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Total Factor Productivity Growth: Survey Report

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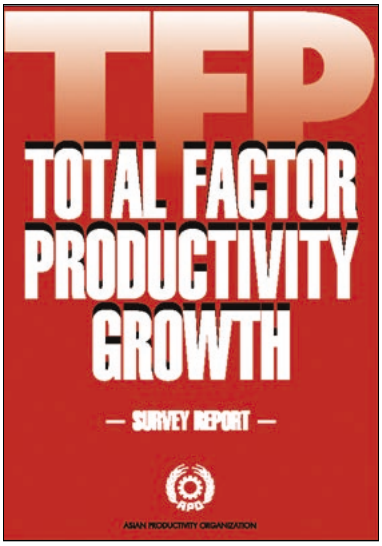
Report of the APO Survey on Total Factor Productivity 2001/2002



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TFP

TOTAL FACTOR PRODUCTIVITY GROWTH

— SURVEY REPORT —

ASIAN PRODUCTIVITY ORGANIZATION

ASIAN PRODUCTIVITY ORGANIZATION

Objective

The Asian Productivity Organization (APO) is an inter-governmental regional organization established in 1961 to contribute to the socio-economic development of its member countries and improve the quality of life of their people through productivity enhancement in the spirit of mutual cooperation among its members. It is non-political, non-profit making, and non-discriminatory.

Membership

APO members are: Bangladesh, Republic of China, Fiji, Hong Kong, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam.

Key Roles

The APO seeks to realize its objective by playing the roles of think tank, catalyst, regional adviser, institution builder, and clearinghouse for information on productivity.

Organization

The supreme organ of the APO is the Governing Body. It comprises one Director from each member country designated by their respective governments. The Governing Body decides on policies and strategies of APO programs and approves its budgets, finances, and matters relating to membership.

Each member country designates a national body to be its national productivity organization (NPO). NPOs are either agencies of the government or statutory bodies entrusted with the task of spearheading the productivity movement in their respective countries. They serve as the official bodies to liaise with the APO Secretariat and to implement APO projects hosted by their governments.

The Secretariat, based in Tokyo, Japan, is the executive arm of the APO. It is headed by the Secretary-General. The Secretariat carries out the decisions, policy directives, and annual programs approved by the Governing Body. It also facilitates cooperative relationships with other international organizations, governments, and private institutions.

The APO Secretariat has six functional departments: Administration and Finance; Research and Planning; Industry; Agriculture; Environment; and Information and Public Relations.

Thrust Areas

The Governing Body has designated five thrust areas to be given emphasis when planning APO activities: Knowledge Management (KM); Green Productivity (GP); Strengthening Small and Medium Enterprises (SME); Integrated Community Development (ICD); and Development of NPOs (DON).

Programs and Activities

APO programs cover the industry, service, and agriculture sectors, with special focus on: socio-economic progress; strengthening of SMEs; KM; total quality management; general management; technology, information technology, and innovation; GP; ICD; DON; agriculture development and agro-industry; resources and technology; and agricultural support systems.

The activities of the APO include basic research studies, surveys, symposia, study meetings, workshops, training courses, seminars, study missions, demonstration projects, technical expert services, information dissemination, and training videos.

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— SURVEY REPORT —

2004
ASIAN PRODUCTIVITY ORGANIZATION
TOKYO

Report of the APO Survey on Total Factor Productivity 2001/2002

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FOREWORD

Total factor productivity (TFP) as a measure of overall productivity has been gaining recognition and acceptance not only for its theoretical correctness but also for its practicality among policy makers and economic analysts. Some governments have begun to include the TFP growth rate as a target in national development plans. Against this background, the APO conducted a survey in 10 member countries in 1998. The basic objective of that first survey project was to develop a common understanding of TFP as well as to select and adopt a common approach for measuring and comparing TFP among member countries. For this purpose, the participating countries compiled TFP data at the macro level using a common framework. It was hoped that the estimation and use of TFP growth would become a widely adopted practice in member countries. The first survey was followed by a symposium in which the results of the survey were discussed along with the experiences of other member countries that did not participate in the survey. The symposium also deliberated on various issues to make TFP measurement an instrument for policy formulation.

The symposium recommended that measurement should be undertaken periodically to provide necessary inputs to decision makers. The necessity for further analysis of TFP, especially of which factors determine TFP growth, for sustained economic progress was recognized.

The APO embarked on a second survey project in 2001 as a follow-up to the first project to improve TFP estimation and to identify the determining factors of TFP growth. Twelve countries participated in this project. The results were discussed at a workshop held in Kuala Lumpur in November 2002.

This publication is a compilation of the finalized version of the national survey reports and findings presented at the workshop by the experts of the participating countries. We hope that this publication will prove useful to policy makers in member countries by helping them better understand the process of TFP growth, allowing them to formulate policies that will nurture an environment for TFP growth and ultimately achieve higher economic growth.

Our special thanks are due to Dr. Noriyoshi Oguchi, Chief Expert of this survey, for his total commitment and effective leadership during the survey and for bringing the survey and publication to completion.

Takashi Tajima
Secretary-General

Tokyo
January 2004

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INTEGRATED REPORT

Dr. Noriyoshi Oguchi
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INTRODUCTION

There is still wide diversity in economic conditions among Asian economies. Some have already reached the highest levels of per capita income in the world. Others are well on the way to sustained growth, while still others are among the lowest income group in the world. Starting with Japan in the 1960s, Asian economies achieved high economic growth through the 1990s in a spectacular display of vitality and energy. The Asian financial crisis in 1997, however, raised inevitable questions concerning the sustainability of growth and revitalization of many economies in Asia. As one of the lessons from the crisis, it is now widely recognized that productivity growth is the key factor in economic development and sustained growth. Most governments are putting emphasis on productivity growth as one of the major goals of economic policy.

Measurement of productivity is an important and necessary step in understanding it. There are various measures such as labor productivity, capital productivity, etc. Among them, total factor productivity (TFP) is a comprehensive measure of productivity and has gained acceptance as such among government officials, policy makers, and productivity specialists and economists.

With this background, the Asian Productivity Organization (APO) undertook an international survey project on measuring TFP among member countries in 1998 with the participation of 10 member economies. Through that project, we examined and established the reliability of standard estimation methods of TFP growth for national economies. The next step was to refine the estimation and investigate factors that determine the growth of TFP. That is especially important for both practical and policy purposes. Most governments and policy makers are eager to improve overall productivity, especially after the Asian financial crisis. Many theories and arguments have been presented on policies to improve productivity but we still are not certain what is important for improvement in TFP. It is an important step in the formation of policies to analyze the factors that generate improvements in TFP.

In this survey, we refined the estimation of TFP growth and then investigated the factors affecting it. In the first survey, the estimation of TFP growth was based on a two-factor framework. We thus considered only the aggregated capital stock and total employment as productive factors. In reality, however, the productivity of labor varies from individual to individual, as the accumulated human capital is different. Hence even when total employment is the same, if the workers have accumulated more human capital, the productivity will be higher. In the two-factor framework, this change in the quality and productivity of labor would be considered as improvement in TFP, although it is really the contribution of the improved quality of labor. In the present survey, we estimated the contributions of quality changes of labor and capital and separated them from the improvement inefficiency, i.e., TFP growth, whenever data were available. We also separated the effect of the change in capacity utilization on the estimated TFP growth, as in our previous survey.

Another exploration in this survey was into the causes of TFP growth. There have been other studies on factors affecting TFP growth. However, most were isolated case studies on some economies. In this project, we conducted a coordinated investigation of several Asian economies using a similar methodology and tried to identify factors important in improvement of TFP.

ESTIMATION OF TFP GROWTH

Methodology

We follow the same framework of estimation of TFP growth as in the previous study. The detailed methodology is presented in the Appendix to avoid repetition. This time, however, we estimated the effect of quality change in the factors of production, as explained above. The method for this estimation is also given in the Appendix.

Estimation Results

Table 1 gives the GDP growth rate, and the TFP growth estimated in the two-factor framework is presented in Table 2. For the period 1980 to 2000, most of the economies recorded consistently high economic growth rates. Iran, Japan, and the Philippines were the poor performers in the group, with less than 3% average growth rates during the period. The rest of the group achieved higher than 5% average growth rates. In some economies, the growth rate fluctuated markedly, especially for the period from 1995 to 1999 as the region experienced the Asian financial crisis as well as political instability in some countries. Indonesia, Malaysia, the Republic of Korea, and Thailand recorded negative growth in 1998, the year following the crisis.

Table 1. GDP growth rate (% per year).

Year	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980	−5.34	10.27	−14.79	4.22	−3.19	7.44	−1.38
1981	6.92	8.47	−2.23	4.22	6.93	6.94	10.74
1982	5.80	3.06	14.43	4.22	7.89	5.94	4.08
1983	2.90	4.93	11.44	4.22	11.69	6.25	−0.10
1984	7.39	7.66	0.04	4.22	9.25	7.76	10.13
1985	3.92	3.34	1.75	4.64	7.18	−1.12	8.33
1986	4.79	6.61	−8.80	4.64	11.43	−0.02	4.66
1987	4.24	5.70	0.41	4.64	11.47	3.14	1.97
1988	3.76	6.50	−3.50	4.64	10.71	9.94	7.03

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1989	9.96	8.07	4.24	4.64	6.17	9.06	5.43
1990	6.49	7.86	11.53	1.02	9.25	9.01	4.92
1991	5.42	7.58	10.10	1.02	9.50	9.55	6.44
1992	1.29	7.11	5.91	1.02	5.81	8.89	4.62
1993	4.99	7.14	4.95	1.02	5.96	9.89	3.29
1994	5.71	7.08	1.63	1.02	8.35	9.21	7.9
1995	7.00	8.09	3.18	0.87	9.39	9.83	2.87
1996	7.09	7.68	4.75	0.87	6.73	10.00	5.7
1997	7.55	4.54	3.12	0.87	5.68	7.54	4.77
1998	4.65	-13.13	2.09	0.87	-6.34	-7.50	3.44
1999	6.36	0.01	2.40	0.87	10.46	5.74	4.47
2000	6.17	4.77		0.87		8.60	6.44
Mean							
1980-84	3.53	6.88	1.78	4.22	6.51	6.87	4.69
1985-89	5.33	6.04	-1.18	4.64	9.39	4.20	5.48
1990-94	4.78	7.35	6.83	1.02	7.77	9.31	5.43
1995-99	6.53	1.44	3.11	0.87	5.18	5.12	4.25
1980-2000	5.10	5.40	2.63	2.60	7.22	6.48	5.04

Table 1. *(continued).*

Year	Philippines	Singapore	ROC	Thailand	Vietnam
1980	7.17	9.53	7.92	4.50	
1981	3.99	9.00	6.55	5.74	
1982	3.49	6.38	3.60	5.21	
1983	1.58	7.27	8.58	5.43	
1984	-6.87	7.37	10.69	5.59	
1985	-7.40	-1.31	5.02	4.54	
1986	3.36	4.06	11.74	5.39	2.10
1987	2.49	9.12	12.35	9.09	5.39
1988	8.31	10.46	7.92	12.48	4.59
1989	4.76	7.82	8.36	11.50	2.35
1990	3.11	8.83	5.40	10.59	4.74
1991	-1.67	7.58	7.54	8.21	6.60
1992	-0.51	4.50	7.64	7.77	8.63
1993	1.78	9.43	6.85	8.05	6.31
1994	3.71	8.38	7.30	8.57	7.72
1995	4.46	8.87	6.35	8.90	8.48

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1996	6.45	7.40	6.14	5.72	10.31
1997	4.66	9.40	6.72	−1.46	7.22
1998	0.57	1.11	4.79	−11.40	6.32
1999	3.66		5.35	4.13	5.95
2000	5.71				8.73
Mean					
1980−84	1.87	7.91	7.47	5.30	
1985−89	2.30	6.03	9.08	8.60	3.61
1990−94	1.28	7.74	6.95	8.64	6.80
1995−99	3.96	6.70	5.87	1.18	7.66
1980−2000	2.51	7.12	7.34	5.93	6.36

Table 2. TFP growth rate [TFPG1)] (% per year).

Year	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980	−8.06	3.22	−17.74	3.18	−10.10	3.80	−6.64
1981	4.36	1.19	−5.15	3.18	1.41	−1.00	7.97
1982	2.17	−4.43	9.77	3.18	2.22	−1.00	0.42
1983	−0.25	−2.28	6.32	3.18	5.77	−0.70	−4.22
1984	4.67	0.69	−5.26	3.18	4.43	2.60	5.32
1985	1.31	3.41	−1.39	2.82	1.96	−5.10	3.46
1986	1.80	0.07	−4.60	2.82	4.60	−3.30	0.68
1987	1.53	−0.53	0.07	2.82	4.68	−1.10	−1.91
1988	1.27	0.12	−3.20	2.82	3.59	5.90	2.13
1989	7.26	1.42	2.89	2.82	−1.06	4.60	1.82
1990	3.74	1.10	10.76	0.60	1.11	3.20	3.04
1991	2.52	1.33	5.18	0.60	3.68	3.90	3.94
1992	−1.48	1.03	2.59	0.60	0.37	2.90	1.78
1993	2.18	0.39	3.03	0.60	0.56	3.40	−0.69
1994	3.11	0.26	0.43	0.60	2.91	3.40	3.29
1995	2.79	0.57	2.23	0.75	3.68	2.30	−2.11
1996	2.77	0.43	2.52	0.75	3.90	2.50	1.16
1997	4.14	−2.61	1.04	0.75	2.72	2.60	1.21
1998	1.22	−14.00	0.06	0.75	−8.47	−8.40	−0.25
1999	3.58	−2.76	−0.08	0.75	8.50	2.60	0.71
2000	3.05	1.43		0.75		3.90	2.24
Mean							
1980−84	0.58	−0.32	−2.41	3.18	0.75	0.74	0.57

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1985-89	2.63	-0.47	-1.25	2.82	2.75	0.20	1.24
1990-94	2.01	0.82	4.40	0.60	1.73	3.36	2.27
1995-99	2.90	-3.67	1.15	0.75	2.07	0.32	0.14
1980-2000	2.08	-0.80	0.47	1.78	1.82	1.29	1.11

Table 2. *(continued).*

Year	Philippines	Singapore	ROC	Thailand	Vietnam
1980	3.72	1.69	0.34	-1.49	
1981	-1.69	-0.16	-1.07	-1.56	
1982	-0.76	-2.49	-2.69	1.88	
1983	-4.20	-0.73	1.20	1.94	
1984	-8.77	0.22	3.36	1.08	
1985	-8.36	-6.27	-0.35	2.56	
1986	1.78	0.38	5.13	1.30	1.07
1987	1.23	4.01	4.84	4.28	3.86
1988	6.28	5.29	1.78	5.37	2.95
1989	1.51	2.83	3.04	4.80	0.22
1990	0.69	1.06	2.15	3.92	2.54
1991	-4.92	4.28	3.54	1.28	5.23
1992	-3.50	-0.92	2.91	-0.10	6.54
1993	-1.22	4.91	2.52	2.74	2.68
1994	0.56	2.33	2.74	2.86	3.60
1995	1.35	3.11	2.37	2.31	3.96
1996	1.60	-1.60	2.52	0.68	6.33
1997	1.06	0.30	2.26	-6.28	2.99
1998	-1.36	-3.43	-0.13	-10.89	1.75
1999	2.50	0.00	0.62	3.36	1.09
2000	4.74	0.00	0.00	0.00	4.17
Mean					
1980-84	-2.34	-0.29	0.23	0.37	NA
1985-89	0.49	1.25	2.89	3.66	2.02
1990-94	-1.68	2.33	2.77	2.14	4.12
1995-99	1.03	-0.41	1.53	-2.16	3.22
1980-2000	-0.37	0.78	1.85	1.00	3.27

In all the economies studied except for Indonesia and the Philippines, the average TFP growth was positive for the period from 1980 to 2000, as shown in Table 2. This is rather remarkable since some of the economies experienced great fluctuations with negative GDP growth for some years. Vietnam recorded the highest growth of 3.27% per year (for the period from 1986 to 2000), followed by India with 2.6%. Both economies underwent extensive economic reform. On the other hand, economies that experienced major political changes such as the Philippines, Indonesia, and Iran showed either negative or low positive growth. It is clear that TFP growth fluctuated more than GDP growth. Many economies experienced negative TFP growth during some of the subperiods.

Table 3 shows the contribution of TFP growth to economic growth in each economy, where the figures are the percentages of GDP growth rate due to TFP growth. For example, more than half of the economic growth in Vietnam from 1986 to 2000 was the result of TFP growth. A negative value indicates that TFP growth was in the opposite direction to GDP growth. Since all the economies recorded positive GDP growth for the period, the negative values for Indonesia and the Philippines indicate that the productive efficiency deteriorated during this period and pulled down the economic growth in these two countries.

Table 3. Contribution of TFP growth to GDP growth (%).

Year	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980-84	16.36	-4.68	-135.71	75.27	11.45	10.78	12.11
1985-89	49.38	-7.71	105.64	60.75	29.32	4.76	22.55
1990-94	42.13	11.18	64.43	58.64	22.20	36.09	41.80
1995-99	44.41	-255.49	37.09	86.95	39.85	6.25	3.41
1980-2001	40.80	-14.80	17.96	94.00	25.26	25.95	26.74

Table 3. *(continued).*

Year	Philippines	Singapore	ROC	Thailand	Vietnam
1980-84	-124.94	-3.72	3.06	6.97	
1985-89	21.22	20.70	31.79	42.59	56.12
1990-94	-130.56	30.11	39.88	24.79	60.58
1995-99	26.00	-6.05	26.01	-183.42	42.09
1980-2001	-14.68	10.95	25.24	16.91	51.32

The contribution of TFP growth was consistently high in India, Japan, and Vietnam throughout the period. The Republic of Korea and Republic of China also had consistently positive and stable contributions from TFP growth. Malaysia and Nepal experienced large fluctuations, but during the five-year period the contribution of TFP growth was positive. Thus in most of the surveyed economies, TFP growth played an important role in overall economic growth. This is counter to the proposition presented by Krugman (1998) in his widely publicized paper "The myth of Asia's miracle" in which he argued that Asian economic growth was largely due to growth in productive factors and that technical progress contributed little.

The difference in the conclusions is partly due to the definition of technical improvement. Krugman included the improvement of quality of inputs in addition to the increase in quantity in the growth of inputs. In the estimation of TFP growth given in

Table 2, the quality improvement of inputs is not taken into consideration. This point is considered below.

Effect of Business Fluctuation

The necessity of adjusting estimates of TFP growth for business fluctuation was agreed on during the previous survey project. We tested two methods of adjustment in the previous project. In this survey, four different methods of adjustment were used: the production function method; Wharton method; proxy for capacity utilization rate; and short-run adjustment equation. A detailed description of the adjustment methods is given in the Appendix.

The first method that uses the estimated production function was adopted by the Republic of Korea, the Philippines, Malaysia, Nepal, and Singapore. The adjustment was done using the Wharton method for India, Thailand, and Vietnam. Iran used the unemployment rate for adjustment as well as the Wharton method. Indonesia used the percentage of employment with stable hours. Similarly, the Republic of China used the ratio of actual hours worked to total employment. The short-run adjustment equation was used for Japan.

TFP growth adjusted for business fluctuation is presented in Table 4 and the effect of business fluctuation on the crude estimate of TFP growth is shown in Table 5. The effect varied from country to country. The adjustment for business fluctuation had very little effect on the estimate of TFP growth for India, but changed the estimate quite a lot for the Philippines, Nepal, Singapore, and Thailand.

Table 4. TFP growth adjusted for business fluctuation [TFPG(2)].

Year	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980	−8.09	0	−17.60	NA	−16.28	1.3	1.15
1981	4.36	1.38	−5.95	NA	5.34	0.6	2.43
1982	2.17	−4.26	9.65	NA	2.16	0.7	0.47
1983	−0.25	−2.1	6.77	NA	9.09	0.6	0.75
1984	4.67	0.88	−4.57	NA	2.67	0.9	1.90
1985	1.31	−3.21	−0.70	NA	2.99	0.4	2.05
1986	1.8	0.26	−3.90	NA	8.27	0.1	1.50
1987	1.53	−0.33	−0.62	NA	2	0	1.07
1988	1.27	0.31	−3.89	NA	5.69	0.5	2.22
1989	7.3	1.59	2.20	NA	0.5	1.2	0.50
1990	3.74	1.43	10.08	NA	2.57	1	0.00
1991	2.52	1.18	4.38	NA	8.99	1.74	0.33
1992	−1.48	1.84	2.37	NA	−1.97	1.48	−0.76
1993	2.18	4.6	2.69	NA	0.34	1.96	0.19
1994	3.15	−3.21	0.33	NA	6.3	1.85	0.96
1995	2.79	−2.83	2.58	NA	4.9	1.86	0.89
1996	2.77	5.51	0.62	NA	4.99	1.09	0.79

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1997	4.14	3.3	4.40	NA	4.62	1.21	0.40
1998	1.22	−11.62	1.78	NA	−10.82	−0.42	0.49
1999	3.58	−4.98	2.50	NA	8.73	0.95	0.63
2000	3.05	−4.47	NA	NA	NA	2.47	1.08

NA, not available.

Table 4. *(continued).*

Year	Philippines	Singapore	ROC	Thailand	Vietnam
1980	0.08	0.87	0.22	−0.04	
1981	−0.84	1.15	−3.62	−1.13	
1982	−0.36	−0.62	−0.14	2.20	
1983	−0.90	−3.65	0.68	2.91	
1984	−1.36	−0.65	1.75	1.96	
1985	−15.44	−4.35	2.52	3.51	
1986	−1.24	2.85	3.04	0.92	0.04
1987	−1.14	0.80	2.49	1.24	0.85
1988	12.61	3.53	1.56	0.47	0.99
1989	−1.14	4.15	2.93	2.53	0.46
1990	−0.92	5.08	4.17	4.92	0.73
1991	−1.26	−0.74	3.79	4.81	2.07
1992	−7.13	2.45	2.93	3.26	2.88
1993	−1.09	−0.09	2.77	5.61	4.64
1994	4.78	3.09	2.23	5.29	5.19
1995	−1.09	4.37	2.27	4.34	6.11
1996	−1.21	−0.26	2.51	4.98	7.62
1997	−0.96	−2.38	1.50	1.37	7.20
1998	−0.95	−6.08	0.96	1.67	7.43
1999	−0.95		1.15	0.78	6.10
2000	10.36				7.29

Table 5. Effect of business fluctuation [TFPG(1) − TFPG(2)].

Year	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980	0.03	0.00	−0.14	NA	6.18	2.50	−7.80
1981	0.00	−0.19	0.80	NA	−3.93	−1.60	5.53
1982	0.00	−0.17	0.11	NA	0.06	−1.70	−0.05
1983	0.00	−0.18	−0.46	NA	−3.32	−1.30	−4.97
1984	0.00	−0.19	−0.69	NA	1.76	1.70	3.41

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1985	0.00	−0.20	−0.69	NA	−1.03	−5.50	1.41
1986	0.00	−0.19	−0.70	NA	−3.67	−3.40	−0.82
1987	0.00	−0.20	0.70	NA	2.68	−1.10	−2.98
1988	0.00	−0.19	0.69	NA	−2.10	5.40	−0.09
1989	−0.04	−0.17	0.69	NA	−1.56	3.40	1.32
1990	0.00	−0.33	0.68	NA	−1.46	2.20	3.04
1991	0.00	0.15	0.80	NA	−5.31	2.16	3.61
1992	0.00	−0.81	0.22	NA	2.34	1.42	2.54
1993	0.00	−4.21	0.34	NA	0.22	1.44	−0.88
1994	−0.04	3.47	0.10	NA	−3.39	1.55	2.33
1995	0.00	3.40	−0.35	NA	−1.22	0.44	−3.00
1996	0.00	−5.08	1.89	NA	−1.09	1.41	0.37
1997	0.00	−5.91	−3.36	NA	−1.90	1.39	0.81
1998	0.00	−2.38	−1.73	NA	2.35	−7.98	−0.74
1999	0.00	2.22	−2.58	NA	−0.23	1.65	0.07
2000	0.00	5.90	NA	NA	NA	1.43	1.15
Mean							
1980-84	0.01	−0.18	−0.07	NA	0.15	−0.08	−0.77
1985-89	−0.01	−0.19	0.14	NA	−1.14	−0.24	−0.23
1990-94	−0.01	−0.35	0.43	NA	−1.52	1.75	2.13
1995-99	0.00	−1.55	−1.23	NA	−0.42	−0.62	−0.50

Table 5. *(continued).*

Year	Philippines	Singapore	ROC	Thailand	Vietnam
1980	3.64	0.82	0.12	−1.46	
1981	−0.85	−1.31	2.55	−0.43	
1982	−0.40	−1.87	−2.55	−0.32	
1983	−3.30	2.92	0.52	−0.97	
1984	−7.40	0.87	1.61	−0.88	
1985	7.08	−1.92	−2.87	−0.95	
1986	3.02	−2.47	2.09	0.39	1.02
1987	2.37	4.81	2.35	3.04	3.01
1988	−6.33	1.76	0.22	4.90	1.96
1989	2.65	−1.32	0.11	2.27	−0.24
1990	1.61	−4.02	−2.02	−1.00	1.82
1991	−3.66	5.02	−0.25	−3.53	3.16
1992		−3.37	−0.02	−3.36	3.66

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1993	3.63	5.00	−0.25	−2.87	−1.96
1994	−0.13	−0.76	0.51	−2.43	−1.58
1995	−4.22	−1.26	0.10	−2.02	−2.15
1996	2.44	−1.34	0.01	−4.31	−1.29
1997	2.81	2.68	0.76	−7.66	−4.21
1998	−0.41	2.65	−1.09	−12.56	−5.67
1999	3.45	0.00	−0.53	2.58	−5.01
2000	−5.62	0.00	0.00	0.00	−3.11
Mean					
1980−84	−1.66	0.29	0.45	−0.81	NA
1985−89	1.76	0.17	0.38	1.93	1.44
1990−94	−0.55	0.37	−0.41	−2.64	1.02
1995−99	2.06	0.55	−0.15	−4.79	−3.67

Table 6 presents the mean and variance of TFP growth for the period of 1980 to 2000 as well as the variance in GDP growth rate. The variances in TFP growth and GDP growth rate are very close, although that of TFP growth is smaller than that of GDP growth in all countries except for Iran. A closer look at the annual growth rates of GDP and TFP growth shows that these two are highly correlated. These indicate that crude estimates of TFP growth are affected by business fluctuation.

Table 6. Mean and variance of TFP growth for 1980−2000 before adjustment.

	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
Mean	2.08	−0.80	0.47	NA	1.82	1.16	1.06
Variance	8.72	12.74	37.50	NA	18.95	12.83	10.66
Variance of GDP	9.20	23.18	46.56	3.22	20.94	19.94	8.75

Table 6. *(continued).*

	Philippines	Singapore	ROC	Thailand	Vietnam
Mean	−0.37	0.78	1.85	1.00	3.27
Variance	15.01	9.09	3.77	14.70	3.42
Variance of GDP	15.97	9.30	5.07	26.20	5.33

The mean and variance of TFP growth after adjustment for business fluctuation are given in Table 7. For the Republic of Korea, Nepal, and the Philippines, adjustment makes the variance significantly larger. These three countries used the production function method for adjustment. We attempted to use the Wharton method for the Republic of Korea and the Philippines, and the variance of TFP growth after adjustment was reduced to 4.65 and 14.25, respectively, as given in parentheses in Table 7. Judging from the results for all countries, it appears that the Wharton method is better than the production function method to adjust for business fluctuation.

Table 7. Mean and variance of TFP growth for 1980–2000 after adjustment for business fluctuation.

	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
Mean	2.08	−0.74	0.66	1.84	2.55	1.01	−1.29
Variance	8.78	15.52	36.96	1.44	40.32 (4.65)	0.52	61.21

Table 7. *(continued).*

	Philippines	Singapore	ROC	Thailand	Vietnam
Mean	−0.48	0.42	1.79	2.58	3.97
Variance	29.50 (14.25)	9.67	2.88	3.84	8.53

In some countries, there were more years in which TFP growth was negative. For example, without adjustment, TFP growth was negative in nine years in the Philippines after 1980, while after adjustment TFP growth was negative in 17 years. The variance in TFP growth was also larger after adjustment. This suggests that the effect of business fluctuation on the crude estimate of TFP growth is very significant and that crude estimates of TFP growth are not very good measures of efficiency improvement of the production process on an annual basis.

Effect of Quality Change in Labor and Capital

Labor

As explained above, the growth rate of labor and capital in the above estimation does not consider the quality change in labor and capital. For example, even with the same number of workers, if the ratio of skilled workers in employment rises, the overall productivity should increase. This increase in productivity due to the quality change in labor is included in the above estimates of TFP growth(1) as a part of TFP growth. In this survey, we separated this effect of the quality change in labor.

Table 8 presents the rate of the quality change in labor. The positive figures for all economies except for India indicate improvement in the quality of labor. Most of the Asian economies made considerable efforts to improve the educational level of the labor force as well as occupational skills. Table 8 shows the results of those efforts.

Table 8. Rate of quality change in labor.

Period	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980–84	−0.02	NA	NA	1.02	3.29	0.27	NA
1985–89	−0.15	0.38	NA	0.54	4.23	0.45	NA
1990–94	−0.34	2.84	NA	0.50	2.54	2.19	NA
1995–99	−0.61	1.64	NA	0.07	1.24	0.69	NA
1980–2000	−0.29	2.29	NA	0.51	2.83	1.05	NA

Table 8. *(continued).*

Period	Philippines	Singapore	ROC	Thailand	Vietnam
1980-84	1.23	3.19	0.47	NA	NA
1985-89	1.53	0.81	0.38	NA	0.78
1990-94	0.65	1.80	0.35	NA	0.29
1995-99	1.21	1.96	0.59	NA	1.95
1980-2000	1.14	1.94	0.45	NA	1.13

The figures for some countries are relatively large. The Republic of Korea and Indonesia achieved more than 2% growth. Singapore's rate was close to 2%. These countries achieved high economic growth during the period, and the improvement in the quality of labor was one of the causes of high growth.

The Indian case was an exception since it was negative for the entire period. This, however, does not necessarily mean that the overall quality of labor did not improve in India. Due to the availability of data, this estimation was made comparing the organized and unorganized sectors in India. Thus negative estimates in Table 8 indicate that the employment in the less productive unorganized sector increased more rapidly than in the organized sector, resulting in a lower overall average labor productivity.

