0.5106	-0.3932	-1.7674*
Adj R^2 = 0.9043, DW statistics = 1.6465						
RUBP	-43.2954	-3.3248	10.9502	0.5570	-0.2155	-1.4160
t-ratio	-0.1760	-0.5302	0.2449	0.6796	-0.5055	-0.3469
Adj R^2 = 0.9529, DW statistics = 0.9300						
NMET	-0.7313	2.0899	-1.3451	0.8126	-1.0160	-0.5490
t-ratio	-0.0277	0.3133	-0.1559	0.1937	-0.1988	-0.1623
Adj R^2 = 0.9542, DW statistics = 1.1999						
MET	6.6188	-13.1649	9.0941	0.1614	1.4866	-0.9196
t-ratio	0.0531	-0.8575	0.2931	0.1027	1.7535**	-0.2464
Adj R^2 = 0.9291, DW statistics = 0.7526						
MACH	172.4833	9.5205	-40.3778	-1.5221	0.7940	5.1614
t-ratio	1.8017*	0.9464	-1.5327**	-1.0153	1.2246	1.3788**
Adj R^2 = 0.9847, DW statistics = 1.4333						
ELCM	45.8617	2.0560	-10.1554	-0.9443	1.1010	1.7330
t-ratio	1.9343*	0.4088	-1.6442**	-0.5121	0.5285	1.0640
Adj R^2 = 0.9334, DW statistics = 0.8775						
VEC	-3.0592	-0.9407	1.7913	2.5624	-2.8350	-2.2944
t-ratio	-0.0429	-0.0719	0.0991	1.6550**	-1.9008*	-0.8061
Adj R^2 = 0.7839, DW statistics = 1.4882						

Remark * means statistically significant at 5 per cent (one tailed test) ** means statistically significant at 10 per cent (one tailed test)

Note β_k and β_L in CRS-T here is not the same as β_k and β_L in CRS-CD (discussed in Chapter 4)

Source Author's calculations

Table A5.7
TFP growth in thirteen industries, 1971 - 89

average per cent of output growth per annum

Food

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	8.84	9.49	-1.12	0.47
1976 - 80	7.21	5.57	-0.02	1.66
1971 - 80	**8.03**	**7.53**	**-0.57**	**1.06**
1981 - 85	7.55	9.67	-0.26	-1.87
1986 - 89	9.26	1.85	-0.14	7.56
1981 - 89	**8.31**	**6.19**	**-0.21**	**2.32**
1971 - 89	**8.16**	**6.90**	**-0.40**	**1.66**

Beverage and tobacco

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	5.80	1.16	1.80	2.83
1976 - 80	9.09	1.57	4.51	3.01
1971 - 80	**7.44**	**1.37**	**3.16**	**2.92**
1981 - 85	3.51	0.93	2.72	-0.15
1986 - 89	8.25	0.93	3.41	3.90
1981 - 89	**5.61**	**0.93**	**3.03**	**1.65**
1971 - 89	**6.58**	**1.16**	**3.10**	**2.32**

Textiles, leather and footwear

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	13.91	11.98	1.09	0.84
1976 - 80	9.38	6.60	0.56	2.22
1971 - 80	**11.64**	**9.29**	**0.83**	**1.53**
1981 - 85	5.46	6.02	0.30	-0.86
1986 - 89	14.04	6.52	0.52	7.00
1981 - 89	**9.27**	**6.24**	**0.40**	**2.63**
1971 - 89	**10.52**	**7.85**	**0.62**	**2.05**

Wood, paper and furniture

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	4.55	6.80	4.48	-6.72
1976 - 80	7.66	7.80	-0.69	4.12
1971 - 80	**6.10**	**7.30**	**1.89**	**-1.30**
1981 - 85	1.08	4.32	1.11	-4.35
1986 - 89	7.24	-2.14	3.34	6.03
1981 - 89	**3.82**	**1.45**	**2.10**	**0.26**
1971 - 89	**5.02**	**4.53**	**1.99**	**-0.56**

Printing and publishing

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	11.89	11.24	-0.41	1.06
1976 - 80	10.22	12.18	-0.13	-1.83
1971 - 80	**11.06**	**11.71**	**-0.27**	**-0.39**
1981 - 85	7.02	9.16	-0.65	-1.49
1986 - 89	3.65	2.56	-0.11	1.20
1981 - 89	**5.52**	**6.22**	**-0.41**	**-0.29**
1971 - 89	**8.43**	**9.11**	**-0.34**	**-0.34**

Industrial chemicals and other chemicals

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	8.90	5.90	4.06	-1.07
1976 - 80	13.29	0.71	2.11	10.47
1971 - 80	**11.09**	**3.31**	**3.08**	**4.70**
1981 - 85	6.75	1.04	-1.31	7.02
1986 - 89	9.95	-0.36	2.76	7.54
1981 - 89	**8.17**	**0.42**	**0.50**	**7.25**
1971 - 89	**9.71**	**1.94**	**1.86**	**5.91**

Petroleum refineires and miscellaneous petrochemical products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	15.63	5.39	3.56	6.67
1976 - 80	1.81	6.22	3.44	-7.85
1971 - 80	**8.72**	**5.80**	**3.50**	**-0.59**
1981 - 85	2.98	4.78	-0.86	-0.94
1986 - 89	7.38	15.40	1.99	-10.01
1981 - 89	**4.94**	**9.50**	**0.41**	**-4.97**
1971 - 89	**6.93**	**7.56**	**2.04**	**-2.66**

Rubber and plastic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	10.24	10.88	-0.30	-0.34
1976 - 80	10.25	8.41	0.20	1.63
1971 - 80	**10.25**	**9.64**	**-0.05**	**0.65**
1981 - 85	2.14	8.22	-0.11	-5.98
1986 - 89	15.08	7.08	-0.11	8.14
1981 - 89	**7.89**	**7.72**	**-0.11**	**0.30**
1971 - 89	**9.13**	**8.73**	**-0.08**	**0.48**

Non-metallic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	8.76	3.95	1.00	3.80
1976 - 80	8.33	5.52	0.93	1.88
1971 - 80	**8.55**	**4.74**	**0.96**	**2.84**
1981 - 85	6.82	5.53	1.71	-0.42
1986 - 89	15.46	2.62	0.66	12.18
1981 - 89	**10.66**	**4.24**	**1.24**	**5.18**
1971 - 89	**9.55**	**4.50**	**1.10**	**3.95**

Metallic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	1.62	3.73	0.69	-2.80
1976 - 80	8.35	3.23	1.78	3.34
1971 - 80	**4.98**	**3.48**	**1.23**	**0.27**
1981 - 85	4.04	4.03	-0.12	0.13
1986 - 89	9.19	4.83	0.33	4.03
1981 - 89	**6.33**	**4.39**	**0.08**	**1.86**
1971 - 89	**5.62**	**3.91**	**0.69**	**1.02**

Machinery

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	9.51	8.76	0.81	-0.07
1976 - 80	11.15	10.88	2.00	-1.73
1971 - 80	**10.33**	**9.82**	**1.41**	**-0.90**
1981 - 85	6.40	4.84	1.42	0.15
1986 - 89	17.83	7.58	0.68	9.57
1981 - 89	**11.48**	**6.06**	**1.09**	**4.33**
1971 - 89	**10.87**	**8.04**	**1.26**	**1.58**

Electrical machinery and supplies

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	10.02	9.52	2.48	-3.57
1976 - 80	17.46	4.94	5.29	7.23
1971 - 80	**13.74**	**7.23**	**3.88**	**1.83**
1981 - 85	4.79	-2.08	1.96	4.90
1986 - 89	16.84	12.09	2.04	2.70
1981 - 89	**10.14**	**4.22**	**2.00**	**3.93**
1971 - 89	**12.04**	**5.81**	**2.99**	**2.82**

Transport equipment and vehicle

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	11.97	2.34	15.84	-6.22
1976 - 80	14.01	1.47	2.40	10.13
1971 - 80	**12.99**	**1.91**	**9.12**	**1.96**
1981 - 85	-9.30	1.51	-2.54	-8.27
1986 - 89	27.99	-0.74	4.72	24.01
1981 - 89	**7.27**	**0.51**	**0.69**	**6.08**
1971 - 89	**10.28**	**1.24**	**5.13**	**3.91**

Source Author's calculations

Table A5.8

Share of contribution to output growth, 1971 - 89

Food

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	107.40	-12.70	5.29
1976 - 80	100.00	77.26	-0.33	23.05
1971 - 80	**100.00**	**93.87**	**-7.14**	**13.27**
1981 - 85	100.00	128.10	-3.41	-24.73
1986 - 89	100.00	19.95	-1.53	81.58
1981 - 89	**100.00**	**74.51**	**-2.48**	**27.95**
1971 - 89	**100.00**	**84.53**	**-4.89**	**20.35**

Beverage and tobacco

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	20.02	31.12	48.86
1976 - 80	100.00	17.31	49.60	33.07
1971 - 80	**100.00**	**18.36**	**42.41**	**39.22**
1981 - 85	100.00	26.60	77.64	-4.24
1986 - 89	100.00	11.31	41.37	47.33
1981 - 89	**100.00**	**16.61**	**53.95**	**29.43**
1971 - 89	**100.00**	**17.66**	**47.08**	**35.26**

Textile, leather and footwear

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	86.12	7.85	6.04
1976 - 80	100.00	70.40	5.98	23.61
1971 - 80	**100.00**	**79.79**	**7.10**	**13.12**
1981 - 85	100.00	110.29	5.47	-15.74
1986 - 89	100.00	46.43	3.69	49.87
1981 - 89	**100.00**	**67.31**	**4.27**	**28.42**
1971 - 89	**100.00**	**74.58**	**5.92**	**19.51**

Wood, paper and furniture

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	149.36	98.40	-147.76
1976 - 80	100.00	101.86	-9.05	53.83
1971 - 80	**100.00**	**119.56**	**31.00**	**-21.31**
1981 - 85	100.00	400.37	102.85	-403.18
1986 - 89	100.00	-29.51	46.16	83.35
1981 - 89	**100.00**	**38.03**	**55.07**	**6.91**
1971 - 89	**100.00**	**90.20**	**39.67**	**-11.15**

Printing and publishing

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	94.57	-3.46	8.88
1976 - 80	100.00	119.13	-1.23	-17.91
1971 - 80	**100.00**	**105.92**	**-2.43**	**-3.51**
1981 - 85	100.00	130.47	-9.29	-21.18
1986 - 89	100.00	70.00	-2.89	32.92
1981 - 89	**100.00**	**112.69**	**-7.41**	**-5.27**
1971 - 89	**100.00**	**108.02**	**-3.97**	**-4.05**

Industrial chemicals and other chemicals

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	66.35	45.64	-12.00
1976 - 80	100.00	5.33	15.86	78.84
1971 - 80	**100.00**	**29.80**	**27.81**	**42.40**
1981 - 85	100.00	15.44	-19.39	103.99
1986 - 89	100.00	-3.57	27.78	75.80
1981 - 89	**100.00**	**5.15**	**6.14**	**88.74**
1971 - 89	**100.00**	**19.98**	**19.17**	**60.87**

Petroleum refineires and miscellaneous petrochemical products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	34.50	22.80	42.71
1976 - 80	100.00	343.87	190.48	-434.36
1971 - 80	**100.00**	**66.58**	**40.19**	**-6.76**
1981 - 85	100.00	160.43	-28.87	-31.56
1986 - 89	100.00	208.54	26.97	-135.50
1981 - 89	**100.00**	**192.41**	**8.25**	**-100.65**
1971 - 89	**100.00**	**109.06**	**29.40**	**-38.46**

Rubber and plastic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	106.21	-2.93	-3.29
1976 - 80	100.00	82.06	1.97	15.95
1971 - 80	**100.00**	**94.13**	**-0.48**	**6.33**
1981 - 85	100.00	384.69	-5.05	-279.59
1986 - 89	100.00	46.94	-0.76	53.97
1981 - 89	**100.00**	**97.77**	**-1.40**	**3.76**
1971 - 89	**100.00**	**95.62**	**-0.86**	**5.28**

Non-metallic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	45.15	11.39	43.44
1976 - 80	100.00	66.24	11.15	22.60
1971 - 80	**100.00**	**55.43**	**11.27**	**33.28**
1981 - 85	100.00	81.09	25.03	-6.09
1986 - 89	100.00	16.95	4.28	78.78
1981 - 89	**100.00**	**39.75**	**11.65**	**48.61**
1971 - 89	**100.00**	**47.14**	**11.47**	**41.39**

Metallic products

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	230.90	42.49	-173.21
1976 - 80	100.00	38.69	21.30	39.98
1971 - 80	**100.00**	**69.85**	**24.74**	**5.42**
1981 - 85	100.00	99.83	-2.92	3.13
1986 - 89	100.00	52.58	3.61	43.81
1981 - 89	**100.00**	**69.33**	**1.29**	**29.39**
1971 - 89	**100.00**	**69.57**	**12.24**	**18.20**

Machinery

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	92.16	8.52	-0.70
1976 - 80	100.00	97.61	17.96	-15.56
1971 - 80	**100.00**	**95.10**	**13.61**	**-8.72**
1981 - 85	100.00	75.58	22.13	2.29
1986 - 89	100.00	42.53	3.82	53.65
1981 - 89	**100.00**	**52.77**	**9.49**	**37.75**
1971 - 89	**100.00**	**73.93**	**11.55**	**14.52**

Electrical machinery and supplies

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	95.01	24.75	-35.60
1976 - 80	100.00	28.30	30.28	41.41
1971 - 80	**100.00**	**52.63**	**28.26**	**13.33**
1981 - 85	100.00	-43.39	40.96	102.43
1986 - 89	100.00	71.81	12.13	16.06
1981 - 89	**100.00**	**41.61**	**19.69**	**38.71**
1971 - 89	**100.00**	**48.23**	**24.84**	**23.46**

Transport equipment and vehicle

	Output growth	Capital growth	Labour growth	TFP growth
1971 - 75	100.00	19.56	132.36	-51.92
1976 - 80	100.00	10.51	17.16	72.34
1971 - 80	**100.00**	**14.68**	**70.24**	**15.07**
1981 - 85	100.00	-16.22	27.32	88.92
1986 - 89	100.00	-2.65	16.86	85.79
1981 - 89	**100.00**	**6.99**	**9.43**	**83.57**
1971 - 89	**100.00**	**12.10**	**49.86**	**38.03**

Source Author's calculations

Table A5.9
TFP level index, 1970 - 89

point of output given in 1970 = 100

Food

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	111.75	11.75	5.57	-0.67	6.85	106.85
1972	113.55	1.80	1.20	1.33	-0.73	106.12
1973	124.11	10.56	9.96	-1.95	2.54	108.66
1974	136.62	12.51	25.44	-3.68	-9.25	99.41
1975	152.28	15.66	15.79	-1.99	1.86	101.27
1976	177.97	25.69	14.44	-0.59	11.84	113.11
1977	198.09	20.13	10.97	0.16	9.00	122.11
1978	207.26	9.17	6.98	1.56	0.63	122.74
1979	223.04	15.77	22.25	-0.67	-5.82	116.92
1980	213.29	-9.75	-4.57	-0.64	-4.54	112.38
1981	241.19	27.90	22.08	-0.09	5.91	118.29
1982	271.22	30.03	33.65	-0.19	-3.45	114.85
1983	261.72	-9.49	5.07	-0.13	-14.42	100.42
1984	294.34	32.61	31.20	-1.27	2.67	103.09
1985	303.87	9.54	30.15	-1.86	-18.76	84.33
1986	329.82	25.95	-5.50	2.53	28.92	113.26
1987	340.49	10.67	-10.18	2.18	18.67	131.93
1988	384.78	44.29	17.13	-0.96	28.13	160.05
1989	432.01	47.23	27.93	-6.83	26.14	186.19
1971 - 80	**165.80**	**11.33**	**10.80**	**-0.71**	**1.24**	**110.96**
1981 - 89	**317.72**	**24.30**	**16.84**	**-0.74**	**8.20**	**123.60**
1971 - 89	**237.76**	**17.47**	**13.66**	**-0.72**	**4.54**	**116.95**

Beverage and tobacco

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	87.41	-12.59	2.54	3.79	-18.91	81.09
1972	95.85	8.44	1.36	3.78	3.29	84.38
1973	112.69	16.84	1.34	-0.19	15.68	100.06
1974	130.08	17.40	0.78	8.85	7.77	107.83
1975	128.68	-1.40	-0.51	-8.78	7.88	115.71
1976	148.04	19.37	3.34	10.55	5.48	121.19
1977	163.75	15.71	2.90	13.52	-0.72	120.47
1978	177.07	13.31	2.75	7.99	2.57	123.04
1979	205.17	28.10	1.83	1.24	25.03	148.07
1980	196.53	-8.64	1.23	-0.74	-9.13	138.94
1981	204.82	8.29	1.39	-15.82	22.71	161.65
1982	199.64	-5.18	1.12	-3.81	-2.48	159.17
1983	223.98	24.34	1.53	11.03	11.78	170.95
1984	241.24	17.27	3.13	21.58	-7.44	163.51
1985	231.45	-9.79	3.01	20.17	-32.97	130.54
1986	232.47	1.02	4.30	-0.02	-3.25	127.28
1987	250.03	17.55	1.17	2.48	13.91	141.19
1988	288.29	38.27	1.18	5.72	31.36	172.55
1989	316.25	27.95	2.59	29.70	-4.34	168.21
1971 - 80	**144.53**	**9.65**	**1.76**	**4.00**	**3.89**	**114.08**
1981 - 89	**243.13**	**13.30**	**2.16**	**7.89**	**3.25**	**155.01**
1971 - 89	**191.23**	**11.38**	**1.95**	**5.84**	**3.59**	**133.47**

Textiles, leather and footwear

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	118.44	18.44	14.20	1.75	2.49	102.49
1972	135.72	17.28	10.30	1.91	5.07	107.56
1973	161.83	26.11	17.71	1.47	6.93	114.50
1974	168.66	6.83	19.27	2.31	-14.74	99.75
1975	190.67	22.01	20.30	-0.70	2.41	102.16
1976	208.25	17.58	3.05	-0.68	15.20	117.37
1977	230.41	22.16	2.92	1.33	17.91	135.28
1978	257.18	26.77	26.18	2.89	-2.31	132.97
1979	276.29	19.11	20.32	1.68	-2.89	130.08
1980	298.37	22.08	29.70	1.70	-9.32	120.76
1981	319.34	20.98	19.98	-1.68	2.67	123.43
1982	331.48	12.14	13.09	0.24	-1.18	122.25
1983	353.39	21.91	19.19	1.55	1.17	123.41
1984	373.68	20.28	18.55	2.44	-0.69	122.72
1985	389.00	15.32	30.85	3.08	-18.59	104.13
1986	439.02	50.02	4.44	2.61	42.97	147.10
1987	507.06	68.04	32.66	2.95	32.43	179.52
1988	586.31	79.24	45.36	0.17	33.71	213.24
1989	657.69	71.38	50.13	4.08	17.17	230.41
1971 - 80	**204.58**	**19.84**	**16.40**	**1.37**	**2.08**	**116.29**
1976-1986	**439.66**	**39.92**	**26.03**	**1.72**	**12.18**	**151.80**
1971-1986	**315.94**	**29.35**	**20.96**	**1.53**	**6.86**	**133.11**