The quality changes shown in Table 8 are converted into the impacts on TFP growth presented in Table 2. The figures in Table 9 present the magnitude of TFP growth caused by the quality change in labor. In other words, the figures in Table 9 are the effects of quality change in labor on GDP growth rates. A positive value in Table 9 indicates that quality improvement in employed labor helped to raise GDP growth. For example, 0.24 for the Republic of China for the period 1980 to 2000 means that the quality improvement of employed labor pushed up the growth rate of GDP by 0.24 point. In other words, of the 1.85% TFP growth for the Republic of China for the same period given in Table 2, 0.24 point was due to the improved quality of labor.

Table 9. Effects of quality change in labor on TFP growth.

Period	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980-84	0.00		NA	0.62	1.93	0.74	NA
1985-89	-0.09		NA	0.31	2.43	0.20	NA
1990-94	-0.20	1.10	NA	0.29	1.57	0.75	NA
1995-99	-0.36	1.21	NA	0.04	0.76	0.17	NA
1980-2000	-0.17	1.43	NA	0.96	1.67	0.24	NA

Table 9. *(continued).*

Period	Philippines	Singapore	ROC	Thailand	Vietnam
1980-84	0.62	1.32	0.24	0.23	NA
1985-89	0.62	0.35	0.20	0.10	2.29

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1990–94	0.27	0.84	0.19	1.68	0.17
1995–99	0.52	0.92	0.31	−4.21	1.10
1980–2000	0.50	0.85	0.24	−0.43	0.48

Capital

The rates of quality change in capital are given in Table 10. For many economies, this estimation was not possible due to the lack of data on disaggregated capital stock. The figures in Table 11 present the magnitude of TFP growth caused by the quality change in capital. Many entries in Table 10 are negative. As in the case of labor (Table 9), this does not necessarily mean that the overall quality of capital deteriorated during those periods in those countries. It is more likely that the composition of capital stock shifted to contain more of relatively less productive types of capital, i.e., the overall productive capacity of capital did not grow as much as the growth of simple aggregation of capital stock indicated.

Table 10. Rate of quality change in capital.

Period	India	Iran	Japan	Malaysia	Philippines	Singapore	ROC
1980–84	−1.02	−4.16	1.93	NA	1.55	−0.32	0.10
1985–89	−1.02	−2.28	2.10	−2.71	−0.36	−1.15	−1.13
1990–94	−0.76	2.40	0.61	−2.59	0.15	0.96	−0.08
1995–99	−0.83	0.48	−0.04	1.79	0.44	0.02	0.74
1980–2000	−0.90	−0.89	1.09	−0.65	0.46	−0.13	−0.09

Table 11. Effect of quality change in capital on TFP growth.

Period	India	Iran	Japan	Malaysia	Philippines	Singapore	ROC
1980–84	−0.38	−3.28	0.76	NA	0.74	−0.15	0.05
1985–89	−0.37	−1.80	0.88	−6.65	−0.22	−0.62	−0.53
1990–94	−0.30	1.88	0.25	−1.68	0.09	0.53	−0.04
1995–99	−0.34	0.18	−0.01	1.15	0.24	0.01	0.36
1980–2000	−0.35	−0.77	1.10	−1.78	0.23	−0.06	−0.04

It is noteworthy that the mean effects of quality change in capital on TFP growth for the period 1980 to 2000 for many economies were negative. This implies that those economies accumulated more capital of less productive types than the more productive types. This is counter to economic rationality, but there could be many possible reasons for that to happen. For example, sectors that use less productive capital goods heavily may have received large allocations of investment funds for political or social reasons. Examination of the exact reasons for this is left for future study.

Effects of Industry Shift

A shift of employment from a less productive sector to a more productive one improves overall productivity. The same can apply to the allocation of capital. This effect is separated as the effect of change in the allocation of labor and capital. For most of the economies, data on labor only are available. Hence the figures in Table 12 are the effects of change in the sectoral distribution of labor only, except for India and Japan. Figures for India and Japan include the effects of distribution changes in both capital and labor. In most countries, the sectors are categorized by industry type such as agriculture, manufacturing, etc. In the case of India, the subsectors are the formal (organized) and informal (unorganized) sectors.

Table 12. Effect of change in allocation of labor and capital.

Period	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980–84	−0.21	NA	NA	−0.47	−1.22	0.62	4.12
1985–89	−0.34	−0.18	NA	−0.46	−1.80	0.09	5.53
1990–94	−0.39	1.21	NA	−0.38	−1.44	0.33	4.15
1995–99	−0.51	1.51	NA	−0.22	−0.27	−0.04	2.88
1980–2000	−0.37	1.76	NA	−0.38	−1.18	0.11	4.17

Table 12. *(continued).*

Period	Philippines	Singapore	ROC	Thailand	Vietnam
1980–84	0.64	−0.29	0.05	0.26	NA
1985–89	0.00	1.25	0.11	0.52	NA
1990–94	0.07	2.33	0.13	1.43	NA
1995–99	0.63	−0.41	0.09	1.05	NA
1980–2000	0.37	0.78	0.10	0.81	NA

Figures for India and Japan include the effects of changes in allocation of both labor and capital.

Many entries in Table 12 are negative figures. In particular, India, Japan, and the Republic of Korea had negative results throughout the period. This indicates that in those economies the distribution of productive factors over sectors was such that the share in less productive sectors increased. In the case of India, the share of the unorganized sector, which is less productive, increased. In the Republic of Korea, employment in less productive service sectors increased. In Japan, the distribution of capital caused negative results. Relatively more investment was made in less productive sectors in Japan. Protection of less productive sectors may have caused this misallocation of capital.

Narrow Definition of TFP Growth

The results in Tables 8 to 11 show that the effects covered in these tables are relatively large in comparison with TFP growth itself. This indicates that refinement of data on factors of production is a crucial process in the estimation of TFP growth. TFP growth is defined as the improvement of productivity due to unidentifiable technological mixtures. Hence we try to separate identifiable improvement in productivity as much as possible. The decomposition estimation is part of the effort to identify and explain the overall change in TFP. For example, Table 13 shows the ratio of TFP growth(1) explained by the quality change in labor. In Indonesia, more than half of TFP growth(1) in the 1990s was due to the quality change in labor. In that sense, TFP growth(1) estimated using total employment and capital without consideration of their quality overstates the role of TFP growth. When Krugman argued that TFP growth did not play a significant role in Asian growth, he was looking at TFP growth after the effect of the quality change in labor had been removed. That is one reason why the results in Table 2 do not appear to support his argument.

Table 13. Importance of quality change in labor in TFPG(1).

Period	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
1980-84	0.00	NA	NA	0.19	2.58	NA	NA
1985-89	-0.04	NA	NA	0.11	0.88	NA	NA
1990-94	-0.10	1.34	NA	0.49	0.91	0.22	NA
1995-99	-0.12	-0.33	NA	0.05	0.37	0.54	NA
1980-2000	-0.08	0.51	NA	0.54	0.92	0.38	NA

Table 13. *(continued).*

Period	Philippines	Singapore	ROC	Thailand	Vietnam
1980-84	-0.27	NA	1.05	NA	NA
1985-89	1.27	NA	0.07	NA	1.13
1990-94	-0.16	NA	0.07	NA	0.04
1995-99	0.50	NA	0.20	NA	0.34
1980-2000	-1.36	NA	0.13	NA	0.50

When we only have employment data classified by education and by industry separately and not cross-classified by skill level and by sector, it is possible that the division of labor by educational level may coincide with the sectoral categorization. In that case, we should be careful not to "double count" the effect of quality change in factors. It is possible that a large part of estimates in Table 12 coincide with estimates in Tables 9 and 11 except for Japan. For Japan, cross-classified data are used and there was no double counting.

Regression Analysis

There are many possible factors that affect TFP growth. Whether they have had a significant effect on TFP growth is an important question for practical and policy purposes. We conducted multiple regression analysis of TFP growth for countries for which there were sufficient data. In some other countries, correlation analysis was carried out. The following variables were examined in the analysis: degree of openness of the economy; foreign direct investment (FDI); R&D activities; change in economic structure; economic and political stability; economy of scale; and education and job training. The actual variables used in the analysis were not necessarily the same in all countries due to the lack of data. Also the availability of data limited some countries only to correlation analysis rather than regression analysis. Table 14 gives a summary of the results.

Table14. Determining factors of TFP growth.

Factor	India	Indonesia	Iran	Japan	ROK	Malaysia	Nepal
FDI	0		0		+		
Trade	–	0	0		–	0	
Education			+		+	0	
R&D	0		0	+			
Structure	–	0			0	+	
Stability							
Scale	+	0					
Foreign collaboration	–						
R&D in USA					–		
Exports					–		
ISO							
QCC						0	
Public investment							
Stock market							
Regulations				+			
Trend	+						

+, Positive relationship; 0, no effect; –, negative effect on TFP growth.

Table14. *(continued).*

Factor	Philippines	Singapore	ROC	Thailand	Vietnam
FDI	+	+		+	+
Trade	+			+	–
Education		0			
R&D	+		+	0	+
Structure	+			+	
Stability	+				
Scale					
Foreign collaboration					
R&D in USA					
Exports		0	+		
ISO certification					

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QCC					
Public investment			+	0	
Stock market			+		
Regulations					
Trend					

Due to the limited availability of data, the results given in Table 14 should be considered only as rough indications. In the countries where FDI was significant, growth in FDI had a significant effect on TFP growth. Another significant factor is openness of the economy. Some indicators of openness had positive effects in a number of countries.

Since the number of observations available from each country was limited, more statistically reliable results might be obtained by pooling the data for all countries. However, as Table 14 indicates, not many common variables were used in the regression analyses. Only the FDI and trade variables were used in several countries. Even when similar variables were used, the exact data used may not have been the same. For example, as a measure of structural change, some used the share of the agriculture sector in GDP, while another used the share of manufacturing. Thus there were very few variables in common to be pooled. To increase the number of samples included in regression analysis, I supplemented data from the *International Financial Statistics Yearbook* published by the International Monetary Fund. Even then, only a limited number of regression analyses were possible. The results of the regression analyses using pooled data are reported in Table 15. The estimated coefficients on country dummy variables are not listed due space limitations.

Table 15. Regression results of pooled data.

	Dependent variable						
	TFPG	**TFPG**	**TFPG(BF)**	**TFPG(BF)**	**TFPG**	**TFPG(BF)**	**TFPG(BF)**
Equation number	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	2.162932	2.104452	1.78089	1.909028	2.410322	2.926207	4.135532
Standard error	0.780586	0.756271	0.824258	0.788936	0.865118	0.947854	1.954827
EX/GDP	0.521176		1.166427				−4.37531
Standard error	0.6543		0.691091				6.17664
GR(EX/GDP)		−0.08183		−0.78823			
Standard error		1.13225		1.181155			
FDI/GDP					−37.9134	46.57096	60.74027
Standard error					28.50785	31.23423	37.21258
Country dummy							
Standard error							
R-square	0.107882	0.121521	0.11897	0.133472	0.153425	0.221532	0.228833
Sample size	200	191	198	191	59	59	59

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Equations 1 to 4	India, Indonesia, Iran, ROK, ROC, Nepal, Philippines, Thailand, Vietnam
Equations 5 to 7	ROK, Philippines, Thailand, Vietnam

For Equations (1) to (4), the data of the following countries were pooled: India, Indonesia, Iran, Republic of Korea, Republic of China, Nepal, Philippines, Thailand, and Vietnam.
For Equations (5) to (7), the data of the following countries were pooled: Republic of Korea, Philippines, Thailand, and Vietnam.

We used both crude TFP growth(1) and TFP growth(2) adjusted for business fluctuation as the explained variable. Equations 1 and 3 are simple regressions with only the export/GDP ratio as the explanatory variable. Although the R-square values are rather low at 0.11 and 0.12, respectively, the coefficients are positive as expected. The explanatory variable was changed to the growth rate of the export/GDP ratio in Equations 2 and 4. Again there was almost no correlation, and thus the variable did not work.

In Equations 5 and 6, we used FDI/GDP as the explanatory variable. A positive coefficient was obtained in Equation 6 with TFP growth(2) adjusted for business fluctuation as the explained variable. The result indicates that FDI inflow may have helped TFP growth. Although data for Iran and India were available, those were not included in Equation 5, since they were negligibly small in value and did not show significant effects in individual country analysis.

Equation 7 is a multiple regression with the export/GDP ratio and FDI/GDP ratio as explanatory variables. Adding the export/GDP ratio to Equation 6 did not improve the results. The coefficient on export/GDP is negative. Thus, in our analysis, export/GDP could not explain TFP growth for pooled data.

Our regression analysis was very limited due to the availability of data. Although more data are needed, some insights were obtained:

1) It appears that the factors affecting TFP growth vary from country to country.
2) Even factors often considered to be determinants of TFP growth in general did not have clear correlations in many economies. Among them are such factors as exports and R&D spending.
3) On the other hand, exports showed a significant correlation with TFP growth in other economies. The difference may depend on the characteristics of the economies. Those that depend on exports more heavily showed strong correlations.
4) Similarly, for R&D spending to have effects on TFP growth, it appears that there must have been some accumulation of R&D spending in the past and the economy must have reached a certain level of development.
5) FDI is one of the variables affecting TFP growth. It showed strong correlations in separate analyses of several economies and it also showed a statistically significant effect in the pooled data analysis. It appears that for FDI to have a clear effect on TFP growth, there must have been some previous accumulation of FDI.
6) The ratio of exports to GDP also was statistically significant to explain business fluctuation-adjusted TFP growth.

CONCLUSIONS AND POLICY IMPLICATIONS

In this project, we coordinated the estimation method of TFP growth among participating economies and obtained comparable estimates for at least 20 years. We also estimated the quality change in labor and capital quantitatively and separated their effect on TFP growth and economic growth. The effect of reallocation of labor was estimated, although this may not be independent from the quality change in labor and capital. Using the estimates of TFP growth, we tried to identify the factors that affect TFP growth. The major findings were:

1) TFP growth played an important role in the economic growth of most economies, especially in later years. This is contrary to Krugman's (1998) argument in "The myth of Asia's miracle." The difference partly depends on the methodology used. But even after removing the effect of the quality improvement of labor, there is still a significant contribution of TFP growth to economic growth in many economies.
2) Improvement in the quality of labor contributed greatly to economic growth in many economies.
3) Accumulation of capital was another factor that contributed to economic growth. The contribution could have been even larger if the investment had been allocated to more productive sectors and to more productive types of capital goods.
4) Business fluctuation affects the estimation of TFP growth considerably. Hence caution is needed in judging short-term estimates of TFP growth. It also appears that the Wharton method is better than the production function method to adjust estimates for business fluctuation.

Finally, through the investigation of factors determining TFP growth using regression analysis, it appears that the factors affecting TFP growth vary from country to country. Even factors often considered to be determinants of TFP growth in general did not have clear correlations in many economies. Among them were such factors as exports and R&D spending. On the other hand, exports showed a significant correlation to TFP growth in some other economies. Those that depend on exports more heavily showed stronger correlations. Similarly, for R&D spending to have effects on TFP growth, there must have been some accumulation of R&D spending in the past and the economy must have reached a certain level of development.

FDI is one of the variables affecting TFP growth. It showed a strong correlation in separate analyses of several economies and it also showed a statistically significant effect in the pooled data analysis. Again, it appears that for FDI to have a clear effect on TFP growth, there must have been some prior accumulation of FDI.

Policy Implications

We have established that TFP growth analysis is both operational and practical in many economies in two APO surveys. Hence it is recommended that the updating of TFP growth estimates annually or periodically become routine practice. This would provide useful information for policy evaluation as well as policy formation. Although the estimates we obtained are useful, improvement in accuracy and dependability is desired. For this, we need better-quality data. Hence it is strongly recommended that institutions concerned allocate more resources to this field.

Improvement in the average educational or skill level is a major contributor to TFP growth. Many Asian economies have been doing well in this area, but there remains room for further improvement in many. It is important to maintain the drive to raise the average level of education. At the same time, it is also important to increase the mobility of labor so that the right person has the right job. Similarly, better allocation of capital across sectors and more investment in more productive capital goods raise TFP growth. It appears that in many Asian economies these are restricted by various social, political, and cultural factors. Thus liberalization in a very general sense may be important.

It has been widely recognized that FDI is an important factor in raising TFP growth. This proposition was also supported by the results of the present survey. This project was conducted at the national economy level. Although we have obtained many useful findings and insights from this project, the nature and magnitude of TFP growth differ greatly by industrial sector. To devise more precise industrial policies, it is necessary to study each sector in depth. Hence it would be desirable to carry out investigations of productivity at the sectoral level.

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APPENDIX

Basic Model

We adopt the growth accounting framework. We start with the trans-log production function that is homogeneous in the first degree with a multiplicatively separable Hicks neutral efficiency term as given by Equation 1.

$$Qt = AtF(Kt, Lt) \qquad \text{(Eq. 1)}$$

where Qt stands for real output, Lt and Kt represent labor and capital, respectively, and At is the efficiency term.

By totally differentiating both sides of the equation with respect to time, we have:

$$\frac{dQ}{dt} = \frac{dA}{dt} F(Kt, Lt) + At \frac{\partial F}{\partial K} \frac{dK}{dt} + At \frac{\partial F}{\partial L} \frac{dL}{dt} \qquad \text{(Eq. 2)}$$

Dividing both sides by Qt, we have

$$\frac{dQ}{dt} / Qt = \frac{dA}{dt} / At + \frac{\partial F}{\partial K} \frac{dK}{dt} / F(Kt, Lt) + At \frac{\partial F}{\partial L} \frac{dL}{dt} / (Kt, Lt) \qquad \text{(Eq. 3)}$$

Replacing the marginal productivities by factor prices, we have

$$Qtg = TFPG + (rKt/Qt)\, Ktg + (wLt/Qt)\, Ltg = TFG + S_k K_{tg} + s_l L_{tg} \qquad \text{(Eq. 4)}$$

where $TFPG$ is TFP growth, r and w are unit service prices of capital and labor, respectively, Sk and Sl are relative shares of income of capital and labor, respectively, and Qtg, Ktg, and Ltg are the growth rate of output, capital, and labor, respectively.

Since the growth rate terms in the above equations are for an instantaneous rate of change, for the discrete time we take the average of two consecutive periods:

$$TFPG_t^* = (\ln TFP_t - \ln TFP_{t-1})$$

$$= (\ln Q_t - \ln Q_{t-1}) - 1/2\,(S_{kt} + S_{kt-1})(\ln K_t - \ln K_{t-1})$$

$$- 1/2\,(S_{lt} + S_{lt-1})(\ln L_t - \ln L_{t-1})$$

$$= Q_t^* - 1/2\,(S_{kt} + S_{kt-1})\, K_t^* - 1/2\,(S_{lt} + S_{lt-1})\, L_t^* \qquad \text{(Eq. 4A)}$$

This is the equation used in the estimation of the TFP growth rate. Note that we are working with two aggregated factors of production, capital and labor. Also we use the two-year moving average of income shares of labor and capital in estimating the TFP growth rate.

Adjustment Methods for Business Fluctuation

As mentioned in the main text, the change in the rate of capacity utilization is included in TFP growth estimated using Equation 4A above. To separate the increase in the technical efficiency of production from the improved output from intensive use of factors of production, we try to remove the effect of the change in productivity due to business fluctuation from crude TFP growth. In our survey, four different methods were used. The explanation of those four methods is given below.

Production Function Method

This method uses an estimated production function to estimate the change in the capacity utilization rate. In most cases, we assume the Cobb-Douglas production function for simplicity. The steps are:

1) Estimate the Cobb-Douglas production function to compute the theoretical value of output.
2) Take the ratio of actual output to the theoretical value of output given by the estimated production function. The ratio is taken as the proxy for the capacity utilization rate.
3) The rate of change in the capacity utilization rate is subtracted from the TFP growth to obtain the adjusted TFP growth.

Wharton Method

The steps involved in making the adjustment are outlined below (refer also to the chart):

1) Create a capital/output (K/Y) series using the capital stock and GDP data used for the analysis.
2) Fit a linear trend to this K/Y series.
3) Draw a line parallel to this trend line, passing through the lowest points on the K/Y series.
4) The potential or capacity K*/Y* ratio is given by points on the lower line.
5) Potential output is given by Y* = K/(K*/Y*).
6) Y/Y* gives capacity utilization.
7) This ratio is used to adjust the capital stock.

Proxies for Capacity Utilization Rate

In the case of Iran, the unemployment rate was used as the proxy for the capacity utilization rate. Indonesia used the percentage of employment with stable hours as the proxy for capacity utilization. Similarly, the ratio of hours worked to the employment was used for the Republic of China.

Short-run Adjustment

One of the most famous theorems of microeconomics explains that a perfect allocation of nominal output to the compensation of input factors is guaranteed under the following conditions: perfect competition; linear-homogeneous production technology; perfect flexibility of input factors; and producer's rational behavior (profit maximization). In this ideal case, no capital utilization problem occurs because an optimal input level is achieved. One simple method for the utilization adjustment is to make use of this theorem. Suppose the short-run production cost can be expressed by using a variable cost function G as follows:

$$C = G(\, p, Y, K\,) + {}_{pK} K$$

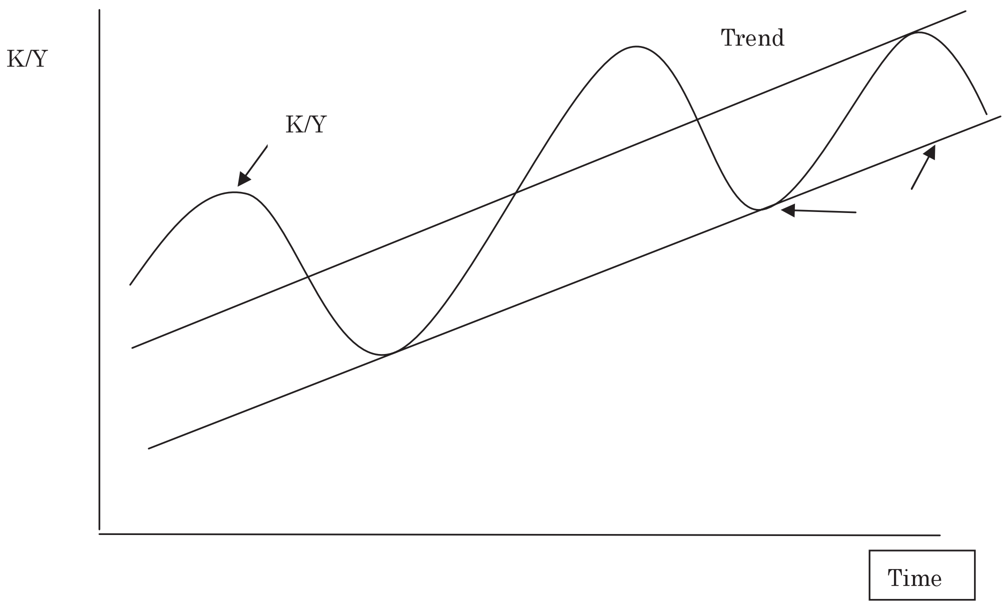
where p stands for price vector of variable inputs, Y for output, K for fixed input (capital stock), and pK for the user cost of capital. Taking a partial derivative in terms of Y, we get the following two different results depending on whether capital stock is adjustable (in the long run) or not (in the short run).

$$\frac{\partial G}{\partial Y} + \frac{\partial G}{\partial K}\frac{\partial K}{\partial Y} + P_K \frac{\partial K}{\partial Y}$$

is a change in variable cost in the long run and $\partial G/\partial Y$ is a change in variable cost in the short run.

We define the optimal input level of K (unity capital stock utilization rate) as one that equalizes the long-run derivative and short-run derivative in terms of Y, that is,

Chart



$$Pk = -\,\partial G / \partial K \qquad \text{(Eq. A)}$$

Since it can be shown that the left-hand side corresponds to the marginal productivity of capital, replacement of the user cost of capital with the left-hand side of Eq. A gives the utilization-adjusted growth accounting.

The marginal productivity of capital can be easily calculated if we assume that the four conditions mentioned above hold. Applying Euler's theorem for a linear-homogeneous production function $Y = F(L,K)$, the following relation holds:

$$Y = \frac{\partial F}{\partial L} L + \frac{\partial F}{\partial K} K = wL - \frac{\partial G}{\partial K} K$$

where w means wage rate, assuming that product price equals unity. Using the equation above, marginal productivity can be calculated as:

$$-\frac{\partial G}{\partial K} = \frac{Y - wL}{K}$$

Considering the discussion above, it is theoretically confirmed that utilization adjustment can be achieved by using the estimated marginal productivity of capital instead of user cost.

Determining Factors of TFP Growth

Based on the estimated TFP growth by the above method, we try to identify the effects of various factors on TFP growth. We consider two methods to estimate the effects of various factors.

Statistical Decomposition for Many Categories of Labor

When the all labor inputs are aggregated into one figure, we use Equation 3 above. However, when there are several kinds of labor, Lt should be divided into several variables to represent each type of labor. Hence Equation 4 becomes:

$$Q_t^{*} = TFP_t^{**} + S_k K_t^{**} + S_l L_t^{**} \qquad \text{(Eq. 4B)}$$

where $L_t^{**} = 1/2(S_{l1t} + S_{l1t\text{-}1})(\ln L_{1t} - \ln L_{1t\text{-}1}) + 1/2(S_{l2t} + S_{l2t\text{-}1})(\ln L_{2t} - \ln L_{2t\text{-}1})$ and S_{l1t} and S_{l2t} are relative income share of the first type of labor L_{1t} and the second type of labor L_{2t} within labor income of year t, respectively.

In Equation 3, L_t is simply $L_{1t} + L_{2t}$, and hence TFP_t^* in Equation 3 and TFP_t^{**} in Equation 4B are different. Since this difference is caused by the more accurate measure of the labor input, taking the quality change into consideration, we can say that the difference between TFP_t^* in Equation 3 and TFP_t^{**} in Equation 4B is the part due to the quality change in labor input. Hence ideally we should estimate both TFP_t^* in Equation 3 and TFP_t^{**} in Equation 4B. To estimate TFP_t^{**} in Equation 4, we need data on wage rates for each group of labor in every period. For many economies, this is a rather difficult requirement. In many economies, however, we do have wage rate data for different groups of labor for some years. Hence we can use those data to estimate $TFP_t{**}$ approximately.

$L_t{*}$ in Equation 3 is the growth rate of simple aggregated labor input, while $L_t{**}$ in Equation 4B is the growth rate of a quality-adjusted aggregate labor input or labor input in efficiency units. $S_l L_t{**}$ in Equation 4B can be rewritten as:

$$S_l L^{**} = \frac{w1L1 + w2L2}{Q}\left(\left(\frac{w1L1}{w1L1 + w2L2}\right)\left(\frac{dL1}{L1}\right) + \left(\frac{w2L2}{w1L1 + w2L2}\right)\left(\frac{dL2}{L2}\right)\right)$$

$$= \frac{\frac{w1L1 + w2L2}{L1 + L2}(L1 + L2)}{Q}\left(\frac{w1dL1}{\frac{w1L1 + w2L2}{L1 + L2}(L1 + L2)} + \frac{w2dL2}{\frac{w1L1 + w2L2}{L1 + L2}(L1 + L2)}\right)$$

$$= \frac{w(L1 + L2)}{Q}\left(\frac{w1}{w}\left(\frac{dL1}{L1 + L2} + \frac{\frac{w2}{w1}dL2}{L1 + L2}\right)\right) = \frac{w(L1 + L2)}{Q}\left(\frac{w1}{w}\left(\frac{dL1 + \frac{w2}{w1}dL2}{L1 + L2}\right)\right)$$

$$= \frac{w(L1 + L2)}{Q}\left(\frac{\frac{w1}{w}dL1 + \frac{w2}{w}dL2}{L1 + L2}\right) \qquad \text{(Eq. 5)}$$

where

$$w = \frac{w1L1 + w2L2}{L1 + L2}$$

is the average wage rate and

$$\frac{w1}{w}\frac{dL1 + \frac{w2}{w1}dL2}{L1 + L2}$$

is the growth rate of labor in efficiency units since

$$\frac{w1}{w}(dL1 + \frac{w2}{w1}dL2)$$

is the efficiency-weighted increase in labor.

We can use Equation 5 to compute the growth rate of labor in efficiency units and the difference between $TFP_t{*}$ and $TFP_t{**}$ can be considered due to the quality change in labor.

Similarly, when all types of capital inputs are aggregated into one figure, we use

Equation 3 above. However, when there are several kinds of capital, K_t should be divided into several variables to represent each kind of capital. Hence Equation 3 becomes:

$$Q_t^{*} = TFP_t^{***} + S_k K_t^{**} + S_1 L_t^{*} \quad \text{(Eq. 6)}$$

where $K_t^{**} = 1/2(S_{k1t} + S_{k1t-1})(\ln K_{1t} - \ln K_{1t-1}) + 1/2(S_{k2t} + S_{k2t-1})(\ln K_{2t} - \ln K_{2t-1})$

and S_{k1t} and S_{k2t} are relative income share of the first type of capital K_{1t} and the second type of capital K_{2t} within capital income of year t, respectively.

Then the difference between $TFPG^*$ and $TFPG^{***}$ ($TFPG^* - TFPG^{***}$) is the GDP growth due to the quality change in capital. For the relative income share of capital, we use the following relation:

S_{k1} = (rental price of capital 1)*K_1/{(rental price of capital 1)*K_1 + (rental price of capital 2)*K_2}
S_{k2} = (rental price of capital 2)*K_2/{(rental price of capital 1)*K_1 + (rental price of capital 2)*K_2}

where rental price of capital 1 = (price of capital 1)* (interest rate + depreciation rate of capital 1 − rate of change in the price of capital 1). In case we do not have data on the price of each type of capital, as first approximation, we use a common inflation rate of capital goods or wholesale price.

Effect of Industry Shift

Labor productivity differs from industry to industry. Hence as workers move from less productive to more productive industries, overall productivity improves even with the same number of employed persons. This improvement is part of TFP growth. Hence we can estimate the part of TFP growth due to labor shift among industries using the same method as above.

Regression Analysis

The method described in the above section can be applied only when we have data on the factor prices for the services of each category of input. In many cases, such data are not available or we may have only partial data. For example, if we divide labor input by educational level, we need the number employed for each educational level as well as the corresponding wage rate to use Equation 4B or 5. However, often we only have the number of employed persons for each educational level but not the corresponding wage rate. In this case, we can compute an index to represent the average educational level of total employed persons and then perform a regression of estimated TFP growth using this index. The regression result will tell us if there is any relationship between TFP growth and average educational level of labor.

Similarly, we can include other variables that might affect TFP growth in the regression. One of the factors often tested is R&D investment, and FDI is another. The actual set of variables used in regression analysis depends on the availability of data and may vary from country to country.

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INTRODUCTION

Total factor productivity (TFP) has been widely used for measuring resource use productivity. Previous research mostly aimed at measuring the TFP growth rates for economies at the national or sectoral levels and at investigating factors explaining such growth. Studies on Taiwan's TFP growth were abundant in the 1990s. In papers on TFP growth comparisons among the Asian Tigers, TFP growth rates and sources of GDP growth were estimated by Kim and Lau (1994), Young (1995), and Nadiri and Son (1997). In addition, Dessus, Shea, and Shi (1995), Liang (1995), Chang (1997), Lin, Wang, and Chiu (1998), Lee (1992), Directorate-General of the Budget, Executive Yuan (various years), Lin (2000), and Hu and Chan (1999) investigated TFP growth in Taiwan at the disaggregated sector level. Although those previous studies provided information on TFP growth for the past few decades, the results of TFP growth measurement were very different (Appendix Table 1). Such discrepancies in TFP measurements may result from differences in the estimation method adopted, sample period studied, definition of input or output variables used, and aggregated or disaggregated sectors selected. Therefore one must be very careful in interpreting those figures or using them for international comparisons.

In this research, the author attempted to measure the TFP growth of Taiwan for the past few decades and to identify important determinants that may explain such growth. However, in contrast to previous studies, in this research the growth accounting method was adopted and input and output variables consistent with other country research in a large-scale Asian Productivity Organization project were used (Appendix Table 2) (Srivastava, 2001). Such consistency allows meaningful international comparisons. It is also an important addition of this research that statistical decomposition is performed to consider the quality dimensions of inputs used in the estimation of TFP growth.

GDP GROWTH IN TAIWAN, 1964−99

Table 1 shows that Taiwan has experienced remarkable GDP growth in the past few decades. The average GDP growth rates for the industry and service sectors in the 1960s and 1970s were higher than 10%. Such growth rates remained high but decreased over time in the 1980s (8%) and 1990s (6.5%). However, as a trade-oriented, small-scale economy, Taiwan's GDP growth rates fluctuated in response to the changing worldwide economic situation. The average GDP growth rate was 8.81% in 1965−99, but in years of economic recession such as the mid-1970s (first oil crisis), mid-1980s (second oil crisis), and 1997 (recent Asian financial crisis) it dropped below 5% (Figure 1).

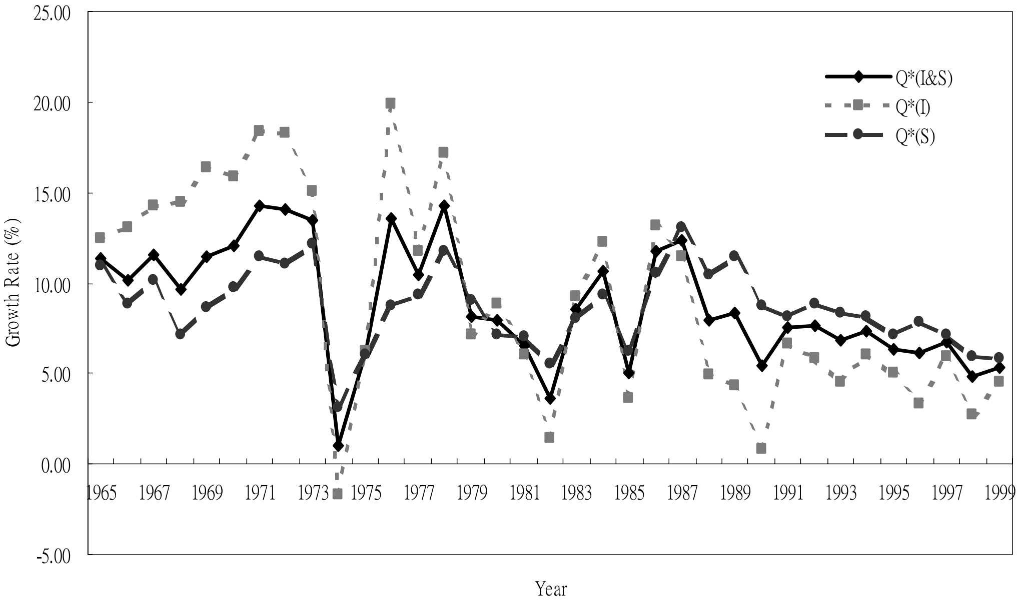
Table 1. Data related to TFP growth in Taiwan (1965−99).

Period	GDP(million NT$) (1996 constant price)	GDP share (%)	Q_t^*(%)	K_t^* (%)	L_t^* (%)	S_l	S_k
Industry & service							
1965−70	60199.00	79.30	11.06	7.29	7.52	0.496	0.504
1971−80	1476125.10	88.25	10.32	10.73	5.99	0.523	0.477
1981−90	3466609.10	93.74	8.02	9.92	3.14	0.537	0.463
1991−99	7015570.78	96.60	6.52	7.27	1.96	0.545	0.455
1965−99	3319104.94	90.43	8.81	9.02	4.40	0.528	0.472
Industry							
1965−70	214899.33	28.09	14.39	5.89	8.34	0.547	0.453
1971−80	657954.90	38.89	12.11	10.41	7.79	0.527	0.473
1981−90	1549802.50	42.21	6.71	9.54	1.95	0.543	0.457
1991−99	2636105.33	36.55	4.96	7.00	0.36	0.562	0.438
1965−99	1345483.37	37.39	9.12	8.51	4.30	0.544	0.456
Service							
1965−70	385299.67	51.21	9.23	10.86	6.90	0.472	0.530
1971−80	818170.20	49.36	8.98	11.43	4.31	0.523	0.477
1981−90	1916806.60	51.53	9.05	10.64	4.34	0.534	0.466
1991−99	4379465.44	60.05	7.49	7.74	3.20	0.533	0.467
1965−99	1973621.57	53.05	8.66	10.16	4.47	0.520	0.481

Q_t^*, K_t^*, and L_t^*, GDP, capital, and labor (annual) growth rates, respectively; S_l, income share of labor; S_k, income share of capital.

The structure of production in Taiwan has changed over time. The share of agriculture in GDP declined from about 20% in the 1960s to 4% in the 1990s, whereas the shares of industry and the service sector increased. The GDP share of the service sector to the total economy was greater than those of the industry and agriculture sectors after 1960. Since the agriculture sector was insignificant in the 1980s and 1990s, this study focuses on industry and services. Table 1 indicates that the GDP growth rates were significantly different between Taiwan's industry and service sectors. The GDP growth rates of industry were much higher than those of services in the 1960s and 1970s. However, after 1980 growth rates of services outpaced those of industry. The substantial growth of the service sector in the past two decades can be attributed to the booming of the financial sector and the growing importance of the telecommunications sector in Taiwan.

Figure 1. GDP Growth for industry, services and industry, and service sector, Taiwan, 1965−99.



TFP GROWTH IN TAIWAN

Growth Accounting Method

In measuring TFP growth, the growth accounting method was adopted, assuming the use of production technology where output is produced by the two inputs of capital and labor. With this method, TFP growth can be obtained by subtracting the contributions of capital and labor growth from GDP growth (Q_t^*). That is:

$$TFG = Q_t^* - S_k K_t^* - S_l L_t^* \qquad \text{(Eq. 1)}$$

where $TFPG$ is TFP growth, S_k and S_l are relative income shares of capital and labor, respectively, and K_t^* and L_t^* are growth rates of capital and labor, respectively.

For a discrete time, we take the average of two consecutive periods for S, and then Eq. 1 can be rewritten as:

$$TFGP = (\ln Q_t - \ln Q_{t-1}) - 1/2\,(S_{k,t-1})(\ln K_t - \ln K_{t-1})$$

$$-1/2\,(S_{l,t} + S_{l,t-1})(\ln L_t - \ln L_{t-1}) \qquad \text{(Eq. 2)}$$

Sources of GDP Growth

The contribution of GDP growth is decomposed into contributions from capital, labor, and TFP growth. Results of the sources of contribution analysis for the industry and service sectors shown in Table 2 indicate that capital is the largest contributor to growth, followed by TFP growth and then labor. For the entire sample period (1965–99), 48% of GDP growth came from capital contribution, labor accounted for 26%, and TFP growth contributed the remaining 26%. A similar pattern was found for the industry sector alone. But for the services sector alone, Table 2 shows that capital contributed 57% of GDP growth, which was the major contribution. The contribution from TFP growth for the service sector only accounted for 17% of its GDP growth, which was about half of the TFP growth contribution to industry.

Table 2. Sources of GDP growth, 1965–99 (% contribution).

Category	Source			
	Q_t^*	$S_k \cdot K_t^*$	$S_l \cdot L_t^*$	TEPG
Industry & service	8.81	4.26 (48.37)	2.28 (25.82)	2.28 (25.81)
Industry alone	9.12	3.91 (42.87)	2.28 (25.02)	2.93 (32.12)
Service alone	8.66	4.91 (56.66)	2.30 (26.55)	1.45 (16.79)

Q_t^*, GDP growth rate; S_K, income share of capital; K_t^*, capital growth rate; S_l, income share of labor; L_t^*, labor growth rate; TFPG, TFP growth rate.
Figures in parentheses represent percentage contribution of capital, labor, or TFP growth (TFPG) to GDP growth.

The sources of GDP growth can be further analyzed by different time periods and by sector (Table 3). The TFP growth for the combined industry and service sectors accounted for 33% of their GDP growth for the years before 1970. The dominant contribution was from the industrial sector (Table 3). However, from 1971, capital became the dominant source of GDP growth for both sectors. This result is consistent with the rapid capital input growth after 1970, as shown in Table 1. For the service sector, capital was the largest contributor after 1965, whereas the contribution of TFP growth was low in the 1960s (3%), 1970s (14%), and 1980s (20%). Nevertheless, by the 1990s the contribution of TFP growth to GDP growth reached a record high for both sectors (34% for industry and 29% for services), which implies a substantial increase in TFP in the Taiwanese economy in the 1990s.

Table 3. Sources of GDP growth, Taiwan, 1965–99 (% contribution).

Period	Source			
	Q_t^*	$S_k \cdot K_t^*$	$S_l \cdot L_t^*$	TEPG
Industry & service				
1965–70	11.06	3.68 (33.29)	3.68 (33.76)	3.65 (32.95)
1971–80	10.32	5.14 (49.77)	3.08 (29.84)	2.10 (20.38)
1981–90	8.02	4.61 (57.42)	1.68 (20.92)	1.74 (21.66)
1991–99	6.52	3.30 (50.58)	1.07 (16.46)	2.15 (32.96)

Continued...

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Industry				
1965−70	14.39	2.69 (18.69)	4.04 (31.69)	7.14 (49.62)
1971−80	12.11	4.94 (40.76)	4.04 (33.39)	3.13 (25.85)
1981−90	6.71	4.37 (65.15)	1.03 (15.32)	1.31 (19.53)
1991−99	4.96	3.07 (61.87)	0.20 (3.96)	1.69 (34.17)
Service				
1965−70	9.23	5.73 (62.05)	3.27 (35.43)	0.23 (2.52)
1971−80	8.98	5.50 (61.20)	2.24 (24.94)	1.24 (13.86)
1981−90	9.05	5.00 (55.22)	2.30 (25.44)	1.75 (19.34)
1991−99	7.49	3.60 (48.09)	1.72 (22.91)	2.17 (29.00)

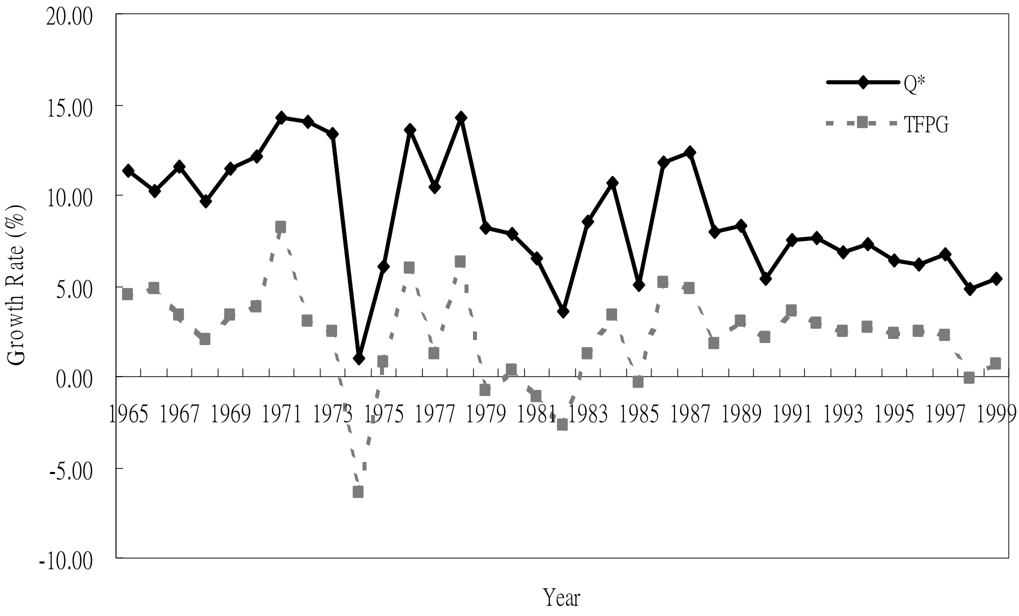
Q_t^*, GDP growth rate; S_K, income share of capital; K_t^*, capital growth rate; S_l, income share of labor; L_t^*, labor growth rate; TFPG, TFP growth rate.

TFP Growth by Period and Sector

The TFP growth rates measured by the growth accounting method are shown in the last column of Table 2. The average TFP growth rate for the combined industry and service sectors in the 1960s was around 4%, but it then decreased over time and became 2% in the 1970s, 1.74% in the 1980s, and 2.15% in the 1990s. Figure 2 also shows that the trend of TFP growth was similar to that of GDP and for years of economic crisis, as stated previously, TFP growth rates became negative.

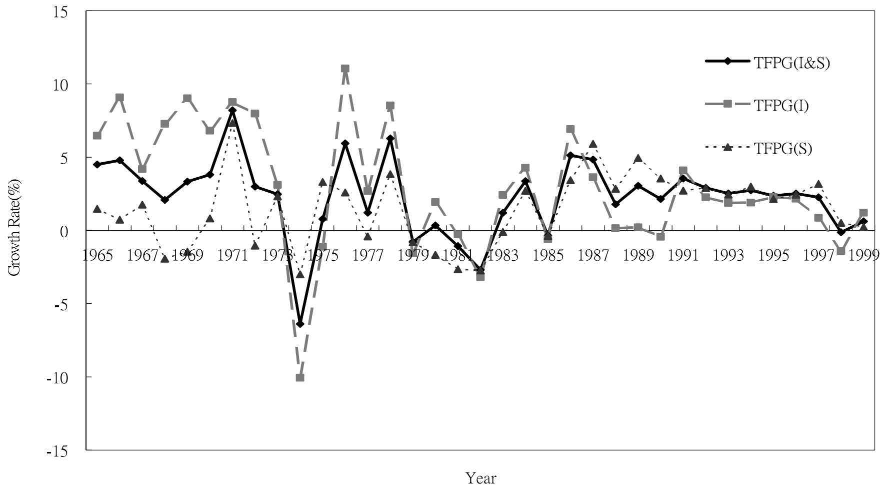
TFP growth was also different by sector. Table 2 shows that the average TFP growth was 2.93% for the industry sector and 1.45% for the service sector from 1965 to

Figure 2. Trends of GDP growth rates (Q*) and TFP growth rates (TFPG) in Taiwan, 1965−99.



1999. However, Table 3 shows that the TFP growth rate for the industry sector decreased from 7.14% in 1965-70 to 1.69% in 1991-99. On the contrary, the TFP growth rates for the service sector in Table 3 indicate an increasing trend, from 0.23% in 1965-70 to 2.17% in 1991-99. It is also noted that the TFP growth rates for the industry sector were much higher than those for the service sector in the 1960s and 1970s, but they became lower in the 1980s and 1990s (Table 3 and Figure 3).

Figure 3. TFPG for industry, services and industry, and services, Taiwan.



TFPG Adjusted for Business Fluctuation

Business fluctuation has been common in Taiwan for the past few decades. However, the common use of "labor employed" cannot fully reflect the actual labor input used in those economic boom or recession years. The effect of business fluctuation can be removed using the following methods: 1) estimate the potential output via the production function approach or via the Wharton method, and then calculate the adjusted TFP growth; and 2) replace the "labor employed" by "labor work hours," which reflect the market demand better, and then apply Eq. 2 to obtain the adjusted TFP growth. This research utilizes the production function approach in adjusting for business fluctuation. (Both the Wharton method and production function approach [in Cobb-Douglas and trans-log functional forms] were attempted empirically. However, only the trans-log results are presented in this paper.)

In this paper, the trans-log functional form was used to estimate production technology. To consider the possible effect of technology change, the time trend variables (T, T^2) were specified in the equation. A neutral technical change is assumed. The estimated function for 1965-99 can be expressed as:

$$\ln Q = \underset{(4.4772)}{95.9476} - \underset{(-1.4710)}{2.1586}\ln K - \underset{(-4.1558)}{15.2043}\ln L + \underset{(2.9251)}{2.0771}\frac{(\ln K)^2}{2} + \underset{(3.4036)}{8.1478}\frac{(\ln L)^2}{2}$$

$$- \underset{(-3.0434)}{3.5407}\ln K + \underset{(5.3687)}{0.2772}T - \underset{(-3.6751)}{0.0034}T^2 \qquad \text{(Eq. 3)}$$

where Q, K, and L are defined as before, T is the time trend variable, T^2 is the quadratic form of the time trend, and figures in parentheses are t-values.

The above estimated function was used to calculate the predicted value of potential output (Q^*). The capacity utilization rate is defined as the ratio of actual output to potential output (Q/Q^*). The TFP growth adjusted for business fluctuation, TFPG(BF), is thus calculated as the difference after subtraction of the rate of change in the capacity utilization rate from TFP growth.

The average estimate of capacity utilization ratio is 1.0003 for the entire sample period (1965–99), whereas it is 0.9974 for the period 1979–99. The third column of Table 4 provides estimates of TFP growth rates adjusted for business fluctuation [TFPG(BF)]. The average TFPG(BF) is 2.29, which is close to that of the TFP growth of 2.28. However, the TFPG(BF) in the period 1979–99 is 1.89%, which is higher than that for unadjusted TFP growth (1.73%).

Table 4. TFP growth (TFPG) and TFPG adjusted for business fluctuation, labor decomposition, and industry shift.

			Business fluctuation	Labor decomposition		Industry shift
				Occupational difference	Educational difference	
Year	**Q^***	**TFPG**	**TFPG(BF)**	**TFPG(OD)**	**TFPG(ED)**	**TFPG(IS)**
1965	11.40	4.50	1.49			4.54
1966	10.20	4.78	9.05			4.86
1967	11.52	3.37	1.74			3.15
1968	9.67	2.08	4.29			2.07
1969	11.48	3.33	3.59			3.33
1970	12.10	3.81	3.45			3.74
1971	14.23	8.20	4.40			8.04
1972	14.07	2.99	0.68			2.99
1973	13.42	2.47	3.56			2.56
1974	1.05	−6.39	0.31			−6.31
1975	6.09	0.77	−1.56			1.01
1976	13.60	5.94	0.96			6.10
1977	10.42	1.21	4.14			1.25
1978	14.24	6.28	4.30			6.51
1979	8.19	−0.78	4.03	−0.74	−0.88	−0.71
1980	7.92	0.34	0.22	−0.11	0.17	0.32
1981	6.55	−1.07	−3.62	−1.25	−1.61	−1.17
1982	3.60	−2.69	−0.14	−2.74	−3.23	−2.91
1983	8.58	1.20	0.68	1.20	1.08	1.14
1984	10.69	3.36	1.75	3.40	3.53	3.49

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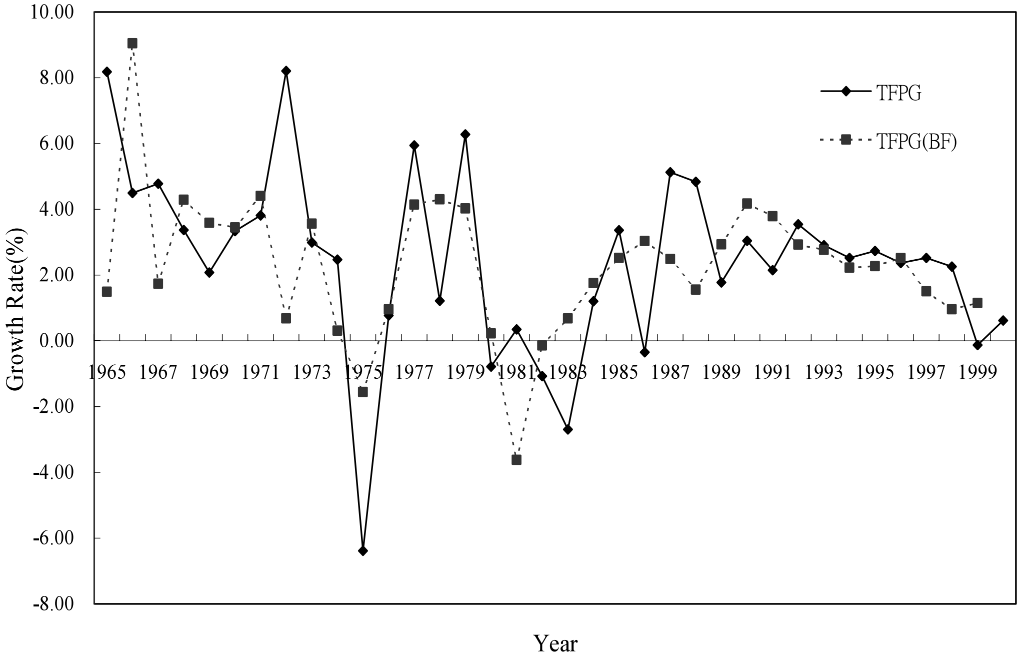
1985	5.02	−0.35	2.52	−0.58	−0.42	−0.52
1986	11.74	5.13	3.04	5.05	4.95	5.08
1987	12.35	4.84	2.49	4.72	4.58	4.90
1988	7.92	1.78	1.56	1.33	1.44	1.55
1989	8.36	3.04	2.93	2.70	2.88	2.88
1990	5.40	2.15	4.17	1.55	1.67	1.90
1991	7.54	3.54	3.79	3.36	3.92	3.39
1992	7.64	2.91	2.93	2.68	2.39	2.80
1993	6.85	2.52	2.77	2.10	2.37	2.37
1994	7.30	2.74	2.23	2.74	2.54	2.72
1995	6.35	2.37	2.27	2.31	2.10	2.29
1996	6.14	2.52	2.51	2.38	2.24	2.35
1997	6.72	2.26	1.50	2.19	1.74	2.32
1998	4.79	−0.13	0.96	−0.26	−0.50	−0.22
1999	5.35	0.62	1.15	0.50	0.51	0.45
Mean (1965−99)	8.81	2.28	2.29	1.55	1.50	2.24
Mean (1979−99)	7.38	1.73	1.89	1.55	1.50	1.64
Variance (1965−99)	11.05	7.18	4.50	3.91	4.26	7.29
Variance (1979−99)	4.85	3.91	2.97	3.91	4.26	4.04
Mean						
1965−70	11.06	3.65	3.93			3.62
1971−80	10.32	2.10	2.10	−0.42	−0.36	2.18
1981−90	8.02	1.74	1.54	1.54	1.49	1.63
1991−99	6.52	2.15	2.23	2.00	1.92	2.05

Figure 4 shows that the variance in TFP growth adjusted for business fluctuation [TFPG(BF)] is smaller than that of TFP growth. That is, TFPG(BF) is 4.50 as compared with TFP growth of 7.18 for 1965−99 (Table 4). The fluctuation in TFPG(BF) was much smaller than that in TFP growth, especially in the 1970s and 1980s. Therefore the trend of adjusted TFP growth became much smoother after removing the effect of business fluctuation.

Figure 4. TFPG and TFPG adjusted for business fluctuation TFPG(BF), Taiwan, 1965-99.



STATISTICAL DECOMPOSITIONS

Procedure for Decomposition

The estimation of TFP growth in the previous section implicitly assumes capital or labor inputs to be homogenous. However, in reality, labor will have different quality due to educational or occupational differences, as does the quality of capital input. To consider those heterogeneous characteristics of labor inputs, one needs a decomposition procedure to measure the TFP growth adjusted for input quality. For ease of presentation, we assume that labor can be divided by two categories, $L = (L_1, L_2)$. Then TFP growth adjusted for input quality [TFPG(IQ)] can be measured using the following equation:

$$TFG\,(\,IQ\,) = GDP_t^{\,*} + S_k^{\,*}\,K_t^{\,*} + S_l\,L_t^{\,**} \qquad \text{(Eq. 4)}$$

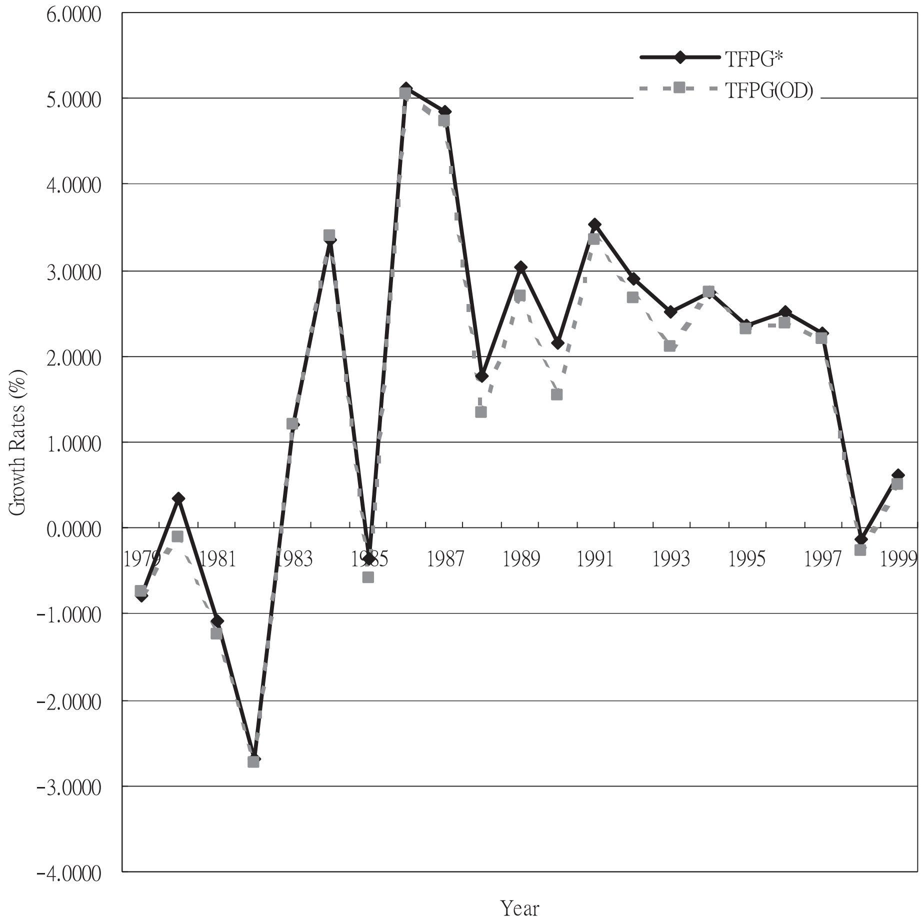
where $L_t^{**} = 1/2(S_{l1,t} + S_{l1,t-1})\ (\ln L_{1,t} - \ln L_{1,t-1}) + 1/2(S_{l2,t} + S_{l2,t-1})\ (\ln L_{2,t} - \ln L_{2,t-1})$, and $S_{l1,t}$ and $S_{l2,t}$ are relative income shares of the first type of labor (L_1) and the second type of labor (L_2) within labor income of the year t.

Labor Decomposition

Decomposition by Occupational Difference

To perform decomposition, labor was classified into the three occupational categories of skilled, semiskilled, and unskilled. Skilled labor is defined to include the occupations of legislators, government administrators, business executives and managers, professions, technicians, and associated professionals. The semiskilled category includes the occupations of clerks, service workers, and shop and market retail workers. Unskilled labor is defined as blue-collar workers including production machinery operators and related workers.The mean estimated TFP growth rates adjusted for occupational difference of labor [TFPG(OD)] is 1.55% for the whole period (1979−99) (fourth column of Table 4). The TFPG(OD)s rates were negative in the late 1970s and early 1980s. They then increased over time until 1997. The average TFPG(OD) rate was 1.53% in the 1980s and 2.0% in the 1990s, which were lower on average than rates of unadjusted TFP growth. The trends for TFP growth unadjusted and adjusted for occupational difference are also shown in Figure 5a.

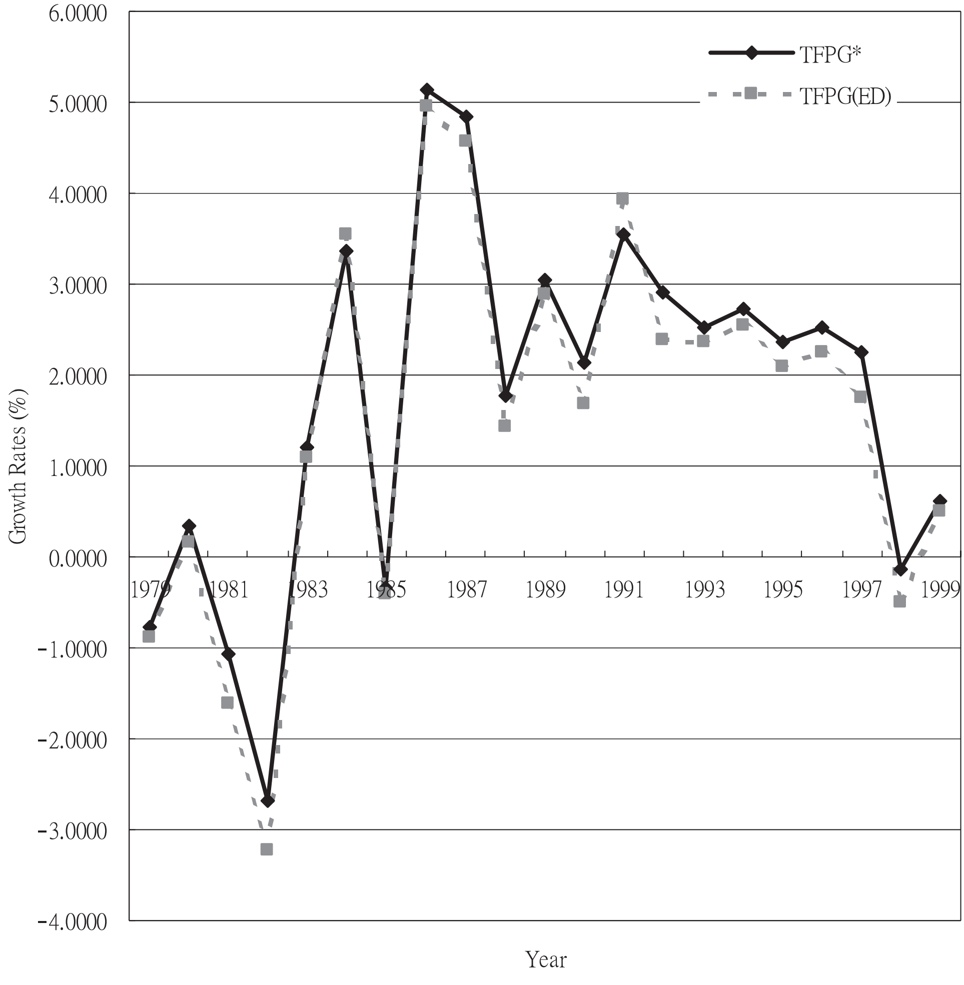
Figure 5a. TFPG and adjusted TFPG for labor quality by occupational difference (OD), Taiwan, 1979−99.