Wood, paper and furniture

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	110.37	10.37	8.27	-1.02	3.11	103.11
1972	113.10	2.73	7.57	2.50	-7.34	95.77
1973	114.17	1.08	5.10	6.20	-10.23	85.54
1974	126.95	12.78	4.95	24.45	-16.63	68.91
1975	124.12	-2.83	12.70	-7.31	-8.21	60.70
1976	143.57	19.45	24.62	4.22	12.77	73.47
1977	158.20	14.63	5.20	2.23	7.20	80.67
1978	167.73	9.54	11.85	-6.54	4.23	84.91
1979	178.57	10.84	4.71	-7.21	13.34	98.24
1980	178.47	-0.11	9.37	0.02	-9.50	88.74
1981	166.76	-11.71	6.15	-6.17	-11.69	77.06
1982	160.70	-6.05	10.38	-8.10	-8.33	68.73
1983	172.31	11.60	10.39	3.19	-1.98	66.75
1984	187.59	15.28	4.11	10.67	0.50	67.24
1985	186.65	-0.94	5.79	10.67	-17.40	49.84
1986	201.06	14.41	-3.38	8.91	8.88	58.72
1987	225.07	24.01	-8.95	4.53	28.43	87.14
1988	241.56	16.49	-8.44	0.52	24.42	111.56
1989	246.31	4.75	3.54	14.76	-13.54	98.02
1971 - 80	**141.52**	**7.85**	**9.43**	**1.75**	**-1.13**	**84.01**
1981 - 89	**198.67**	**7.54**	**2.18**	**4.33**	**1.03**	**76.12**
1971 - 89	**168.59**	**7.70**	**6.00**	**2.98**	**-0.10**	**80.27**

Printing and publishing

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	116.53	16.53	15.81	0.03	0.68	100.68
1972	134.04	17.51	17.88	-0.13	-0.24	100.44
1973	149.55	15.51	10.72	-1.07	5.85	106.29
1974	149.55	0.00	5.50	-1.47	-4.04	102.25
1975	173.93	24.38	17.26	0.42	6.69	108.95
1976	190.63	16.70	7.36	0.43	8.92	117.87
1977	220.58	29.95	14.98	1.10	13.86	131.73
1978	253.13	32.56	36.64	-1.10	-2.99	128.74
1979	261.94	8.81	39.31	-2.45	-28.07	100.68
1980	281.77	19.83	43.67	0.04	-23.87	76.80
1981	300.85	19.08	16.13	1.18	1.77	78.57
1982	330.39	29.54	15.76	0.24	13.53	92.10
1983	375.75	45.36	20.22	-5.00	30.14	122.24
1984	388.57	12.81	66.29	-4.46	-48.99	73.24
1985	393.85	5.28	42.96	-4.11	-33.57	39.68
1986	417.09	23.24	-12.19	0.52	34.92	74.59
1987	413.89	-3.20	22.11	0.36	-25.67	48.93
1988	411.76	-2.13	21.95	1.12	-25.21	23.72
1989	452.93	41.17	11.20	-3.75	33.72	57.44
1971 - 80	**193.17**	**18.18**	**20.91**	**-0.42**	**-2.32**	**107.44**
1981 - 89	**387.23**	**19.02**	**22.72**	**-1.55**	**-2.15**	**67.84**
1971 - 89	**285.09**	**18.58**	**21.77**	**-0.95**	**-2.24**	**88.68**

Industrial chemicals and other chemicals

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	113.55	13.55	10.96	-4.32	6.91	106.91
1972	130.48	16.93	8.01	1.47	7.45	114.37
1973	143.50	13.02	1.74	6.05	5.23	119.60
1974	137.95	-5.55	6.07	8.46	-20.08	99.51
1975	151.63	13.68	8.20	17.66	-12.18	87.34
1976	167.57	15.94	-0.34	5.31	10.97	98.31
1977	193.22	25.65	-1.24	13.52	13.38	111.68
1978	228.62	35.40	9.17	0.32	25.91	137.59
1979	253.41	24.78	4.74	-1.92	21.98	159.57
1980	282.42	29.02	-5.86	-0.92	35.80	195.38
1981	301.40	18.98	7.85	-15.37	26.51	221.89
1982	302.95	1.55	1.74	10.71	-10.90	211.00
1983	323.01	20.06	-0.78	-4.39	25.23	236.22
1984	369.65	46.64	-3.60	-2.85	53.11	289.33
1985	389.80	20.15	11.91	-8.58	16.82	306.15
1986	412.83	23.04	-6.45	5.47	24.04	330.19
1987	467.85	55.02	-6.22	-5.06	66.30	396.49
1988	523.23	55.38	-2.33	7.68	50.03	446.51
1989	568.82	45.59	11.71	48.32	-14.45	432.07
1971 - 80	**180.24**	**18.24**	**4.14**	**4.56**	**9.54**	**123.03**
1981 - 89	**406.62**	**31.82**	**1.54**	**3.99**	**26.30**	**318.87**
1971 - 89	**287.47**	**24.67**	**2.91**	**4.29**	**17.48**	**215.79**

Petroleum refineries and miscellaneous petrochemical products

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	137.71	37.71	5.47	6.34	25.90	125.90
1972	174.20	36.49	9.48	1.35	25.67	151.56
1973	187.43	13.22	10.70	7.30	-4.79	146.78
1974	184.01	-3.41	8.45	16.77	-28.63	118.14
1975	199.03	15.02	7.27	-4.88	12.62	130.77
1976	221.46	22.43	6.60	-3.28	19.11	149.87
1977	241.44	19.98	18.76	-0.07	1.29	151.16
1978	227.94	-13.50	26.23	7.26	-47.00	104.16
1979	240.32	12.38	11.68	27.87	-27.17	76.99
1980	213.67	-26.65	7.94	8.80	-43.40	33.59
1981	223.58	9.91	6.03	-6.08	9.98	43.57
1982	237.17	13.59	5.85	-6.35	14.09	57.65
1983	253.61	16.44	16.93	-2.27	1.78	59.43
1984	235.22	-18.39	14.23	-2.92	-29.71	29.72
1985	245.81	10.59	13.45	8.21	-11.07	18.65
1986	270.78	24.97	21.95	9.94	-6.91	11.74
1987	283.08	12.30	37.87	-6.51	-19.05	-7.32
1988	292.91	9.83	68.09	6.24	-64.50	-71.82
1989	326.20	33.28	42.85	12.08	-21.65	-93.46
1971 - 80	**202.72**	**11.37**	**11.26**	**6.75**	**-6.64**	**118.89**
1981 - 89	**263.15**	**12.50**	**25.25**	**1.37**	**-14.12**	**5.35**
1971 - 89	**231.35**	**11.91**	**17.89**	**4.20**	**-10.18**	**65.11**

Rubber and plastic products

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	108.38	8.38	8.32	-0.38	0.44	100.44
1972	122.27	13.89	12.27	0.05	1.58	102.02
1973	145.80	23.53	15.11	-0.24	8.66	110.67
1974	152.23	6.43	22.00	-1.32	-14.26	96.41
1975	161.91	9.68	11.12	-0.11	-1.34	95.07
1976	179.53	17.62	8.22	0.56	8.83	103.91
1977	209.71	30.18	24.47	0.14	5.56	109.47
1978	222.88	13.17	21.26	0.14	-8.23	101.24
1979	250.29	27.41	13.63	0.54	13.25	114.49
1980	262.73	12.44	17.74	0.70	-6.01	108.47
1981	252.69	-10.04	8.56	0.53	-19.12	89.36
1982	228.76	-23.93	-3.10	0.65	-21.48	67.87
1983	276.96	48.20	24.33	-0.64	24.52	92.39
1984	270.54	-6.43	61.70	-0.91	-67.22	25.17
1985	284.69	14.15	16.71	-1.05	-1.51	23.66
1986	316.88	32.20	-0.54	-0.19	33.18	56.85
1987	369.41	52.53	15.81	0.66	36.06	92.91
1988	440.52	71.11	40.58	0.47	30.06	122.97
1989	498.68	58.16	55.23	-3.18	6.11	129.09
1971 - 80	**181.57**	**16.27**	**15.41**	**0.01**	**0.85**	**104.22**
1981 - 89	**326.57**	**26.22**	**24.37**	**-0.41**	**2.29**	**77.81**
1971 - 89	**250.26**	**20.98**	**19.65**	**-0.19**	**1.53**	**91.71**

Non-metallic products

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	108.32	8.32	3.69	-2.69	7.33	107.33
1972	125.55	17.23	9.69	0.40	7.14	114.47
1973	140.37	14.82	2.36	4.91	7.54	122.01
1974	148.43	8.06	7.41	4.72	-4.07	117.94
1975	151.42	3.00	-0.04	0.06	2.97	120.91
1976	168.11	16.69	9.66	-2.10	9.13	130.04
1977	198.35	30.24	8.33	1.87	20.05	150.09
1978	210.04	11.68	7.55	1.31	2.83	152.91
1979	216.23	6.20	16.96	2.88	-13.64	139.27
1980	224.47	8.24	9.47	6.26	-7.50	131.77
1981	242.83	18.36	1.05	9.71	7.60	139.37
1982	242.83	0.00	0.71	4.35	-5.05	134.32
1983	267.63	24.79	3.95	-0.49	21.33	155.65
1984	312.80	45.18	24.45	-0.53	21.27	176.92
1985	309.14	-3.66	49.16	0.81	-53.62	123.30
1986	327.07	17.93	-21.12	-3.51	42.57	165.87
1987	381.18	54.11	9.48	2.97	41.66	207.53
1988	445.20	64.02	11.97	0.59	51.46	258.99
1989	546.23	101.03	50.20	12.10	38.73	297.72
1971 - 80	**169.13**	**12.45**	**7.51**	**1.76**	**3.18**	**128.67**
1981 - 89	**341.66**	**35.75**	**14.43**	**2.89**	**18.44**	**184.41**
1971 - 89	**250.85**	**23.49**	**10.79**	**2.29**	**10.41**	**155.07**

Metallic products

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	106.16	6.16	5.60	0.56	0.00	100.00
1972	112.06	5.90	0.92	2.00	2.98	102.98
1973	118.81	6.75	6.86	8.41	-8.53	94.45
1974	109.66	-9.15	0.88	2.22	-12.25	82.20
1975	107.51	-2.15	5.84	-9.21	1.22	83.43
1976	123.76	16.24	5.55	2.29	8.41	91.83
1977	133.22	9.47	-6.12	3.24	12.34	104.18
1978	141.87	8.65	4.86	3.15	0.63	104.81
1979	155.69	13.82	8.88	2.46	2.48	107.28
1980	160.00	4.31	9.38	0.08	-5.16	102.13
1981	158.58	-1.42	13.29	-0.70	-14.00	88.12
1982	148.53	-10.05	-5.55	-3.07	-1.43	86.69
1983	153.53	5.01	9.20	-0.19	-4.00	82.69
1984	163.33	9.80	8.18	1.00	0.62	83.31
1985	192.17	28.84	6.24	2.07	20.54	103.85
1986	202.88	10.70	-0.53	-3.22	14.45	118.30
1987	221.78	18.91	10.78	-1.69	9.82	128.12
1988	245.92	24.14	13.29	1.90	8.95	137.08
1989	272.94	27.02	20.41	7.33	-0.72	136.36
1971 - 80	**126.87**	**6.00**	**4.27**	**1.52**	**0.21**	**97.33**
1981 - 89	**195.52**	**12.55**	**8.37**	**0.38**	**3.80**	**107.17**
1971 - 89	**159.39**	**9.10**	**6.21**	**0.98**	**1.91**	**101.99**

Machinery

	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	107.47	7.47	0.19	1.46	5.82	105.82
1972	112.02	4.55	7.12	1.54	-4.12	101.70
1973	116.31	4.29	14.57	4.80	-15.08	86.61
1974	133.50	17.19	12.01	3.77	1.41	88.03
1975	156.50	23.00	18.25	-8.51	13.26	101.29
1976	163.74	7.25	10.09	5.66	-8.51	92.78
1977	191.61	27.87	21.55	3.00	3.32	96.10
1978	214.82	23.20	31.41	3.52	-11.73	84.37
1979	230.93	16.11	16.59	2.90	-3.38	80.99
1980	264.37	33.44	24.67	3.16	5.61	86.60
1981	333.60	69.24	4.50	7.75	56.99	143.60
1982	369.73	36.13	13.91	22.82	-0.61	142.98
1983	412.18	42.45	53.11	1.83	-12.49	130.49
1984	414.51	2.33	36.99	-6.06	-28.61	101.88
1985	343.79	-70.71	-20.83	-7.11	-42.78	59.10
1986	373.56	29.77	13.37	-3.47	19.88	78.99
1987	424.60	51.04	25.09	-0.35	26.30	105.29
1988	486.85	62.25	28.42	-3.35	37.19	142.47
1989	654.06	167.20	63.48	22.47	81.25	223.72
1971 - 80	**169.13**	**16.44**	**15.64**	**2.13**	**-1.34**	**92.43**
1981 - 89	**423.65**	**43.30**	**24.23**	**3.84**	**15.24**	**125.39**
1971 - 89	**289.69**	**29.16**	**19.71**	**2.94**	**6.51**	**108.04**

Electrical machinery and supplies

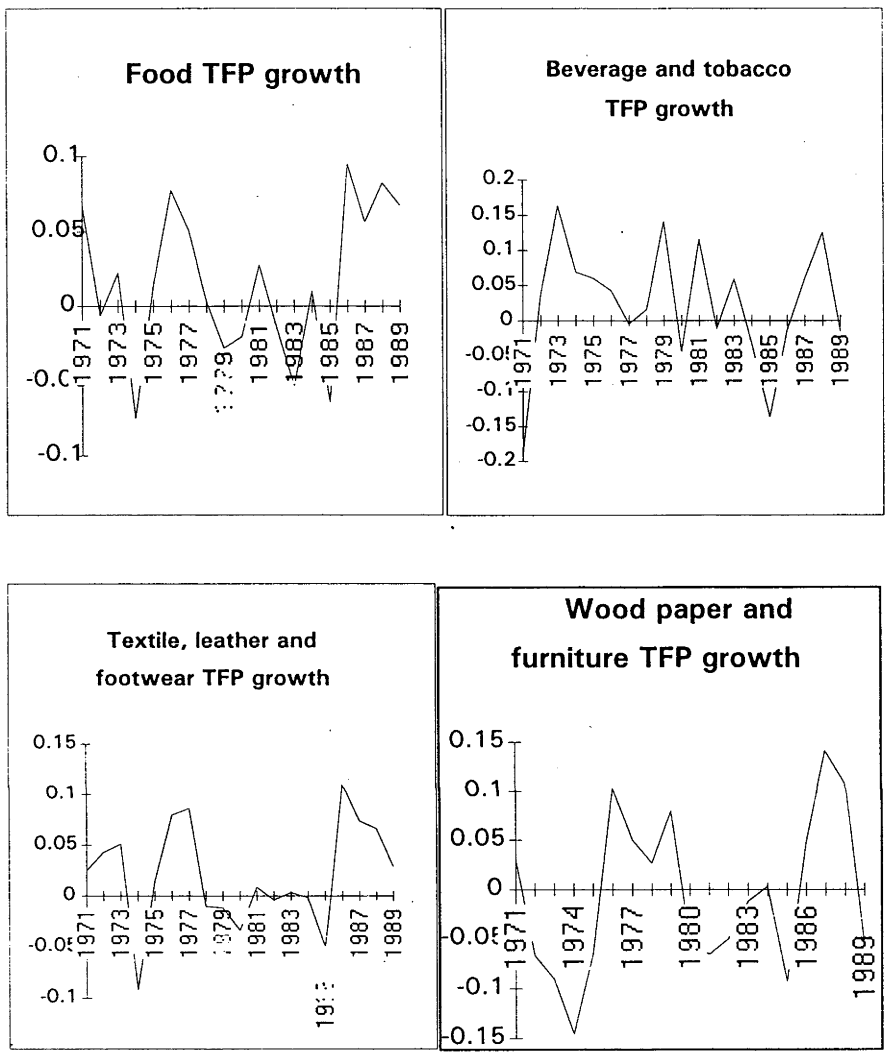
	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	98.11	-1.89	15.18	-8.21	-8.85	91.15
1972	108.74	10.63	9.80	4.85	-4.02	87.12
1973	133.41	24.67	23.99	5.57	-4.88	82.24
1974	138.37	4.96	12.30	19.01	-26.35	55.89
1975	158.81	20.44	-12.21	-5.12	26.78	82.67
1976	183.41	24.60	7.99	31.12	-14.52	68.15
1977	234.52	51.12	17.86	2.02	31.24	99.39
1978	290.01	55.49	18.36	14.91	22.22	121.62
1979	314.72	24.71	-11.40	-4.92	41.02	162.64
1980	351.76	37.04	19.01	3.40	14.61	177.25
1981	349.72	-2.04	-14.38	-16.65	28.98	206.24
1982	355.42	5.70	-15.80	-6.64	28.13	234.36
1983	433.79	78.37	55.07	17.44	5.87	240.24
1984	487.23	53.44	8.44	21.28	23.72	263.95
1985	431.25	-55.98	-93.64	32.26	5.40	269.36
1986	498.40	67.15	0.91	-1.58	67.84	337.20
1987	587.73	89.34	65.78	14.95	8.60	345.80
1988	686.53	98.80	162.91	18.21	-82.32	263.48
1989	803.52	116.98	49.67	16.74	50.58	314.06
1971 - 80	**201.18**	**25.18**	**10.09**	**6.26**	**7.73**	**102.81**
1981 - 89	**357.29**	**30.87**	**-0.69**	**8.42**	**23.14**	**198.22**
1971 - 89	**285.48**	**24.90**	**2.59**	**6.80**	**14.82**	**161.22**

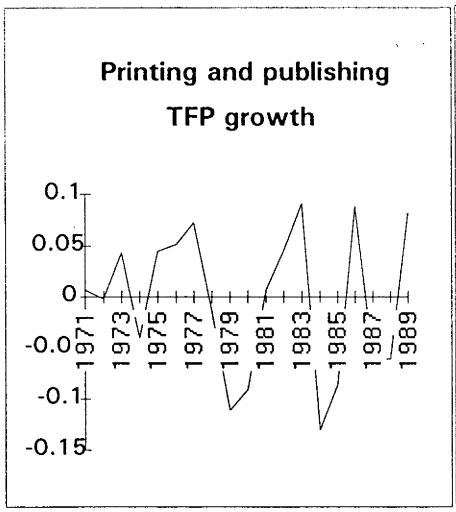
Transport equipment and vehicle

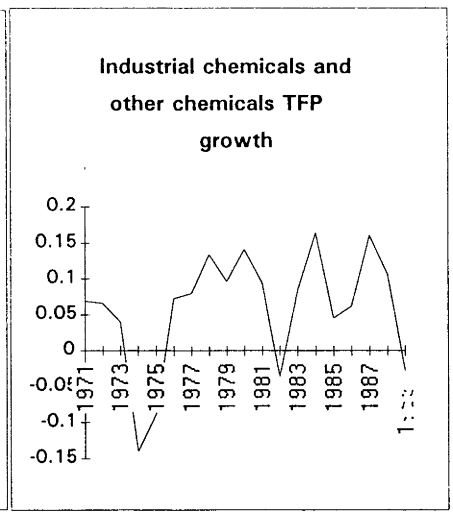
	Output	Output growth	Output increases due to			TFP indices
			Capital growth	Labour growth	TFP	
1970	100.00	0.00	0.00	0.00	0.00	100.00
1971	120.57	20.57	2.85	4.89	12.83	112.83
1972	155.44	34.87	2.87	11.06	20.94	133.77
1973	200.11	44.67	2.35	55.25	-12.94	120.83
1974	201.30	1.19	2.95	52.44	-54.20	66.63
1975	163.12	-38.19	7.03	6.87	-52.07	14.56
1976	214.87	51.76	1.09	15.03	35.64	50.20
1977	289.99	75.12	2.72	5.32	67.07	117.28
1978	303.51	13.51	7.61	7.19	-1.29	115.99
1979	286.99	-16.51	2.93	7.48	-26.90	89.08
1980	298.82	11.82	5.28	-13.26	19.80	108.88
1981	281.22	-17.60	3.57	-33.62	12.45	121.33
1982	245.34	-35.88	6.15	-33.60	-8.45	112.89
1983	278.41	33.07	5.57	-0.12	27.61	140.50
1984	275.84	-2.56	2.28	3.81	-8.66	131.84
1985	164.43	-111.41	2.95	25.32	-139.68	-7.84
1986	212.34	47.91	-1.06	0.88	48.09	40.25
1987	260.12	47.77	-3.35	10.37	40.75	81.00
1988	370.22	110.10	-3.38	26.46	87.02	168.02
1989	436.77	66.55	2.05	12.14	52.36	220.39
1971 - 80	**223.47**	**19.88**	**3.77**	**15.23**	**0.89**	**93.01**
1981 - 89	**280.52**	**15.33**	**1.64**	**1.29**	**12.39**	**112.04**
1971 - 89	**250.49**	**17.72**	**2.76**	**8.63**	**6.34**	**102.02**