Decomposition by Educational Difference

Labor was classified by educational level into three categories: junior high school and below; senior high school; and college and above. Labor adjusted by educational difference was used to replace labor employed in the estimation of TFP growth. The TFP growth rates adjusted for educational difference [TFPG(ED)] are shown in the fifth column of Table 4. While the average TFPG(ED) was 1.50% for 1979−99, it was negative for the late 1970s and early 1980s and then became positive after 1983. As a result, the average TFPG(ED) was 1.5% for for the 1980s and 1.9% for the 1990s, which were also lower than the estimates for unadjusted TFP growth. The trend of TFPG(ED) was lower than that of TFP growth (Figure 5b).

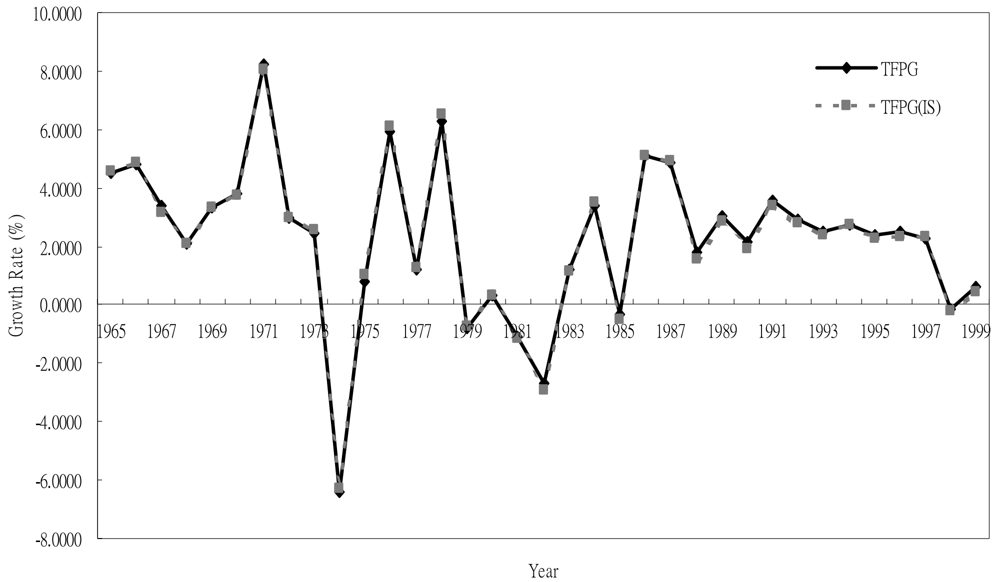
Figure 5b. TFPG and adjusted TFPG for labor quality by educational difference (ED), Taiwan, 1979−99.



TFP Growth Adjusted for Industry Shift

As indicated previously, the structure of industrial production in Taiwan has shifted gradually from industry to the service sector over the past few decades. To capture the effect of such an industry shift on TFP growth, a similar procedure was adopted as for labor quality decomposition for analysis. By assuming that labor employed in industry is different from that in services, labor is divided into the two categories of those working in industry and in the service sector. By adopting a similar procedure as for labor decomposition, we obtain the TFP growth rates adjusted for industry shift [TFPG(IS)]. TFPG(IS) rates were shown to be slightly lower than those of TFP growth (Table 4). However, the trends for both TFP growth and TFPG(IS) were very similar (Figure 6).

Figure 6. TFPG and adjusted TFPG for industry shift (IS), Taiwan, 1965−99.



DETERMINING FACTORS OF TFP GROWTH IN TAIWAN

It is important and interesting to understand the driving forces behind the growth of TFP. To identify those important factors that may explain Taiwan's TFP growth, the least-square regression method was adopted for analysis. The dependent variables are unadjusted TFP growth and adjusted TFP growth rates including TFPG(BF), TFPG(OD), TFPG(ED), and TFPG(IS). The sample period for this regression analysis is limited to the years from 1981 to 1999 due to data availability of some explanatory variables or adjusted TFP growth rates used in the regression analysis.

The variable definition and sample statistics for factors used to explain TFP growth are listed in Table 5. The growth rate of the ratio of trading volume of stock to GDP (STOCKG) is a variable reflecting the degree of capital market openness. The higher the

STOCKG, the easier it is for companies to obtain the needed financing via the open market. The openness of the capital market was very important to Taiwanese industries involved in capital-intensive technology in the 1980s and 1990s. The ratio of imports to GDP (IMR) and the ratio of exports to GDP (EXR) are variables representing the trade openness of an economy. Since Taiwan is a trade-dependent economy, the higher the EXR, the greater the industrial competitiveness of Taiwan, which could imply an increase in TFP growth. The effect of IMR on TFP growth depends on the content of the IMR. The IMR could be regarded as a variable for importing new foreign technology, which would have a positive effect on the growth of TFP. The effect could also be negative if most imports are not for consumption but for production.

Table 5. Variable definitions and sample statistics, 1980−99.

Variable	Definition	Mean	SD
STOCKG	Growth rate of (trading volume of stocks/nominal value of GDP of total sectors)	50.03	103.17
IMR	Value of imports/nominal value of GDP (%)	31.52	5.02
EXR	Value of exports/nominal value of GDP (%)	37.53	3.81
GI	Government investment ratio (%) (government investment/nominal value of GDP)	5.18	1.33
R&DG	Growth rate of (R&D expenditure/nominal value of GDP)	8.54	10.68
DYEARS	Dummy variable, DYEARS = 1 if years in 1987−99; other years = 0	0.65	0.49

The ratio of government investment to GDP (GI) represents government public investment to improve the operational environment and infrastructure of industry. The higher the GI, the higher the TFP growth. The growth rate of the ratio of R&D expenditure to GDP (R&DG) is a variable reflecting efforts for advancing production technology. Therefore a positive effect of R&DG on TFP growth can be expected. It might also be expected that such effects would show a lag period of three years (R&D-3) due to the nature of R&D in the production process. Finally, a dummy variable (DYEARS) to represent the period of industrial outflow (after 1987) of Taiwanese manufacturing industries is used.

The results of TFP growth for combined industry and services [TFPG(I&S)], and the industry sector and the service sector separately using regression analyses are shown in Table 6. The goodness of fit for these three models is reasonable. Table 6 indicates that variables such as STOCKG, IMR, EXR, GI, and R&DG(-3) are significant in TFPG(I&S) regression. The booming of the Taiwanese stock market since the late 1980s has provided an open capital market for firms to finance their investment needs at cheaper cost. Thus the amount of stock market trading (STOCKG) is positively correlated with TFP growth. The lag time of the impact of R&D on TFP growth is three years. The negative sign of IMR indicates that the recent technology advances of Taiwan industries were not due to imports. As expected, exports have had a positive and significant effect on TFP growth since Taiwan is a trade- and export-oriented economy. These results appear to imply that more TFP growth would result if export growth were promoted. In addition, the significant and positive effect of government investment on TFP growth also indicates the importance of the role of government in capital investment. Finally, the results also indicate the importance of the growth of the stock market to TFP growth. The regression results of TFP for the industry and service sectors are similar to that of TFPG(I&S) (Table 6). However, the DYEARS dummy is positive and significant for the service sector but negative and significant for industry.

Table 6. Regression analysis of determinants of TFP growth, 1980−99.

Variable	TFPG(I&S)	TFPG(I)	TFPG(S)
Constant	−7.75 (−2.03)*	−15.99 (−2.31)*	−2.81 (−0.80)
STOCKG	0.01 (3.35)*	0.01 (1.86)**	0.01 (3.69)*
IMR	−0.38 (−4.07)*	−0.45 (−2.65)*	−0.32 (−3.78)*
EXR	0.40 (3.20)*	0.62 (2.76)*	0.26 (2.28)*
GI	1.03 (3.16)*	1.68 (2.84)*	0.43 (1.44)
R&DG (−3)	0.06 (2.87)*	0.07 (1.79)**	0.06 (3.06)*
DYEARS	0.53 (0.70)	−2.47 (−1.78)**	2.96 (4.21)*
Adjusted R^2	0.79	0.65	0.86
F	6.42	3.13	10.47

*Statistically significant at 5% level, **statistically significant at 10% level.

Regression analysis results for adjusted TFP growth rates such as TFPG(BF), TFPG(OD), TFPG(ED), and TFPG(IS) are shown in Table 7. Table 7 indicates that all variables used in the TFP growth regression analysis including STOCKG, IMR, EXR, GI, R&DG(-3), and DYEARS are significant factors in explaining adjusted TFP growth. The signs and magnitudes of those variables in the adjusted TFP growth rate regressions are similar to those in TFPG(I&S) regression. Despite some discrepant results in sign and magnitude for the independent variables in the regression analyses, overall it may be concluded that the amount of stock traded, imports, exports, government public investment, R&D spending, and industrial outflow were all determining factors in TFP growth in Taiwan for the past two decades.

Table 7. Regression analysis on determinants the adjusted TFP growth, 1980−99.

Variable	TFPG(BF)	TFPG(OD)	TFPG(ED)	TFPG(IS)
Constant	1.90	−9.36	−8.03	−8.90
	(0.82)	(−2.25)*	(−1.93)**	(−2.19)*
STOCKG	−0.003	0.01	0.01	0.01
	(−1.64)	(3.26)*	(2.90)*	(3.49)*
IMR	−0.30	−0.37	−0.40	−0.38
	(−5.31)*	(−3.69)*	(−3.92)*	(−3.95)*
EXR	0.17	0.42	0.41	0.41
	(2.23)*	(3.14)*	(3.06)*	(3.22)*
GI	0.52	1.11	1.05	1.06
	(2.64)*	(3.13)*	(2.97)*	(3.17)*
R&DG (−3)	−0.004	0.06	0.06	0.06
	(−0.30)	(2.69)*	(2.79)*	(3.03)*
DYEARS	1.21	1.16	0.41	0.40
	(2.60)*	(0.19)	(0.49)	(0.50)
Adjusted R^2	0.82	0.77	0.77	0.79
F	7.34	5.44	5.64	6.45

*Statistically significant at 5% level, **statistically significant at 10% level.

POLICY IMPLICATIONS AND CONCLUSIONS

The purposes of this research were to measure TFP growth and to identify important determinants that may explain it. When the growth accounting method was used to measure TFP growth rates for different sample periods and sectors, the average was 2.28% for the combined industry and service sectors, 2.93% for the industry sector alone, and 1.45% for the service sector alone for the period from 1965 to 1999. TFP growth rates in the 1960s and 1970s were higher than those in the 1980s and 1990s for the industry and service sectors. The decreasing trend may be mainly attributed to the drastic decrease in TFP growth in industry since 1980. The results of source-of-growth analysis in this paper indicated that the largest contribution to industry came from capital, followed by TFP growth and then by labor.

To investigate the impact of business fluctuation, labor quality, and industrial shift on TFP growth measurement, a decomposition approach was taken to adjust for business fluctuation, labor quality, and industrial shift. The adjusted TFP growth rates were compared with the unadjusted rates. The estimates of TFP growth adjusted for business fluctuation tend to have smaller variance than those of unadjusted TFP growth rates. Thus the adjustment for business fluctuation is important. Except for TFP growth adjusted for business fluctuation, the means for the other adjusted rates tended to be lower than that of the unadjusted rate. Therefore, without appropriate adjustment for input quality, most TFP growth will be overestimated.

Finally, the regression method was used to identify determinants that may explain unadjusted or adjusted TFP growth in Taiwan. The results showed that exports, imports, government investment, trading volume on the stock market, and domestic R&D are significant major factors explaining Taiwanese TFP growth from 1979 to 1999. This strongly suggests that the free trade policy resulted in TFP growth by exposing Taiwan to world competition. It also suggests that further efforts in R&D would be important in improving TFP.

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Appendix Table 1. Previous studies on TFP growth estimates for Taiwan.

Study	Sample period	TFPG (%)	Contribution of TFPG to GDP growth (%)	Sector studied
Young (1995)	1966−90	2.9	30.9	Industry and service
	1980−90	3.9	50.0	
	1966−90	2.6	27.7	
	1980−90	3.3	42.3	
Kim & Lau (1994)	1953−90	0.8	9.2	Whole economy
Dessus, Shea & Shi (1995)	1951−90	3.16	38.0	Whole economy
Liang (1995)	1961−93	1.40	15.6	Excluding government
	1982−93	3.45	44.0	
Collins & Bosworth (1996)	1960−94	2.6	40.6	Whole economy
	1984−94	3.3	54.1	
	1960−94	2.0	31.3	
	1984−94	2.8	45.9	
Chang (1997)	1961−96	3.7	42.0	Whole economy
	1988−96	2.8	41.8	
Nadiri & Son (1997)	1965−90	3.0	34.5	Whole economy
Ling, Wang & Chu (1998)	1952−60	4.22	54.6	Whole economy
	1961−70	3.57	38.8	
	1971−80	1.90	20.4	
	1981−90	3.40	44.6	
	1991−96	2.32	37.0	
	1952−96	3.12	38.1	
DGBS (1998)	1979−96	2.25	27.6	Industry and service
	1979−89	1.81	20.2	
	1989−96	2.85	41.8	
Hu & Chan (1999)	1979−96	2.8	35.9	Industry and service
	1979−86	1.9	23.5	
	1989−96	3.3	44.0	

DGBS, Directorate-General of the Budget and Statistics, Executive Yuan.

Appendix Table 2. Variable descriptions and data sources.

Variable	Definition	Source
GDP	GDP at factor cost at 1996 constant price, unit: million NT$ (excluding agriculture sector)	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *National Income in Taiwan Area of the Republic of China, 1951−99*
Capital	Real net fixed capital stock (excluding land) at 1991 constant price, unit: million NT$	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *The Trends in Multifactor Productivity, 1952−99*
Income share of capital & labor	Share of labor = ratio of labor compensation to domestic income share of capital: 1 – share of labor	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *The Trends in Multifactor Productivity, 1978−99*
Labor	1. Employed persons' educational attainment by industry 2. Employed persons' educational attainment by occupation	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *Report on the Manpower Utilization Survey, 1978−2001*
Wage rate by occupational level	Average monthly income of major jobs for employees classified with occupation, by industry	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *Social Indicators in Taiwan Area of Republic of China, 1978−99*
Wage rate by educational level	Average monthly income of major jobs for employees classified with education by age	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *Report on the Manpower Utilization Survey, 1978−99*
Work hours	Annual growth rate of work hours	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *Yearbook of Earnings and Productivity Statistics, Taiwan Area, Republic of China, 1973−99* (Table 14, Average monthly working hours)
R&D	R&D expenditure, unit: 100 million NT$	Council for Economic Planning and Development, Taiwan, *Taiwan Statistical Data Book, 1979−99*
FDI	Foreign direct investment, unit: US$1000	Investment Commission Ministry of Economic Affairs, *Taiwan, Statistics on Overseas Chinese & Foreign Investment, Outward Investment, Outward Technical Cooperation, Indirect Mainland Investment, Guide of Mainland Industry Technology, 1979−99*

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Exports	Value of exports, unit: million NT$	Department of Statistics, Ministry of Finance, Monthly Statistics of Exports and Imports, Taiwan, R.O.C., 1979–1999 (Table 1, Value of foreign trade)
Imports	Value of imports, unit: million NT$	Department of Statistics, Ministry of Finance; *Monthly Statistics of Exports and Imports, Taiwan, R.O.C., 1979–1999* (Table 1, Value of foreign trade)
Government investment	Gross fixed capital formation by general government with deflator, unit: million NT$	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *National Income in Taiwan Area of the Republic of China, 1979–99* (Table 15, Gross capital formation by type of goods and owner)
Share of services	Value of services sector/GDP	Directorate-General of the Budget, Accounting and Statistics, Executive Yuan, Taiwan, *Social Indicators of the Republic of China, 1979–99* (Table 8, Structure of domestic production)
Stock	Trading volume of stock, unit: 100 million NT$	Department of Statistics, Ministry of Finance, *The Republic of China Monthly of Financial Statistics, 1979–99* (Table 1, Major financial and economic indicators)

INDIA

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INTRODUCTION

Total factor productivity (TFP) analysis of India was carried out at the macro level in 1998 (Srivastava, 1998) as part of a larger project of the Asian Productivity Organization (APO). The study was conducted for India for the period of 1973-74 to 1994-95. The main objective of the APO in promoting such a study on Asian countries was to evolve a common methodology to evaluate TFP growth performance. The present study intends to fulfill the APO objective of extending the earlier study to more recent years using a similar methodology with some refinements and of evaluating the key determinants of TFP growth performance in India during 1977-78 to 2000-01. The results are expected to enable the APO to make a comparative analysis of TFP growth and its determinants among its member countries.

Productivity Growth and Economic Progress

Productivity is an important concept in the context of the economic growth of a nation. In the macroeconomic context, productivity refers to the rate at which output is generated from the employed resources. Output can be increased by increasing the quantum of physical inputs deployed in the production process. However, every nation has constraints on physical inputs. For example, advanced countries like the USA and Japan face severe shortages of labor. The problem of physical input constraints is more severe in developing countries like India. In India, capital inputs are scarce and therefore costlier, due to lower per capita income, lower savings rate, and income inequalities. Both the public and private sectors find it increasingly burdensome to mobilize capital resources on a continuous basis to support their growth needs. Although labor is abundant in India, there are even labor input limitations because of structural deficiencies such as an imbalance between skill availability and skill requirements and because of poorer productivity. Accelerating the rate at which output is generated from the employed resources is an imperative for India, i.e., productivity growth must occur.

Role of TFP

Productivity changes as production continues. It improves under favorable circumstances and deteriorates when unfavorable changes occur. The changes that lead to higher productivity of inputs are technological improvements, improvement in efficiency, increased education of labor, improvement in the quality of labor due to training, etc. Since such changes simultaneously affect different physical inputs favorably or unfavorably and since the resultant change in output cannot be attributed to the individual physical inputs, productivity improvements arising from such changes are collectively termed TFP growth. The origin of the term can be traced to the "Abramovitz residual," which refers to the growth of output unaccounted for by the factor inputs (Abramovitz, 1956). Today, TFP is considered an important source of output growth worldwide due to rapid progress in science and technology and various efficiency-enhancing measures.[1]

In the past, India did not experience very significant growth in TFP in such limited areas as manufacturing, which were used to estimate TFP growth. Analyzing the various estimates, Goldar (1985) found that TFP growth accounted for about 21-24% of the output growth in India during 1951–65. The share of TFP declined to 15% when it was estimated for the period 1959–79. Large-scale manufacturing industry in particular experienced sluggish growth in TFP during 1951–79. TFP growth in the small-scale sector during 1959–79 was not significantly different from that in the large-scale sector and accounted for 22% of small-scale sector output growth per annum during thiat period. Ahluwalia (1991) reported that during 1959–60 to 1985–86, the organized manufacturing industries accounting for about 56% of value added had negative TFP growth, those accounting for 33% of value added had 0–1.5% TFP growth, and only industries accounting for 11% of value added had TFP growth exceeding 1.5%. Further, Unni et al. (2001) found negative TFP growth rates for both the organized and unorganized manufacturing sectors during 1978–95.

Protection from international competition had a depressing effect on TFP growth in India during 1960–70 (Goldar, 1985). The TFP environment, however, has seen tremendous changes during the past 20 years. Since the early 1980s, India has carried out some degree of reforms and liberalization. This process was accelerated during the 1990s. Consequently, several restrictive rules and regulations that had earlier suppressed efficiency disappeared or were diluted significantly. Foreign technologies and efficient practices began penetrating rapidly. The removal of import barriers and entry restrictions after 1991 unleashed competitive forces in the economy. The disappearance of government protection and the reality of foreign competition forced Indian entrepreneurs to seek urgent measures for cost-effectiveness.

The years since the early 1980s have also produced faster average growth of GDP in India. In short, the 1980s and 1990s invigorated TFP forces in India. Therefore sustained TFP growth is expected to have occurred. Ahluwalia (1991) found that TFP in the manufacturing sector grew at a compounded annual rate of 3.4% during the first half of the 1980s as compared with the near zero or negative growth in the previous one-and-a half decades. In the earlier APO study, Srivastava (1998) reported the average TFP growth for the macro economy during 1973–74 to 1984–85 was only 1.25% while that during 1985–86 to 1994–95 was 2.11%. However, Balakrishnan and Pushpangadan (1994; see also 1995, 1996, 1998) showed that TFP growth estimates for the manufacturing sector revealed deceleration during the 1980s when appropriate methodological precautions were taken during estimation. Unni et al. (2001) also found a decline in manufacturing TFP growth rates during the early 1990s. Moreover, the results of Balakrishnan et al. (2000; see also Balakrishnan and Pushpangadan, 2002) appear to imply that TFP growth rates in manufacturing did not accelerate even during the late 1990s. Since previous studies did not establish whether the changed economic environment of India after the 1980s played a positive role in TFP growth, this study was undertaken to determine the actual TFP growth performance of India during the past two decades.

Scope of the Study

This study estimates TFP growth in India from 1976–77 to 2000–01 and determines whether the trend in TFP growth indicated in the earlier APO study continued. The study aims further at evaluating the impact of qualitative differences in factor inputs on TFP growth estimates. Finally, an attempt is made to identify the major determinants of TFP growth in India from 1977–78 to 2000–01 using an econometric model. The study attempts to verify the following possibilities:

1) Liberalization and deregulation may improve the allocative efficiency of factor inputs by shifting existing or new factor inputs from inefficient/low value-added sectors to efficient/high value-added sectors (such as the private/organized sector). Thus structural changes in factor allocation may be favorable to TFP growth.
2) The organized sector may be more efficient due to its economies of scale and higher quality of technology, inputs, and management. Therefore the contribution of the organized sector to TFP growth may be higher than that of the unorganized sector.
3) R&D, as a mechanism to generate scientific knowledge and to translate that knowledge into practicable techniques, is an important source of technical efficiency and hence of TFP growth. With faster increases in R&D spending, TFP should grow faster. In India, however, R&D investment has yet to become a significant force in proportion to output and the impact of R&D on TFP growth may be limited.
4) Foreign capital and collaboration may lead to greater efficiency due to associated benefits such as the inflow of better technology, inputs, technical and managerial expertise, etc. and due to the demand for higher returns. TFP growth should thus accelerate with the increasing inflow of foreign capital and collaboration. However, foreign capital has yet to become a significant proportion of investment in India, and hence foreign capital may not explain TFP growth significantly. However, since foreign collaboration has been an important source of technology, expertise, etc. in the past, TFP growth may be significantly influenced by greater foreign collaboration.
5) Past studies suggested a strong association between growth rates of output and of TFP (Goldar, 1985). This could be attributed to technological progress and to economies of scale in the following ways. Faster output growth may culminate in the addition of superior new capacity. Faster output growth may also attract better managers, reduce employee resistance, and lower uncertainty, leading to quicker decision making. In addition, faster output growth may enable the adoption of technologies permitting higher economies of scale at higher levels of output (economies of size). The removal of the restrictions on expansion of operations, especially since 1991, has given Indian producers the opportunity to expand production and reap the benefits of scale economies in a significant way. Scale economies are one important source of TFP growth. Therefore a significant proportion of TFP growth, particularly since the 1990s, may have come from scale economies. Since growth rates of output may capture such effects, the output growth differentials might be useful in explaining their impact on TFP growth.
6) Trade restrictions have been partly blamed in the past for poor TFP growth in India, especially during the 1970s and earlier. The trade liberalization of the 1980s and 1990s could be expected to assist faster TFP growth. Trade-related variables in TFP analysis should therefore have positive coefficients. However, whether trade actually facilitated TFP growth in India is a moot question given its negligible share of world trade and relative lack of openness in the economy.

Methodological Issues

Requirements for TFP Analysis

TFP growth can be evaluated at various levels such as firm, industry, sector, and economy. To assess the overall improvement of TFP including technological progress, improvement of efficiency, etc., TFP growth must be analyzed at the national level with appropriate analyses at the subnational level to determine the impact of changes in subnational structures. TFP analysis requires numerous quantitative data in addition to qualitative information on forces affecting TFP growth. At the national level, the main items of quantitative data needed for measuring TFP growth rate are national output, capital stock, and employment. To explain changes in TFP growth, data on factors affecting it such as R&D investment, foreign investment participation, structural changes in industry (e.g., intersectoral shifts in factor inputs), scale changes, etc. are required. For subnational analysis, similar data are required on various sectors, industries, etc. In this study, the focus is restricted to the national level.

Until the 1998 APO study, no comprehensive TFP growth studies on India involved the national macro economy with or without a growth accounting framework. The major reason for this was data problems, especially aspects of employment. A few TFP studies concentrated on specific sectors such as manufacturing, for which data were readily available. Even in the earlier APO study, the author faced severe data constraints and was forced to derive the necessary employment data under various assumptions and through methods of extrapolation and interpolation. Such constraints still exist.

Problems in TFP Analysis

It is difficult to conduct TFP growth analysis in India because of the paucity of data, especially on the informal or unorganized sector. For example, India does not report systematic annual data on employment since there is no mechanism to estimate athe annual workforce, employment in the unorganized sector, and actual unemployment. Dependable labor force data for the entire economy exist only for census years.

Several agencies collect and/or circulate data on employment and other vital economic variables, such as the National Sample Survey Organization (NSSO), Central Statistical Organization (CSO), and Planning Commission. Only the NSSO generates primary employment data through periodic sample surveys and data on employment in the unorganized sector. However, it is unable to provide annual data in a systematic way over the years because its surveys are not carried out annually and because its method of estimation is a sample one with changing methodology and coverage over the years. Obtaining reliable data on the components of capital stock such as structures or buildings, machinery and equipment, etc. along with the capital invested in them, as suggested by the APO, is also difficult.

Methodological Limitations

The data constraints are compelling reasons to use assumptions and approximations. Some data points on employment are available for some years before and after 1991. Using interpolations, an approximate employment series can be constructed for the period up to 1997–98. Srivastava (1998) also reported interpolated data on employment. In this study, data on employment were extended to 2000–01 through extrapolation for which the moving three-year averages of employment growth rates were used.

While aggregate capital stock data for 1975–76 to 2000–01 were taken from publications of the CSO and Centre for Monitoring the Indian Economy (CMIE), it was not possible to find or derive data on the components of capital stock (such as structures, machinery, etc.). Thus, while adjusting TFP growth for capital quality differences, capital stock components of the organized and unorganized sectors that could be derived under relevant assumptions were used. The base period of capital stock data used in this study is 1993–94 (1980–81 in the previous APO study). Also, unlike the previous study in which net fixed capital stock was used as a capital stock measure, the capital stock measure used in this study was net domestic capital stock, which includes "change in stocks." Partly as a result of this, the TFP growth rates in this study differed slightly in numerical magnitude, although not in direction, from the results of the earlier APO study.

Another important aspect in which the present study differs from the earlier APO study is that the factor shares are computed in the present study as a percentage of GDP, not as a percentage of NDP. There is also a slight difference in the method of dividing "mixed incomes" into wages and capital charges.[2] Therefore the factor share values in this study are likely to be different from the earlier ones. The present study is based on 1993–94, not 1980–81, series data. This also could cause some difference in the factor share values between the two studies. Any differences in the factor share values might lead to corresponding differences in TFP growth estimates.

MODELS, RESULTS, AND ANALYSES

Unadjusted TFP Growth

Model

There are several underlying models available from previous studies conducted in different countries for measuring TFP growth. These include the arithmetic model of Kendrick, the geometric model of Solow, and the trans-log model (Christensen et al., 1971, 1973). In this study, the trans-log model was used as part of the common APO methodology. In general, the advantages of a trans-log model include the absence of restrictions on the properties of the underlying technology, on the rate or type of technological progress, on the elasticity of substitution between the factor inputs, etc.

Within a growth accounting framework, the estimate of annual TFP growth is derived based on the following trans-log-based expression:

$$TFPG = (\ln GDP_t - \ln GDP_{t-1}) - (\tfrac{1}{2}(s^k_t + s^k_{t-1})(\ln K_t - \ln K_{t-1})) - (\tfrac{1}{2}(s^l_t + s^l_{t-1})(\ln L_t - \ln L_{t-1})) \quad \text{(Eq. 1)}$$

where $TPFG$ is the growth rate of TFP, GDP is gross domestic product at factor cost at 1993–94 prices, K is capital stock at 1993–94 prices, L is employment, and s^k and s^l denote, respectively, the shares of capital and labor in factor incomes (as measured by GDP).

Results and Analysis

The unadjusted estimates of TFP growth and its contribution to GDP growth in India during 1976−77 to 2000−01 are presented in Table 1. TFP growth rates ranged between −8.06% in 1979−80 to 7.26% in 1988−89. In contrast, the earlier APO study reported a range of TFP growth during the relevant period of -8.11 in 1979−80 to 7.07 in 1988−89. In both estimates, the limits appear in the same years, but the present study found a marginally lower peak decline as well as a marginally higher peak growth in TFP. Further, except in one case (1982−83) declines in TFP growth were found in the present study only in years (1976−77, 1979−80, and 1991−92) that coincided with or followed years of political disturbance or uncertainty. The above result also conforms with the earlier APO finding. Comparing the TFP growth rates of the 1990s and earlier, TFP growth was generally better and more consistent during the 1990s than earlier, although the peak TFP growth rate was higher during the 1980s. This can be verified with reference to Table 2, which presents the mean and standard deviation (SD) of TFP growth during 1977−78 to 1989−90 and 1990−91 to 2000−01.