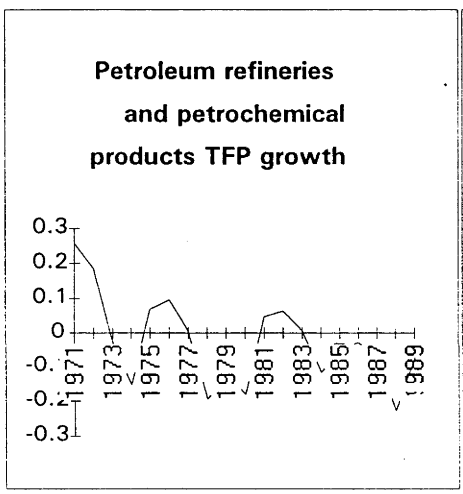
Source Author's calculations

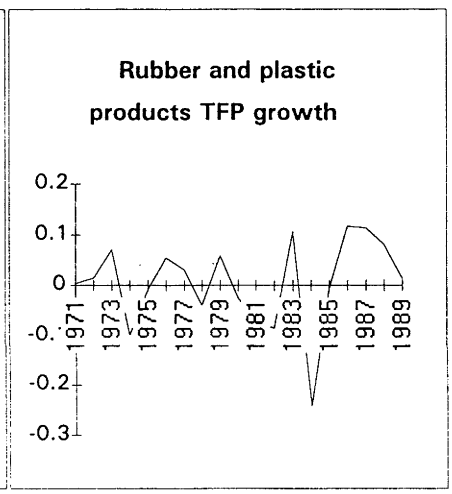
Figure A5.1
TFP growth of thirteen industries

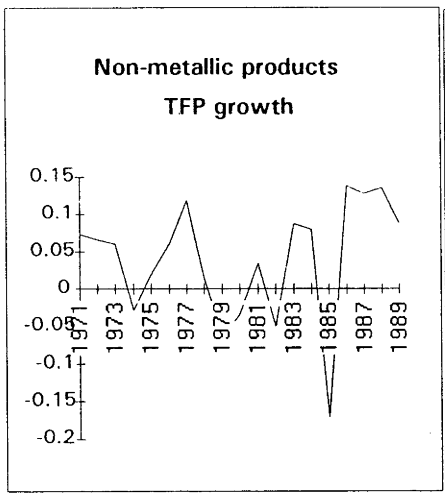


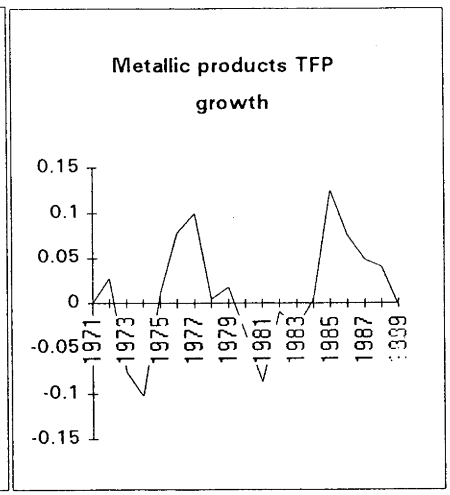

Printing and publishing
TFP growth
0.1
0.05
0
-0.0
-0.1
-0.15
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989

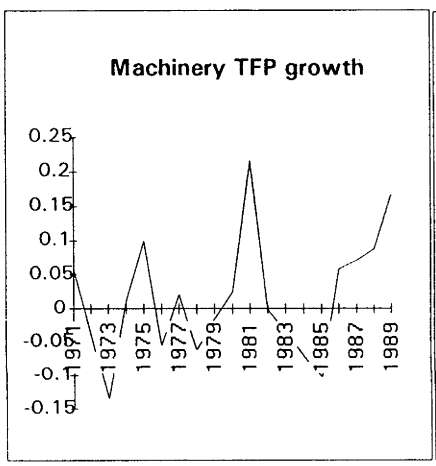

Industrial chemicals and
other chemicals TFP
growth
0.2
0.15
0.1
0.05
0
-0.1
-0.15
1971
1973
1975
1977
1979
1981
1983
1985
1987

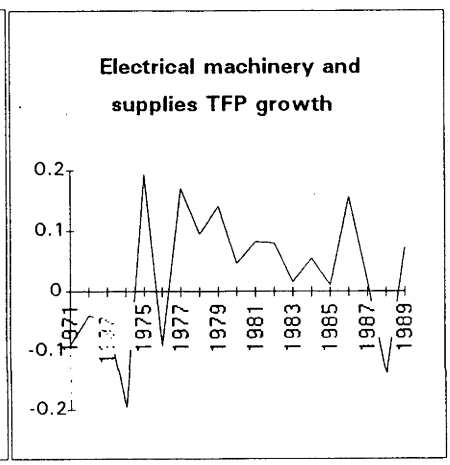

Petroleum refineries
and petrochemical
products TFP growth
0.3
0.2
0.1
0
-0.3
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989


Rubber and plastic
products TFP growth
0.2
0.1
0
-0.2
-0.3
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989


Non-metallic products
TFP growth
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989


Metallic products TFP
growth
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1971
1973
1975
1977
1979
1981
1983
1985
1987


Machinery TFP growth
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989


Electrical machinery and
supplies TFP growth
0.2
0.1
0
-0.2
1975
1977
1979
1981
1983
1985
1987
1989

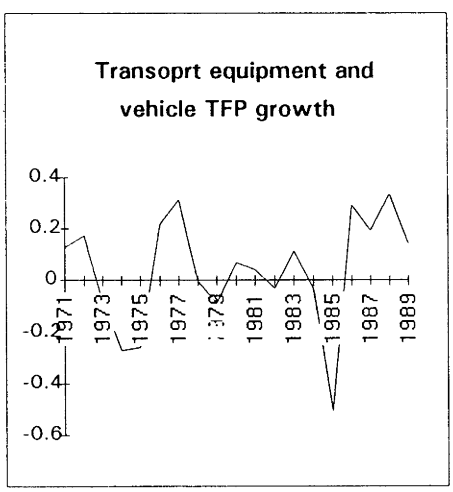
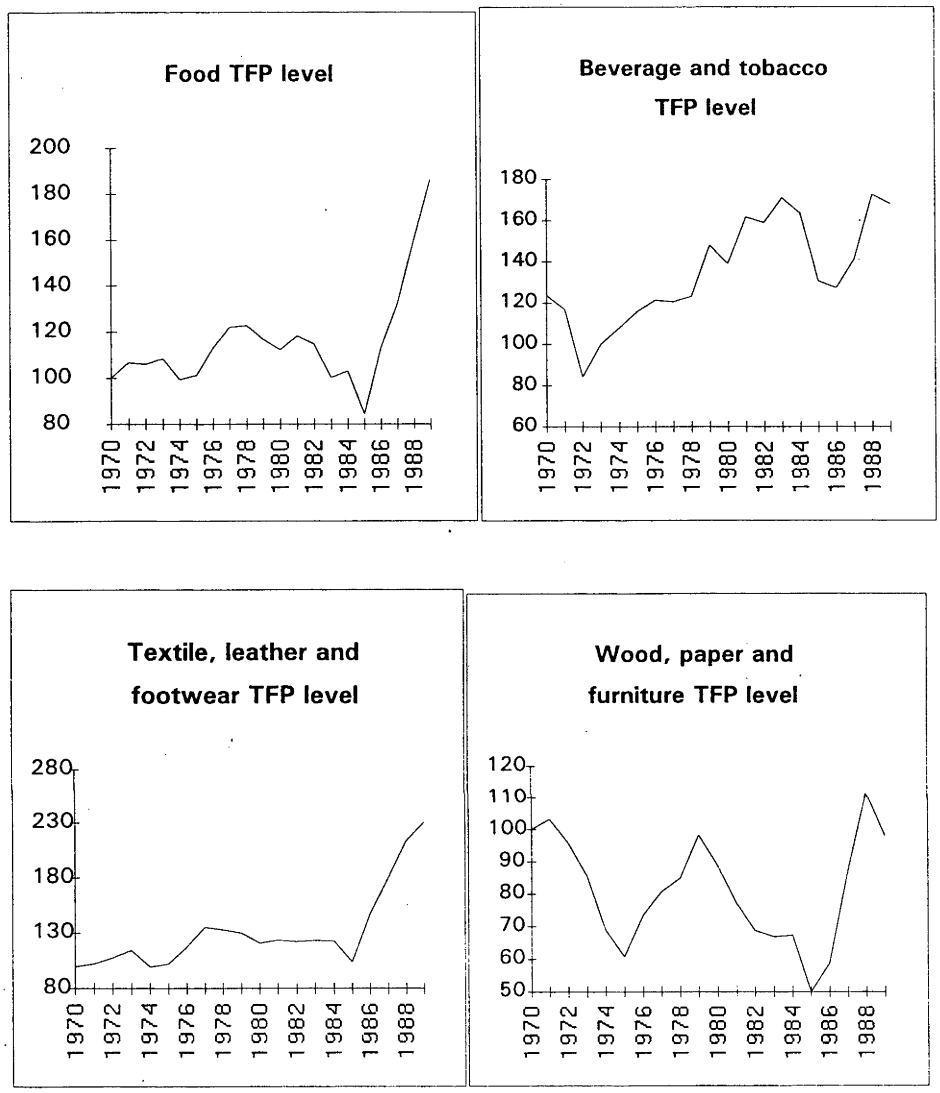
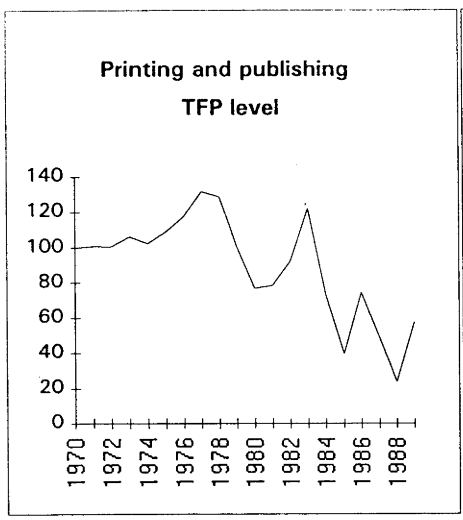
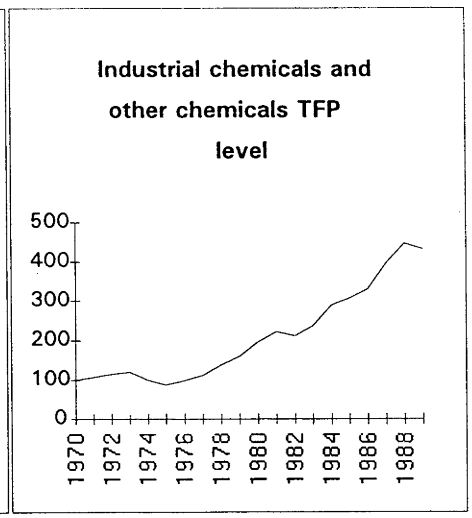
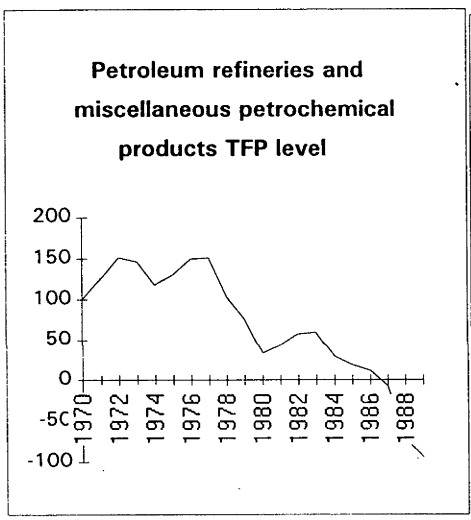

Transoprt equipment and
vehicle TFP growth
0.4
0.2
0
-0.4
-0.6
1971
1973
1975
1977
1981
1983
1985
1987
1989

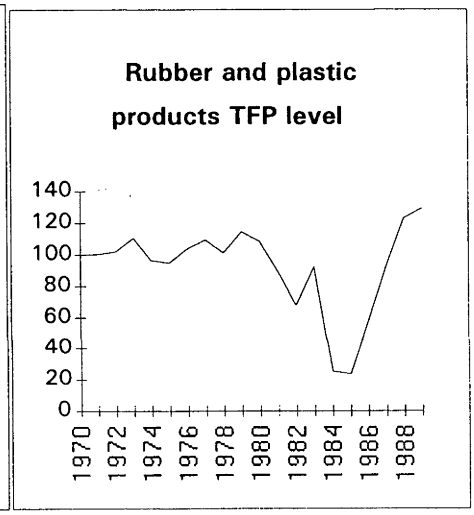
Figure A5.2
TFP level of thirteen industries

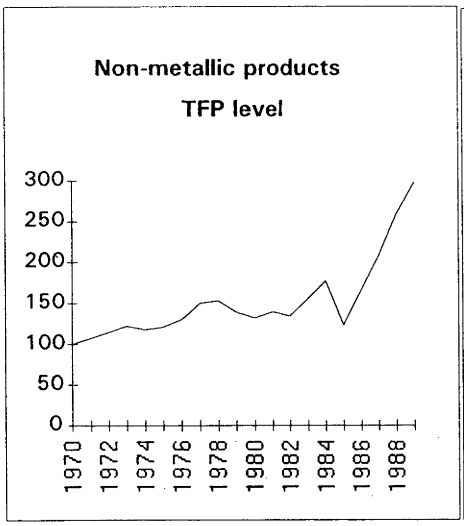


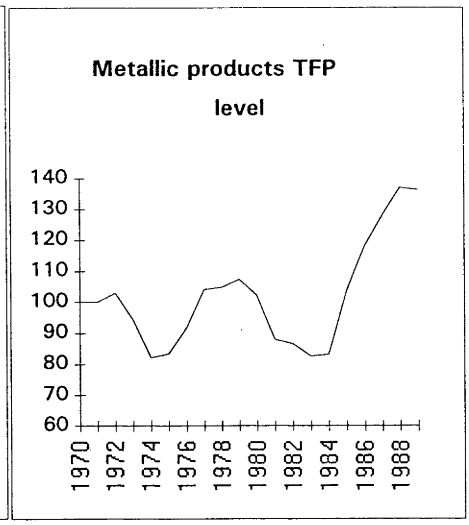

Printing and publishing
TFP level
140
120
100
80
60
40
20
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988

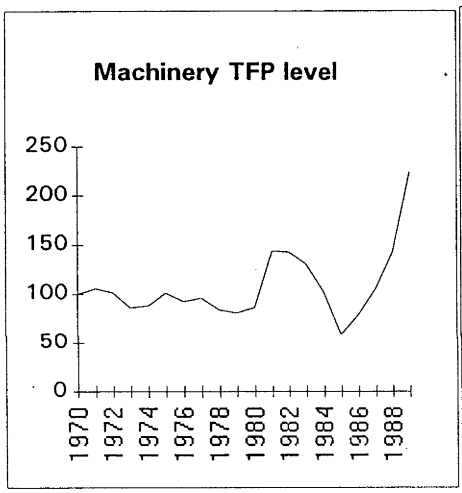

Industrial chemicals and
other chemicals TFP
level
500
400
300
200
100
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988

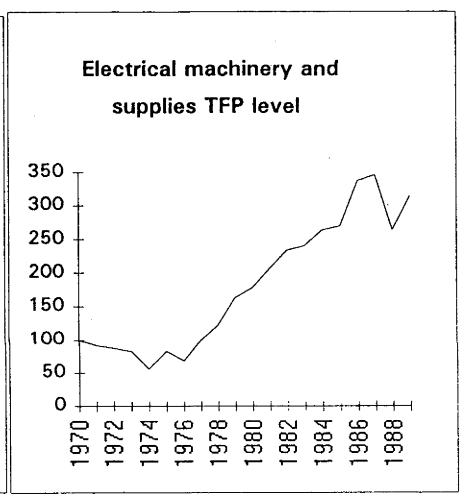

Petroleum refineries and
miscellaneous petrochemical
products TFP level
200
150
100
50
0
-50
-100
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988

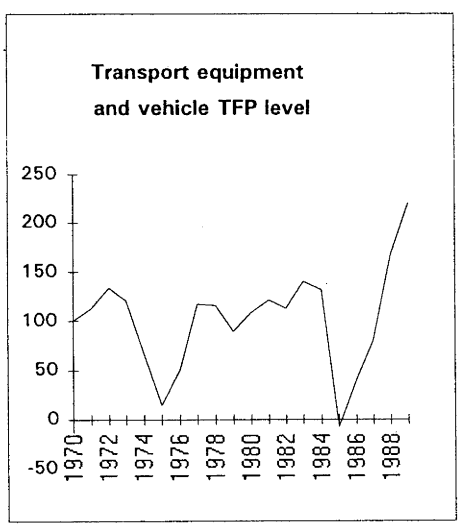

Rubber and plastic
products TFP level
140
120
100
80
60
40
20
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


Non-metallic products
TFP level
300
250
200
150
100
50
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


Metallic products TFP
level
140
130
120
110
100
90
80
70
60
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


Machinery TFP level
250
200
150
100
50
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


Electrical machinery and
supplies TFP level
350
300
250
200
150
100
50
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988


Transport equipment
and vehicle TFP level
250
200
150
100
50
0
-50
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988

6 Estimation of TFP growth in five agricultural crops

This chapter analyzes disaggregated agricultural data estimating TFP growth and sources of growth in five major crops: paddy; cassava; sugar cane; maize and soya beans.

Several factors explain the relatively small (but steady) growth of agriculture. These include a domestic income elasticity of demand of less than unity for agricultural products (especially food) and the Rybczynski theorem of factor intensity (an increase in the endowment of one factor, say capital (K), causes a more than proportionate increase in output of the commodity which uses that factor relatively intensively). A relative decline in the share of agricultural output (although agricultural output was growing) is inevitable during the modernization of an economy and its diversification into industry and services.