Table 1. Contribution of factor inputs and TFP growth (TFPG) to GDP growth without adjustment in capital stock for capacity utilization.

Year	TFPG (%)	GDP growth (%)	Contribution to GDP growth (%)		
			Capital	Labor	TFPG
1976−77	−1.64	1.24	125.81	106.45	−132.26
1977−78	4.13	7.20	20.83	21.94	57.36
1978−79	2.67	5.36	28.54	21.64	49.81
1979−80	−8.06	−5.34	−25.47	−25.47	150.94
1980−81	4.36	6.92	20.81	16.18	63.01
1981−82	2.17	5.80	39.48	23.10	37.41
1982−83	−0.25	2.90	65.17	43.79	−8.62
1983−84	4.67	7.39	19.89	16.78	63.19
1984−85	1.31	3.92	40.56	26.02	33.42
1985−86	1.8	4.79	37.37	25.05	37.58
1986−87	1.53	4.24	41.04	22.88	36.08
1987−88	1.27	3.76	35.11	30.85	33.78
1988−89	7.26	9.96	15.66	11.45	72.89
1989−90	3.74	6.49	22.65	19.72	57.63
1990−91	2.52	5.42	30.63	22.88	46.49
1991−92	−1.48	1.29	120.93	93.02	−114.73
1992−93	2.18	4.99	32.87	23.45	43.69
1993−94	3.11	5.71	22.94	22.59	54.47
1994−95	2.79	7.00	37.86	22.29	39.86
1995−96	2.77	7.09	45.70	15.23	39.07
1996−97	4.14	7.55	30.99	14.04	54.83

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1997–98	1.22	4.65	47.96	26.02	26.24
1998–99	3.58	6.36	27.67	16.04	56.29
1999–2000	3.05	6.17	32.41	18.15	49.43
2000–01	2.82	5.83	34.99	16.64	48.37

Table 2. Comparison of TFP growth (TFPG) performance during the 1990s and earlier (mean and SD).

TFPG measure	1977–78 to 1989–90		1990–91 to 2000–01	
	Mean	SD	Mean	SD
TFPG	2.05	3.60	2.43	1.49
Adjusted TFPG	2.05	3.62	2.43	1.50
TFPG**	2.20	3.17	2.90	1.56

In 22 of the 25 years reported in Table 2, TFP growth accounted for a quarter or more of GDP growth. In 12 of those 22 years, the contribution amounted to about half or more of GDP growth. The fact of only five of the years since 1990–91 showed a contribution of TFP growth to GDP growth of nearly 50% or more indicates that the performance of TFP growth during the 1990s was consistently moderate compared with the large fluctuations between highly negative and positive values in the earlier period. This result is also in conformity for the relevant period with the earlier APO results (Srivastava, 1998).

The averages of the annual (unadjusted) TFP growth values for various periods are given in Table 3. The choice of periods for computing the averages takes into consideration the unique economic and political conditions prevailing in the Indian economy in the respective periods. For example, the periods 1976–77 to 1979–80 and 1989–90 to 1991–92 had political and economic disturbances and uncertainties, whereas 1980–81 to 1988–89 and 1992–93 to 1996–97 were periods of reform and more rapid industrial and economic growth.

Table 3. Contribution of factor inputs and TFP growth (TFPG) to GDP growth: subperiod averages (without adjustment in capital stock for capacity utilization).

Period	Averages (%)				
	TFPG	GDP growth	Contribution to GDP growth (%)		
			Labor	Capital	TFPG
1976–77 to 2000–01	2.07	5.07	23.7	35.5	40.8
1976–77 to 1979–80	–0.73	2.12	64.1	70.3	–34.3
1980–81 to 1988–89	2.68	5.52	21.1	30.4	48.6
1989–90 to 1991–92	1.59	4.40	28.2	35.5	36.2
1992–93 to 1996–97	3.00	6.47	19.0	34.6	46.4
1992–93 to 2000–01	2.85	6.15	18.9	34.7	46.4

Table 3 shows that the annual average of TFP growth rates exceeded 2% in both the 1980–81 to 1988–89 and 1992–93 to 2000–01 periods, which were reform periods. During the 1990s, if we consider only the 1992–93 to 1996–97 period, the annual average TFP growth was an impressive 3%. The period 1997–98 to 2000–01 had a slightly lower average annual TFP growth of 2.66% (data not shown). Unfortunately, the average values computed here cannot be compared in most periods with the average values computed by Srivastava in the earlier APO study because the periods are not comparable. Since the present classification of periods is based on logical (economic and political) factors, it was not thought necessary to compute values on the basis of the periods used in the previous study (which appeared arbitrary). For the period of the 1980s for which the average TFP growth values of the two studies can be compared, the values are similar.

The average share of TFP growth in GDP growth during different selected periods can also be similarly interpreted. Notably, in all the subperiods since 1980–81, the share of TFP growth exceeded that of both labor and capital, suggesting that TFP growth was the prime mover of GDP growth throughout the 1980s and 1990s. This is contradictory to the results of the earlier APO study, in which TFP growth contributed the most to average GDP growth only during 1980–81 to 1989–90.

Adjustments in TFP Growth for Capacity Utilization

Model

To estimate the impact of variations in capacity utilization, the capital stock is adjusted for capacity utilization using the Wharton method (Srivastava, 1998). A separate estimate of TFP growth is obtained after adjusting the capital stock for capacity utilization. A comparison of these estimates of TFP growth with the results reported in the previous section will reveal how much the estimated values of TFP growth change with the adjustment of capital stock for variations in capacity utilization.

Results and Analysis

The estimates of TFP growth adjusted for variations in capacity utilization and its contribution to GDP growth in India during 1976–77 to 2000–01 are presented in Table 4. TFP growth rates did not change much due to the adjustment. Also, none of the other conclusions given in the preceding section needs to be modified in any significant manner following the adjustment for capacity utilization. This can be verified further by referring to Table 5. This finding is at variance with the earlier APO study findings, which showed significant changes in TFP growth rates in India with adjustments in capital stock for capacity utilization. One reason for the above result in this study may be that in the Indian economy the phenomenon of recurring business cycles and associated sharp falls in output and capacity utilization have never been a problem as in developed economies like the USA, although India has experienced occasional slowdowns in economic growth. India's problem in the past has been one of perennial capacity underutilization in various activities, notably in industry and the public sector, irrespective of the existence of slowdowns or faster growth. Thus the minor capacity utilization variations associated with the limited fluctuations in output growth may not have affected TFP growth in India significantly.

Table 4. Contribution of factor inputs and adjusted TFP growth (TFPG) to GDP growth.

Year	Adjusted TFPG (%)	GDP growth (%)	Contribution to GDP growth (%)		
			Capital	Labor	Adjusted TFPG
1976-77	-1.64	1.24	125.8	106.5	-132.3
1977-78	4.17	7.20	20.3	21.9	57.9
1978-79	2.67	5.36	28.5	21.6	49.8
1979-80	-8.09	-5.34	-26.2	-25.5	151.5
1980-81	4.36	6.92	20.8	16.2	63.0
1981-82	2.17	5.80	39.5	23.1	37.4
1982-83	-0.25	2.90	65.2	43.8	-8.6
1983-84	4.67	7.39	19.9	16.8	63.2
1984-85	1.31	3.92	40.6	26.0	33.4
1985-86	1.80	4.79	37.4	25.1	37.6
1986-87	1.53	4.24	41.0	22.9	36.1
1987-88	1.27	3.76	35.1	30.9	33.8
1988-89	7.3	9.96	15.3	11.4	73.3
1989-90	3.74	6.49	22.7	19.7	57.6
1990-91	2.52	5.42	30.6	22.9	46.5
1991-92	-1.48	1.29	120.9	93.0	-114.7
1992-93	2.18	4.99	32.9	23.4	43.7
1993-94	3.15	5.71	22.2	22.6	55.2
1994-95	2.79	7.00	37.9	22.3	39.9
1995-96	2.77	7.09	45.7	15.2	39.1
1996-97	4.14	7.55	31.0	14.0	54.8
1997-98	1.22	4.65	48.0	26.0	26.2
1998-99	3.58	6.36	27.7	16.0	56.3
1999-2000	3.05	6.17	32.4	18.2	49.4
2000-01	2.82	5.83	35.0	16.6	48.4

Adjusted TFPG refers to TFPG adjusted for capacity utilization.

Table 5. Contribution of factor inputs and adjusted (Adj.) TFP growth (TFPG) to GDP growth: subperiod averages.

Period	Averages (%)				
	Adj. TFPG	GDP growth	Contribution to GDP growth (%)		
			Labor	Capital	Adj. TFPG
1976-77 to 2000-01	2.07	5.07	23.7	35.4	40.8
1976-77 to 1979-80	-0.72	2.12	64.1	70.3	-34.1
1980-81 to 1988-89	2.68	5.52	21.1	30.3	48.6

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1989-90 to 1991-92	1.59	4.40	28.2	35.5	36.2
1992-93 to 1996-97	3.01	6.47	19.0	34.4	46.5
1992-93 to 2000-01	2.86	6.15	18.9	34.6	46.4

Decomposition of TFP Growth: Effect of Factor Quality Differences

Model

To measure the impact of quality/efficiency differences in labor and capital inputs across sectors on TFP growth, the capacity-adjusted TFP growth was decomposed to determine their effects. For decomposing the factor quality/efficiency effects, it was proposed to consider as many categories of labor and capital and/or as many sectors of the economy as possible. However, due to data constraints, only two categories/sectors were incorporated, the organized and unorganized sectors. In India, the organized sector consists of larger production/business units that are registered under the Factories Act. The organized sector is considered to be more efficient due to various factors such as the availability of better capital and labor inputs, better management, human resources development efforts, etc. Therefore any relative movement of labor or capital toward the organized sector is expected to improve both quality and TFP growth. The following models were used to evaluate the quality effect:

$$TFG^{*L} = (\ln GDP_t - \ln GDP_{t-1}) - \left(\tfrac{1}{2}(S^k + S^k{}_{t-1})(\ln K_t - \ln K_{t-1}) \right) - (S^l L^L)$$

(Eq. 2)

for labor quality effect where $TFPG^{*L}$ = TFP growth after accounting for quality/efficiency differences in labor in the two sectors and

$$L^L = \left(\tfrac{1}{2}(S^{lO}{}_t + S^{lO}{}_{t-1})(\ln L^O{}_{t-1}) \right) + \left(\tfrac{1}{2}(S^{lU}{}_t + S^{lU}{}_{t-1})(\ln L^U{}_t - \ln L^U{}_{t-1}) \right)$$

(Eq. 3)

where $S^l = \tfrac{1}{2}(s^l{}_t + s^l{}_{t-1})$ and the superscripts O and U denote the organized and unorganized sectors, respectively. Then

$$TFG^{*K} = (\ln GDP_t - \ln GDP_{t-1}) - (S^k K^k) - \left(\tfrac{1}{2}(S^l{}_t + S^l{}_{t-1})(\ln L_{t-1}) \right) \quad \text{(Eq. 4)}$$

for the capital quality effect, where $TFPG^{*K}$ is the TFP growth after accounting for quality differences in capital in the two sectors.[3]

$$K^K = \left(\tfrac{1}{2}(S^{kO}{}_t + S^{kO}{}_{t-1})(\ln K^O{}_t - \ln K^O{}_{t-1}) \right) +$$
$$\left(\tfrac{1}{2}(S^{kU}{}_t + S^{kU}{}_{t-1})(\ln K^U{}_t - \ln K^U{}_{t-1}) \right) \quad \text{(Eq. 5)}$$

and $S^k = 1/2\,(s^k{}_t + s^k{}_{t-1})$

$$TFPG^{**} = (\ln GDP_t - \ln GDP_{t-1}) - (S^k K^K) - (S^l L^L) \quad \text{(Eq. 6)}$$

for the combined effect of the intersectoral shift and resultant quality differences in both factors where $TFPG^{**}$ is TFP growth after accounting for quality differences in both capital and labor in the two sectors. Since the capital stock used for computing $TFPG^{**}$ was adjusted for capacity utilization, $TFPG^{**}$ has been purged of the effects of variations in capacity utilization and factor quality/efficiency differences in the selected sectors. Further analysis to identify the various explanatory factors of TFP growth has been performed on the $TFPG^{**}$ measure of TFP growth.

Results and Analysis

The estimates of TFP growth decomposed for the effect of differences in the factor quality/efficiency across sectors and the contribution of the decomposed TFP growth to GDP growth in India during 1977–78 to 2000–01 are presented in Table 6. Quality decomposition of TFP growth was done in three stages. First, only the labor quality effect was removed from the adjusted TFP growth. Second, the effect of capital quality differences alone was removed from the adjusted TFP growth. Finally, both the labor and capital quality effects were separated from the adjusted TFP growth. The estimates of TFP growth corresponding to each of these steps are presented in Table 6. The table also presents the contribution of labor, capital, and TFP growth to GDP growth, but the TFP growth measure there refers to the one in which decomposition was done for both labor and capital quality effects and is denoted by TFPG**.

Table 6. Contribution of factor inputs and TFPG to GDP growth: adjusted TFP growth (TFPG) decomposed for factor quality effects.**

Year	GDP growth (%)	Adjusted TFPG decomposed for dactor quality effect			Contribution to GDP growth (%)*		
		Labor	Capital	Labor & capital	Labor	Capital	TFPG**
1977–78	7.2	3.70	4.48	4.00	29.2	15.3	55.6
1978–79	5.4	1.52	2.98	1.85	42.6	24.1	34.3
1979–80	–5.3	–6.94	–7.66	–6.59	–7.5	–17.0	124.3
1980–81	6.9	4.10	4.82	4.33	26.1	11.6	62.8
1981–82	5.8	1.40	2.69	1.61	44.8	27.6	27.8
1982–83	2.9	–0.12	–0.13	–0.16	48.3	55.2	–5.5
1983–84	7.4	4.46	5.06	4.74	23.0	13.5	64.1
1984–85	3.9	1.19	1.55	1.30	35.9	33.3	33.3
1985–86	4.8	2.19	2.22	2.47	20.8	27.1	51.5
1986–87	4.2	1.29	1.71	1.35	33.3	35.7	32.1

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1987-88	3.8	1.61	3.26	3.51	26.3	-21.1	92.4
1988-89	10.0	7.36	6.29	6.23	13.0	24.0	62.3
1989-90	6.5	3.74	4.09	4.00	23.1	15.4	61.5
1990-91	5.4	2.69	2.84	2.89	24.1	22.2	53.5
1991-92	1.3	-1.41	-1.28	-1.35	107.7	92.3	-103.8
1992-93	5.0	2.61	2.58	2.87	20.0	22.0	57.4
1993-94	5.7	3.45	3.36	3.61	21.1	15.8	63.3
1994-95	7.0	3.43	2.76	3.20	18.6	35.7	45.7
1995-96	7.1	3.02	3.32	3.25	16.9	36.6	45.8
1996-97	7.5	4.26	4.68	4.61	16.0	22.7	61.5
1997-98	4.7	1.80	1.54	1.97	19.1	38.3	41.9
1998-99	6.4	3.80	3.90	4.00	15.6	21.9	62.5
1999-2000	6.2	3.30	3.37	3.52	16.1	25.8	56.8
2000-01	5.8	3.08	3.10	3.29	13.8	29.3	56.7

*Contribution is computed based on TFPG** where TFPG** refers to adjusted TFPG decomposed for the factor quality effect of both labor and capital.

Table 6 shows that TFP growth rates change significantly due to decomposition for factor quality effects from the capacity-adjusted range of about -8.09% to 7.30%. With only the labor quality effect decomposed, it improved to -6.94% to 7.36%; with decomposition of only the capital quality effect, it changed to -7.66% to 6.29%; and with both the labor and capital quality effect decomposed, it changed to -6.59% to 6.23%. It should be noted, however, that the broad trend and direction of TFP growth rates did not change substantially due to the quality adjustments. The last column in Table 6 shows that the estimated contribution of TFP growth to GDP growth increased substantially in several years after it was shorn of the factor quality effects. After decomposition, the TFP contribution to GDP growth was the highest in only 18 of the 24 years, as compared with 21 of the corresponding years before decomposition. However, in most of the years after 1988-89, the contribution of TFP growth to GDP growth showed increases. It is also noteworthy that as a consequence of the decomposition process, the share of capital in GDP growth in most of the years showed declines while that of labor registered increases in many years. Several of the years in which the share of labor in GDP growth declined were in the 1990s. Importantly, given that the factor quality decomposition of TFP growth was performed based on the organized and unorganized sectors, the results (higher TFP growth after decomposition) may imply a TFP and GDP growth-dampening effect of the existing structure of factor distribution between the organized and unorganized sectors and the need for reallocating the factor inputs between the two sectors to improve their productivity potentials.

The averages of the annual TFPG** values for various periods are given in Table 7. In comparison with the case before decomposition, the annual average of TFPG** was higher during both the 1980s and 1990s. It was over 2.8% during 1980-81 to 1988-89 and a still higher 3.5% during 1992-93 to 1996-97. Those periods were the best in the postindependence Indian macroeconomic history. The annual average TFP growth for the period 1997–98 to 2000–01 (data not shown), when macroeconomic and industrial slowdowns occurred in India, was about 3.2%. There was more consistency in TFPG** performance during the 1990s than earlier, as can be seen from the values of the SD reported in Table 2. Such consistent performance also resulted in higher average TFPG** during 1990–91 to 2000–01 compared with the previous decade. Therefore the 1990s clearly produced better TFP growth performance than hitherto suggested in other studies, including the previous APO one.

Table 7. Contribution of factor inputs and TFPG to GDP growth: subperiod averages.**

Period	Averages (%)						
	Adjusted TFPG decomposed for factor quality effect			GDP growth	Contribution to GDP growth (%)*		
	Labor	Capital	Both		Labor	Capital	TFPG**
1977–78 to 2000–01	2.31	2.56	2.36	5.23	26.4	27.0	46.6
1977–78 to 1979–80	−0.57	−0.07	−0.54	2.41	74.9	50.6	−25.5
1980–81 to 1988–89	2.61	3.05	2.82	5.52	27.2	21.7	51.1
1989–90 to 1991–92	1.67	1.88	1.85	4.40	31.9	26.1	42.0
1992–93 to 1996–97	3.35	3.34	3.51	6.47	18.2	27.6	54.2
1992–93 to 2000–01	3.19	3.18	3.37	6.15	17.3	27.9	54.8

*TFPG** refers to adjusted TFP growth decomposed for the quality effect of both labor and capital.

The average share of TFPG** in GDP growth during different selected periods is also given in Table 7. It is remarkable that in all periods except in the politically and economically disturbed and uncertain period of 1977–78 to 1979–80, the average annual share of TFP growth exceeded that of both labor and capital. During the period of political and economic disturbances in India, the contribution of TFPG** to GDP growth was negative.

Comparative Analysis: Adjustment Effects on TFP Growth

A comparative picture of the behavior of annual TFP growth estimates before and after capacity adjustment and factor quality decomposition is shown in Figure 1. The various estimates differ from each other not in the direction of change in TFP growth, but only in the magnitude of change. In particular, the trend lines of TFP growth decomposed for capital quality alone and for both capital and labor quality are mostly higher than those of the other estimates. Notably, fitting a single linear trend line for the entire study period for any of the TFP growth estimates was not justified as the linear trends differed, as Appendix 1, Figure 1 shows for the unadjusted estimates for the pre- and post-1991 periods. Subsequent efforts to investigate the interperiod differences in TFP growth trends yielded scarcely any meaningful results as the trend equations could not capture the TFP growth trends properly. The results corresponded to the following trend equation:

$$TFPG = a + b_1 TIME + b_2 (TIME)(Dummy) + u \qquad \text{(Eq. 7)}$$

where *TFPG* is TFP growth, *TIME* is the index 1 to 24 for years from 1977–78 to 2000–01, and *Dummy* = 1 for the years up to 1990–91 and 0 for the years after 1991–92.

The results of the linear trend analysis of TFP growth are presented in Table 8. It is clear that the predictive power of the equation is very poor in all cases and, further, only the base trend coefficient of TFPG** is statistically significant at the 10% level.

Figure 1. TFP growth (TFPG) before and after adjustment for quality in labor and capital.

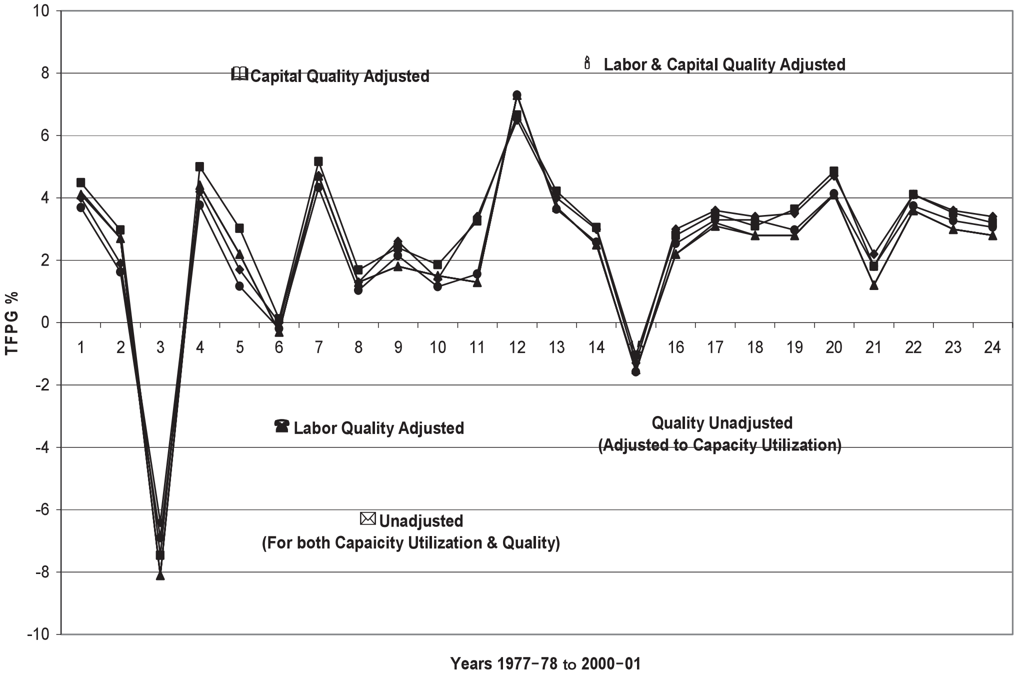

Table 8. Comparative linear trends in TFP growth (TFPG): TFPG, adjusted TFPG, and TFPG.**

Parameter	TFPG measure (dependent variable)		
	TFPG	Adjusted TFPG	TFPG**
a (Intercept)	0.1263	0.1297	0.0653
b_1 (Time)	0.1207	0.1207	0.1480*
b_2 ([Time] [Dummy])	0.1340	0.1341	0.1383
Adjusted R^2	0.009	0.009	0.080
F–value	1.11	1.10	2.00

*Significant at 10% level.

Dummy = 1 for years before 1991–92.

Tables 9 and 10 provide summaries of the mean effect on TFP growth of the adjustment for capacity utilization and decomposition of factor quality effects during different periods. As the second column of Table 9 shows, adjustments for capacity utilization alone yielded little change in TFP growth estimates in any period. However, decomposition resulted in increases in the standardized4 average TFP growth in the following way: in the case of the capital quality effect alone, it increased in each of the periods; in the case of the labor quality effect, the increase was mainly during the 1990s; and in the case of the combined effect of labor and capital quality, the increase was during the 1980s and 1990s. It is also clear from the last column of Table 9 that in each period TFPG** exceeded the capacity-adjusted TFP growth, meaning that true TFP growth is distorted by the presence of unfavorable factor quality effects.

Table 9. Decomposition of TFP growth (TFPG) (capacity utilization and factor quality differences).

Period	Decomposition of TFPG (%)					
	Effect of capacity utilization adjustment	Effect of quality differences in				
		Labor		Capital		Labor & capital
		Nonstandardized	Standardized*	Nonstandardized	Standardized	
1977-78 to 2000-01	0.0	−0.09	−0.06	−0.34	−0.24	−0.30
1977-78 to 1979-80	0.0	−0.15	+0.13	−0.35	−0.30	−0.17
1980-81 to 1988-89	0.0	−0.07	+0.06	−0.37	−0.30	−0.24
1989-90 to 1991-92	0.0	−0.08	−0.06	−0.29	−0.20	−0.26
1992-93 to 1996-97	−0.01	−0.34	−0.25	−0.33	−0.25	−0.50
1992-93 to 2000-01	−0.01	−0.33	−0.26	−0.32	−0.25	−0.51

*Standardization makes the sum of individual effects of labor and capital quality differences on TFPG equal to the joint effect of labor and capital quality differences on TFPG (i.e., column 4 + column= 6 column 7).

Table 10. Decomposition effect on TFP growth (TFPG) (capacity utilization and factor quality differences).

Period	TFPG (%)	TFPG** (%)[1]	Total change in TFPG[2]	Contribution to change in TFPG (% share)[3]		
				Capacity utilization variations	Labor quality effect	Capital quality effect
1977-78 to 2000-01	2.22	2.52	−0.30	0.0	20.0	80.0
1977-78 to 1979-80	−0.42	−0.25	−0.17	0.0	−76.5	176.5
1980-81 to 1988-89	2.68	2.82	−0.14	0.0	−42.9	214.3
1989-90 to 1991-92	1.59	1.85	−0.26	0.0	23.1	76.9
1992-93 to 1996-97	3.00	3.51	−0.51	2.0	49.0	49.0

Continued...

...*Continued*

1992-93 to 2000-01	2.85	3.37	-0.52	1.9	50.0	48.1

[1]TFPG after adjusting for the effect of capacity utilization and decomposing for factor quality differences.
[2]Column 3 - column 2.
[3]Share in column 4.

Table 10 gives the percentage impact of the individual effects of capacity adjustment and factor quality decomposition on TFP growth estimates. Clearly, the separation of the factor quality effects increased the values of TFP growth in different periods. The capital quality effect contributed more to such negative changes in adjusted TFP growth. The plausible interpretation of this is that the true TFP growth has a greater impact on GDP growth than generally thought. Such an impact is obvious only when the adverse factor quality/efficiency effects are removed. In other words, the quality (and probably efficiency) differences in capital and labor between the organized and unorganized sectors in India have a negative impact on GDP growth, and therefore if such effects are not removed from TFP growth estimates, the estimates may tend to underestimate the true contribution of TFP growth to GDP growth. It may also be construed as evidence of the existence of an allocative problem in respect of labor and capital between the two sectors and point to the need for an efficiency-enhancing reallocation of factor resources between them.

To substantiate the argument above on the contribution of intersector factor quality differences to GDP growth, the percentage contribution of the former to GDP growth was calculated (Table 11). As shown in Table 11, labor quality contributed positively to GDP growth during 1977-78 to 1988-89 and the capital quality difference did not enhance GDP growth in any year. In summary, factor quality differences caused GDP to decline within a range of about 4-9% of actual GDP growth during the different time periods.

Table 11. Factor quality effect on GDP growth (% contribution).

Period	Contribution to GDP growth (%)			
	TFPG**	Factor quality effect		
		Labor	Capital	Total
1977-78 to 2000-01	45.1	-1.15	-4.59	-5.74
1977-78 to 1979-80	-22.4	5.39	-12.45	-7.05
1980-81 to 1988-89	51.1	1.09	-5.44	-4.35
1989-90 to 1991-92	42.0	-1.36	-4.55	-5.91
1992-93 to 1996-97	54.3	-3.86	-3.86	-7.72
1992-93 to 2000-01	54.8	-4.23	-4.06	-8.29

Determinants of TFP Growth

Model

The estimates of TFP growth were derived after making adjustments for capacity utilization and decomposing the effects of factor quality differences in the selected sectors. This measure of TFP growth, denoted as TFPG**, is the basis for analyzing the determinants of TFP growth in India. To identify the various explanatory factors of TFP growth, a single-equation, multiple-variable econometric model is used. In the model, seven probable explanatory factors with due regard for data constraints are taken into account:

X1 (CRRDS) = % change in R&D spending in 1993–94 prices;
X2 (CFCN) = % change in the number of foreign collaborations;
X3 (CGNPGR) = % change in real GNP growth rates (in 1993–94 prices);
X4 (ROUGDP) = ratio of organized-sector GDP to unorganized-sector GDP;
X5 (CPPGDCF) = % change in the ratio of private-sector GDCF to public-sector GDCF;
X6 (CNAS) = % change in the ratio of nonagricultural-sector GDP to total GDP; and
X7 (CTTO) = % change in the ratio of total trade (exports + imports) to GDP.

A variable for foreign direct investment (FDI) was also considered. However, it neither affected the estimates in any useful way nor was its own coefficient statistically significant or numerically different from zero, thus suggesting its lack of importance in TFP growth in India. Therefore it was discarded. The variables X4 and X5 are expected to capture the structural shift effects: one affecting organized-sector GDP and the other private-sector investment. The rationale for including variables X1 to X5 can be understood in light of the propositions stated in the Introduction. The inclusion of X6 is based on the general belief that Indian agriculture is generally inefficient and therefore that a shift toward nonagricultural sectors could enhance efficienty and positively influence TFP. Similarly, foreign trade is expected to enhance TFP due to its effect on competition and its ability to make available to India technically superior foreign inputs and equipment. That influence of foreign trade necessitated the inclusion of variable X7.

In summary, the explanatory (X) variables considered here are expected to capture the following effects on TFP growth:

X1 (CRRDS) = impact of changes in R&D activities;
X2 (CFCN) = impact of changes in the use of foreign inputs such as technology, management control, etc.;
X3 (CGNPGR) = impact of changes in the scale of economies and business sentiments due to economic fluctuations;
X4 (ROUGDP) = impact of the changing importance of the (more efficient?) organized sector;
X5 (CPPGDCF) = impact of the changing importance of the (more efficient?) private sector;
X6 (CNAS) = impact of the changing importance of the (more efficient?) nonagricultural sector; and
X7 (CTTO) = impact of the changing level of trade openness.

However, two of the seven variables were removed from the model after the first few rounds of estimation, as they did not appear to contribute in any statistically significant manner. In removing the variables, the econometric method of stepwise inclusion and exclusion was used. The contribution of variables to the model was judged on the basis of their impact on the explanatory power (adjusted-R2) and tests of significance. The variables thus removed were:

X1 (CRRDS) = impact of changes in R&D activities; and
X5 (CPPGDCF) = impact of the changing importance of the (more efficient?) private sector.