The TFP growth results for agriculture (Chapter 4) will not be the same for all crops. It is useful to determine which, if any, crops in agriculture have a high TFP level.

Estimation of five crop production functions

Pooled cross section data for each of the five crops from four regions and over the period, 1977 - 89, are employed to estimate the production function of each crop. The data used are described in Appendix CH 6 Section 6.1. A single production function for each crop is estimated for the whole country. No attempt is made to analyze disparities in production functions between regions. It is assumed that while the intercept of each region may be different, the slope of each crop's production function will be the same for all regions, as is usually the case in pooled data estimation. The slope is used to calculate TFP in each crop for the whole country.

Given factor mobility, in estimating each crop's production function it is reasonable to postulate that there will be no effect on slope, or output elasticity of the production function, due to regional factors. Thailand is not a very large country in terms of area. People can move freely from one place to another within a short period of time.

Production factors, particularly labour and capital, can move freely from those locations, crops and sectors providing lower returns to higher return sectors. Land is not mobile, but as capital and labour are, returns to land should be equated across regions, at least in the long-run. This assumption is tested and confirmed in this chapter.

The intercepts of the pooled data estimation equations may differ due to the different character of each region. In the production function, the intercepts can be interpreted as reflecting differences in technology of regions so that they might have different values for different regions. A test to determine if the intercepts are different intercepts but a common slope exists is done to test this hypothesis. A brief description of the pooled data estimation used in this study is presented in Section 6.2 Appendix CH 6.

The results for crop production functions

The CRS-CD production function (as is used for the agricultural sector in Chapter 4) is estimated for each of five crops to use the output elasticity of each factor as a weight to calculate TFP growth (Chapter 3).

Table 6.1

Estimation results of five major crops' production function: CRS-CD by pooling cross-sectional and time-series data

Model 1 common slopes and intercepts across regions

Crop	Paddy	Cassava	Sugar cane	Maize	Soya beans
F_1-test	10.2850*	0.5653	1.4231	3.8065*	6.8050*
$\hat{\beta}_l$	-1.8559	-0.5794	2.3371	0.4717	-0.0762
t-ratio	-3.5845*	-2.0384*	4.0201*	0.4901	-0.1464
$\hat{\beta}_k$	0.3876	0.1184	0.5215	0.5783	0.7220
t-ratio	18.6460*	4.3083*	5.7245*	4.2238*	6.5504*
$\hat{\beta}_p$	0.1138	0.1841	-0.0179	-0.2390	0.0284
t-ratio	1.1918	3.6375*	-0.1787	-1.7378*	0.7044
$\hat{\beta}_L$	0.4986	0.6975	0.4964	0.6607	0.2496
t-ratio	6.3537*	15.1121*	3.7984*	4.2970*	2.2984*
Buse R^2	0.9671	0.6053	0.4769	0.3317	0.5706

Model 2 common slopes but different intercepts across regions

Crop	Paddy	Cassava	Sugar cane	Maize	Soya Beans
F_2-test	1.7122	0.4182	0.4374	0.4696	2.4654
Hausman-χ^2	1.5276	2.0940	0.0000	0.0000	0.0000
$\hat{\beta}_k$	0.3136	0.1278	0.4982	0.7076	0.8651
t-ratio	7.2592*	2.9000*	4.6645*	5.0676*	9.6713*
$\hat{\beta}_p$	0.2741	0.1257	-0.1165	-0.4174	0.0460
t-ratio	1.9044*	1.8471*	-0.9979	-2.2736*	0.7397
$\hat{\beta}_L$	0.4123	0.7465	0.6183	0.7098	0.0889
t-ratio	3.3286*	11.5006*	3.7755*	3.8942*	0.9967
$\overline{R}^2$	0.6718	0.2826	0.3395	0.3644	0.7417

Remark

The F_1-test is the F-test for common intercepts and slopes. It is F(9, 40) for paddy and F(6, 30) for the other four crops since four regions which grow rice but only three regions grow the other four crops.

The F_2-test is the test for varying intercepts but common slopes. It is F(6, 40) for paddy and F(4, 30) for the other four crops.

The Huasman-χ^2 test is the test of whether the random (effect) term is uncorrelated with X_i. It is $\chi^2_{(2)}$.

$$t\,\hat{\beta}_L = \frac{\hat{\beta}_L}{SE\,\hat{\beta}_L}\text{;where } Var(\hat{\beta}_L) = Var(\hat{\beta}_k) + Var(\hat{\beta}_p) + 2\,Cov(\hat{\beta}_k\,\hat{\beta}_p)$$

* means statistically significant at 5 per cent (one tail test)

Highlighted boxes indicate the selected results

Source Author's calculations

The results for the paddy production function estimation are shown in Table 6.1. The F_1-test indicates that the hypothesis that the intercept and the slope are identical can be rejected, while the F_2-test cannot reject the hypothesis that there are common slopes but individual intercepts for each region. The study, therefore, uses the second production function structure; that is, same slope, individual intercepts. Since the Hausman-χ^2 test could not reject the null hypothesis that the effect term is uncorrelated with explanatory variables, the random effect (RE) estimation is used (Appendix CH 6 for more discussion of the F_1 and F_2 tests (H_{01} and H_{02}), and fixed effect (FE) and RE hypothesis tests). Coefficients are found to be significant. The output elasticity of labour shows the largest size (0.4123) among all factors implying that the return to labour share is the largest part of paddy production while the output elasticity of capital input (0.3136) is the second largest.

The F_1 and F_2 tests for cassava estimation can not reject the null hypotheses. Therefore, the estimating production function used has the same intercepts and same slopes across regions (as H_{01} encompasses H_{02}, Appendix CH 6 Section 6.2). The estimation results from Model 1 show that all coefficients are statistically significant. Compared with the other inputs, the output elasticity with respect to labour (β_L) is the highest, 0.6975 and planted area (β_p) the second largest, 0.1841.

Both F_1 and F_2 tests of the sugar production function estimation can not be rejected. The single intercept and common slopes model is again employed. The output elasticity of capital (β_k) is the highest in the sugar production function (0.5251) while the output elasticity of labour is the second largest (0.4964). In both estimations, the output elasticity of the planted area (β_p) is insignificant. The likely reason for this is that land that can be used for sugar cane is limited by the constraint that it must be near to sugar mills. In addition, as the sugar industry is dominated by monopoly groups of farmers and millers in each region, the expansion of planted area may not have been efficient.

For the maize production function, the F_1-test rejects the null hypothesis of a common intercept while the F_2-test cannot reject the hypothesis of individual intercepts. The second model (of regional intercepts) is therefore used in the estimation of maize's production function. The output elasticity of planted area (β_p) for maize has a

negative sign and is statistically significant. This implies that the marginal productivity of the planted area is negative (output elasticity of planted area equals marginal product of planted area divided by its (non-negative) average product). This means in general that the planted area under production is too large relative to the other factor inputs used. Another possible explanation for the negative marginal productivity of planted area relates to use of inefficient production techniques. This hypothesis is supported by evidence, given later in this chapter, that TFP growth and the trend in maize production have been declining (Appendix CH 5 Table A6.1 and Figure A6.1).

The most likely explanation of the negative output elasticity of planted area (β_P) is that the expansion of maize production has been concentrated in a limited area in eight provinces (Lop Buri, Nakhon Sawàn, Phetchabun, Nakhon Ratchasima, Saraburi, Phitsanulok, Leoi and Uthai Thani). These maize producing provinces accounted for 76 per cent of the total maize planted areas in 1967 to 1979. The degree of concentration of maize production area has been relatively constant over the last two decades. The stability of concentration in the geographic location of maize is based on comparative soil characteristics (Teera 1983). The limestone content of the soil, necessary for maize production, is higher in these provinces. However, there has been a significant decline in the planted area of maize in these provinces, particularly in the late 1980s. The planted area of these eight provinces dropped to only 61 percent of the total maize planted area. This may indicate that maize has increasingly been grown in less suitable areas causing the output elasticity of the planted area to be negative as a result. The drop in planted area in these eight provinces suggests that presumably more profitable crops have competed with maize for planted area.

The F_1-test rejects the null hypothesis for soya beans while the F_2-test does not and so model 2 is used. The output elasticity of capital (β_K) is significant and is the largest (0.8651). The output elasticities of the planted area (β_P) and labour (β_L) are both insignificant and small.

No significant differences were found between regional slopes. This supports the hypothesis of factor mobility, which would equate factor returns across regions. However, the test against different intercepts is significant in paddy, maize and soya beans implying that there are differences in technological structure and natural charac-

teristics of the land in each region growing these crops. In addition, the R^2 values of sugar and maize are rather low. This is likely to result from the omission of some relevant independent variables, notably fertilizer, due to the data limitations. As the inclusion of fertilizer did not significantly affect the estimated TFP growth results consistent with the estimation and analysis to the major inputs of land, labour and capital and it means that the crop estimations are consistent with the estimation and analysis of TFP growth in agriculture presented in Chapter 4.

Sources of growth in five major agricultural crops

In general, soya bean output grew at the fastest rate, on average at 16.5 per cent per annum during the period of the study (1978 - 89). Maize, sugar, paddy and cassava followed (Table A6.1 Appendix CH 6). But the growth of maize and paddy declined, while that of sugar rose over some periods in the study. For example, the growth of paddy output dropped from 6.6 per cent per annum in 1978 - 80 to 2.8 per cent and to only 0.3 per cent in 1981 - 85 and 1986 - 89 respectively. The growth of maize output dropped sharply from 20.5 per cent per annum during 1978 - 80 to 10.1 per cent in 1980 - 85 and declined by -2.9 per cent during 1986 - 89. This indicates that maize and paddy supply is declining, possibly because farmers were turning to other crops.

Decreases in input growth is found for many crops. The decline in input growth (capital, labour and land but not their contributions to growth as in Table A6.1 in Appendix CH 6) in maize and paddy were major sources for the decline in their growth (Table 6.2). In addition, from Chapter 4, the study found that the growth of factor inputs in agriculture is lower than in other sectors which indicates a relative slowdown in agriculture, mainly driven by the slow growth of paddy and maize output, the principal crops. The rate of output growth of other crops - sugar, cassava and soya beans - increased. Compared with the overall results for agriculture in Chapter 4, the low growth of this sector is therefore largely due to the slow growth of these two crops.

Table 6.2

Growth of inputs (at constant 1972 prices for capital stock) in five crops, 1978 - 89

per cent per annum

	Capital growth	Labour growth	Land growth
Paddy			
1978 - 80	9.7	2.9	4.9
1981 - 85	5.3	-1.8	1.1
1986 - 89	1.6	-1.4	0.9
Maize			
1978 - 80	13.4	3.5	5.7
1981 - 85	10.7	8.0	3.5
1986 - 89	-0.8	-2.5	0.3
Cassava			
1978 - 80	10.5	2.8	4.9
1981 - 85	3.7	0.3	1.1
1986 - 89	10.2	2.2	0.9
Sugar			
1978 - 80	1.3	-5.2	-4.4
1981 - 85	7.5	4.8	4.5
1986 - 89	5.7	6.7	4.7
Soya beans			
1978 - 80	1.1	-5.0	2.3
1981 - 85	17.5	7.5	12.2
1986 - 89	13.6	16.7	17.4

Source Author's calculations

TFP growth and input growth contribution

The coefficients of factor inputs from the estimated production functions were used to calculate TFP growth (Table A6.1 Appendix CH 6). The trend of TFP growth is illustrated in Figure A6.1 Appendix CH 6. Output growth in paddy and maize dropped while TFP growth was positive in these two crops, which indicates the decline in contribution of input growth, particularly capital and labour contributions.

Table 6.3 below (details in Table A6.2 Appendix CH 6) indicate that, on average during 1978 - 89, capital input most influenced growth, contributing 63.7 per cent to the growth of maize output, 63.3 per cent for soya beans, 60.0 per cent for sugar and 56.1 per cent for paddy. Land is the main source of growth for cassava (53.9 per cent). TFP growth is the most influential for paddy (32.2 per cent), followed by 30.6 per cent for soya beans, maize 22.6 per cent, sugar 9.5 per cent and cassava -64.7 per cent.

Although over the whole period of the study (1978 - 89), TFP growth in cassava made a negative contribution to output growth, its contribution became positive and higher in the late 1980s with 58.5 per cent in 1986 - 89. If the whole period of the study (12 years from 1978 to 1989) is considered as 3 sub-periods: 1978 - 80, 1981 - 85 and 1986 - 89 (following Table A6.1), TFP growth contribution to output declined in soya beans, from 62.2 per cent, to 30.0 per cent and 29.6 per cent, respectively. The high level of protection in soya beans compared with other crops may explain the decline of TFP contribution to growth in this crop. For the other crops, the proportion of TFP growth in output growth did not clearly decline or increase. For example, for paddy, it increased steadily in 1981 - 85 but dropped in 1986 - 89.

Some trends in other sources of growth are clear. The contribution of capital to output growth grew strongly in paddy. This reflects the rapid introduction of capital, possibly mainly in the form of tractors, to rice farming. The growth of labour made an increasing contribution to output growth in maize and soya beans, but not in paddy.

Many of the farmers moving from rice farming to work in other sectors are comparatively young. This is particularly true of the seasonal migrants (Chalongphob 1987, Kosit 1991). The increasing role of capital in paddy production has kept output growing, but not enough to keep the growth at the high rate of the late 1970s.

Table 6.3

Share of contribution to output growth, 1978 - 89

average per cent in 100 per cent output growth

Year	Capital growth	Labour growth	Land growth	TFP growth
Paddy				
1978 - 80	46.5	18.00	20.6	14.9
1981 - 85	59.2	-26.9	10.9	56.8
1986 - 89	190.5	-213.9	94.5	28.9
1978 - 89	56.1	-7.2	19.0	32.2
Soya beans				
1978 - 80	60.3	-29.3	6.8	62.2
1981 - 85	66.4	1.1	2.5	30.0
1986 - 89	59.00	7.5	4.0	29.6
1978 - 89	63.3	3.00	3.2	30.6
Maize				
1978 - 80	46.1	12.1	-11.6	53.4
1981 - 85	74.5	56.0	-14.4	-16.0
1986 - 89	18.4	60.4	3.6	17.6
1978 - 89	63.7	28.6	-14.8	22.6
Sugar cane				
1978 - 80	47.7	-185.8	5.8	232.3
1981 - 85	102.5	62.5	-2.1	-62.9
1986 - 89	36.6	41.0	-1.0	23.4
1978 - 89	60.00	31.5	-0.9	9.5
Cassava				
1978 - 80	43.4	68.1	44.9	-56.4
1981 - 85	-14.6	-6.5	-67.9	189.0
1986 - 89	15.8	20.0	5.7	58.5
1978 - 89	44.9	53.9	66.0	-64.7

Source Author's calculations

It should be noted also that although the estimated production function coefficients for labour (output elasticity of labour, β_L) are high in most crops except soya beans, the influence of labour growth on output growth in these crops is found not to

be very high because the actual numbers of new workers employed in these crops are low. Soya beans, a relatively new crop, is an exception.

TFP level index

To show the level of TFP in each period of time, a TFP level index is constructed. Detailed estimates of TFP levels for each year (1977=100) are shown in Table A6.3 Appendix CH 6. A summary is given in Table 6.4.

Table 6.4
TFP level of five major crops in Thailand, 1977 - 89

1977 = 100

Year	Soy bean	Paddy	Cassava	Maize	Sugar cane
1977	100.0	100.0	100.0	100.0	100.00
1978	140.4	108.4	97.3	122.9	115.4
1979	117.4	116.3	99.7	124.1	75.3
1980	98.6	100.6	94.5	140.3	93.8
1981	116.8	108.2	90.0	119.9	103.2
1982	121.6	99.8	86.4	91.4	76.1
1983	118.6	106.4	87.9	111.5	77.8
1984	130.8	122.5	81.6	124.1	81.7
1985	133.6	108.0	66.4	126.2	75.6
1986	121.0	101.7	90.5	108.6	76.2
1987	45.4	97.7	82.1	45.0	76.4
1988	134.6	110.2	92.7	97.1	95.5
1989	213.7	106.8	75.5	81.9	79.6
1978 - 80	118.8	108.4	97.2	129.1	94.9
1981 - 85	124.3	109.0	82.5	114.6	82.9
1986 - 89	128.7	104.1	85.2	83.1	81.9

Two of the five crops, paddy and soya beans, have TFP index levels higher than 100 in almost every year. Only in one year, 1987, does the soya beans TFP level index drop significantly (to 45.4). The other group have a TFP level in some years higher than 100 and in some years lower than 100. This group includes maize and sugar cane. Cassava does not have a TFP index level higher than 100 in any year after 1977. In

general, TFP levels for the five crops show little clear upward trend -with the possible exception of soya beans. For some crops the TFP levels, if anything, tend to decline.

The results in Table 6.4 suggest that soya beans production techniques and efficiency have improved since 1977 while those for paddy have been static. The TFP levels of maize, sugar cane and cassava declined from 1977 - 89. However, any trend movements tend to be obscured by large year-to-year fluctuations in TFP levels.

To understand why TFP growth levels differed for each crop, the study will examine in more detail some of the general characteristics of each crop (the factors determining TFP growth will be examined in detail in Chapter 7). As is done for the industry groups, the study groups the five crops into two groups according to the level of their TFP index. The higher TFP level index crops are those whose TFP level index is greater than 100 in most of the years in the study (paddy and soya beans) and the lower TFP level index crops are those whose indices were less than 100 (maize, sugar cane and cassava).

The two higher TFP level index crops

Paddy

Paddy has been the most important crop for Thailand, both historically and economically. Most of the farmers in Thailand grow rice, which is the staple food. Thailand is one of the world's largest rice exporters and has been so for many years, even though rice is mainly consumed domestically. In 1989 for example, 42 per cent of the tonnage and 36 per cent of the value of world rice exports came from Thailand (Office of Agricultural Economics 1990).

Total Thai rice output was about 6.9 million tonnes in the 1967/68 crop year. It rose to 9.2 million tonnes in 1971/72, 17.8 million tonnes in 1981/82 and 21.3 million tonnes in 1988/89. While total rice exports were just under 1 million tonnes in 1968, they rose to 1.6, 3.1 and 6.6 million tonnes in 1972, 1982 and 1989 respectively. Major importers of Thai rice are Hong Kong, Malaysia, Singapore, Iran, Indonesia, Japan, the United States and Saudi Arabia. Occasional importers include Sri Lanka, India, the Philippines and Senegal.

Owing to the importance of rice in Thai society and to the economy, most Thai governments have given it a great deal of attention. Intervention in the rice trade began after the Second World War when the government monopolized rice exports and rice trading was restricted to government. Government rice policies have both encouraged and discouraged the TFP growth of this crop. Discouraging measures have included an export tax which was only gradually reduced and recently abolished, compulsory sales to the government of a specified quantity of rice, export quotas and licenses (Tipaporn 1981, Juanjai, Supote and Sorrayuth 1986, Ammar and Wiroj 1990, Ammar and Suthad 1991). The government has also set minimum prices for paddy and provided relatively high expenditure on research and development and measures such as seed development, farming information and export packing credit. Rice policies have thus been contradictory.

Table 6.5
The effective rate of protection (ERP) of four agricultural crops, 1981 - 87

	1981	1984	1987
Rice	-0.105	-0.105	-0.082
Cassava	0.002	0.001	0.009
Maize	-0.003	-0.003	0.012
Sugar	0.001	0.000	-0.011

Source Paitoon Wiboonchutikula, Rachain Chintayarangsan and Nattapong Tongpaked, 1989. 'Trade in manufacturing goods and mineral products", Background Paper for the 1989 TDRI Year-end Conference on 'Thailand in the International Economic Community', Thailand Development Research Institute, Bangkok.

The government tried to offset the bias against rice by subsidizing research and development. Rice receives around 20 to 30 per cent of the agricultural research budget (Ammar and Wiroj 1990). Fertilizers and insecticides have been subsidized from time to time and encouraged soil nourishment, appropriate techniques of production and advanced techniques. All these efforts are, however, small compared to the negative impact of taxes in the past. TFP may be expected to rise as the effects of past biases wear off.

Soya beans

Soya beans are a new crop in Thailand. Soya beans originated in the warm area in southern China, needing moisture but not a damp climate. Until recently, soya beans were mainly used to feed chickens, the meat from which was then exported.

Soya beans are planted in four main parts of Thailand: the lower north, upper north, central plain and northeastern regions. The lower north region has the most productive soya bean acreage and accounts for more than half of the planted area. The output per area in this region is quite high because of abundant rain. The product grown in this area, therefore, is called wet season soya beans. The second most important planted area is in the upper north. This regions accounts for about one-fourth of the total planted area. Soya beans in this area are usually grown after the paddy harvest season, which is the dry season. Output, therefore, is called dry season soya beans.

Land devoted to soya bean production has increased from about 1.0 million rai (about 395,000 acres) in the 1983/84 crop year to 2.5 million rai (about 987,500 acres) in 1988/89 (Office of Agricultural Economics 1985, 1990). Exports of soy beans have not been high, declining from 9.7 thousand tonnes in 1979 to 0.01 thousand tonnes in 1989. This decline in exports has been due to the increase in domestic consumption by vegetable oil and oil cake for animal feed production. It is thus linked with the food industry, which is one of the largest and the fastest growing manufacturing groups. This high demand is possibly a factor which has induced producers (farmers) to specialize and produce more efficiently. Table A6.4 Appendix CH 6 shows that most soya beans are used in the food industry.

Owing to the rapid increase in demand for the residue (oil cake) from oil extraction for use as animal feed in the last decade, imports of soya beans increased very sharply peaking up to 80 per cent per annum in 1983. The government introduced import restrictions on oil cake in 1984 thus markedly increasing already existing protection for soya bean products. Increases in protection (Table 6.6) and government intervention in this crop probably caused a deterioration in the contribution of TFP growth to output. The share of TFP growth in the output growth in soya beans has

dropped from 62.2 per cent during 1978 - 80 (before the introduction of import controls in 1984) to 30.0 per cent and 29.6 per cent during 1981 - 85 and 1986 - 89 respectively.

Nominal rates of protection (NRP) for the components of the industry and seeds are showed in Table 6.6. This induced an increased demand for soya beans and raised their prices. The apparent increase in the TFP of soya beans may in fact merely reflect these rising prices. According to the hypothesis of an inverse U-shaped relationship between price and productivity (Meer and Yamada 1990, P: 23), technological change is likely to be slower at lower output prices, but at high price levels, total productivity growth may be negatively affected due to excessive input levels. The positive relationship between high prices and high TFP growth is likely to be the case in soya beans because it is a new crop. Increases in soya bean production could also induce greater specialization and also led to new economies of scale. The government has also encouraged research on seeds and provided credit to farmers (Suthad 1990). TFP growth of soya beans has been quite high, but the TFP contribution has declined, probably due to rising protection during the late 1980s (Table A6.2 Appendix CH 6 and Table 6.3).

Table 6.6

Nominal rate of protection (NRP) of soya bean seeds, oil cake and oil industry, 1983 - 87

	Seeds	Oil cake	Cooking oil
1983	0.0014	0.2753	0.1952
1984	0.0128	0.2708	0.2993
1985	0.0393	0.3668	-0.0644
1986	0.1470	0.5298	0.0967
1987	0.2143	0.5851	0.2901

Source Suthad Setboonsarng (1990), "The Protection Rate in soy bean Industry", *Thammasat Economic Journal.* September (in Thai).

Table 6.7

Effective rate of protection (ERP) of soya bean industry, 1986

	ERP
Northern region	0.2843
Northeastern region	0.2882
Central region	0.3030

Source Suthad Setboonsarng (1990), "The Protection Rate in soy bean Industry", *Thammasat Economic Journal.* September (in Thai).

Suthad (1990) studied the cost of oil cake production in Thailand and evaluated the possibility of oil cake production under government protection. The domestic resource cost ratio (DRC) methodology was used for 1986 data. The DRC ratio of the oil cake industry was only about 60 - 70 per cent of the import value indicating the cheaper cost of oil cake production. Oil cake from soya beans could thus have been produced without protection. If a shadow exchange rate were taken into account (when the official exchange rate = 25.82 B/$US, the shadow exchange rate = 28.2 B/$US, for 1986), DRC ratio would be only 55 - 64 per cent of the international US dollar cost.

In 1987, the TFP level of soya beans fell due to a sudden drop in total output while inputs remained relatively constant. The drop of output was due to a large fall (23 per cent) in output from the lower-northern area which is the most efficient soya bean producing area, produces the highest quality beans and has the highest production per area in Thailand. It appears from the records of the Bank of Thailand that 1987 was a drought year in which many crops were damaged. The output from the other regions still increased.

The lower TFP level index crops

Maize

Maize was introduced to Thailand in the 1950s, essentially as an animal feed crop (Tipaporn 1981). It is a highland and dry land area crop that has become an increasingly important export crop for Thailand. About 90 per cent of production is now grown in the upper central plains area. Production increased rapidly from 0.9 million tonnes in 1963/64, to 4.7 million tonnes in 1988/89 (Office of Agricultural Economics).

Most maize production, about 85 - 90 per cent, is exported. An average of 1.8 million tonnes has been exported each year since 1971. Exports peaked at 4.0 million tonnes in 1986, then dropped to 1.6, 1.2 and 1.2 million tonnes in 1987, 1988 and 1989 respectively (Office of Agricultural Economics, various issues). Thailand's maize exports go to three markets. In the early 1970s, Japan and Taiwan took about 70 per cent of exports under long-term agreements . Malaysia, Philippines, Singapore, Hong

Kong and the European Community are traditional markets. Irregular importers such as the Middle East countries.

Prior to 1960, the maize trade was considered free of control (Ammar and Suthad 1991). The government intervened to regulate the maize trade in 1961 when all exporters were required to obtain permission from the government before exporting maize (Juanjai, Supote and Sorrayuth 1986). It was argued that the toxicity of exported maize had to be controlled but the government also wanted to set a minimum export price and quality standards. Export agreements were negotiated by the government and export quotas were allocated accordingly. This resulted in windfall gains for quota holders. Some firms wanting a larger quota tried to establish dummy companies to obtain new quota allocations. Maize growing was thus highly influenced by regulation.

As the contract prices for Taiwan and Japan were lower than domestic prices, exporters pushed the burden on to farmers by offering farmers a lower price. In December 1981, the price of maize dropped to a very low level. This induced the government to cancel the export quota system. Exports have been diversified.

After the sharp drop in 1987, the TFP index of maize improved in 1988 with a small drop in 1989 (although export quantities declined still further) (Table 6.4). Production recovered rapidly from 2.8 million tonnes in 1987 to 4.7 and 4.5 million tonnes in 1988 and 1989 respectively. Land productivity showed an improvement as well; planted area of maize production was 12.2 thousand rai in 1986, dropping to 10.9 thousand rai in 1987 and increasing to only 11.5 and 11.4 thousand rai in 1988 and 1989, while output in 1988 and 1989 was higher than in 1986.

Sugar cane

Sugar cane is grown in every province in Thailand except in the southern region, but 80 per cent of production is grown in the central region. Total sugar production increased from 0.18 million tonnes in 1967, to 2.6, 27.2 and 33.6 million tonnes in 1978, 1988, and 1990 respectively (Office of Agricultural Economics various issues). Sugar exports rose from an average 0.77 million tonnes in 1971 to 1.2 million tonnes in 1979. They then fluctuated around 1.0 to 2.5 million tonnes from 1979 to 1988. Sugar ex-

ports, however, increased steadily again in 1989 and 1990 to 3.6 and 3.3 million tonnes. The major markets for Thai sugar are Japan, the Republic of Korea, China, Malaysia, Middle East, Iran and the United States.

Sugar cane is one of the crops which experienced decline in its TFP level index (Table 6.4). The TFP level of sugar dropped most obviously after 1981, though the level of TFP was still between 75 and 95, during 1982 to 1989.

Expansion of output was encouraged by protectionist measures which consisted of monopolized milling. Prior to 1960, Thailand was a sugar importer, most sugar production is consumed domestically, with less than 10 per cent exported. TFP growth has not been very high because of government intervention and the instability of world sugar prices.

Government intervention between the late 1920s and 1950s took the form of direct investment in milling facilities and heavy protection of domestic millers through taxes and import restrictions (Tipaporn 1981). This caused the domestic price to be above local production costs, providing incentive for the growth of local factories. In 1952, there was an excess supply of sugar in the world market which caused a sharp drop in the world price. A lot of low cost sugar was imported, especially from Taiwan. As a result, the government increased protection by raising import tariffs and set up the Thailand Sugar Corporation in 1953. The Thailand Sugar Corporation was the sole sugar importer. Its power, however, did not stimulate the sugar mills to utilize their resources efficiently. Domestic sugar was so uncompetitive that consumers preferred imported sugar.

Since 1960, the domestic sugar market has changed dramatically. The policy approach adopted was to subsidize exports when there was a domestic surplus and to impose an export tax or sugar premium on exports when there was an excess demand. To deal with over production in 1962 - 66, for instance, the government supported the sugar price by subsidizing sugar exports.

The sugar price rose significantly between 1971 and 1975, with an improvement in the (highly regulated) international shortage of sugar. This led to a shift in government policies. Export taxes and a domestic price ceiling were adopted with the aim of

stabilizing domestic prices. In 1976, the world price began to drop due to a high level of excess supply. The government intervened again by raising the export (tax) premium to 100 per cent (the rate was progressive) if the export value exceeded a certain amount (6,670 baht per tonne).

In 1982/83, the government introduced the so called 70:30 revenue sharing system. This system sets the allocation of benefits between a farmer and a factory. It became law in 1984. This system has reduced competition among sugar producers because it links the interests of the millers and farmers. The factories have been able to control the domestic supply of sugar to such an extent that the domestic price of sugar was about 12 to 13 baht per kilogram, while the world market price was only around 4 to 5 baht per kilogram.

The government has also declared economic zones for sugar production. In each zone, the government is a large shareholder in sugar mills to which farmers must sell their products. The price of domestic sugar is set by the government. Organized groups of farmers were also set up to negotiate sugar cane prices with the millers.

Cassava

Cassava has had the lowest TFP level since 1977. The TFP index dropped to 75.5 in 1989. The problems that have faced cassava producers explain cassava's poor TFP growth/levels.

Cassava has only become a popular crop in the eastern seaboard provinces during the past 40 years. It spread rapidly to many provinces in the central and northern regions since 1970. The main reason for its spread was the increase in demand in the European Community for animal feed. But this demand was created by trade diversion from maize purchases from the United States and was hence inherently unstable.

Cassava products can be classified into two types: cassava flour (starch) and cassava for animal feed. Cassava flour is consumed domestically, but more than 50 per cent of production is exported to Japan and the United States. Cassava for animal feed has largely been exported in the form of pellets. Most of the pellets have been exported to the European Community countries since 1973. The quantity of cassava products exported has fluctuated between 5.0 and 7.8 million tonnes from 1980 to 1987. It rose

from 6.2 million tonnes in 1987 to 8.1 and 9.8 million tonnes in 1988 and 1989 respectively. It dropped again to 8.1 million tonnes in 1990 (Office of Agricultural Economics various issues).

Cassava products were exported under a free trade system until 1963 when the government declared cassava to be controlled for export. Certain conditions were set regarding the quality, composition, outward characteristics and packing of the product when it was exported. From 1963 to 1971, exports were controlled by three private organizations licensed by the government (Tipaporn 1981). Exporters and shippers decided which organization would control their transactions. In 1973, the government gave authority to private surveyors to act as quality inspectors because export quality problems had arisen under the previous scheme.

In 1979, the European Community complained of excessively rapid increases in cassava imports from Thailand, also claiming that the Thai product was adulterated. Because Thailand was not a GATT member, Brazilian suppliers were given preferred access to the European Community market to restrain Thai exports. The government entered into an Agreement of Voluntary Export Restraint and introduced export quotas to implement it. The Agreement created economic rents to exporters who could obtain the export quota, but lowered the domestic price to farmers (Suphat 1986).

After 1979, the government added more measures to regulate exports. It set a minimum export price for cassava pellets and noodles in 1980, required all exporters to guarantee export quantities with their bank and maintain stocks in quantities aimed at stabilizing the domestic price of roots and required producers to seek government approval of their sales agreements and the quantity of output before exports (Juanjai, Supote and Sorrayuth 1986). In 1982, the government allowed free exports of any cassava products in excess of the European Community quota set by the agreement. It cancelled minimum price regulation to make prices more flexible to world demand.

Thailand then began to diversify cassava exports, but exports to the European Community still accounted for about 90 per cent of the value of total cassava exports in 1989. Cassava-flour is only about 9 per cent of cassava exports. Of this, more than 50 per cent goes to Japan and the United States.

Appendix CH 6

6.1 Data

Five crops important to Thai agriculture are selected for study of sources of growth: paddy, cassava, maize, sugar cane and soya beans. The crop selection was influenced by the availability of data as well as the importance of the crops. Over the past two decades these five crops have accounted for more than 50 per cent of total agricultural value added at 1972 constant prices.

Data used are taken from the Thai Office of Agricultural Economics. The data include information on prices and quantity of outputs, labour employed, and tractors used. All data are deflated by their base year prices to obtain their value at constant prices, as required by the definition of the productivity index. Since the data series is available only from 1977 to 1989, it is necessary to use panel data. The panel data consist of 13 years of time-series and four regions of cross-sectional data. The only data which are unavailable are those for capital stock used for each crop, classified by regions. Hence, the study allocates total capital used in each region and each crop is allocated on the basis of the ratio of tractors used in each crop and region to the total tractor fleet. This is done on the assumption that there is a fixed relationship between the proportion of tractors employed to cultivate each crop by region, the total tractor fleet and total capital employed.

6.2 A brief description of pooled data estimation used in this study [1]

In general, the model can be written as

$$y_{it} = \beta_{1i} + \sum_{j=2}^{J} \beta_{ji} X_{jit} + e_{jit} \qquad (1)$$

where

i = 1, ..., N cross section units, (where the units studied are four regions)

j = 1, ..., J explanatory variables (= labour (L), capital (K), and planted area (PA))

t = 1, ..., T time period

Two types of test in the study are:

H_{01}: regression intercepts and slopes coefficients are identical across regions

$$y_{it} = \beta_1 + \sum_{j=2}^{J} \beta_j X_{jit} + e_{it} \text{ ; i.e., } \beta_{ji} = \beta_j; j = 2, ..., J \text{ for all } i \qquad (2)$$

In other words, this hypothesis tests whether or not intercepts and slopes are homogeneous among regions.

The null hypothesis, H_{01}, is tested within the general model (1) via an F-test, called F_1 in the following tests with (N-1)(K+1), N(T-K-1) degrees of freedom (Hsiao 1986) for more details). N is the number of regions, K is the number of explanatory variables used in that crop's equation and T is the total time period (=13).

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1 More details, see Walters (1986), Mundlak (1978), Judge, Griffiths, Hill and Lee (1980), Kmenta (1986), Maddala (1989) and Greene (1993).

If the H_{01} hypothesis of overall homogeneity (intercepts and slopes) is accepted, the testing will not have to proceed further since H_{01} encompasses H_{02} (the next step).

However, if H_{01} is rejected this study then tests the H_{02} hypothesis, whether or not the regression intercepts are the same.

H_{02}: regression slope coefficients are identical (and intercepts are not)

$$y_{it} = \beta^{*}_{1i} + \sum_{j=2}^{J} \beta_j X_{jit} + e_{it} \text{ ; i.e., } \beta_{ji} = \beta_j; j = 2, ..., J \text{ for all } i \qquad (3)$$

In other words, this hypothesis tests whether or not the regression intercepts are the same across regions.

The null hypothesis, H_{02}, is tested within the general model (1) via an F-test, called F_2, in the following test with (N-1)K, NT-N(K+1) degrees of freedom.

Accepting either H_{01} or H_{02} implies that the slopes of the estimated production function are the same across regions. It does not really make sense to test for common intercepts but different slope and so common intercepts are only accepted if H_{01} is accepted.

In addition, to make the estimation more flexible, the study uses a cross-sectionally correlated and timewise autoregressive model (details in Kmenta 1986) in the estimation if the F_1-test is accepted. This is because it is frequently assumed that regression disturbances are heteroscedastic and for time series data, it is also expected that the disturbances are autoregressive.

When the cross-sectional units are geographical regions as in this study, it would not be expected that the assumption of cross-sectional independence would be

well satisfied. There may be some mutual correlation between disturbances. Therefore the estimation in the study took into account cross-sectional dependence.

The specification of the behaviour of the disturbances in the model is, therefore:

$$E(e_{it}^2) = \sigma_i^2 \qquad \text{(Heteroscedasticity)}$$

$$E(e_{it}, e_{jt}) = \sigma_{ij} \qquad \text{(Mutual Correlation)}$$

$$e_{it} = \rho_i e_{i,t-1} + \mu_{it} \qquad \text{(Autoregression)} \qquad \textbf{(4)}$$

where

$\mu_{it} \sim N(0, \varphi_i)$ which has the usual properties under the classical assumptions.

The estimation method is Generalized Least Squaress (Kmenta 1986). First, having applied the OLS to all the pooled data, the resulting errors e_{it} are then calculated. These residuals e_{it} are used to estimate $\hat{\rho}_i$ in (4). The $\hat{\rho}_i$'s are used to transform the observations; then OLS method is used on the transformed data. The resulting regression residuals, $\hat{\mu}_{it}^*$, can then be used to estimate the Variance-Covariance matrix of e_{it} (or σ_{ij}). In this way consistent estimation of $\hat{\rho}_i$ and σ_{ij} is obtained which can then be used to estimate the model coefficients by Generalized Least Squares (GLS). Buse-R^2 will be used to measure the goodness of fit, since it is an appropriate measure of fit in GLS.

If the F_2-test is not rejected (while the F_1-test is rejected), this means that the pooled regression should have varrying intercepts across regions but with a common slope. This study analyzes this case in two types of models: the fixed effect model (the dummy variable model) and the random effect model (error component model). Both the models assume, for simplicity, that the observations are independent across both dimensions (time and region).

The fixed effect (FE) model is estimated by OLS, giving the best linear unbiased estimator (BLUE), under the usual classic assumptions for e_{it}. However in the random effect (RE) model, the sector-specific variables are treated as random variables and then. GLS estimation is needed to estimate the model. Whether to treat the effects as fixed or random is difficult to determine. One criterion that can be used to decide which model should be employed is the Hausman-χ^2 test (Hausman 1978) used in this study. This test is whether the conditional mean of the effect, say α_i, is independent of the explanatory variables, say X_{it}'s, or $E(\alpha_i|X_{it}) = 0$. If the test can be rejected, the random effects estimator is biased and inconsistency so the fixed effect model is used.