The experiments outlined above confirm the suspicion that R&D activities are not yet a significant force in TFP growth in India. They also suggest that even changes in the investment profile of the private sector before or after liberalization are not significant factors in explaining TFP growth in India. In other words, changes in the private-sector investment profile in India do not make any marked contribution to TFP growth, while R&D spending does not yet influence the TFP growth profile in a significant way.

One remark on data availability for the selected variables should be made here. Data on CRRDS and CFCN were available only during 1977–78 to 1995–96. Thus, while incorporating the two variables in the model, a dummy variable with a value of 1 for the above period and 0 for other years was incorporated. Also, the variable CNAS (X6) in its original form did not exert a uniformly significant impact on TFP growth during the entire period of 1977–78 to 1995–96. Its influence on TFP growth was significant only during the stable years that exclude 1977–78 to 1978–99 and 1989–90 to 1990–91. So, instead of incorporating CNAS in the original forms, it was included in interactive forms where their interaction is with a dummy variable, which is 0 for the above four years and 1 for other years.

The linear trend equation does not give a good fit for TFPG** as well as other TFP growth measures during the study period. Thus it was felt useful to verify whether a trend variable is useful as an additional explanatory factor in the multivariable econometric model of TFPG**. The coefficient of the trend variable is expected to capture effects such as technological change, organizational learning, etc. that change with time. The trend variable was represented by a time index, i.e., 1 to 24 for the 24 years.

The relevant final model used in explaining TFP growth in India is:

$$TFPG^{**} = a_1 + b_1 D2\,(CFCN) + b_2\,CGNPGR + b_3\,ROUGDP + b_4\,D6\,(CNAS) + b_5\,CTTO + b_6\,T + u_1 \qquad \text{(Eq. 8)}$$

where $D2$ = 0 for 1996–97 to 2000–01 for which data are not available on CFCN, and 1 for other years; and $D6$ = 0 for 1977–78 to 1978–79 and 1989–90 to 1990–91, which were the peak disturbance years, and 1 for other years.

The models were estimated in both the lagged (one-period lag) and current forms of the variables. But, since the estimates in the lagged form of the variables were either small or negatively different on statistical parameters from the estimates of the current-value model, the lagged variable results were discarded and not reported in this study.

Results and Analysis

As noted above, of the seven explanatory variables originally considered, CRRDS (X1) and CPPGDCF (X5) (and also the variable on FDI), were eliminated at appropriate stages since they had an adverse impact on the explanatory power and significance of coefficients at the relevant stages of estimation. Of the remaining five variables, three, CGNPGR (X3), ROUGDP (X4), and CTTO (X7), along with the time index (T) for the trend effect, were incorporated as is, while the others were in interactive form with dummies. The final six variables were arrived at through successive stages of estimation. Table 12 summarizes the sequence in which they were entered into the estimation and shows that the inclusion and exclusion of variables X1 (CRRDS) to X7 (CTTO) and T in different given combinations changed the explanatory power of the model. However, when the dummies D2 and D6 interacted with, respectively, CFCN (X2) and CPPGDCF (X5), and without the variables CRRDS (X1) and CPPGDCF (X5) (and also without FDI [X8]) the adjusted R2 became the highest (0.896) and significant coefficients were the most numerous (i.e., seven of seven at the 5% level of significance).

Table 12. Contribution of explanatory (X) variables to TFPG model (1977–78 to 2000–01).**

Model	Variables entered	Movement of adjusted R^2	No. of significant coefficients* at 5% level
1	D1X1, D2X2, X3, X4, X5, X6	0.732	2
	↓	↓	
2	D1X1, D2X2, X3, X4, X5, X6, X7	0.743	2
	↓	↓	
3	D1X1, D2X2, X3, X4, X5, X6, X7, T	0.834	5
	↓	↓	
4	D2X2, X3, X4, X5, X6, X7, T	0.838	6
	↓	↓	
5	D2X2, X3, X4, D3X5, X6, X7, T	0.841	6
	↓	↓	
6	D1X1, D2X2, X3, X4, X6, X7, T	0.844	6
	↓	↓	
7	D1X1, D2X2, X3, X4, X7, T	0.846	6
	↓	↓	
8	D2X2, X3, X4, X6, X7, T	0.848	6
	↓	↓	
9	D2X2, X3, X4, D4X6, X7, T	0.856	6
	↓	↓	
10	D2X2, X3, X4, D4X6, X7, D5X8, T	0.895	7
	↓	↓	
11	D2X2, X3, X4, D6X6, X7, T	0.896	7

*Including intercept.
Dummy D1 = 0 for years during 1996–97 to 2000–01 for which data are not available, and 1 for other years.
D2 = 0 for years during 1996–97 to 2000–01 for which data are not available, and 1 for other years.
D3 = 0 for years during 1977–78 to 1978–79 and 1989–90 to 1991–92, and 1 for other years.
D4 = 0 for years during 1977–78 to 1979–80 and 1989–90 to 1991–92, which are the disturbance years, and 1 for other years.

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D5 = 0 for years during 1977–78 to 1980–81, which are the prereform years, and 1 for other years.
D6 = 0 for years during 1977–78 to 1978–79 and 1989–90 to 1990–91, which are peak disturbance years, and 1 for other years.
Model 11 is the final model for further analysis on the basis of its explanatory power and number of significant coefficients. Three other variables, X1, X5, and X8, have been discarded on the basis of their contribution to the explanatory power of the model or the significance of coefficients.
The variables are: X1 = CRRDS X4 = ROUGDP X7 = CTTO
X2 = CFCN X5 = CPPGDCF X8 = CFDI
X3 = CGNPGR X6 = CNAS.
For explanation of variables, see Appendix 5.
Estimation is based on the 1977–78 to 2000–01 period.
The dependent variable is TFPG**.

Table 13 presents the regression results explaining TFPG**. In Table 13, the estimated model and all seven of the coefficients are statistically significant as indicated by the F and t values. In the estimated model, the variables representing the changes in foreign collaboration (CFCN), structural shifts in GDP between the organized and unorganized sectors (ROUGDP) and between nonagricultural and agricultural sectors (CNAS), and changes in trade openness (CTTO) have coefficients with negative signs,[5] which is unexpected. This suggests that with increases in foreign collaboration activities, organized-sector GDP share, nonagricultural-sector GDP share, and trade openness there is a decline in TFP growth. This contradicts the proposition of a favorable effect of these factors. The result might actually indicate the possibly disruptive effect of technological and managerial discontinuities associated with the frequent or widespread foreign collaborations and the inefficient current distribution of economic activities between the organized and unorganized sectors on the one hand and between nonagricultural and agricultural sectors on the other. Further, it also throws light on the adverse TFP growth consequences of trade openness, which could mean that the increased flow of foreign goods and associated scare/depression effects on domestic economic players might hamper domestic TFP growth-enhancement efforts.

Table 13. Estimated TFPG model: 1977–78 to 2000–01.**

Variable	Coefficient	SE	t–Value
(Intercept)	6.7812***	1.9935	3.40
D2 X2 (CFCN)	–0.0317***	0.0063	5.01
X3: CGNPGR	0.3618***	0.0578	6.26
X4: ROUGDP	–10.8665**	4.8345	2.25
D6 X6 (CNAS)	–0.6518***	0.2203	2.96
X7: CTTO	–0.0923***	0.0242	3.82
T	0.3053***	0.0819	3.73
R^2 = 0.923 Adjusted R^2 = 0.896			
F–Value = 34.1 (significance = 1% level)			

***Significant at 1% level.

Continued...

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**Significant at 5% level.

D2 = 0 for years 1996-97 to 2000-01, and 1 for other years.

D6 = 0 for years 1977-78 to 1978-79 and 1989-90 to 1990-91, and 1 for other years.

Dependent variable is TFPG**.

In the factor of changes in output growth (CGNPGR), the expectation of a positive impact on TFP growth was justified by the estimates. The coefficient implies that with increases in GNP growth rates, TFP growth improves considerably, probably due to scale effects and to the addition of better technologies and resources. Moreover, both the trend factor and the mean effect of the discarded variables captured by the intercept term are significantly positive. The positive trend coefficient implies that time-related factors such as technological progress and organizational efficiency and learning play an important role in TFP growth in India.

The average prediction errors of the estimate given in Eq. 8 are presented in Table 14. On the basis of the dummy interaction with variables CFCN and CNAS, the estimates can be segmented into three components for the following three subperiods: 1) the disturbance years of 1977-78 to 1978-79 and 1989-90 to 1990-91; 2) the reform and/or faster growth years of 1979-80 to 1988-89 and 1991-92 to 1995-96; and 3) the slowdown years (in both reforms and economic growth) of 1996-97 to 2000-01. Table 14 reveals that the models predicted the average value of actual TFPG** reasonably well, within about a 3-19% range in absolute terms.

Table 14. Average prediction error (%) of the TFPG model.**

Model & period	Actual average TFPG**	Predicted average TFPG**	Average prediction error[1]	
			Value	% of Actual average TFPG**
Eq. 8 (1)[2] 1977-78 to 1978-79 & 1989-90 to 1990-91	3.18	2.58	-0.60	-18.9
Eq. 8 (2) 1979-80 to 1988v89 & 1991-92 to 1995-96	2.02	2.08	0.06	3.0
Eq. 8 (3) 1996-97 to 2000-01	3.48	3.61	0.13	3.7

[1]Average prediction error = (predicted average TFPG** - actual average TFPG**).

[2]The model given in Eq. 8 is segmented into three groups of years on the basis of the dummies D2 and D6 used on CFCN and CNAS while estimating.

The average percentage contributions of different explanatory factors to average TFPG** are given in Table 15. The excluded variables and structural factors represented in the intercept have highly positive average contributions and were profoundly favorable to average TFP growth. The average contributions of CFCN (with dummy interaction), ROUGDP, CNAS (with dummy interaction), and CTTO are also negative in the respective groups of years, with the negative contribution of the ROUGDP factor being large. However, the positive contribution of the intercept and trend factors is so large that it, together with a modest positive average contribution from the output growth differentials (CGNPGR) factor, is able to explain the impressive net positive average TFPG** in all periods.

Table 15. Average contribution of explanatory variables to TFPG, 1977−78 to 2000−01.**

Variable	Estimated coefficient	1977−78 to 1978−79 & 1989−90 to 1990−91[1]			1979−80 to 1988−89 & 1991−92 to 1995−96[2]			1996−97 to 2000−01[3]		
		Mean value[4]	Contribution		Mean value[4]	Contribution		Mean value[4]	Contribution	
			Value	%[5]		Value	%[5]		Value	%[5]
D2 X2 (CFCN)[6]	−0.0317	−2.96	0.0938	2.95	15.54	−0.4926	−24.39	–	–	–
X3: CGNPGR	0.3618	−0.07	−0.0253	−0.80	0.37	0.1339	6.63	−0.28	−0.1013	−2.91
X4: ROUGDP	−10.8665	0.51	−5.5419	−174.27	0.55	−5.9766	−295.87	0.77	−8.3672	−240.4
D6 X6 (CNAS)[7]	−0.6518	–	–	–	0.69	−0.4497	−22.26	1.22	−79.52	−22.85
X7: CTTO	−0.0923	11.01	−1.0162	−31.96	12.71	−1.1731	−58.08	6.74	−0.6221	−17.88
T	0.3053	7.50	2.2898	72.00	10.67	3.2576	161.26	22.00	6.7166	193.01
Intercept	6.7812	6.7812	6.7812	213.25	6.7812	6.7812	335.70	6.7812	6.7812	194.86
Total[8]			2.58	81.1		2.08	103.0		3.61	103.7

[1]Average actual TFPG** =3.18.
[2]Average actual TFPG** =2.02.
[3]Average actual TFPG** =3.48.
[4]Mean value of the variable for the relevant period.
[5]% of respective average actual TFPG**.
[6]D2 =0 for years during 1996−97 to 2000−01, and 1 for other years.
[7]D6 =0 for years during 1977−78 to 1978−79 and 1989−90 to 1990−91, and 1 for other years.
[8]Total % may be different from 100 due to the prediction error (negative prediction error is to be added and the positive is to be subtracted).

CONCLUSIONS

The objective of this study was to extend the estimates of TFP growth in India obtained in the previous APO study to more recent years, with necessary refinements. The study also aimed to identify and examine the factors determining TFP growth in India after the estimates were adjusted for variations in capacity utilization and decomposed for factor quality differences in different sectors of the economy. The following paragraphs provide a summary of the findings discussed in the various preceding sections of this paper, along with the policy implications of the findings.

TFP Growth

TFP growth was an important component of economic growth in the past, especially in advanced economies. In contrast, previous productivity studies on India did not report satisfactory TFP growth performance. Since the restrictive policy framework prevailing earlier was partly blamed for India's poor TFP growth contribution in the past, the liberalization process initiated mildly during the 1980s and significantly in 1991 might be expected to change the TFP growth situation in India, although some earlier sector-level studies indicated otherwise.

As the present analyses reveal, there was more consistency in Indian TFP growth performance during the 1990s. Such consistent performance also resulted in a higher average TFP growth during 1990–91 to 2000–01 than earlier. This finding is true both before and after the factor quality effects were separated from the estimates of TFP growth. Therefore the 1990s produced better TFP growth performance than hitherto suggested in other studies, including the previous APO one. There was also a higher trend of GDP growth during the post–1991 period. The lower linear trend rate of change in TFP growth for this period implies a consistently higher average TFP growth rate during this period. Also, unlike in the previous APO study, adjustments for capacity utilization were not found to change the TFP growth estimates much. This may be due to the fact that in India cyclical movements in output are not such a serious problem as in economies like the USA.

TFP growth contributed substantially to GDP growth, especially after the effect of factor quality differences were removed from the TFP growth measure in many of the years during the 1980s and 1990s. However, the quality (and probably efficiency) differences in capital and labor between the organized and unorganized sectors in India have a negative impact on GDP growth. Further, when the quality effects are not removed from the TFP growth estimates, the estimates tend to be lower and hence might underestimate the true contribution of TFP growth to GDP growth. This may also be construed as evidence of the existence of an allocative problem in terms of labor and capital between the two sectors and point to the need for an efficiency-enhancing reallocation of factor resources between the two sectors.

Determinants of TFP Growth

As decided at the APO meeting in July 2001, the study selected seven explanatory factors to account for the decomposed TFP growth in India. These factors represent the R&D effect, foreign technology and control effects, business prospects effect (to capture also economies of scale effect), structural shift/efficiency effects (with respect to the organized- versus unorganized-sector GDP, private- versus public-sector capital formation, and nonagricultural- versus agricultural-sector GDP), and trade openness effect. At an appropriate stage, variables for FDI (in forms such as ratio to GDP or GDCF, cumulated over time, lagged, etc.) but they were discarded due to poor impact on the model. Of the five variables in the final model along with the time index (T) representing the trend effect on TFPG**, three, CGNPGR, ROUGDP, and CTTO, were incorporated as is, while the two others were found useful in interactive form with dummies for the different relevant years.

The study revealed that R&D activities have yet to become a significant force in TFP growth in India. Furthermore, even changes in the private-sector investment profile before or after liberalization are not significant factors in explaining TFP growth in India. With increases in foreign collaboration activities, organized-sector GDP share, nonagricultural-sector GDP share, and trade openness, TFP growth declined. The results also throw light on the adverse TFP growth consequences of trade openness. This could mean that the increased flow of foreign goods and its associated scare/depression effect on domestic economic players might hamper domestic TFP growth improvement efforts. However, with increases in GNP growth rates, TFP growth improves considerably, probably due to scale effects and better technologies and resources. Finally, the positive trend effect implies that time-related factors such as technological progress and organizational efficiency and learning play an important role in TFP growth in India.

Policy Recommendations

The findings and observations of this study on TFP growth in India allow certain policy recommendations.

1) There is an urgent need to revamp and standardize the Indian statistical data system in tune with international ones used in advanced nations, especially in the Asia-Pacific region. The system of data should be able to report periodic (at least annual) and detailed data on such important variables as employment, education and skill level of the labor force, and capital stock (with details on asset categories, economic segments, etc.). Without such detailed data, TFP growth cannot be evaluated regularly and accurately.
2) TFP growth should be used as a regular indicator of the health and resource conservation or productivity efforts of the nation. TFP growth statistics should be periodically reported along with other macroeconomic indicators like GDP.
3) R&D and FDI policies should be drastically revamped to make R&D investment and FDI sufficiently large and influential to contribute significantly to TFP growth in India. Without this, R&D and FDI activities cannot be meaningful.
4) There should be more serious efforts to accelerate economic growth. Faster economic growth and higher TFP growth go together, since resource utilization becomes more efficient during a rapid-growth phase.
5) There should be effective policies (or removal of ineffective policies) to ensure efficient resource allocation and shifts between the organized and unorganized, nonagricultural and agricultural, and private and public sectors in a TFP-enhancing manner. Current resource movements between these sectors are not helpful to TFP growth.
6) There should be concerted efforts and serious policies to increase India's international trade substantially and to change its composition to induce a positive and significant contribution of trade to TFP growth. Trade presently has an inhibiting effect on TFP growth in India.

Finally, a word of caution may be in order. The findings and observations of this study on the TFP growth in India were constrained by significant data problems. Therefore discretion is advised when using the above recommendations as policy guidelines.

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FOOTNOTES AND APPENDICES

Footnotes

[1]As Sato and Suzawa (1983) noted, "The process of science-based technical change... [is] a process of creating (producing) stocks of basic (fundamental) and applied (practical) knowledge that serve as inputs in the generation of new techniques... the process of science-based technical change implies improvement in the index of total factor productivity" (pp. 48–49).

[2]For computing factor income shares, the methodology is logically more convincing but slightly different from that of Srivastava (1998). As earlier, the factor income ratios have in their respective numerators wages and capital charges for the labor and capital inputs. However, for obtaining total wages, the proportion of the "mixed income of self-employed" is added to the "compensation to employees" (in the nonself-employed part) by defining the proportion of wages in the mixed income as equal to "compensation to employees/(NDP minus mixed income of the self-employed)." The above definition of the proportion implies that the wages appear in the "mixed income" in the same proportion as in the "nonmixed income." Total capital charges are similarly derived but contain in addition to the sum of "operating surplus in the nonself-employed part" and remaining proportion of "mixed income of self-employed" (i.e., after accounting for the component of wages), an additional component of "depreciation charges" as decided at the APO National Experts' meeting and consistent with the use of GDP as the denominator in computing the factor income shares. The basic data needed for computing factor income shares were from the various publications of the CSO and CMIE on the national account statistics of India.

[3]It was assumed that the share of the unorganized sector in capital stock was the (square root of [(1 - share of the unorganized sector in labor)] × [(1 - share of the unorganized sector in GDP)]).

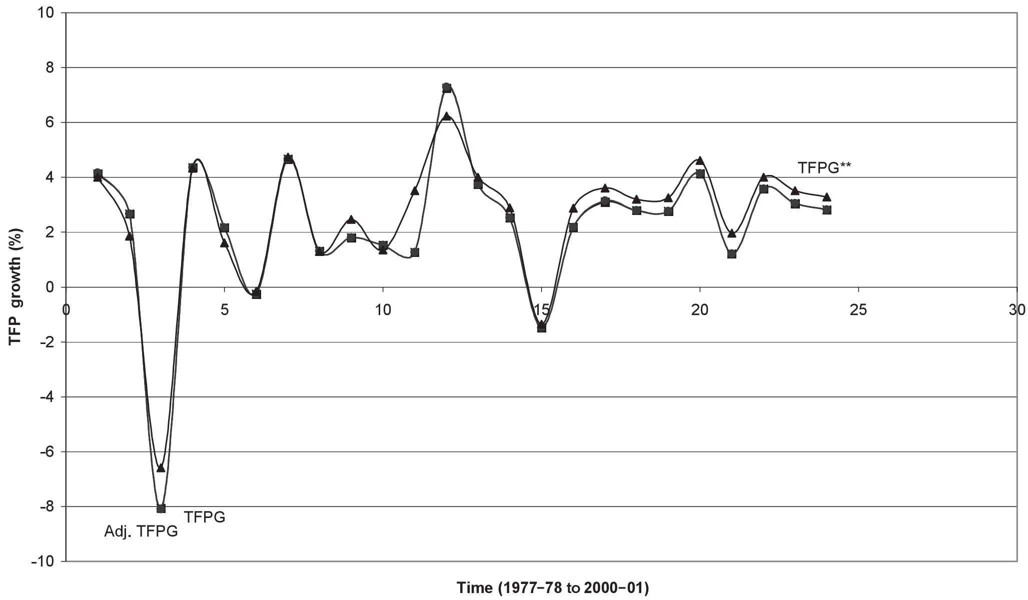
[4]Standardization refers to making the sum of effects of individual adjustments for labor and capital quality differences equal to the joint effect of simultaneous adjustments for labor and capital quality differences (so that in Table 9, column 4 + column 6 = column 7).

[5]In the case of trade openness (CTTO), the results of this study are slightly different from those of Athukorala and Chand (2000) for the international production of transnational corporations (TNCs). They found a significant impact of trade-oriented regimes on TFP growth in the international production of TNCs. The present results agree with such a trade impact in the macroeconomic context of India, but the direction of the impact was negative.

Appendices

Appendix 2, Table 1, and Appendix 3, Tables 1 and 2, provide basic data for calculation of TFP growth and for adjustment of TFP growth, respectively. Factor income shares are given in Appendix 3, Table 3. Appendix 4, Table 1, lists basic data for estimating TFPG** determinants. Explanatory variables for TFPF** determinants are presented in Appendix 5, Table 1. As stated previously, all other data used for estimation of TFP growth are given in Appendix 1, Tables 1−12.

Appendix 1, Figure 1. Trends in TFP growth(TFPG) (without and with adjustment for capacity utilization) & TFPG**



Appendix 1. Data for TFP growth estimation.

Appendix 1, Table 1. Adjustment of GDP, 1975−2000 (prices in billion rupees).

Year	GDP	GDP prices	Adjusted prices	GDP	GDPG (official) (%)
(1)	(2)	(3)	(4)	(5)	(6)
1975	12642.5	7630.8	12870.1	93124.9	
1976	15466.7	8156.3	15884.3	100418.2	7.54
1977	19010.7	8870.9	19695.1	110173.1	9.27
1978	21967.4	9471.2	22955.9	118650.6	7.41
1979	32025.4	10164.9	33754.8	128437.5	7.93
1980	45445.7	11169.2	48217.9	142332.5	10.27
1981	54027.0	12054.6	57916.9	154915.9	8.47
1982	59362.6	12325.4	64171.0	159725.9	3.06
1983*	71214.7	12842.2			

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1983**	77622.8	77622.8	77622.8	167805.0	4.93
1984	89885.1	83037.4	90711.9	181160.0	7.66
1985	96996.9	85081.9	98780.6	187310.7	3.34
1986	102682.6	90080.4	105514.5	200104.7	6.61
1987	124816.9	94517.9	129406.3	211839.9	5.70
1988	142104.8	99981.4	148635.8	226070.7	6.50
1989	167184.7	107436.6	176404.7	245063.1	8.07
1990	195597.2	115217.3	208181.7	265099.9	7.86
1991	227450.2	123225.2	244174.3	285973.1	7.58
1992	259884.5	131184.9	281381.8	307053.2	7.11
1993*	302017.8	139707.1			
1993**	329775.9	329775.9	329775.9	329775.9	7.14
1994	377354.3	353973.2	377354.3	353973.2	7.08
1995	454514.1	383792.3	454514.1	383792.3	8.09
1996	532630.8	414418.9	532630.8	414418.9	7.68
1997	627695.5	433245.9	627695.5	433245.9	4.54
1998	955753.5	376374.9	955753.5	376374.9	−13.13
1999	1109979.5	379557.7	1109979.5	379557.7	0.08
2000	1290684.2	397666.3	1290684.2	397666.3	4.77

GDPG, GDP growth.
For columns 2 and 3: 83* = in 1973 prices 93* = in 1983 prices;
83** = in 1983 prices 93** = in 1993 prices.

Appendix 1, Table 2. Unpublished CBS estimates of capital stock (1993 prices in billion rupees).

Year	Capital stock	Investment	Implicit depreciation rate (%)	Capital growth rate (%)
(1)	(2)	(3)	(4)	(5)
1980	31223.0	31223.0		
1981	60185.4	34700.0	18.400	1.93
1982	96379.0	39208.8	5.010	1.60
1983	149737.3	57818.7	4.628	1.55
1984	201913.4	56251.4	2.722	1.35
1985	261476.1	64357.6	2.375	1.29
1986	323684.5	68540.0	2.421	1.24
1987	389022.7	70105.8	1.473	1.20
1988	450040.3	64765.9	0.010	1.16

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1989	517705.7	72736.6	1.127	1.15
1990	593031.9	80652.6	1.030	1.15
1991	674970.7	88371.4	1.080	1.14
1992	764838.2	97426.2	1.120	1.13
1993	864112.8	109575.5	1.350	1.13
1994	978330.1	126482.8	1.420	1.13

Appendix 1, Table 3. Estimates of level and growth of capital stock (billion rupees).

Year	GDFCF (constant 60, 73, 83 & 93 prices)	GDFCF (current prices)	GDFCF (constant 93 prices)	Capital stock (93 prices)	Capital stock growth (%)
1975	1650.2	2571.7	14635.06	162005.4	
1976	1749.2	3204.9	15513.05	172658.3	6.37
1977	2027.5	3826.4	17981.2	185459.7	7.15
1978	2332.9	4670.7	20689.69	200585.6	7.84
1979	2436.0	6704.3	21604.05	216172.1	7.48
1980	2896.0	9485.2	25683.63	235370.6	8.51
1981	3218.5	11553.4	28543.77	256853.3	8.73
1982	3636.7	13467.1	32252.64	281400.3	9.13
1983*	3921.2	17187.7			
1983**	19467.9	19467.9	34775.77	307734.1	8.95
1984	18296.5	20136.1	37019.2	335521.2	8.64
1985	19615.8	22366.9	39688.53	365144.1	8.46
1986	21421.7	24781.9	43342.4	397532.2	8.5
1987	22596.8	30980.2	45719.97	431326.2	8.16
1988	25200.9	36802.6	50988.83	469375.2	8.45
1989	28568.1	45659.8	57801.67	513095.7	8.91
1990	32731.5	55633.4	66225.45	563928.2	9.45
1991	34867.2	63893.9	70546.6	617557	9.08
1992	36589.4	70820.2	74031.11	673061.4	8.61
1993*	38671.2	78243.2			
1993**	86667.3	86667.3	86667.3	739536.8	9.42
1994	97582.8	104220.7	97582.8	814933.5	9.71
1995	118386.4	129217.5	118386.4	908871.9	10.91
1996	128698.6	157652.7	128698.6	1010304	10.58
1997	139725.5	177686.1	139725.5	1119720.4	10.84

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1998	93604.7	243043.4	93604.7	1179733.5	5.36
1999	75467.9	240322.2	75467.9	1219809.4	3.40
2000	88984.5	313915.2	88984.5	1272199.0	4.29

For column 2 only:83* = in 1973 prices; 93*= in 83 prices;
83** = in 1983 prices; 93**= in 93 prices.

Appendix 1,Table 4. Sources and adjustment of employment data.

Source	Year	Labor force (1000 persons)	LFPR (%)	No.employed (1000 persons)	Employment rate (%)	Employment growth (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
NFLS (Sept.–Dec)	1976	48430.9	54.90	47306.2	97.68	 2.17 3.77
Pop. census (Sept.)	1980	52421.2 56355.7	50.23 54.00	51553.1 54856.6	98.34	 5.89 3.60
NLFS (average)	1982	59598.6 60702.3	54.00 55.00	57802.8 58875.1	97.86	 2.61 3.26
Intercensal pop. survey (Sept.)	1985	63825.6 66234.1	53.00 55.00	62457.0 64816.0	97.86	 4.13 3.17
NLFS (average)	1989	75508.1	56.81	73424.9	97.24	
Pop. census (Sept.)*	1990	73913.7	54.73	71569.9	96.83	3.30 2.71
NFLS (average)	1990	77802.3 77354.5	57.33 57.00	75850.6 75412.9	97.49	 0.75 1.34
NFLS (average)	1991	78455.5	57.14	76423.2	97.41	 2.74
NFLS (average)	1992	80704.0	57.30	78518.4	97.29	 2.30
NFLS (average)	1993	82631.3	57.92	80323.0	97.21	 2.14
NFLS (average)	1994	85775.6	58.03	82038.1	95.64	
Intercensal pop. survey (Sept.)*	1995	86361.3	56.62	80110.1	92.76	2.21
NFLS (average)	1996	90109.6	58.30	85701.8	95.11	 1.52

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NFLS (average)	1997			87004.5	95.11	
NFLS (average)	1998	92314.9	57.10	85843.8	92.99	

LFPR, labor force participation rate; Pop., population.

*Data discarded.

Figures in italics are revised.

Appendix 1, Table 5. I-O table and survey data on employment income and estimates of their shares in value added (columns 2. 3. 5. 6 in billion rupees; column 8 in thousand rupees).

Year	Gross value added (GVA) from I-O Table	Wages & salaries	Share of wages & salaries in GVA (%)	Employees income from survey data	Wages % salaries adjusted for all employment	Share of employment income in GDP (%)	Average employment income	Growth of average employment income (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1975	15466.7	3408.5	22.04					
1976				2098.3	6358.5	40.03		
1980	45445.7	11667.4	25.67					
1985	97645.9	27076.9	27.73					
1989				18992.3	69771.5	39.55	950	1.16
1990	207801.3	56977.8	27.42	22692.0	80615.2	38.72	1069	1.16
1991				29295.9	99002.5	40.54	1287	1.16
1992				33473.4	111578.0	39.65	1421	1.16
1993				36926.9	123089.7	37.33	1532	1.16
1995	535564.8	163376.4	30.51	61031.2	177340.0	39.02	2115	1.16

Appendix 1,Table 6. Estimates of labor income shares in GDP (column 2 in thousand rupees; columns 6 and 7 in billion rupees).