Table A6.1
Sources of growth in five major crops, 1978 - 89

average contribution to output growth per cent per annum

Paddy

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	6.56	3.05	1.18	1.35	0.98
1981 - 85	2.80	1.66	-0.75	0.30	1.59
1986 - 89	0.27	0.51	-0.57	0.25	0.08
1978 - 85	**4.21**	**2.18**	**-0.03**	**0.70**	**1.36**
1981 - 89	**1.67**	**1.15**	**-0.67**	**0.28**	**0.92**
1978 - 89	**2.90**	**1.62**	**-0.21**	**0.55**	**0.93**

Cassava

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	2.87	1.25	1.95	1.29	-1.62
1981 - 85	-3.02	0.44	0.20	2.05	-5.71
1986 - 89	7.63	1.21	1.52	0.43	4.47
1978 - 85	**-0.81**	**0.74**	**0.86**	**1.77**	**-4.18**
1981 - 89	**1.71**	**0.78**	**0.79**	**1.33**	**-1.19**
1978 - 89	**2.00**	**0.90**	**1.08**	**1.32**	**-1.30**

Sugar cane

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	1.38	0.66	-2.56	0.08	3.21
1981 - 85	3.80	3.90	2.38	-0.08	-2.39
1986 - 89	8.11	2.97	3.33	-0.08	1.90
1978 - 85	**2.89**	**2.68**	**0.52**	**-0.02**	**-0.29**
1981 - 89	**5.72**	**3.48**	**2.80**	**-0.08**	**-0.48**
1978 - 89	**4.63**	**2.78**	**1.46**	**-0.04**	**0.44**

Maize

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	20.55	9.48	2.48	-2.38	10.98
1981 - 85	10.14	7.55	5.68	-1.46	-1.62
1986 - 89	-2.94	-0.54	-1.77	-0.11	-0.52
1978 - 85	**14.04**	**8.27**	**4.48**	**-1.81**	**3.10**
1981 - 89	**4.33**	**3.95**	**2.37**	**-0.86**	**-1.13**
1978 - 89	**8.38**	**5.34**	**2.39**	**-1.24**	**1.90**

Soya beans

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	1.53	0.92	-0.45	0.10	0.95
1981 - 85	22.77	15.21	0.25	0.56	6.83
1986 - 89	19.93	11.75	1.49	0.80	5.89
1978 - 85	**1.53**	**0.92**	**-0.45**	**0.10**	**0.95**
1981 - 89	**21.50**	**13.62**	**0.80**	**0.67**	**6.41**
1978 - 89	**16.51**	**10.45**	**0.49**	**0.53**	**5.05**

Source **Author's calculations**

Table A6.2
Contribution to output growth, 1978 - 89

Paddy

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	100.00	46.50	17.97	20.60	14.93
1981 - 85	100.00	59.18	-26.87	10.85	56.83
1986 - 89	100.00	190.53	-213.92	94.48	28.89
1978 - 85	**100.00**	**51.77**	**-0.65**	**16.55**	**32.34**
1981 - 89	**100.00**	**68.53**	**-40.19**	**16.81**	**54.84**
1978 - 89	**100.00**	**56.05**	**-7.24**	**18.96**	**32.23**

Cassava

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	100.00	43.44	68.13	44.85	-56.42
1981 - 85	100.00	-14.55	-6.52	-67.90	188.98
1986 - 89	100.00	15.84	19.97	5.65	58.54
1978 - 85	**100.00**	**-91.22**	**-105.20**	**-216.96**	**513.39**
1981 - 89	**100.00**	**45.65**	**45.95**	**77.77**	**-69.36**
1978 - 89	**100.00**	**44.86**	**53.90**	**65.98**	**-64.73**

Sugar cane

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	100.00	47.71	-185.78	5.76	232.32
1981 - 85	100.00	102.52	62.53	-2.13	-62.93
1986 - 89	100.00	36.60	41.04	-1.04	23.40
1978 - 85	**100.00**	**92.72**	**18.10**	**-0.72**	**-10.09**
1981 - 89	**100.00**	**60.94**	**48.97**	**-1.44**	**-8.47**
1978 - 89	**100.00**	**59.96**	**31.49**	**-0.91**	**9.46**

Maize

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	100.00	46.13	12.05	-11.60	53.42
1981 - 85	100.00	74.47	55.98	-14.43	-16.02
1986 - 89	100.00	18.41	60.35	3.62	17.62
1978 - 85	**100.00**	**58.92**	**31.87**	**-12.88**	**22.09**
1981 - 89	**100.00**	**91.37**	**54.66**	**-19.88**	**-26.16**
1978 - 89	**100.00**	**63.65**	**28.55**	**-14.80**	**22.61**

Soya beans

	Output growth	Capital growth	Labour growth	Land growth	TFP growth
1978 - 80	100.00	60.30	-29.31	6.76	62.24
1981 - 85	100.00	66.41	1.10	2.47	30.01
1986 - 89	100.00	58.97	7.46	4.01	29.56
1978 - 85	**100.00**	**60.30**	**-29.31**	**6.76**	**62.24**
1981 - 89	**100.00**	**63.35**	**3.72**	**3.10**	**29.82**
1978 - 89	**100.00**	**63.28**	**2.96**	**3.19**	**30.57**

Source Author's calculations

Table A6.3

TFP level index in five crops, 1977 - 89

points of output (given 1970 = 100)

Paddy

	Output	Output growth	Output increase due to				TFP indices
			Capital	Labour	Land	TFP	
1977	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1978	118.99	18.99	4.77	2.99	2.85	8.37	108.37
1979	129.97	10.98	1.65	-1.96	3.41	7.88	116.26
1980	118.88	-11.09	3.89	2.86	-2.17	-15.68	100.58
1981	122.35	3.47	2.52	-7.28	0.62	7.60	108.19
1982	114.83	-7.51	2.12	-1.19	-0.08	-8.36	99.82
1983	127.36	12.52	2.28	3.57	0.09	6.59	106.42
1984	144.96	17.61	1.47	-1.34	1.40	16.08	122.49
1985	134.06	-10.90	1.87	1.86	-0.17	-14.46	108.03
1986	126.61	-7.45	0.38	-2.12	0.64	-6.35	101.68
1987	116.29	-10.32	-0.31	-5.01	-1.03	-3.97	97.71
1988	133.04	16.75	1.64	4.09	-1.42	12.44	110.15
1989	133.54	0.50	0.79	-0.37	3.42	-3.34	106.80
1978 - 80	122.61	6.29	3.44	1.29	1.37	0.19	108.41
1981 - 85	128.71	3.04	2.05	-0.88	0.37	1.49	108.99
1986 - 89	127.37	-0.13	0.63	-0.85	0.40	-0.31	104.08
1978 - 85	126.43	4.26	2.57	-0.06	0.75	1.00	108.77
1981 - 89	128.12	1.63	1.42	-0.86	0.39	0.69	106.81
1978 - 89	126.74	2.80	1.92	-0.33	0.63	0.57	107.21

Cassava

	Output	Output growth	Output increase due to				TFP indices
			Capital	Labour	Land	TFP	
1977	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1978	61.65	-38.35	-3.23	-36.30	3.88	-2.70	97.30
1979	86.27	24.62	3.07	15.51	3.62	2.41	99.71
1980	92.33	6.06	1.71	14.67	-5.09	-5.23	94.48
1981	92.56	0.23	0.47	-1.08	5.37	-4.53	89.95
1982	98.60	6.05	1.69	6.39	1.55	-3.58	86.37
1983	102.15	3.55	0.58	0.11	1.35	1.51	87.88
1984	99.94	-2.21	1.10	2.44	0.49	-6.25	81.63
1985	76.63	-23.31	-1.79	-7.25	0.92	-15.20	66.44
1986	96.82	20.19	1.52	-4.59	-0.76	24.01	90.45
1987	108.10	11.28	1.72	17.77	0.15	-8.35	82.09
1988	117.30	9.21	0.91	-4.55	2.26	10.59	92.68
1989	98.54	-18.76	0.26	-2.42	0.55	-17.16	75.52
1978 - 80	80.08	-2.56	0.52	-2.04	0.81	-1.84	97.16
1981 - 85	93.97	-3.14	0.41	0.12	1.94	-5.61	82.45
1986 - 89	105.19	5.48	1.11	1.55	0.55	2.27	85.18
1978 - 85	88.76	-2.92	0.45	-0.69	1.51	-4.20	87.97
1981 - 89	98.96	0.69	0.72	0.76	1.32	-2.11	83.67
1978 - 89	94.24	-0.12	0.67	0.06	1.19	-2.04	87.04

Sugar cane

	Output	Output growth	Output increase due to				TFP indices
			Capital	Labour	Land	TFP	
1977	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1978	105.71	5.71	-3.01	-6.47	-0.23	15.42	115.42
1979	57.63	-48.08	-2.73	-5.51	0.27	-40.11	75.31
1980	82.94	25.31	4.36	2.30	0.12	18.52	93.83
1981	117.81	34.87	14.98	10.60	-0.10	9.40	103.23
1982	91.42	-26.39	-0.22	1.49	-0.52	-27.14	76.10
1983	89.85	-1.57	0.57	-3.91	0.04	1.73	77.82
1984	94.22	4.37	-0.50	1.03	0.02	3.83	81.65
1985	90.64	-3.58	1.45	0.92	0.09	-6.03	75.62
1986	92.11	1.46	0.82	0.13	-0.01	0.53	76.15
1987	101.52	9.42	5.79	3.36	0.04	0.23	76.38
1988	131.71	30.19	3.78	7.43	-0.15	19.14	95.52
1989	119.70	-12.01	1.28	2.91	-0.28	-15.92	79.59
1978 - 80	82.09	-5.69	-0.46	-3.23	0.05	-2.06	94.85
1981 - 85	96.79	1.54	3.25	2.02	-0.09	-3.64	82.89
1986 - 89	111.26	7.26	2.92	3.46	-0.10	0.99	81.91
1978 - 85	91.28	-1.17	1.86	0.06	-0.04	-3.05	87.37
1981 - 89	103.22	4.08	3.10	2.66	-0.10	-1.58	82.45
1978 - 89	97.94	1.64	2.21	1.19	-0.06	-1.70	85.55

Maize

	Output	Output growth	Output increase due to				TFP indices
			Capital	Labour	Land	TFP	
1977	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1978	154.39	54.39	13.21	14.23	4.07	22.87	122.87
1979	175.01	20.62	21.93	8.62	-11.16	1.24	124.11
1980	164.33	-10.68	1.79	-21.68	-6.98	16.19	140.31
1981	183.75	19.42	18.52	17.10	4.22	-20.42	119.89
1982	163.82	-19.94	15.76	-0.35	-6.84	-28.51	91.38
1983	190.83	27.01	3.33	8.26	-4.71	20.13	111.50
1984	224.04	33.22	15.43	5.68	-0.44	12.55	124.05
1985	259.51	35.46	17.44	22.73	-6.86	2.16	126.20
1986	223.68	-35.83	4.34	-13.25	-9.34	-17.59	108.62
1987	126.90	-96.78	-11.35	-23.20	1.39	-63.63	44.98
1988	192.31	65.41	-0.12	7.68	5.74	52.11	97.09
1989	180.35	-11.96	2.57	4.49	-3.80	-15.21	81.88
1978 - 80	164.58	21.44	12.31	0.39	-4.69	13.44	129.10
1981 - 85	204.39	19.04	14.10	10.68	-2.92	-2.82	114.60
1986 - 89	180.81	-19.79	-1.14	-6.07	-1.50	-11.08	83.14
1978 - 85	189.46	19.94	13.43	6.82	-3.59	3.28	120.04
1981 - 89	193.91	1.78	7.32	3.24	-2.29	-6.49	100.62
1978 - 89	186.58	6.70	8.57	2.53	-2.89	-1.51	107.74

Soya beans

	Output	Output growth	Output increase due to				TFP indices
			Capital	Labour	Land		
1977	100.00	0.00	0.00	0.00	0.00	0.00	100.00
1978	150.75	50.75	8.55	-0.11	1.89	40.43	140.43
1979	84.16	-66.59	-38.03	-5.91	0.37	-23.03	117.40
1980	82.48	-1.68	16.36	2.27	-1.54	-18.77	98.63
1981	105.44	22.96	6.02	-1.82	0.56	18.19	116.83
1982	111.76	6.32	2.60	-1.09	0.05	4.76	121.59
1983	139.54	27.78	27.27	3.63	-0.12	-2.99	118.60
1984	185.12	45.58	31.36	0.40	1.67	12.16	130.76
1985	226.73	41.61	35.11	1.80	1.85	2.86	133.62
1986	259.68	32.95	39.92	3.63	2.05	-12.66	120.96
1987	248.35	-11.33	59.64	2.64	1.98	-75.59	45.37
1988	354.43	106.08	11.67	2.56	2.61	89.23	134.61
1989	449.51	95.08	6.14	8.13	1.69	79.12	213.73
1978 - 80	105.80	-5.84	-4.37	-1.25	0.24	-0.46	118.82
1981 - 85	153.72	28.85	20.47	0.58	0.80	7.00	124.28
1986 - 89	327.99	55.69	29.34	4.24	2.08	20.03	128.67
1978 - 85	135.75	15.84	11.15	-0.11	0.59	4.20	122.23
1981 - 89	231.17	40.78	24.41	2.21	1.37	12.79	126.23
1978 - 89	199.83	29.13	17.22	1.34	1.09	9.48	124.38

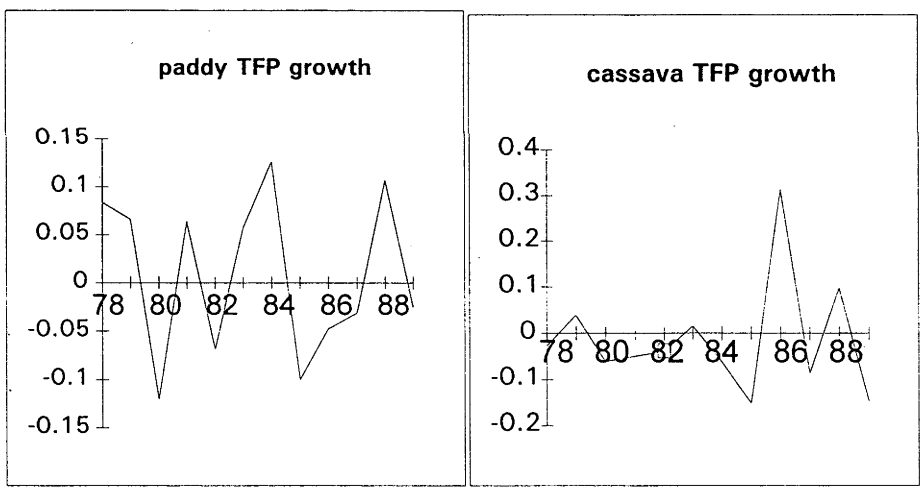
Source Author's calculations

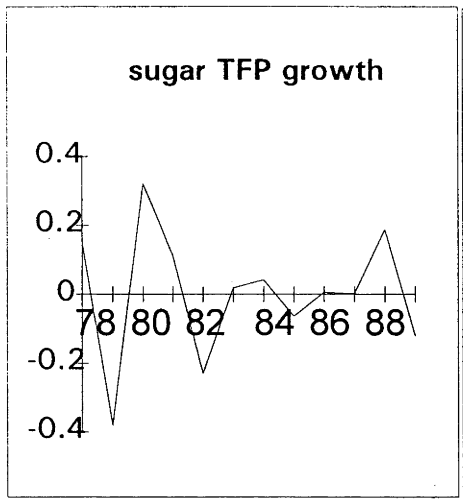
Table A6.4
Usage of soya beans, 1977 - 89

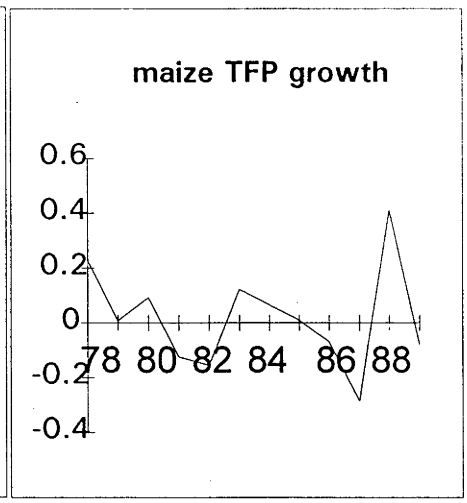
	Seeds		Direct consume		Extracted Industry	
	million tonnes	per cent	million tonnes	per cent	million tonnes	per cent
1977	44.5	3.8	323.5	27.5	893.0	67.7
1980	47.6	4.1	150.0	12.8	943.0	80.3
1983	54.5	4.8	439.7	38.8	629.5	55.5
1986	106.7	3.1	585.2	17.2	2,682.5	79.0
1989	175.5	3.4	778.9	15.1	4,213.7	81.5

Source Suthad Setboonsarng, 1990. "Protection rate of soya bean industry", *Thammasat Economic Journal*, 8 (3): 59-88 (in Thai).