Year	Employment Income Per Worker	Growth of average employment income (%)	No. employed (1000)	Estimates of employment income	GDP current prices	Employment income share (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1975	115.6		45522.8	5263.0	12870.1	40.89
1976	134.4	1.1626	47306.2	6358.5	15884.3	40.03
1977	156.3	1.1626	49089.6	7671.1	19695.1	38.95
1978	181.7	1.1626	50940.3	9254.6	22955.9	40.31
1979	211.2	1.1626	52860.8	11165.1	33754.8	33.08
1980	245.6	1.1626	54856.6	13470.6	48217.9	27.94
1981	285.5	1.1626	56831.4	16224.7	57916.9	28.01
1982	331.9	1.1626	58875.1	19541.2	64171.0	30.45
1983	385.9	1.1626	60788.5	23456.9	77622.8	30.22
1984	448.6	1.1626	62764.2	28157.3	90712.0	31.04
1985	521.6	1.1626	64816.7	33806.2	98781.6	34.22
1986	606.4	1.1626	66864.9	40545.1	105516.6	38.43
1987	705.0	1.1626	68977.8	48627.3	128261.8	37.91
1988	819.6	1.1626	71157.5	58320.5	148641.6	39.24
1989	950.2	1.1594	73424.9	69771.5	176413.3	39.55
1990	1069.0	1.1250	75412.9	80615.2	208193.7	38.72
1991	1286.7	1.2037	76943.8	99002.5	244190.5	40.54
1992	1421.0	1.1044	78518.4	111578.0	281379.2	39.65
1993	1532.4	1.0784	80323.0	123089.7	329775.9	37.33
1994	1781.6	1.1626	82038.1	146159.7	377354.3	39.15
1995	2115.1	1.1872	83842.9	177340.1	454514.1	39.02
1996	2511.1	1.1872	85701.8	215208.1	532630.8	40.40
1997	2773.3	1.1044	87004.5	241293.0	624337.1	38.65
1998	2773.3	1.0000	85843.8	238074.1	951385.9	25.02

Apendix 1, Table 7. Estimates of TFP, 1980–2000 (%).

Year	Labor income share (LIS)	Average LIS (ALS)	Average capital income share (AKS)	Labor growth (LG)	Capital growth (mid-year) (KG)	Share of labor srowth (SLG)	Share of capital growth (SKG)	TFP	GDPG
1980	27.94	0.3051	0.6949	3.71	8.51	1.13	5.91	3.22	10.27
1981	28.01	0.2798	0.7203	3.54	8.73	0.99	6.29	1.19	8.47
1982	30.45	0.2923	0.7077	3.53	9.13	1.03	6.46	−4.43	3.06
1983	30.22	0.3034	0.6967	3.2	8.95	0.97	6.24	−2.28	4.93
1984	31.04	0.3063	0.6937	3.2	8.64	0.98	5.99	0.69	7.66
1985	34.22	0.3263	0.6737	3.22	8.46	1.05	5.7	−3.41	3.34
1986	38.43	0.3633	0.6368	3.11	8.5	1.13	5.41	0.07	6.61
1987	37.91	0.3817	0.6183	3.11	8.16	1.19	5.05	−0.53	5.7
1988	39.55	0.3873	0.6127	3.11	8.45	1.2	5.18	0.12	6.5
1989	38.72	0.3914	0.6087	3.14	8.91	1.23	5.42	1.42	8.07
1990	40.54	0.3963	0.6037	2.67	9.45	1.06	5.7	1.1	7.86
1991	39.65	0.401	0.5991	2.01	9.08	0.81	5.44	1.33	7.58
1992	37.33	0.3849	0.6151	2.03	8.61	0.78	5.3	1.03	7.11
1993	37.33	0.3733	0.6267	2.27	9.42	0.85	5.9	0.39	7.14
1994	38.73	0.3803	0.6197	2.11	9.71	0.8	6.02	0.26	7.08
1995	39.02	0.3888	0.6113	2.18	10.91	0.85	6.67	0.57	8.09
1996	40.4	0.3971	0.6029	2.19	10.58	0.87	6.38	0.43	7.68
1997	38.65	0.3953	0.6048	1.51	10.83	0.6	6.55	−2.61	4.54
1998	30.02	0.3434	0.6566	0.77	5.36	0.03	1.84	−14	−13.13
1999	30.02	0.3002	0.6998	1.31	3.4	0.39	2.38	−2.76	0.01
2000	30.02	0.3002	0.6998	1.13	4.3	0.34	3	1.43	4.77

GDPG, GDP growth.
Except for 1996–2000, capital growth is end of year.

Appendix 1, Table 8. Hours (h) worked, employment rates, and growth of capital and GDP.

Year	LT 10 h	LT 25 h	25−34 h	ER	KG	GDPG
1980	0.0311	0.2016	0.2776	98.34	8.51	10.27
1982	0.0256	0.2071	0.2272	97.86	9.13	3.06
1989	0.0242	0.1959	0.2626	97.24	8.91	8.07
1990	0.0261	0.1990	0.2602	97.49	9.45	7.86
1991	0.0256	0.1934	0.2598	97.41	9.08	7.58
1992	0.0286	0.2085	0.2557	97.29	8.61	7.11
1993	0.0260	0.2115	0.2390	97.21	9.42	7.14
1995	0.0231	0.1866	0.2612	92.76	10.91	8.09
1997	0.0286	0.2132	0.2189	95.11	10.83	4.54
1998	0.0323	0.2248	0.2029	92.99	5.36	−13.13
1999	0.0282	0.2193	0.2091	93.64	3.4	0.01
2000	0.0243	0.1967	0.2260	93.86	4.3	4.77

LT, less than; ER, employment rate (%); KG, capital growth (%); GDPG, GDP growth (%).

Appendix 1, Table 9. Distribution of employment by level of education, 1986−2000 (in thousands).

	1986	1987	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No school	12917	12383	11937	11306	10242	10429	9840	9371	9683	8537	8469	7947	7570	7148
Not finish ES	20830	20889	20574	20240	18807	19770	19439	19553	19618	17283	18799	16642	15860	14323
ES	22954	24085	26195	27952	29008	29164	29746	30737	26732	32947	30843	32861	32949	34341
GJHS	4511	4998	5554	6346	8378	7343	7480	8205	8267	9669	10159	10760	11831	13933
VJHS	890	934	933	948		1161	1129	1148	747	1016	1429	1439	1544	
GSHS	2526	2882	3543	3965	8445	4727	5311	5951	7048	7802	8576	8999	9678	16078
VSHS	2830	3068	3453	3716		4250	4341	4863	5146	5482	5513	5545	5565	
DIP I/II	173	179	237	262	294	294	321	331	460	500	517	695	746	868
DIP III	401	519	503	552	568	634	684	894	862	983	970	958	1018	1102
UNIV	305	464	497	562	680	747	911	987	1546	1483	1775	1827	2054	2032
Total	68338	70402	73425	75851	76423	78519	79201	82038	80110	85702	87050	87672	88817	89824

ES, elementary school; GJHS, general junior high school; VJHS, vocational junior high school; VSHS, vocational senior high school; DIP I/II/III, college; UNIV, university.

Appendix 1, Table 10. Average wages and salaries by education level of employees, 1986−2000 (rupees).

Education	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
None	37730	42194	51821	56121	65039	72577	92110	101478	120650	162105	206206
Not finish ES	46211	50784	61387	64791	74682	93823	122432	135422	160883	191721	232009
ES	59575	64865	74501	90372	101393	113232	145735	173368	199395	239708	286264
GJHS	86037	106424	102586	112801	161437	148261	186729	210850	247680	298710	363817
VJHS	97657	103128	117822	126362	159413	171353	209329	242760	275450	358469	
GSHS	110609	130433	141960	159249	199121	204979	256274	300950	345360	426735	511645
VSHS	111972	122275	137915	154344	201541	210485	263449	310351	358358	455437	
DIP I/II	138594	143613	160229	203299	231052	278548	333171	360353	436738	551219	564076
DIP III	169182	224594	249516	269031	310536	367738	419001	472345	528036	640050	755404
UNIV	208120	251680	272500	295246	355650	396041	487463	543759	610807	701651	935328
Total	77164	89676	101651	115951	143493	157343	207108	240732	282251	346950	430197

ES, elementary school; GJHS, general junior high school; VJHS, vocational junior high school; VSHS, vocational senior high school; DIP I/II/III, college; UNIV, university.

Appendix 1, Table 11. Estimates of capital stock by sector, 1980–2000 (billion rupees).

Year	Agriculture	Mining & quarrying	Manufacture	Electricity, water & gas	Construction	Trade, hotel & restaurant	Transport & commun.	Banking & finance	Services	Total
1980	9115	62046	61662	4986	18748	17591	35457	13406	12358	235371
1981	11522	63473	64632	6136	19025	18729	38690	22158	12487	256853
1982	13122	64868	73649	6832	20647	19983	41549	27138	13612	281400
1983	14810	61256	82245	6416	24087	23545	40181	40293	14901	307734
1984	16712	62067	90651	6671	26536	25550	42316	48132	16887	335521
1985	17215	63067	105421	7007	28952	27533	44794	53605	17549	365144
1986	17886	65569	119533	7781	31292	29857	49798	56385	19433	397532
1987	19370	66297	131348	8401	34689	34320	53542	62617	20742	431326
1988	21556	69649	141295	9113	39133	39783	57936	67485	23425	469375
1989	24874	72559	151892	9677	46474	45345	62893	72265	27118	513096
1990	27216	77225	165067	10290	55802	51966	68541	76193	31629	563928
1991	29001	81294	177114	10702	65749	60319	74612	82721	36046	617557
1992	30880	85657	189305	10996	77755	68349	81335	88022	40764	673061
1993	33660	91640	203120	11359	90538	79212	88792	95811	45404	739537
1994	36876	96787	221302	13531	108862	90450	105788	110462	46888	814934
1995*	41339	103560	255118	15650	129755	99879	128308	125119	48541	947269
1996	44684	126493	277942	17195	151778	112036	138615	132858	52060	1053660
1997	47320	150029	284465	18951	168814	123116	147217	133289	55878	1129078
1998	48788	168483	244783	18994	111024	104291	123897	95132	55588	970980
1999	52271	189259	246681	19989	113834	108014	121733	85504	58565	995850
2000	55337	221920	254096	21118	125462	117954	131661	86936	61804	1076287

*Figures for 1995–2000 are estimated using the estimated capital output ratio, 1980–94.

Commun., communications.

Appendix 1, Table 12. Capital output ratio (COR), 1980−2000.

Year	Agriculture	Mining & quarrying	Manufacture	Electricity, water & gas	Construction	Trade, hotel & restaurant	Transport & commun.	Banking & finance	Services	Total
1980	0.21	4.71	2.84	5.02	2.30	0.75	4.57	1.94	0.76	1.65
1981	0.25	4.62	2.68	5.31	2.06	0.71	4.45	2.92	0.70	1.66
1982	0.28	5.33	2.99	5.00	2.10	0.71	4.47	3.29	0.73	1.76
1983	0.39	1.76	3.84	9.45	2.42	0.95	4.54	3.95	0.79	1.83
1984	0.28	5.33	2.99	5.00	2.10	0.71	4.47	3.29	0.73	1.76
1985	0.41	1.85	3.57	8.82	2.92	1.01	4.53	4.44	0.83	1.95
1986	0.41	1.81	3.67	8.15	3.06	1.00	4.80	4.21	0.86	1.99
1987	0.43	1.81	3.61	7.58	3.22	1.07	4.84	4.43	0.86	2.04
1988	0.45	1.94	3.44	7.34	3.29	1.12	4.92	4.58	0.90	2.08
1989	0.50	1.91	3.35	6.89	3.47	1.15	4.74	4.42	0.98	2.09
1990	0.53	1.91	3.21	6.16	3.63	1.22	4.68	4.20	1.08	2.13
1991	0.55	1.81	3.10	5.47	3.82	1.33	4.68	4.12	1.17	2.16
1992	0.54	1.93	3.00	5.06	4.04	1.39	4.60	3.96	1.26	2.19
1993	0.58	2.00	2.92	4.71	4.16	1.47	4.53	3.87	1.34	2.24
1994	0.62	2.92	2.68	3.66	4.22	1.52	4.21	3.58	1.37	2.30
1995	0.67	2.92	2.78	3.65	4.44	1.56	4.70	3.65	1.37	2.36
1996	0.70	3.37	2.72	3.55	4.61	1.62	4.67	3.55	1.42	2.41
1997	0.73	3.89	2.64	3.46	4.78	1.67	4.63	3.46	1.47	2.45
1998	0.77	4.50	2.57	3.36	4.94	1.73	4.59	3.36	1.52	2.50
1999	0.80	5.18	2.49	3.27	5.11	1.79	4.55	3.27	1.58	2.54
2000	0.83	5.93	2.42	3.18	5.27	1.85	4.50	3.18	1.63	2.59

Figures for 1995−2000 are estimated using regression analysis based on COR 1980−1994.
Commun., communications.

Appendix 2, Table 1. Basic data for calculation of TFP growth in India (capital stock with and without adjustment for capacity utilization).

Year	GDP	Capital stock	Labor force	Adjusted capital stock	Wages	Capital charges	NDP
1975-76	343954	1017728	25.6	1004498			269748
1976-77	348253	1055384	26.2	1041664	213133	135120	276720
1977-78	374267	1095489	26.9	1080152	227567	146699	320929
1978-79	394861	1141500	27.4	1125519	245586	149275	355008
1979-80	374323	1183736	28.0	1168347	276253	98069	315183
1980-81	401162	1231085	28.5	1215081	294592	106569	338393
1981-82	425111	1312238	29.1	1295179	293491	131621	357867
1982-83	437638	1379366	29.7	1361434	292042	145597	366589
1983-84	471191	1433963	30.3	1415321	318720	152471	396946
1984-85	490027	1496083	30.8	1476634	332292	157736	407828
1985-86	514059	1568302	31.4	1547914	338497	175562	423722
1986-87	536337	1640960	31.9	1619628	352922	183415	439921
1987-88	556874	1699672	32.5	1677576	382961	173912	459297
1988-89	615206	1771459	33.1	1746659	410931	204275	507444
1989-90	656469	1839659	33.8	1813904	432821	223648	542127
1990-91	693051	1918761	34.5	1891898	461516	231535	577193
1991-92	702067	1995190	35.2	1967257	475236	226830	583428
1992-93	738003	2077675	35.9	2048588	478627	259376	612396
1993-94	781345	2144285	36.7	2112121	491319	290026	716118
1994-95	838031	2283999	37.7	2249739	535947	302084	775893
1995-96	899563	2470063	38.4	2433012	573953	325610	833740
1996-97	970083	2615023	39.1	2575798	617839	352244	904762
1997-98	1016266	2762869	39.9	2721426	649264	367002	958738
1998-99	1083047	2882955	40.6	2839711	679221	403826	1030980
1999-2000	1151991	3022264	41.4	2976930	688206	463785	1105353
2000-01	1221200	3171688	42.1	3124113	729561	491638	1178694

All monetary values are in 1993-94 prices.
GDP is at factor cost.
Capital stock was calculated using the perpetual inventory method, assuming a 5% annual depreciation ra
Labor force is in tens of million, and all other values are in tens of million rupees.
Adjusted capital stock is the capital stock adjusted for capacity utilization (adjusted with the Wharton method (see Srivastava, 1998, for details).
Capital charges are calculated as GDP minus wages.

Appendix 3, Table 1. Basic data for adjustment of TFPG for quality differences in labor and capital across sectors.

Year	Organized-sector GDP	Unorganized-sector GDP	Wages (Rs 10 million)		Capital charges (Rs 10 million)	
			Organized sector	Unorganized sector	Organized sector	Unorganized sector
1976-77	106772	241481	60829	152304	45943	89177
1977-78	114460	259807	64948	162619	49512	97188
1978-79	120595	274266	70088	175498	50507	98768
1979-80	114155	260168	78838	197415	35317	62753
1980-81	122055	279107	84075	210517	37980	68590
1981-82	134645	290466	87420	206071	47225	84395
1982-83	147013	290625	92136	199906	54877	90719
1983-84	158540	312651	100540	218180	58000	94471
1984-85	169733	320294	108230	224062	61503	96232
1985-86	180613	333446	111556	226941	69057	106505
1986-87	195038	341299	121965	230957	73073	110342
1987-88	169167	387707	132793	250168	36374	137539
1988-89	222208	392998	139882	271049	82326	121949
1989-90	237334	419135	147654	285167	89680	133968
1990-91	253314	439737	157012	304504	96302	135233
1991-92	262282	439785	163619	311617	98663	128168
1992-93	275050	462953	164225	314402	110825	148551
1993-94	291848	489497	169250	322069	122598	167428
1994-95	340245	497786	176692	359255	163553	138531
1995-96	379077	520486	199412	374541	179665	145945
1996-97	403655	566428	210010	407829	193645	158599
1997-98	440924	575342	220157	429107	220767	146235
1998-99	474484	608563	231548	447673	242936	160890
1999-2000	506286	645705	233696	454510	272590	191195
2000-01	540496	680704	247685	481876	292811	198828

All values are in 1993-94 prices.

Appendix 3, Table 2. Basic data for adjustment of TFP growth for quality differences in labor and capital across sectors.

Year	Labor force (10 million)		Capital stock (Rs 10 million)	
	Organized sector	Unorganized sector	Unorganized sector	Organized sector
1975-76	2.02	23.58	201904	802594
1976-77	2.11	24.09	210416	831248
1977-78	2.18	24.72	217111	863041

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1978-79	2.28	25.12	227355	898164
1979-80	2.24	25.76	233669	934678
1980-81	2.29	26.21	243016	972065
1981-82	2.38	26.72	269397	1025782
1982-83	2.41	27.29	298154	1063280
1983-84	2.46	27.84	309955	1105366
1984-85	2.5	28.3	332243	1144391
1985-86	2.51	28.89	351376	1196538
1986-87	2.56	29.34	380613	1239015
1987-88	2.57	29.93	333838	1343738
1988-89	2.6	30.5	406972	1339687
1989-90	2.64	31.16	422640	1391264
1990-91	2.67	31.83	444596	1447302
1991-92	2.71	32.49	472142	1495115
1992-93	2.72	33.18	489613	1558975
1993-94	2.74	33.96	504797	1607324
1994-95	2.75	34.95	580433	1669306
1995-96	2.79	35.61	649614	1783398
1996-97	2.83	36.27	680011	1895787
1997-98	2.82	37.08	748392	1973034
1998-99	2.84	37.76	786600	2053111
1999-2000	2.86	38.54	824610	2152320
2000-01	2.87	39.23	871628	2252485

Capital stock for each year has been computed for the unorganized sector assuming that its share in capital stock is the geometric mean of the inverses of its shares in the labor force and GDP for each year.
Capital stock has been adjusted for capacity utilization.
Monetary values are in 1993-94 prices.

Appendix 3, Table 3. Factor income shares in India (for calculation of TFP growth with and without adjustment for factor quality across sectors).

Year	Factor income shares					
	Total		Organized sector		Unorganized sector	
	Wages	Capital charges	Wages	Capital charges	Wages	Capital charges
1975-76	0.5566	0.4434				
1976-77	0.5827	0.4173	0.5697	0.4303	0.6307	0.3693
1977-78	0.6148	0.3852	0.5674	0.4326	0.6259	0.3741
1978-79	0.6434	0.3566	0.5812	0.4188	0.6399	0.3601
1979-80	0.6083	0.3917	0.6906	0.3094	0.7588	0.2412

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1980-81	0.6576	0.3424	0.6888	0.3112	0.7543	0.2457
1981-82	0.6255	0.3745	0.6493	0.3507	0.7094	0.2906
1982-83	0.618	0.382	0.6267	0.3733	0.6878	0.3122
1983-84	0.6236	0.3764	0.6342	0.3658	0.6978	0.3022
1984-85	0.6258	0.3742	0.6376	0.3624	0.6996	0.3004
1985-86	0.6143	0.3857	0.6177	0.3823	0.6806	0.3194
1986-87	0.6162	0.3838	0.6253	0.3747	0.6767	0.3233
1987-88	0.6317	0.3683	0.785	0.215	0.6453	0.3547
1988-89	0.6146	0.3854	0.6295	0.3705	0.6897	0.3103
1989-90	0.6085	0.3915	0.6221	0.3779	0.6804	0.3196
1990-91	0.6051	0.3949	0.6198	0.3802	0.6925	0.3075
1991-92	0.5944	0.4056	0.6238	0.3762	0.7086	0.2914
1992-93	0.5974	0.4026	0.5971	0.4029	0.6791	0.3209
1993-94	0.5728	0.4272	0.5799	0.4201	0.658	0.342
1994-95	0.5863	0.4137	0.5193	0.4807	0.7217	0.2783
1995-96	0.5867	0.4133	0.526	0.474	0.7196	0.2804
1996-97	0.5922	0.4078	0.5203	0.4797	0.72	0.28
1997-98	0.5979	0.4021	0.4993	0.5007	0.7458	0.2542
1998-99	0.5737	0.4263	0.488	0.512	0.7356	0.2644
1999-2000	0.5782	0.4218	0.4616	0.5384	0.7039	0.2961
2000-01	0.5753	0.4247	0.4583	0.5417	0.7079	0.2921

Appendix 4, Table 1. Basic data for estimating the determinants of TFPG in India.**

Year	R&D spending*	No. of foreign collaboration	Total trade*	Organized-sector GDP	Unorganized-sector GDP	Nonagriculture-sector GDP	Ratio of private to public GDCF	Implicit GDP deflator
1975-76	NA	NA	9542	105465	238489	184617	1.024	0.24
1976-77	391.0	277	10590	106772	241481	197487	0.943	0.252
1977-78	450.2	267	11478	114460	259807	208857	1.343	0.249
1978-79	558.7	307	12400	120595	274266	225613	1.244	0.241
1979-80	674.3	267	16066	114155	260168	225660	1.128	0.292
1980-81	813.6	526	19543	122055	279107	233392	1.22	0.326
1981-82	1003.5	389	22026	134645	290466	247770	1.224	0.36
1982-83	1255.0	588	24994	147013	290625	260338	1.025	0.389
1983-84	1441.0	673	27262	158540	312651	277683	1.031	0.422
1984-85	1912.7	740	30639	169733	320294	293674	1.071	0.457

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1985-86	2223.9	1041	32742	180613	333446	315706	1.194	0.49
1986-87	2692.7	960	35984	195038	341299	337597	1.076	0.523
1987-88	3179.8	903	42089	169167	387707	360139	1.321	0.569
1988-89	3683.4	957	54649	222208	392998	388111	1.488	0.618
1989-90	4144.2	639	68871	237334	419135	425080	1.479	0.67
1990-91	4616.5	703	83239	253314	439737	451039	1.577	0.737
1991-92	4512.8	976	96341	262282	439785	462814	1.486	0.839
1992-93	5004.6	1520	126762	275050	462953	485798	1.782	0.911
1993-94	6073.0	1476	155015	291848	489497	519286	1.578	1.0
1994-95	6821.0	1854	197078	340245	497786	561982	1.684	1.091
1995-96	7753.8	915	255023	379077	520486	624410	2.464	1.186
1996-97	NA	NA	294947	403655	566428	670622	2.148	1.275
1997-98	NA	NA	323211	440924	575342	721216	2.469	1.362
1998-99	NA	NA	344350	474484	608563	768651	2.32	1.489
1999-2000	NA	NA	402865	506286	645705	835211	2.216	1.538
2000-01	NA	NA	475950	540496	680704	898647	2.231	1.597

*In Rs. 10 million.

R&D spending and total trade values are in current prices.

Sectoral GDP values are in 1993-94 prices.

Appendix 5, Table 1. Determinants of TFPG in India: explanatory (X) variables.**

Serial no.	Year	TFPG** (%)	% Change in real R&D spending	% Change in foreign collaboration no.	% Change in GNP growth rate	Ratio of organized to unorganized GDP	% Change in private to public GDCF	Change in nonagriculture share %	% Change in total trade openness
		Y	X1 (CRRDS)	X2 (CFCN)	X3 (CGNPGR)	X4 (ROUGDP)	X5 (CPPGDCF)	X6 (CNAS)	X7 (CTTO)
1	1977-78	0.1	9.66	-3.61	6.2	0.441	42.4	-0.9	4.1
2	1978-79	-3.0	25.6	14.98	-1.9	0.44	-7.4	1.3	4.26
3	1979-80	-4.6	24.69	-13.03	-11.6	0.439	-9.3	3.2	30.82
4	1980-81	4.3	-0.41	97.0	12.3	0.437	8.2	-2.1	15.38
5	1981-82	2.0	10.48	-26.05	-1.5	0.464	0.3	0.1	5.0
6	1982-83	-0.2	13.25	51.16	-3.2	0.506	-16.3	1.2	4.76
7	1983-84	4.5	6.26	14.46	4.9	0.507	0.6	-0.6	2.84
8	1984-85	0.9	22.35	9.96	-3.6	0.53	3.9	1.0	8.47
9	1985-86	1.8	7.36	40.68	1.0	0.542	11.5	1.5	0.85
10	1986-87	0.7	12.93	-7.78	-0.8	0.571	-9.9	1.5	2.19

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11	1987-88	2.8	10.64	-5.94	-0.5	0.436	22.8	1.8	12.19
12	1988-89	5.7	6.47	5.98	6.5	0.565	12.6	-1.6	15.71
13	1989-90	2.9	3.59	-33.23	-3.4	0.566	-0.6	1.7	21.7
14	1990-91	2.0	2.75	10.02	-1.2	0.576	6.6	0.3	13.97
15	1991-92	-0.7	-11.13	38.83	-4.4	0.596	-5.8	0.8	19.76
16	1992-93	2.4	-2.58	55.74	4.0	0.594	19.9	-0.1	21.16
17	1993-94	3.1	11.76	-2.89	0.8	0.596	-11.4	0.7	15.26
18	1994-95	2.9	2.32	25.61	1.3	0.684	6.7	0.6	12.69
19	1995-96	3.2	4.19	-50.65	0.3	0.728	46.3	2.3	23.59
20	1996-97	4.1	NA	NA	0.7	0.713	-12.8	-0.3	4.36
21	1997-98	1.5	NA	NA	-3.4	0.766	14.9	1.9	5.27
22	1998-99	4.1	NA	NA	1.7	0.78	-6.0	1.9	5.01
23	1999-2000	2.1	NA	NA	0.0	0.784	-4.5	1.5	7.42
24	2000-01	2.1	NA	NA	-0.4	0.794	0.7	1.1	11.63

The X variables are defined in the following way:

X1 (CRRDS) = % change in R&D spending in 1993-94 prices;
X2 (CFCN) = % change in number of foreign collaborations;
X3 (CGNPGR) = % change in real GNP growth rates (in 1993-94 prices);
X4 (ROUGDP) = ratio of organized sector GDP to unorganized sector GDP;
X5 (CPPGDCF) = % change in the ratio of private-sector GDCF to public-sector GDCF;
X6 (CNAS) = % change in the ratio of nonagricultural-sector GDP to total GDP; and
X7 (CTTO) = % change in the ratio of total trade (exports + imports) to GDP.

The X variables considered here are expected to capture the following:

X1 (CRRDS) = impact of R&D activities;
X2 (CFCN) = impact of foreign inputs such as technology, management control, etc.;
X3 (CGNPGR) = impact of changes in business sentiments due to economic fluctuations;
X4 (ROUGDP) = impact of the changing profile of the (more efficient?) organized sector;
X5 (CPPGDCF) = impact of the changing profile of the (more efficient?) private sector;
X6 (CNAS) = impact of the changing profile of the (more efficient?) nonagricultural sector; and
X7 (CTTO) = impact of the changing level of trade openness.

INDONESIA

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INTRODUCTION

Economic Growth in Indonesia

In the past 20 years, the Indonesian economy experienced rapid economic growth following the high-growth period termed the "miracle economy" of the East Asian countries. During the first half of 1997, before the Asian financial crisis, Indonesia succeeded in developing its economy by more than 8% per year. Economic reform programs implemented during the second half of the 1980s, following the decline in oil prices, were the underlying factors in that success. In principle, the reforms promoted private domestic and foreign investment to substitute for the decline in the government's revenues from oil. At the same time, other exports were boosted through macro- and microeconomic policies.

By the end of the 1980s, the Indonesian economy was growing by 6–7% yearly. This was close to the level in the period of the high-growth economy during the oil-boom period. GDP grew even faster approaching the crisis in 1997, achieving 7.5% to 8.2% growth during the period 1994–96. Along with the growth of the economy, investments were rising quickly. Domestic and foreign investment grew rapidly, responding to favorable government policies. Approved foreign investment projects increased from only US$8 billion in 1993 to almost US$40 billion in 1996.

The crisis experienced in mid-1997 caused the growth rate in 1997 to decline to only 4.6%, which fell further in 1998 with a negative growth of –13.1% and zero growth in 1999. The economy started to grow again, achieving 4.2% growth in 2000. The increasing trend of investment was reversed in 1997. Capital stock grew by less than 3% from the previously high growth of more than 6%. Meanwhile, the labor force increased by around 2–4% per year, caused mainly by population growth. This trend and fluctuation in the Indonesian economy have aroused great interest in investigating the underlying factors affecting the growth and decline of the economy. It is essential to understand whether the output growth has been primarily input or efficiency driven to cope with the problems and formulate better economic policies in the future.

Objectives of the Study

Theoretically, economic growth is based on two components. The use of more inputs, such as the employment of more labor, increases in the skill of workers, and more stock of physical capital (land, machines, buildings, roads, etc.), will produce more outputs. However, it may also be generated by increases in output per unit of input, resulting from better policies and management. In the long run, growth may be primarily generated by advances in knowledge or technology. The fundamental idea of separating the two sources of growth is to discover how much growth is due to inputs and how much to increased efficiency. This analysis can be conducted by computing total factor productivity (TFP), which is simply the ratio of aggregate output to aggregate factors of production.

This study on Indonesia is part of a survey on TFP for selected Asian countries conducted by the Asian Productivity Organization (APO) (Oguchi, 1998). This regional study uses similar data and methodology to obtain results comparable among selected Asian countries to shed more light on the explanation of Asian economic growth. TFP growth for Indonesia was estimated during a previous study (Sigit, unpublished report). But there is still controversy about the causes of growth of the Asian economies over the past two decades. It is therefore necessary to update the estimation of TFP using more current data. Although the concept is straightforward, in practice there are difficulties concerning the accuracy and availability of data.

The current study additionally explores the impact of business fluctuation on TFP growth to take into account the intensity of the use of capital. To improve the estimation, it also attempts to decompose TFP growth according to changes in the structure of employment and capital. Decomposition of employment covered only changes in the structure of education and type of industry. The share of capital in GDP growth cannot be decomposed due to the unavailability of data. The breakdown of capital by land, buildings, and machinery is only available for several years. The final part of the study attempts to identify factors affecting TFP growth. Determining factors, such as exports (especially influential within the period of nonoil boom), foreign direct investment (FDI), and share of the formal sector are explored using regression and correlation analysis with TFP growth as the dependent variable.