Figure A6.1
TFP growth of 5 crops




sugar TFP growth
0.4
0.2
0
-0.2
-0.4
78 80 82 84 86 88


maize TFP growth
0.6
0.4
0.2
0
-0.2
-0.4
78 80 82 84 86 88

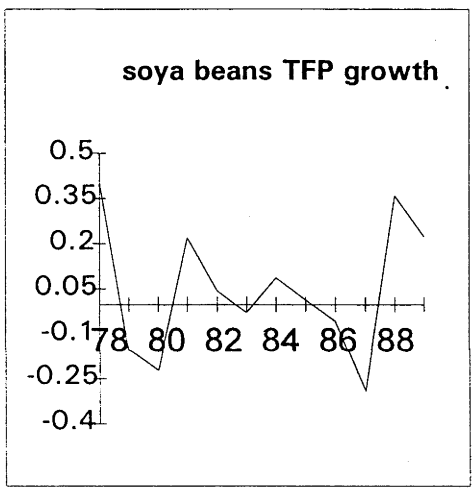
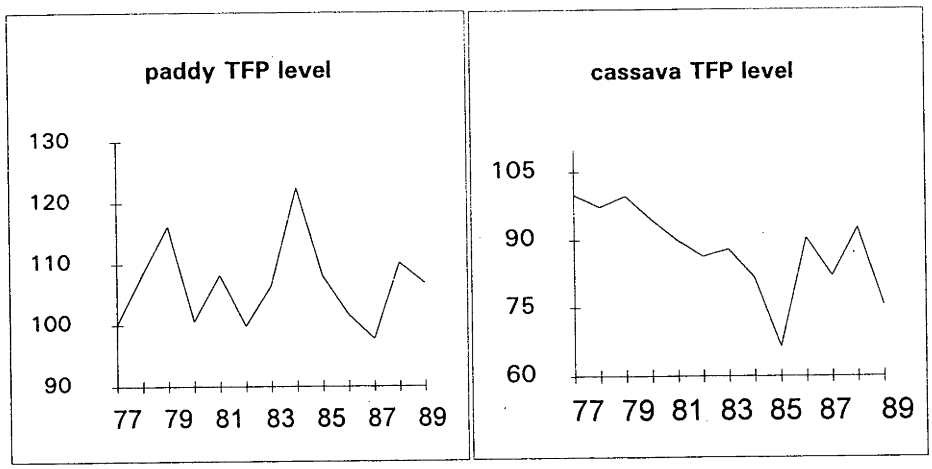
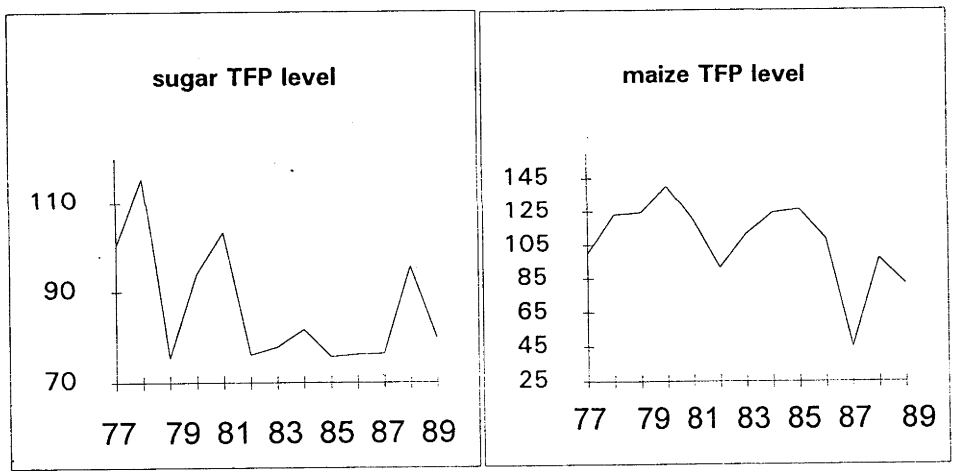
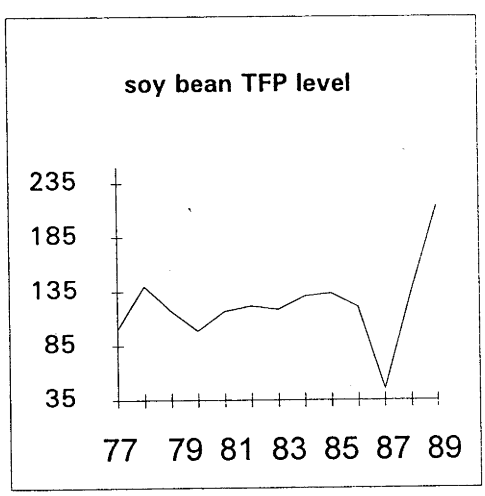

soya beans TFP growth
0.5
0.35
0.2
0.05
-0.1
-0.25
-0.4
78 80 82 84 86 88

Figure A6.2
TFP level of 5 crops







7 Factors affecting TFP growth

An explanation of economic growth will not be satisfactory if the rate of TFP growth is treated as an exogenous factor; that is, as an unexplained or residual term or natural drift of the system. Recent endogenous growth models differ principally according to whether they emphasize returns to physical investment, returns to investment in education and skills, learning by doing or returns to the stock of knowledge (Dowrick 1992). In addition, most new endogenous growth models also permit assumptions of increasing returns to scale, spillover effects and monopolistic competition such as in Romer (1986, 1990a and 1990b). However, Jones and Manuelli (1990) show that increasing returns to scale are not a necessary and sufficient condition for endogenous growth. Other studies have also focused on endogenous growth and endogenous technological progress, for example Baranson (1970), Mansfield (1980), Griliches and Lichtenberg (1984), Adams (1990), Grossman and Helpman (1990), Rebelo (1991) and Lucas (1988, 1993).

For Thailand, Kitti (1988b) estimated TFP growth and sources of growth in Thailand. Demand side study using input - output analysis was also undertaken as a multisectoral framework similar to Chenery, Robinson and Syrquin (1986). The study found that manufacturing growth has been led by outward - oriented strategy and liberalized trade regime. However, the framework was dealt with output growth decomposition other than decomposition of factors influencing TFP growth.

Brimble (1987) analyzed the components of the decomposition of TFP growth in manufacturing industries in Thailand. The model followed that in Nishimizu and Page (1982) where TFP growth was described as "TFP growth equals technological progress plus change in the level of technical efficiency plus residual due to differences between frontier output elasticities and observed factor share". The result showed that, for all industries studied, TFP growth of 3.86 per cent during period of the study (1975 - 83) can be decomposed of which technological progress (2.96 per cent), change in technical efficiency (-0.05 per cent) and residual (0.95 per cent).

Paitoon (1985) compared TFP growth of the import - competing industries and exporting industries during 1963 - 79, however, the study did not decompose TFP growth. He found that TFP growth of protected import - substituting industries on average was much lower than that of non - import - competing and exporting industries.

An in-depth analysis of all the causes of TFP growth would require a highly sophisticated model and more data than are available. The study of factors affecting TFP growth is similar idea to the endogenous growth approach. Within the scope of this thesis, only some major factors concerning competition and liberalization are analyzed and discussed empirically. The factors affecting TFP growth are postulated to have resulted from a combination of two major influences: advances in technology both domestically and from abroad and changes in the competitive environment (competitiveness, market structure and organization).

Advances in technology

Advances in technology - knowledge factor of growth - can occur in several ways, including research and development (R&D) that provides local inventions and innovations and licensing agreements and transfer of technological knowledge through plants and equipment mainly through foreign direct investment. In this study, two sources of technological advance are discussed: internal technological knowledge or R&D and external technological knowledge. External technology can be obtained from many sources including foreign direct investment, patents and licensing agreements. Because of unavailability of data on many of these methods of technology transfer, only foreign direct investment is discussed.

Research and development (R&D)

To understand the relationship between R&D and technological progress via growth, R&D activity should be treated as a direct input into the production process. Some research has examined the importance of R&D for output growth, while other research has focused on R&D and productivity growth.

Much research has shown the contribution of R&D to output growth. Griliches (1964) studied research expenditure, education and the aggregate agricultural production function in the United States. He explicitly introduces the level of public expenditure on agricultural research and extension per farm into the Cobb Douglas production function. The study indicates that this expenditure was statistically significant with a coefficient of 0.05, indicating that a doubling of R&D expenditure per farm would raise output by 5 per cent. This shows a large absolute effect of R&D on output growth. Mansfield (1968) studies industrial research and technological change. He uses a Cobb-Douglas production function and assumes that R&D expenditure, as an input, grew exponentially over time. He experiments with embodied and disembodied models and also finds that R&D expenditure was important, but the rate of return to R&D expenditure that he derives is smaller than that found by Griliches.

Other studies have also found that R&D expenditure is an important explanatory variable in cross-industry differences in productivity growth (Nelson 1981). Mansfield (1980) studies inter-industry differences in productivity growth in the United States. Research and development is disaggregated into two types: basic R&D and applied R&D. By using production functions, the rate of TFP growth is derived as a function of industry's expenditures on basic research and applied research in relation to value-added. A highly significant relationship was obtained.

To date, empirical studies have not, however, been able to identify a significant relationship between a country's output growth and the proportion of resources it devotes to R&D. One explanation for this may be that the results of R&D eventually become international commodities which can be borrowed or purchased (Kennedy and Thirlwall 1972). A country which undertakes only a small amount of R&D can compensate by purchases from abroad. Hence expenditure on purchases of technology from abroad should be included in any study of the impact of technology on output growth.

Other studies which have found a positive relationship between R&D, growth and productivity growth include Adams (1990), Griliches (1964), Griliches and Lichtenberg (1984), Kakazu (1990), Mansfield (1966, 1980, 1984) and Terleckyj (1980).

There is no unique measure for the impact of R&D activity on growth. In this study, R&D expenditure is estimated as the ratio of government R&D expenditure to value added as a proxy for the total amount an economy invests to improve technology in each sector. This data is used because there is very limited data on R&D in Thailand. Only government R&D expenditure is available and those data are only for a limited period and range of activities (1979 - 86 in 5 sectors). R&D expenditure by the government is usually a major part of R&D expenditure in developing economies. In Thailand, accordingly, private spending on R&D was only 7 per cent of the country's total R&D expenditure (Thailand Development Research Institute 1991).

Foreign direct investment

The transfer of technology from the international pool is the way that developing economies 'catch up' technologically. Most of this transfer occurs implicitly in the 'catching up' stage of development through product and production adaptation in the private sector. In addition, at the margin foreign direct investment plays an important role in technology acquisition (Pavitt 1974). Thailand has acquired technology from joint ventures with Japan and the United States, these being the most important sources of foreign investment (Kakazu 1990). Japanese investment is concentrated in food, textiles, light electrical machinery and appliances and transport equipment while technology transfers from the United States have been concentrated in chemical products, weaving, apparel and services (Chapter 2).

Foreign direct investment adds technological and skills, and assists in innovations in products and production techniques. Technical assistance may also be provided to suppliers and customers of the foreign enterprises. The training of labour often benefits other employers as workers leave foreign owned enterprises.

Mingsarn (1977) finds that foreign direct investment was a main source of technology in the Thai textile industry. Typically, she finds that the relatively high productivity and profitability of foreign firms is attributable more to management than capital equipment inputs. Jeerasak, Wisarn, Somjai, Pipat and Duangmanee (1989) finds that a certain amount of technology transfer is made by foreign investors in the form of training. Kakazu (1990) finds in a study of industrial technology capabilities in Asian

countries that foreign investment through joint ventures has been a major method of technology acquisition in Thailand.

The transfer of technology through direct foreign investment is not automatic. High protection and associated incentives may so distort prices that the technology transferred is inappropriate to a country's factor proportions. Foreign investors are not encouraged to adapt technology or to train local staff. They often become monopolists or oligopolists. These trends were evident when foreign direct investment in Thailand was predominantly in import substitution in the 1970s.

In this study, foreign direct investment would be expected to make a positive contribution to TFP growth as foreign enterprises usually have more advanced production technology than do domestic enterprises. Normally, foreign enterprises are at a disadvantage because they have limited information about the local market, environment, tastes and customs, compared to local firms. If foreign enterprises exist in the local market, this implies that other factors lower their production costs below those of local enterprises and raise their products' quality.

This study uses time-series data on net foreign direct investment expenditure classified by sector to measure the influence of foreign direct investment on TFP growth. Owing to data limitations, the study only include some sectors. So that this net expenditure is comparable with the other variables studied and across sectors, it is divided by sectoral value-added. A high ratio of foreign direct investment relative to sectoral value-added should have a positive relationship with TFP growth.

The competitive environment

The competitive environment of sectors/industries also affects TFP growth. Competition motivates industry to improve the efficiency and productivity of its operation. The competitive environment includes the existence of government protection, exports, market structure (measured in this study by concentration of industry) and organization (a part of effect from quality of human resource).

Trade protection: a disincentive to improving technology

It is sometimes argued that low product prices may retard innovation and consequently, growth of productivity due to investment being less profitable (the inverse U-shaped relationship). This hypothesis argues that, at low output prices, technological change is likely to be slower and maximum growth cannot be achieved, although marginal productivity of inputs is likely to be higher (Meer and Yamada 1990). Higher levels of profitability are likely to induce the development of better techniques. This positive relationship, however, is likely to be the case for a new crop or industry, like soya beans (Chapter 6), but after a point the relationship is likely to be negative.

A more general hypothesis suggests that high protection causes a degree of monopoly power because of barriers against imports so that producers do not have the incentive or necessity to develop technology. Prices that are above internationally competitive levels make producers less thrifty and less innovative as they enjoy excess profits. A competitive market encourages firms to utilize efficient techniques of production. Plant scale of firms in a competitive market are not too small or lack the profitability to improve technology or invest in research and development. Invention effort will normally be optimized by competition.

The effective rate of protection (ERP) is used as an indicator of protection in this chapter. The ERP of 111 traded manufacturing goods (Paitoon, Rachain and Nattapong 1989) is used to estimate the weighted average ERP of the thirteen industries studied (Table 7.1). The weights given to the ERP of each good are based on their value of exports, imports, and the arithmetic mean of export and import values. Paitoon et al. (1989) suggested using export and import values as the weights as there are no available data on the value of domestic consumption available. Exported and imported products are treated as heterogeneous products in this approach. Use of exports and imports as weights, should not lead to results that are different from those obtained by using value-added as weights, as values of exports and imports are highly correlated with value-added.

Table 7.1

The average ERP for thirteen industries, 1981, 1984 and 1987

	Average ERP		
	1981	1984	1987
Printing and publishing	-0.0250	-0.0190	0.0220
Food	-0.0097	0.0051	0.0552
Rubber and plastic products	0.0312	0.0277	0.0179
Petroleum refineries and miscellaneous petrochemicals	0.0441	0.0639	0.0070
Textiles, leather and footwear	0.0714	0.1057	0.1684
Electrical machinery and supplies	0.1042	0.1181	0.1378
Non-metallic products	0.1123	0.0920	0.1060
Beverage and tobacco	0.1384	0.1604	0.2222
Metallic products	0.1494	0.1402	0.2305
Wood, paper and furniture	0.1460	0.2491	0.2516
Industrial chemicals and other chemicals	0.2265	0.3020	0.3570
Machinery	0.2388	0.2882	0.3549
Transport equipment and vehicles	0.1902	0.4371	1.9202

Source Author's calculations

Exports: a driving force for competition

Empirical studies suggest that exports contribute more to gross domestic product growth than the increases in export earning would suggest. Countries that have adopted outward-oriented policies benefit because resources shift from the less efficient non-exporting sectors to higher productivity export-oriented sectors and from the beneficial externalities generated by the export sector (Feder 1982).

In recent years the hypothesis that a rapid growth of exports accelerates economic growth has been widely discussed and tested. On a theoretical level, there are three distinct approaches to explaining the relationship between export expansion and growth. The first approach points out the benefits from the expansion of exports which enables producers to capture scale economies. The second approach highlights competitive forces; if domestic markets are protected, export expansion will introduce more competition. This means that export expansion leads to more efficient operations and higher productivity. The third approach argues that growth can also result from positive intersectoral externalities generated by the higher productivity of the export sector. This approach raises the possibility that marginal factor productivities may be higher in export than in the non-export sectors of the economy. Exports also remove balance of

payments constraints increasing economy's ability to import the raw materials and capital necessary for the expansion of production.

Krueger (1980) tested three major hypotheses relating to growth performance and exports. The first hypothesis was concerned with characteristics such as minimum efficient plant size, benefits from increasing returns to scale, indivisibility in the production process and the necessity for competition. The second hypothesis postulated that inefficiencies in the ways in which import-substitution policies were administered led to low growth. The third hypothesis argued that export-oriented policies encouraged the allocation of resources to move closer to the optimum. Free trade results in equalization of the domestic and international marginal rates of transformation; this will not be the case under an import substitution regime. Krueger concluded that all of these hypotheses contain elements of the truth.

Balassa (1983) also concludes that an export orientation makes a major contribution to economic growth. He argues that export orientation enables gains to be made from international specialization, the utilization of economies of scale, high capacity utilization and stimulation of technological advance. A large volume of empirical evidence supports the hypothesis that exports are favourable for economic growth including studies by Balassa 1978, Michaely 1977, Heller and Porter 1978, Tyler 1981, Kavoussi 1984, Jung and Marshall 1985, Ram 1987, Atchana and Teerana 1989, Chen and Tang 1990 and Alam 1991.

This study, however, is concerned with the effect of export growth on TFP growth. It focuses on whether exports promote TFP growth via their effects on competition. International competition is expected to force firms to cut costs, improve productivity, seek new techniques of production and improve product quality and lower prices. Exporting firms also often benefit from technology transfer from abroad through production engineering advice and aid in product design and marketing.

Table 7.2

Exports (local constant 1972 prices) to value-added ratios,1970 - 89

per cent per annum

	Exports per value added
Metallic products	1.18
Electrical machinery and supplies	1.03
Food	0.71
Machinery	0.37
Textiles, leather and footwear	0.36
Rubber and plastic products	0.36
Wood, paper and furniture	0.29
Industrial chemicals and other chemicals	0.22
Non-metallic products	0.18
Printing and publishing	0.04
Petroleum refineries and miscellaneous petrochemical products	0.04
Transport equipment and vehicles	0.03
Beverages and tobacco	0.002

Sources calculated from International Economic Data Bank, The Australian National University, Canberra.

The values of exports from thirteen industries are calculated in local currency (baht) at constant 1972 prices and are divided by value added in local currency at constant prices to estimate the ratio of exports to value added from 1970 to 1989. The resulting ratios of average exports-value added are presented in Table 7.2.

Market structure

Monopoly power exists when a firm, or a few firms, control a large amount of industry output. A concentration ratio indicates how much output is controlled by the few largest firms. Industrial concentration can be measured in various ways (Ellis 1976, Rothwell and Zegveld 1982, Shepherd 1985 and Martin 1988). This study uses a concentration ratio where a large size firm is defined as employing 100 or more people.

Data available from the National Statistical Office for industrial and business establishments in 1970 and 1984, enable the calculation of a concentration ratios for the large firms in each of the thirteen industries. The results were as follows (Table 7.3).

Table 7.3

The concentration ratio of thirteen industries, 1970 and 1984

	Concentration ratio	
	1970	1984
Machinery	2.86	6.76
Food	5.66	18.12
Textiles, leather, and footwear	6.69	11.48
Rubber and plastic products	10.53	12.87
Printing and publishing	12.32	3.70
Industrial chemicals and other chemicals	13.24	12.27
Wood, paper and furniture	16.32	7.22
Non-metallic products	17.24	10.16
Metallic products	20.05	2.86
Transport equipment and vehicles	23.08	7.66
Electrical machinery and supplies	29.73	13.41
Beverages and tobacco	31.04	24.69
Petroleum refineries and miscellaneous petrochemical products	50.00	22.50

Source Author's calculations

The concentration ratio for 9 out of 13 industries declined over this period. In other words, in 1984 there were more small and medium scale firms in most industries than in 1970. This is a sign of greater competition, possibly a result of greater exposure to external competition, but also results from demand growth and the absence of severe barriers to entry to industries in Thailand.

Industrial organization and management

Organization and management of both sectors and industries is another important aspect of the competitive environment affecting TFP growth. Factors that explain why one firm adopts new techniques more rapidly than another include higher than expected profitability (due for example to strong product demand), lower costs of technology adoption, the age of the firm's existing capital stock and the level of industrial concentration. Mansfield (1968) shows that interfirm variations in the costs of adoption and prices of output affected the rate of adoption of new techniques. This is due to variations in the ability, age and education of managers and workers, barriers to adoption such as patents, geographic location, inertia and uncertainties about the outcome of new techniques (Baranson 1966).

The data for ERP, export-value added ratios and concentration ratios are available for the thirteen industries basis, but the data for technological advance variables (R&D and foreign direct investment) are available only for five economic sectors. The differing degree of data aggregation means that not all variables can be included in the same equation. The study, therefore, uses two separate set of equations, in a main model and sub-model. The main model includes technological advance (R&D and foreign direct investment) and a proxy for the competitive environment (dummy variables for five sectors are used to proxy the difference in the competitive environment for each sector). The dummy variables for each sector should capture the effects of all variables for the different competitive environment. The sub-model is used to examine the effect of the environment factor on TFP growth in more detail. It is used to test the relationship between TFP growth and the three competitive environment variables (ERP, the export-value added and concentration ratios) by regression across cross-section data (thirteen industries)[1].

Agriculture, mining and quarrying, manufacturing, transportation, and commerce and finance, are used to estimate the main model. The main model is shown in Equation (7.1). Details are provided in Appendix Section 7.1.

$$\dot{TFP} = \beta_0 + \beta_r R + \beta_f F + \beta_{AG} D_{AG} + \beta_{MQ} D_{MQ} + \beta_{MF} D_{MF} + \beta_{TC} D_{TC} \quad (7.1)$$

1 There may be a problem of a biased estimator resulting from excluding relevant variables in the regression of this sub-model. However, under the data limitations, the absolute size of impacts of these three variables are not of as much interest as their signs and the significant results of the test, so that the study can confirm the hypothesis of their impacts on TFP growth.

where

$\dot{TFP}$ is TFP growth (per cent)

R is industry R&D expenditure (million baht) per unit value added (million baht)

F is net flow of foreign direct investment (million baht) per unit value added (million baht)

D_{AG}, D_{MQ}, D_{MF}, D_{TC} = Dummy variables for agriculture; mining and quarrying; manufacturing; and transportation

The base case (when all dummy variables are zero) is therefore the commerce and finance sector

Since data is only available for eight years (1979 - 86), the study used panel data estimation, pooling time series across the 5 sectors (more details in Chapter 6). The results are in Table 7.4.

The hypothesis, H_{01}, that the intercept is the same across sectors is tested. The F_1-statistic from the estimation cannot reject the null hypothesis of common intercept.

Table 7.4
Estimation results of factors affecting TFP growth

TFP growth of the agricultural sector using the results of the model without the fertilizer variable

$\hat{\beta}_0$	$\hat{\beta}_r$	$\hat{\beta}_f$	$\hat{\beta}_{AG}$	$\hat{\beta}_{MQ}$	$\hat{\beta}_{MF}$	$\hat{\beta}_{TC}$
-0.0243	4.2656	1.9497	0.0073	-0.1081	-0.0214	0.0250
(-3.1776)*	(4.4745)*	(4.2485)*	(0.8635)	(-4.1921)*	(-2.3523)*	(1.8037)*
0.0000	0.3521	0.8591	0.0708	-1.0459	-0.2074	0.2421
F_1-statistic (28, 5) = 0.0315, R^2 = 0.7649						

TFP growth of the agricultural sector used the result of the model including the fertilizer variable

$\hat{\beta}_0$	$\hat{\beta}_r$	$\hat{\beta}_f$	$\hat{\beta}_{AG}$	$\hat{\beta}_{MQ}$	$\hat{\beta}_{MF}$	$\hat{\beta}_{TC}$
-0.0221	3.8947	1.7903	0.00826	-0.1023	-0.0224	0.0216
(-2.9053)*	(4.5079)*	(4.0429)*	(0.9156)	(-3.9821)*	(-2.5027)*	(1.5946)**
0.0000	0.3155	0.7740	0.0784	-0.9711	-0.2128	0.2050
F_1-statistic (28, 5) = 0.03256, R^2 = 0.7621						

Note numbers in brackets are t-ratios

F_1-statistic is the test of whether the intercept and the slope coefficients are the same across sectors (H_{01}) (more detail in Chapter 6)

Standardized coefficients are presented in the highlighted box

* means 5 per cent level of significant (one tailed test) and ** means 10 per cent level of significant (one tailed test)

Source Author's calculations

The results from both specifications show that R&D and foreign direct investment have a positive impact on TFP growth. The substantial effect of R&D and foreign direct investment on TFP growth (4.3 and 1.9) indicates the policy importance of providing both R&D and foreign direct investment in encouraging TFP growth. To compare the influence of a unit of R&D expenditure and a unit of foreign direct investment on TFP growth, the standardized coefficients should be used to compare due to the difference in size and arbitrary measurement scale of dummy variables (Younger 1979). The standardized regression coefficient provides unitless measure of the effects of independent variables on dependent variable. The results show (in the highlighted box) that the standardized coefficient of foreign direct investment is higher than that of R&D.

The different signs and sizes of the coefficients of the dummy variables also show that sectoral differences have a significant effect on TFP growth in all sectors. In agriculture, the coefficient on the dummy variable (D_{AG}) was not significant implying that sector specific influences for the agricultural sector were approximately the same as those for the commerce and finance sector, whose size is given by intercept, β_0. The negative and significant coefficients in mining and manufacturing, β_{MQ} and β_{MF}, compared with agriculture and transportation may indicate the difference in the competitive environment of these sectors, due to, for example higher protection, higher concentration and greater rigidity and complexity of organizational structure of these sectors.

The significant intercept (β_0 or 'm' in Section 7.1 Equation (4) Appendix CH 7) indicates that some other factors excluded from the model also determine TFP growth (assuming their effects are fixed).

Owing to the data of variables concerning competitive environment factors are not available such that they can be included in the same (main) model above, the study used dummy variables to proxy for the competitive environment. While the data of variables proxied for competitive environment, especially ERP and CON defined below, are available across industries with only on some years, the data of variables in the main model are available across sectors. The sub-model of the relationship between TFP growth and the three competitive environment variables (ERP and the export-

value added and concentration ratios) is derived and estimated separately from the main model using cross-section data (13 industries) as shown in Equation (7.2) (Appendix CH 7 Section 7.1 for details of the estimated equation and units of variables included).

$$TFPGR_{85} = \alpha + \beta_p CHERP + \beta_x XGR_{84} + \beta_c CHCON \qquad (7.2)$$

where

$TFPGR_{85}$ = the TFP growth of industries in the year 1985 (per cent)

CHERP = the average change in ERP per annum

$$= \frac{\ln(ERP\,84) - \ln(ERP81)}{3} \text{ (per cent)}$$

XGR84 = the export growth of industries in the year 1984 (per cent)

CHCON = the average change in the concentration ratio of industries between 1970 and 1984 $= \frac{\ln(CON\,84) - \ln(CON\,70)}{14}$ (per cent)

The results from the estimation of Equation (7.2) are presented in Table 7.5.

Table 7.5

Estimation results of the relationship between TFP growth and three major competitive environment variables for thirteen industries

	$\hat{\alpha}$	$\hat{\beta}_p$	$\hat{\beta}_x$	$\hat{\beta}_c$
Coefficient	-0.0491	-5.5082	0.0934	-0.4651
t-ratio	(-1.5503)**	(-5.0328)*	(2.5820)*	(-1.1254)
$R^2 = 0.6713$, n = 13				

Source Author's calculations

The estimation results in Table 7.5 indicate that the two variables, the change in protection (CHERP) and export growth have a significant impact on the TFP growth in the 13 industries. However, the coefficient of change of industrial concentration (β_C) was not significant at 5 per cent level. This was probably because the variable CHCON (based on firms which employ more than 100 persons) was not a good measure for monopoly power in the market. A better measure of monopoly power may be the share of output produced by the largest few firms (for example four) in each industry, unfortunately there was no data available to measure this.

As expected, the CHERP (protection) and the concentration ratio have a negative impact on TFP growth while export growth had a positive impact on the TFP growth. This confirms the impact of these three major aspects of the competitive environment on TFP growth. The coefficient of determination (R^2) of the estimation of Equation (7.3) is 0.6713. This may indicate that some of the other factors examined (technological advance and sector-specific organizational factors of the competitive environment) also influence TFP growth.

However, given the year by year variation in TFP growth, it would be more satisfactory to test by using average TFP growth over the period of 1981 - 85. The results are presented in Table 7.6 with similar sign but different size of coefficients of variables in the equation, compared to Table 7.5.

Table 7.6

Estimation results of the relationship between TFP growth and three major competitive environment variables for thirteen industries, using average TFP growth

	$\hat{\alpha}$	$\hat{\beta}_p$	$\hat{\beta}_x$	$\hat{\beta}_c$
Coefficient	-1.2517	-100.5602	4.0719	-13.4669
t-ratio	(-1.2586)	(-2.9275)	(3.5859)	(-1.0384)
$R^2 = 0.5492$, n = 13				

Source Author's calculations

Appendix CH 7

7.1 Factors affecting TFP growth

The main model

The model used here is adapted from that employed by Mansfield (1980). It is assumed that the two major sets of factors which affect TFP growth are technological advance and a competitive environment. Technological advance includes Research and Development and Foreign Direct Investment The competitive environment was described by such measures as the effective rate of protection (ERP), the role of exports, concentration ratios, and industrial aspects of the managerial structure of sectors or industries. Owing to limits on data available, the study used dummy variables as proxies for the competitive environment in the main model Equation (4) below. A more detailed examination was then made of the relationship between TFP growth and three other major variables in the competitive environment: ERP, the export-value-added ratio, and the concentration ratio. This relationship was estimated in the sub-model outlined in Equation (7).

A Cobb-Douglas production function is used for all sectors and industries in Chapters 4 and 5. Using the endogenous technological change approach, the unexplained term (or TFP) will no longer be exogenous. The hypothesis of endogenous technological progress due to advances in technology and improvement in the competitive environment can be incorporated in the production function as in Equation (2).

$$y_t = A(t)\, f(K_t, L_t) \qquad (1)$$

where

A(t) endogenous technological progress

$A(t) = Ae^{(m+s_j)t} SR^{\gamma_r} SF^{\gamma_f}$

s_j is the effect of the structure of the competitive environment (later proxied by a dummy variable) which is assumed to be fixed (constant) for each of the j sectors. This factor, therefore, affects in part the vertical shift of the production function (1).

Equation (1) is equivalent to Equation (2).

$$y = Ae^{(m+s_j)t} SR^{\gamma_r} SF^{\gamma_f} K^{\alpha_k} L^{\alpha_L} \qquad (2)$$

where

y is value-added at constant prices (million baht)

SR is the stock of research and development (million baht)

SF is the stock of foreign direct investment (million baht)

K is the capital stock (million baht)

L is employed labour (persons)

Taking the logarithm of Equation (2) and the partial derivative with respect to time 't', then rearranging yields

$$TFP = m + \beta_r \frac{\partial SR}{\partial t}\frac{1}{y} + \beta_f \frac{\partial SF}{\partial t}\frac{1}{y} + s_j \qquad (3)$$

where

TFP = TFP growth (per cent)

$\beta_r = \partial y/\partial SR$ = marginal output of research and development **input** (stock of R&D)

$\beta_f = \partial y/\partial SF$ = marginal output of foreign direct **capital**

The study assumes that an industry's expenditure on research and development capital during year t is approximately equal to that year's change in the industry's

stock of research and development capital. In other words, it is assumed that depreciation of research and development capital is small and the lag in the effect of investment is small (Mansfield 1980). One of the reasons for making this assumption is that there is little information about the length of the relevant lags.

Hence,

$\frac{\partial SR}{\partial T}\frac{1}{Y}$ is proxied by industry's research and development **expenditure** (million baht) per unit of value-added (million baht) = R

$\frac{\partial SF}{\partial t}\frac{1}{y}$ is proxied by net flow of foreign direct **investment** (million baht) per unit of value-added (million baht) = F

The effect of the structure of the competitive environment (s_j) was captured by use of dummy variables for industries. They are D_{AG}, D_{MQ}, D_{MF}, D_{TC} for agriculture, mining and quarrying, manufacturing, and transportation respectively. The base case refers to the commerce and finance sector.

The estimating equation can, therefore, be written as

$$\dot{TFP} = m + \beta_r R + \beta_f F + \beta_{AG} D_{AG} + \beta_{MQ} D_{MQ} + \beta_{MF} D_{MF} + \beta_{TC} D_{TC} \quad (4)$$

Here, 'm' or 'β_0' may be thought of as the effect from other factors (assumed fixed).

The sub-model

The sub-model examines in more detail the effect of the competitive environment on TFP growth. This analysis is undertaken separately as the data on the all variables concerned do not cover the same period of time and are not at the same level of aggregation. While the main model was estimated for sectors, the data for the sub-model was only available at the industry level for different years.

The production function is of the Cobb-Douglas form as shown in Equation (2). But the assumption underlying here are little changed with the introduction of three major variables representing the structure of the competitive environment into the model. Earlier, s_j, or the effect of the structure of the competitive environment was assumed to be fixed (constant) for each industry j. Production is now affected by the three major environment components as well, that is, protection (ERP), exports (X) and concentration ratio (CON).

The model can be written as in Equation (5)

$$y = Ae^{mt} sSR^{\gamma_r} SF^{\gamma_f} K^{\alpha_k} L^{\alpha_L} \tag{5}$$

where

$$s = f(ERP, X, CON) = A_s ERP^{\beta_P} X^{\beta_X} CON^{\beta_C}$$

A_S is fixed and should capture the organizational effect of the competitive environment

Hence, Equation (5) can be written as

$$y = A_0 e^{mt} ERP^{\beta_P} X^{\beta_X} CON^{\beta_C} SR^{\gamma_r} SF^{\gamma_f} K^{\alpha_k} L^{\alpha_L} \tag{6}$$

Taking logarithm and differente with respect to "t", then rearrange. Equation (6) can be written for the relationship between TFP growth and structure of the competitive environment (s) for the sub-model as Equation (7) (by a similar process to that adopted for Equation (3)).

$$TFP = \beta_o + \beta_P CHERP + \beta_X XGR + \beta_C CHCON \tag{7}$$

where

CHERP represents changes in ERP (per cent). In this thesis it was estimated by (ln(ERP84-ln(ERP81))/3
XGR represents export growth (per cent)
CHCON represents changes (growth) in the concentration ratio (per cent), in this thesis it was estimated by (ln(CON84)-ln(CON70))/14
Here intercept (βo) is constant and should capture the other technological factors such as R&D and FDI

8 Conclusions

The importance of TFP growth and other sources of growth in Thailand

Thailand has been one of the fastest growing economies in the world during the last 30 years. Its growth rate has accelerated during the late 1980s and early 1990s. This study has sought to identify the main sources of growth in Thailand.

The study decomposes Thailand's growth into two sources, input growth and TFP growth. Eight major sectors are taken to be representative of the whole economy, but thirteen industries in manufacturing and five major crops in agriculture are also estimated and analyzed for sources of growth. Estimated output elasticity of capital, labour and land (for agriculture) from the estimated production functions are used as weights in the TFP growth estimation.

Both input and TFP growth have been the sources of economic growth in Thailand. Input growth made the greater contribution to growth in all sectors, industries and crops over the whole period studied, but its role has been declining, particularly in agriculture. TFP growth, on average over the period of study, of most of the sectors and industries are found insignificant, except for electricity and water, industrial chemicals and other chemicals, textile, leather and footwear, and non-metallic products. TFP growth has been distinctly higher with a more significant contribution to output growth in most sectors and industries during the high growth period of the late 1980s than in the previous two decades.

Sectoral TFP growth is found on average to be highest in electricity and water for the whole period of the study, while mining and quarrying on average have the lowest TFP growth. Agriculture has a rather low TFP growth (around 1 - 2 per cent per annum) but it is steady. While manufacturing has a high TFP growth, it fluctuates. All sectors, except services, have significantly higher TFP growth during 1986-89, the high growth period. The contribution of TFP growth to output growth is highest in agriculture (average 32.5 per cent for the whole period of the study). TFP growth is a major factor in increasing output in agriculture since input growth is limited. The other sectors showed that capital growth is the most influential factor for growth. Except for

services and electricity and water, TFP growth clearly increased its contribution to growth in all sectors in the late 1980s. TFP growth had declined in services and fluctuated in electricity and water. The TFP level is high in five sectors: agriculture; manufacturing; electricity and water; communication and transportation; and commerce and finance. The other TFP levels are lower.

Capital input is the most influential factor in growth in most industries, except beverage and tobacco, industrial chemicals and other chemicals, and transport equipment and vehicle. TFP growth is found to be highest in the industrial chemicals and other chemicals, while it is lowest in petroleum refineries and miscellaneous petrochemical products. TFP growth in the thirteen industries is quite large but fluctuated and it is significantly larger in most industries in the late 1980s, as is found consistently in the manufacturing sector. TFP growth share in output growth is highest in industrial chemicals and other chemicals (average 60.9 per cent) and lowest in petroleum refineries and miscellaneous petrochemical products (-38.5 per cent). The share of TFP growth in output growth is found to be clearly higher over the period of the study in most industries, except beverage and tobacco, printing and publishing, petroleum refineries and miscellaneous petrochemical products, and rubber and plastic products. Most industries are found to have higher TFP level from 1970 to 1989, particularly in the late 1980s, except in wood paper and furniture; printing and publishing, and petroleum refineries and miscellaneous petrochemical products.

Capital input is also the most influential factor for growth in the principal five crops. The share of the capital input contribution to output growth is highest in maize (63.7 per cent). For all five crops, TFP growth share in output growth is highest in paddy (32.3 per cent), while the contribution of labour for this crop clearly declined owing to negative employment growth. Farmers are apparently turning to other crops. Paddy and soya beans are two crops where the TFP level was higher while in cassava, maize and sugar cane, TFP levels are lower during the period of study.

While input growth plays the major role in determining growth, its influence has been declining. The population growth rate fell from 3.5 per cent per annum in the early 1970 to only 1.5 per cent per annum in 1990. Education and health are therefore essential to enhancing the contribution of labour to growth. Land expansion is limited.

Forest felling has been excessive. Some of the new farming land is inappropriate for farming contributing to its low productivity. The limited availability of land requires concern with increasing agricultural efficiency and productivity. Investment in infrastructure and neutral pricing policies (particularly vis a vis manufacturing) are essential. Limited growth of inputs place greater weight on capital and TFP growth in future output growth.

Government policies have also affected the availability of inputs to other sectors in the economy. In the past, repressed interest rates have encouraged the use of capital and discouraged the use of labour in privileged manufacturing industries. The use of capital in agriculture was discouraged. Controls of capital movements, including the limit on the amount of foreign currency taken in and out of the country, also hindered efficient capital utilization.

Total labour force growth has been declining because of the reduction in population growth. To compensate for the decline in the number of new workers available, more emphasis has to be placed on increasing the quality and productivity of labour. Access to secondary education, which lags behind neighbouring countries, is a particular cause of concern, but education, training, labour flexibility and health more generally require attention.

In agriculture, constraints on land and labour inputs are compounded by policies biased in favour of manufacturing and against the agricultural sector. Direct and indirect imposition of taxes on agricultural product has further depressed the agricultural sector. Industrialization policies have also affected factor allocation within sectors. The price of industrial goods have often been raised relatively to agricultural products. Recent policy reforms have, however, begun to offset these biases.

The factors affecting TFP growth

Several factors affect TFP growth. Sectors, industries, and crops with high TFP growth are those with low protection, high export growth, low concentration, high levels of foreign direct investment, and a high level of research and development.

Industrialization and trade policies also have an important impact on TFP growth. Protection is associated with low TFP growth in most cases because protection not only causes inefficient allocation of resources to protected industries, but gives them monopoly power. Export-oriented strategies on the other hand promote competition and TFP growth. Export-orientation is associated with high TFP growth because exporters need to improve their production techniques and produce high quality products at low cost to compete in international markets. The structure of the domestic market and particularly industrial concentration, also had a significant effect on TFP growth. The reduction in concentration levels of large-scale industries is associated with an increase in their TFP growth, while increased domestic competition has a similar effect on productivity as increased international competition.

Foreign direct investment is another important factor for TFP growth. Foreign direct investment contributes to TFP growth through the transfer of technology and by improving learning by workers and managers. Industries where foreign direct investment is relatively high normally perform better than others in TFP growth. Foreign direct investment is likely to advance technological knowledge in developing economies. Other ways of transferring technology are via patents and licensing agreements. However, systematic data on the importance of these mechanisms for TFP growth in Thailand are not available.

Research and development is found to be a crucial factor explaining TFP growth. Although expenditure on research and development and science and technology did not form a high component of government budget expenditure during the late 1980s, the study suggested that it had a significant impact on TFP performance (Chapter 7).

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