ESTIMATION OF TFP GROWTH

Methodology

The data needs depend on the methodology adopted for TFP growth measurement. In this case, the direct accounting method is considered the most appropriate in the estimation of TFP growth. The formula used is derivable from a trans-log production function adjusted for the discrete time by taking the average of two consecutive years. The model incorporates two factors (capital and labor):

$$Q_t = A_t F(K_t, L_t) \qquad \text{(Eq. 1)}$$

The formula for the calculation of TFP is derived from a trans-log production function:

$$\ln Q_t = \ln \alpha_0 + \alpha_t T + \alpha_k \ln K_t + \alpha_l \ln L_t + 1/2\beta_{kk} (\ln K_t)^2 + \beta_{kl} \ln K_t \ln L_t + 1/2\beta_{ll} (\ln L_t)^2 + \beta_{kT} T \ln K_t + \beta_{Tl} T \ln L_t + 1/2\beta_{TT} T^2 \qquad \text{(Eq. 2)}$$

Differentiation of Eq. 2 with respect to time gives:

$$Q_t^* = \alpha_t + \alpha_k K_t^* + \alpha_l L_t^* + \beta_{kk} (\ln K_t) K_t^* + \beta_{lk} (K_t^* \ln L_t + L_t^* \ln K_t)$$
$$+ \beta_{ll} (\ln L_t) L_t^* + \beta_{kT} (TK_t^* + \ln K_t) + \beta_{lT} (TL_t^* + \ln L_t) + \beta_{TT} T \qquad \text{(Eq. 3)}$$

where * indicates the instantaneous growth rate of the variable.
It can be shown that:

$$Q^*_t = TFP_t^* + S_k K_t^* + S_l L_t^* \qquad \text{(Eq. 4)}$$

Since the rate of change of TFP given in the above equation is an instantaneous rate of change, for the discrete time we take the average of two consecutive periods:

$$TFPG_t = 1/2 (TFP_t^* + TFP_{t-1}^*)$$
$$= (\ln Q_t - \ln Q_t - 1) - 1/2 (Sk_t + Sk_{t-1}) (\ln K_t - \ln K_{t-1})$$
$$- 1/2 (S_{lt} + S_{lt-1}) (\ln L_t - \ln L_{t-1}) \qquad \text{(Eq. 5)}$$

where $TFPG_t$ is TFP growth over time, ($\ln X_t$-$\ln X_{t-1}$) indicates the exponential growth of X, and the two-year moving averages of capital and labor income shares are used.

Data Needs

The estimation of TFP growth requires data on GDP, capital stock, labor, and labor income. Since TFP growth is computed at the macro level for the national economy, the main sources of data are the national account statistics and the national labor force surveys. In place of output, GDP (value added) is selected for its accuracy and availability. Accordingly, for the inputs, only primary factors of production, capital, and labor are taken into account in the model. Raw materials and intermediate inputs have been taken out. This is fortunate as raw materials and intermediate goods, which are only available every five years from the input-output table, can be omitted.

For consistency, the domestic concept used in GDP must be in line with the concept for the primary inputs. Capital stock and labor must also adopt the domestic concept. Capital stock is the totality of capital, regardless of ownership, available in the country for use in the production of goods and services. Since value added in the government sector is included in GDP, capital owned by the government is also included. Since capital goods for military purposes are not included in the capital stock, GDP also excludes value added directly created by the military.

Similarly, employment is the total number of people working with the available capital stock to produce goods and services. Foreigners working in the country are included in the working population. On the other hand, Indonesians working abroad are excluded. Government officials are included, but military persons are excluded in the working population to match GDP, which also excludes value added created by the military.

Data on employment income are also required to estimate the labor income share in GDP. They must include all incomes accrued to all employment working for the production of goods and services. However, property incomes and operating surplus are excluded.

Gross Domestic Product

To represent output, GDP at factor cost is used. Indirect taxes and subsidies are not included. To eliminate the influence of prices, GDP at constant 1993 prices was chosen. Since the data series are given in 1973, 1983, and 1993 base years, they must first be adjusted to obtain uniform 1993 base year pricing. In addition, adjustment must also be made to account for underestimation in the level of GDP. GDP is marked up every 10 years based on the input-output table. The mark-up can clearly be seen in GDP current prices, since both the previous and the adjusted levels are published for the years 1973, 1983, and 1993.

The marked-up percentages are computed and separated from the effect of base year pricing. The price and underestimation adjustment indexes are shown in Table 1.

Table 1. Price and underestimation adjustment indexes for GDP.

Price indexes (times)	Underestimation indexes (%)
$I_{(73/60)} = 9.34$	$U_{1973} = 2.25$
$I_{(83/73)} = 5.54$	$U_{1983} = 9.00$
$I_{(93/83)} = 2.16$	$U_{1993} = 9.19$

In 1973, along with the changes in the base year, the GDP was adjusted upward by 2.25%, in 1983 by 9.00%, and in 1993 by 9.19%. The same corrections were then applied for the constant prices, and the degree of correction was assumed to be linearly declining for the 10 previous years. In 1973, the figure was adjusted upward by 2.25%. This percentage was also spread for the adjustment of GDP in the period 1960–72. Similarly, for 1993 the adjustment of 9.19% was assumed to be linearly decreasing until 1982. This assumption is made based on the assumption that in the preparation of GDP the underestimation accumulates every year.

After underestimation adjustment, the data were converted from the 1960, 1973, and 1983 base years to 1993 constant prices. Prices of domestic product in 1983 increased by 4.54 times compared with prices in 1973; similarly, prices in 1993 compared with 1983 increased by 1.16 times. First, the conversion from 1973 to 1983 pricing was done by multiplying the adjusted GDP (1974–82) by the index $I_{(83/73)} = 5.54$, and then all the GDP values (1974–92) were multiplied by $I_{(93/83)} = 2.16$ to obtain GDP at 1993 constant prices. The 1993 pricing was chosen since it is the most recent and able to give a better picture of the magnitude and growth of GDP.

The final results of the series data on GDP in 1993 prices and their yearly growth rates together with the original data in current and different constant prices are presented in Table 1 of the Appendix.

Capital Stock

By definition, capital stock is investment accumulation after taking account of depreciation. Investment or gross domestic capital formation (GDCF) equals the realized domestic fixed capital formation and increase in stock. Only the net value of capital formation, which is obtained from GDCF with depreciation subtracted, accumulates to form capital stock. Increases in stock are included.

The data on capital stock at 1993 constant prices for the years 1980–94 were unofficially estimated by BPS-Statistics Indonesia (Central Bureau of Statistics, 1996). The estimation of capital stock is undertaken by employing the perpetual inventory model (PIM) using data on gross domestic fixed-capital formation (GDFCF) found in the national income accounts. Conceptually, GDFCF includes the provision, manufacture, and purchase of new capital goods in the country, as well as new or used capital goods from abroad. Capital goods are used repetitively in the production process for a duration of more than one year.

In the estimation of capital stock using the PIM, the role of depreciation is crucial. The strength of this estimation is in using different depreciation rates for different types of capital goods. GDFCF, which is only given its total value in the national accounts, was disaggregated into the relevant categories of capital goods using information obtained from the input-output tables for 1980, 1985, and 1990. The distribution of these different capital goods is used for disaggregating the total GDFCF. For years for which the input-output table was not available, the distribution of capital goods is interpolated

The results are only available for the years 1980–94, as given in Table 2 in the Appendix. Moreover, the method assumes that the capital stock for the benchmark year 1980 equaled the investment in that year, and not the accumulation of investments for several years. This resulted in unacceptable and inconsistent depreciation rates, which are very low for most years, at around 1%, and very high for the beginning years, at 18.4% for 1980 and around 5% for 1981 and 1982. Therefore this unofficial capital stock estimate cannot be used for estimation of TFP. Consequently, capital stock must be reestimated.

Similar to GDP data, investment data must also be corrected from underestimation and converted into uniform 1993 base year data to obtain a consistent data series with uniform pricing. The indexes for pricing and underestimation adjustments are shown in Table 2.

Table 2. Indexes for pricing and underestimation adjustments of investment data.

Price indexes (times)	Underestimation indexes (%)
$I_{(73/60)}$ =10.32	U_{1983} = 1.29
$I_{(83/73)}$ = 4.38	U_{1993} = 1.02
$I_{(93/83)}$ = 2.53	

The procedure of adjustment for investment data is similar to that for GDP data. The underestimation indexes here are also assumed to decline linearly for 10 years backward. The conversion to 1993 prices is undertaken in three steps. First, the 1960–72 investment data are converted to 1973 pricing by multiplication of investment figures by 10.32. Then, the 1960–82 data are multiplied by 4.38 to obtain the investment in 1983 pricing. Finally, the 1960–92 investment data are converted to 1993 pricing by multiplying the data by 2.53. The results are given in Table 3 of the Appendix.

The adjusted 1993 base year investment is used to estimate the capital stock using the PIM, with 15-year accumulation of investments (from 1961–76) with a depreciation rate of 3% to form the 1976 benchmark. Depreciation rates are determined by considering the economic or technical lifetime of each type of capital goods. The rates of depreciation also depend on the user of the capital goods. The business sector is believed to depreciate capital goods faster than household enterprises. The PIM estimation is done using the following formula:

$$K_t = 0.97K_{t-1} + I_t \qquad \text{(Eq. 6)}$$

where t = 1976–98, K_t is capital stock in year t, K_{t-1} is capital stock in year t-1, I_t is investment in year t, and 0.03 is the depreciation rate. The capital stock estimates are also provided in Table 3 of the Appendix.

Employment

Employment data were obtained from various surveys and population censuses conducted by BPS-Statistics Indonesia. These surveys and censuses are data collected from regular households, including dormitories and boardinghouses, but hotels and military barracks are excluded. Therefore the employment data cover all the working population, except military members living in barracks. Military personnel living in regular households are included, and it is not possible to separate them. However, they can be neglected, since their number is small. Government employees are included in the surveys, since most live in regular households.

The labor force and employment data are available for the duration 1976–2000, intermittently from the population censuses for 1980 and 1990, from the Intercensal Population Surveys for 1985 and 1995, and from the National Labor Force Surveys (NLFS) for 1976, 1982, and 1989–98. Since some data fluctuated erratically, the labor force participation rates (LFPR) and employment rates are adjusted based on the trends shown by the data. Yearly employment is estimated by interpolation based on exponential growth, in conformity with the nature of population growth. The original data, their corrections, and the final results of the yearly employment data and their growth are given in Table 4 in the Appendix.

The number and growth rate of the labor force and employment depend on the number of population and the LFPR. The trend of the LFPR is slightly increasing every year, making the increase in the labor force higher than population growth. The increase in the working-age population is influenced by the cohort born in particular years. From the 1970s until the 1980s, the working-age population increased dramatically caused by the baby boom early in the 1950s after World War II. This caused a sharp increase in the labor force and employment in the 1970s of almost 4% per year, which slowly declined but remained high (above 3%) in the 1980s. As the birth rate declined, with the successful family planning program embarked on in 1976, the labor force and employment growth declined further, reaching around 2% in the 1990s. From 1997 to 2000, employment declines were mainly caused by the financial crisis.

Labor Income Share

The data on labor income are only available every five years in the input-output table computed using wages and salaries collected in the NLFS, adjusted for income from self-employment (Appendix Table 5). However, the data in the input-output table do not include the income of unpaid family workers and employers only receiving operating surplus. For estimating TFP growth, labor income is adjusted through the calculation of average income per employee. The overall labor income was then obtained by multiplication of average income by the ratio of total employment to the number of employees. In the years where survey data are not available, the average income per employee was estimated by exponential interpolation. The labor income shares were obtained by dividing the labor income by the corresponding GDP in current prices.

The results of the adjustment in Table 6 in the Appendix show higher labor income share than the input-output data. Instead of an increasing share, the revised data show a fluctuation in labor income shares during the period 1976–98. The share was high in the 1970s during the oil boom. In that period, many economic activities were generated by the proceeds from oil and were received as income by the people involved. With the decline in oil prices early in the 1980s, the labor income shares declined, reaching only 27% in 1980. With the success of industrialization, the income share gradually increased, and by 1988/89 it almost achieved the level during the oil boom. In the two years before the Asian financial crisis, it showed increases in 1995 and 1996, reaching its peak at 43%. This is believed to be the result of the increase in minimum wage. During the crisis, labor income share started to decline again, hitting the bottom in 1998 caused by the decline in employment. It is estimated to have increased slightly in 1999 and 2000 with the economic recovery.

SOURCES OF ECONOMIC GROWTH

Estimates of TFP Growth

The results of TFP growth estimation are given in Table 3 (and in detail in Appendix Table 7). Economic growth in Indonesia is markedly pushed by the growth of capital. Rapid accumulation of capital occurred, especially during the early 1980s and 1990s, with an average growth of above 6%. This was the driving force behind the rapid economic growth in Indonesia until 1996. The Asian financial crisis slowed investment, resulting in declining GDP. In 2000, GDP growth seems to have started recovery.

Table 3. TFP growth estimates for Indonesia, 1980-2000 (%).

Year	SLG	SKG	TFPG	GDPG	Year	SLG	SKG	TFPG	GDPG
1980	1.13	5.91	3.22	10.27	1991	0.81	5.44	1.33	7.58
1981	0.99	6.29	1.19	8.47	1992	0.78	5.30	1.03	7.11
1982	1.03	6.46	-4.43	3.06	1993	0.85	5.90	0.39	7.14
1983	0.97	6.24	-2.28	4.93	1994	0.80	6.02	0.26	7.08
1984	0.98	5.99	0.69	7.66	1995	0.85	6.67	0.57	8.09
1985	1.05	5.70	-3.41	3.34	1996	0.87	6.38	0.43	7.68
1986	1.13	5.41	0.07	6.61	1997	0.60	6.55	-2.61	4.54
1987	1.19	5.05	-0.53	5.70	1998	0.03	1.84	-14.00	-13.13
1988	1.20	5.18	0.12	6.50	1999	0.39	2.38	-2.76	0.01

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1989	1.23	5.42	1.42	8.07	2000	0.34	3.00	1.43	4.77
1990	1.06	5.70	1.10	7.86	-	-	-	-	-

SLG, Share of labor in GDP growth; SKG, share of capital in GDP growth; TFPG, TFP growth; GDPG, GDP growth.

Labor only contributes a small portion to the growth of GDP. This is caused by the consistent but slow growth of employment of around 2–2.5% annually, and by the small labor income share. The growth of employment is mainly caused by the increase in labor brought about by population increase. Most labor is able to work due to the large informal sector in the Indonesian economy. These activities only contribute a small part to economic growth.

Productivity increases in Indonesia are generally low, mostly less than 1%. In some cases it is even negative. Only during the early 1980s was the productivity growth high due to high economic growth based on oil exports. During the financial crisis starting in 1997, TFP growth became negative and then began to recover in 2000.

These results of TFP growth estimates are more or less consistent with those of other studies, as summarized in Table 4. Unfortunately, direct quantitative comparison cannot be made because most studies used different periodicities and different methodologies. But at a glance similarities of the findings are seen. For 1980–85, Collins and Bosworth (1997) found TFP growth of –1.1%. This is about the average figure found in this study. Similarly, for the most recent period, 1986–90, TFP growth of 0.8% is also more or less equal.

Table 4. Results of other studies on TFP growth estimation.

Author	Period	Annual rate of TFP growth (%)	Output growth (%)
Young (1994)	1970–85	1.2	
Ikemoto (1986)	1970–80	2.4	31.5
	1970–75	3.1	39
	1975–80	1.8	24.3
World Bank (1993)	1960–89	1.6	23.1
Marti (1996)	1970–85	0.8	
	1970–90	–0.5	–9.6
Collins and Bosworth (1997)	1960–94	0.8	23.4
	1960–73	1.1	44
	1980–86	–1.1	–42
	1986–92	0.8	20
Elias (1990)	1950–87	1.2	22.8
Kawai (1994)	1970–90	1.5	24.2
Lindauer and Roemer (1994)	1965–90	2.7	
Drysdale and Huang (1995)	1950–88	2.1	31.3

TFP Growth in Different Periods of Economic Development

Oil Boom Period, 1976–81

The result of the estimation of TFP for selected periods is presented in Table 5. TFP during the oil boom period (1976–81) was positive and high. Starting in 1976, oil prices began to rise and achieved the highest level in 1981. In this period, oil exports dramatically increased from only US$6 billion to US$22 billion, contributing to high GDP growth and providing revenues for the government budget.

Table 5. Sources of GDP growth in various years (%).

Period	Years	SLG	SKG	TFPG	GDPG
	(1)	(2)	(3)	(4)	(5)
Oil boom	1976–81	1.33	4.96	2.19	25.27
Transition	1982–85	1.01	6.10	–2.36	–71.04
Recovery	1986–89	1.19	5.26	0.27	2.77
Nonoil boom	1990–96	0.86	5.92	0.73	10.19
Economic crisis	1997–99	0.34	3.59	–6.46	–2.86
Recovery	2000–	0.34	3.00	1.43	4.77

SLG, Share of labor in GDP growth; SKG, share of capital in GDP growth; TFPG, TFP growth; GDPG, GDP growth.

Capital formation in the oil boom period was invested predominantly by the government. Foreign funds and private investments were still small. Capital growth was still relatively low but sharply increasing. The capital stock grew only by around 6% and increased to almost 8%.

In this period, labor growth was high due to high population growth, making the highest contribution to output growth. Labor income share was high since the economy was still dominated by the agricultural sector, but during this period the share started to decline with the increasing value added from oil, which was not enjoyed much by workers. The labor income share achieved its lowest level in 1980–81 when the oil revenues were the highest.

At the beginning of the development period, even with relatively low capital stock growth, the increase in GDP was relatively high due to sharp increases in oil production. Therefore TFP growth was positive at around 2.19%. In this period the largest share in GDP growth was from capital growth (4.96%), while the share of labor growth was 1.33%. This share of labor was the highest in all periods due to the high labor growth and labor income share early in the period.

This period of positive TFP growth was also confirmed by several other researchers. Ikemoto (1986) found TFP growth of 1.8% during 1975–80. Similarly, Young (1986) found TFP growth equal to 1.2% during 1970–85.

Transition Period, 1982–85

The years from 1982 to 1985 were the transition period from the oil- and government-dominated economy to a market economy relying on nonoil exports. During this period oil prices and its exports were still high but started to decrease sharply. To replace the sources of revenue from oil, the government policy shifted to encouraging private investment, domestic and foreign, to boost industrialization. Export-oriented industries were given incentives to step up nonoil exports to replace foreign exchange earnings from oil. Reform toward a market economy started to occur.

Investment started to increase, boosted by the increase in private investment. Consequently, capital stock grew higher around 8–9%. The growth of GDP was slower resulting from the decline in the contribution of oil value added, while the increase in private investment had not yet fully affected the growth of GDP. In this period, labor force growth was still high, at above 3%, but the decline continued consistently. With a greater role of private enterprises resulting in more employment and slower growth of GDP, the labor income share began to increase more than 30% after the sharp decline in 1981, achieving the lowest figure of only 28%.

With lower growth of GDP, increasing growth of capital stock and high labor force growth, TFP growth declined and became negative. On average, the TFP growth in this period was negative at around −2.36%. Bosworth (1995) also found negative TFP growth during the period 1980–86 of around −1.1%, and Kawai (1994) found negative TFP growth of −0.1% in 1980–90.

Recovery Period, 1986–89

The recovery period began in 1986–89. At the end of this period, the growth of GDP achieved the same level as during the oil boom at 8%. This time the cause of growth was the export of nonoil products, which doubled from around US$6 billion in 1986 to more than US$13 billion in 1989. Capital growth, mainly from private investment, continued to grow by almost 9%. The labor income share started to increase since participation in the production process increased, even though the growth rate of the labor force continued to decline. TFP growth begin to be positive (0.25%), caused by the use of technology through private investment, particularly FDI. In this period the contribution of labor to GDP growth reached its maximum level of 1.19%. As expected, the largest contribution was made by capital growth, but at 5.26% the share in the output growth was less dominant compared with other periods. Bosworth (1995) also estimated positive TFP growth of 0.8% for 1986–92, and Collins and Bosworth (1997) estimated TFP growth of 0.9% for 1984–94.

Nonoil Boom Period, 1990–96

In the nonoil export boom (1990–96), nonoil exports increased from US$19 billion to more than US$39 billion. Capital growth accelerated, exceeding 10%, causing GDP to increase rapidly by around 7–8%. In this period, labor growth continued to decline and was only slightly more than 2%. However, the labor income share increased slightly due to the enforcement of the minimum wage, which was rapidly adjusted by the government to catch up with basic needs and the increase in the cost of living.

Along with the increase in private investment and imported technology, TFP was positive and increasing compared with the previous period. But with TFP growth of only 0.73%, the contribution of technology was still small. During this period of the miracle economy, the growth of the Indonesian economy was mainly due to the growth of capital. With its share in GDP growth of 5.92%, the contribution of capital growth was almost 79% of the growth of GDP, while the contribution of TFP growth was only 10.19%. In this period the share of labor growth declined to 0.86% due to the decline in labor force growth.

Financial Crisis Period, 1997–98

The Asian financial crisis started in 1997 and began to spread into economic and political crises in 1998. GDP growth declined to only 4.65% in 1997, contracted to −13.13% in 1998, and showed zero growth in 1999. Capital formation in 1997 still increased to Rp137 trillion and declined to Rp80 trillion in 1998. Capital growth was still high in 1997 due to previous commitments, but in 1998 was reduced to only 5.36% and reached the bottom in 1999 with only 3.4%. But these figures are still believed to be overestimated, since the computation of investment data does not take account of the value of capital liquidation. In the last two years of the crisis, the labor income share declined due to many layoffs in the formal sector and the slower employment growth, reaching 0.71% in 1998 and 1.31% in 1999.

With much slower growth of GDP and contraction in 1998, TFP growth was again negative (−2.6%) in 1997. In 1998, TFP growth was a negative −13.1%. Even though sharply declining, capital still contributed positively to GDP growth, by 6.55% in 1997 and 1.84% in 1998. These shares of capital growth may have been less, since in this case capital growth is overestimated. Labor growth decreased to only 0.09%. This was particularly caused by the decline in labor share in 1998 of −1.34% due to the decline in employment.

Recovery Period

The recovery began in 1999 with zero growth, which continued in 2000 with GDP growth of 4.1%. There were still political struggles in 2001 hindering further acceleration of growth, but the environment was much more conducive. The growth of TFP was still low but positive at 1.4%. A great deal of GDP growth in 2000 was contributed by capital (3%), while labor also positively contributed to growth, however little, since employment started to grow again in 2000. Growth in coming years is expected to continue, with both capital and labor contributing positively to GDP growth, although it will still be mostly driven by capital.

ADJUSTMENT FOR BUSINESS FLUCTUATION

Employment of Stable Workers

Capital in Indonesia is scarce due to limited funds, especially during the period before the miracle economy. Infrastructure is still very much lacking. Similarly, the supply of machinery, which is mostly imported, remains much below the demand. The economy remains generally constrained by supply. Demand is plentiful. Therefore the intensity use of capital is believed to be high. There is probably the problem of inefficient use of capital, which is reflected in the low productivity of capital, or high capital-output ratio. But this is a structural problem and not a business fluctuation.

Industrialization of the Indonesian economy began early in the 1990s, speeded up by the decline in sources of funds from oil. The government must rely on private funding to build the economy. The switch to private sources of funds for investment has forced the government to open up the economy for private investment, both domestic and from abroad. As mentioned earlier, this has resulted in large accumulation of capital mostly funded by foreign funds in the form of FDI and loans. The opening of the stock market in

Jakarta has made portofolio investments another source of funds.

The government received large amounts of loans from international organizations or bilateral agreements. Still larger amounts of loans were received by private businesses. This large accumulation of capital investment was further induced by the positive environment in the region. This flood of funds flowing in the economy is believed to cause great inefficiency in the use of capital. The government loans were badly managed by the unclean administration. Moreover, the totalitarian government at that time caused bad practices in private businesses, especially in efforts to obtain and use loans, since the cost of those funds is much lower compared with domestic loans. This resulted in a great deal of inefficinecy in the use of the funding. Investments were made improperly, making a number of factories inoperable, or below standard and with low productivity. In general, there was low-intensity use of capital. Capital-output ratios (COR) increased and remained very high during the period.

The accounting for total capital invested for the calculation of TFP growth is believed to overestimate the share of capital and consequently underestimate TFP growth, especially during the early 1990s. To obtain a better accounting for capital that contributed to output growth, a correction of the capacity use of capital must be made. However, there are no data indicating the use of capital. An approximation must therefore be made. One candidate is to use the COR. But this measurement is never satisfactory since output is influenced by many factors, positive or negative. Regressing capital to output cannot reveal the capacity use of capital. Another method is to use inventory data. Higher inventory will lower the use of capital to reduce production in the coming period. Conversely, low inventory will increase the capacity use of capital. This relationship is indirect, however, and inventory data in Indonesia are estimated as the balance of supply and demand to capture the estimation error.

A more direct method to estimate the capacity use of capital is employment. Labor and capital are used together in production. Since the employment of labor is more flexible, the amount of labor used in production can be a good approximation of the capacity of capital used in actual production. The question is which variable should be used to represent the amount of labor. The number of employed cannot be used, since in Indonesia with its large informal sector almost all the labor force is employed in activities to produce goods and services. The hours spent by labor might be a good choice, but total hours worked are not representative, since during economic downturns people may work harder on informal activities to compensate for the decline in income from the formal sector. Consequently, the underemployment rate is misleading for this purpose. Similarly, unemployment rates have definition problems (using the limit of one hour per week) and cannot be employed.

After carefully examining the data, it was determined that the percentage of employment with stable hours is reasonably connected with output. Theoretically those stable workers are mostly employed in the formal sector or stable informal sector to produce most of the national output. They work by employing mainly domestic capital in production. This choice of stable workers eliminates the so-called marginal workers, who mostly use no capital or only small amounts for simple activities. Theoretically there is a positive correlation between stable workers and the capacity use of capital to produce output. This relationship is confirmed by the data on hours worked and output, as presented in Table 8 in the Appendix.

Shares of Capital Growth and TFP Growth Adjusted for Business Fluctuation

The results of the estimation are provided in Table 6. The adjustment for business fluctuation generally reduces the growth of capital. Consistent accumulation of capital has caused increasing unused capacity of capital, resulting in a declining rate of the use of capital, which culminated in 1997–98 during the financial crisis. This caused the share of capital growth to be −1.54% in 1998, even though the growth of physical capital was still positive at 1.84%. In 1993–95, the figures sharply increased, caused by rapid capital growth. In 1999–2000, the share of capital started to grow again, caused by the increasing capacity use of capital.

Table 6. TFP growth adjusted for business fluctuation (%).

Year	SLG	SKG	BFSKG	TFPG	BFTFPG	GDPG
1980	1.13	5.91		3.22		10.27
1981	0.99	6.29	6.10	1.19	1.38	8.47
1982	1.03	6.46	6.29	−4.43	−4.26	3.06
1983	0.97	6.24	6.06	−2.28	−2.10	4.93
1984	0.98	5.99	5.80	0.69	0.88	7.66
1985	1.05	5.7	5.50	−3.41	−3.21	3.34
1986	1.13	5.41	5.22	0.07	0.26	6.61
1987	1.19	5.05	4.84	−0.53	−0.33	5.7
1988	1.2	5.18	4.99	0.12	0.31	6.5
1989	1.23	5.42	5.25	1.42	1.59	8.07
1990	1.06	5.7	5.37	1.1	1.43	7.86
1991	0.81	5.44	5.59	1.33	1.18	7.58
1992	0.78	5.3	4.49	1.03	1.84	7.11
1993	0.85	5.9	1.69	0.39	4.60	7.14
1994	0.8	6.02	9.49	0.26	−3.21	7.08
1995	0.85	6.67	10.07	0.57	−2.83	8.09
1996	0.87	6.38	1.30	0.43	5.51	7.68
1997	0.6	6.55	0.64	−2.61	3.30	4.54
1998	0.03	1.84	−1.54	−14	−11.62	−13.13
1999	0.39	2.38	4.60	−2.76	−4.98	0.01
2000	0.34	3	8.90	1.43	−4.47	4.77

SLG, share of labor growth; SKG, share of capital growth; BFSKG, share of capital growth adjusted for business fluctuation; TFPG, TFP growth; BFTFPG, TFP growth adjusted for business fluctuation.

Interestingly, TFP growth adjusted for business fluctuation is better able to explain the stages of economic development in Indonesia. TFP growth adjusted for business fluctuation is generally higher than unadjusted TFP growth. This is caused by lower growth of used capital, causing the share of capital in GDP growth to be lower. Before 1990, TFP growth was low, fluctuated, and was even negative for some years. It started to increase early in the 1990s, but due to rapid capital accumulation it fluctuated more widely. It is interesting to note that during the years of the most rapid growth and rapid capital accumulation, 1995–96, the TFP growth was negative, meaning that the rapid GDP growth was solely caused by capital input. TFP growth adjusted for business fluctuation declined in 1997, the starting year of the crisis, and became negative at almost −12% in 1998 (the worst year of the crisis) with the negative growth of GDP. TFP growth started to increase again in 1999–2000 but was still negative by more than 4%.

DECOMPOSITION OF EMPLOYMENT BY EDUCATION

Level of education is a good factor to decompose employment to estimate TFP growth in Indonesia. Indonesia has achieved significant progress in education. The percentage of those having no education or only finishing elementary school has declined. On the other hand, the portion of those with higher education has been increasing. Table 9 in the Appendix shows the distribution of employment by educational level, and Table 10 in the Appendix that workers with higher education consistently receive higher wages and salaries. With the faster growth of those with higher education, the share of labor growth in GDP growth is higher than the rates calculated in aggregate. Only in 1990 was the share of labor growth in GDP growth lower than the share of labor growth in GDP growth with decomposition of education (Table 7).

Table 7. TFP growth adjusted for decomposition of employment by education.

Year	EDSLG	SKG	EDTFPG	GDPG
1989	1.13	5.42	1.52	8.07
1990	2.04	5.70	0.12	7.86
1991	2.12	5.44	0.02	7.58
1992	0.97	5.30	0.84	7.11
1993	1.62	5.90	−0.38	7.14
1994	1.70	6.02	−0.64	7.08
1996	2.18	6.67	−1.17	7.68
1997	1.34	6.38	−3.18	4.54
1998	0.88	6.55	−20.56	−13.13
1999	0.92	1.84	−2.75	0.01
2000	0.77	3.00	1.00	4.77

EDSLG, share of labor growth in GDP growth adjusted for education of labor; SKG, share of capital growth in GDP growth; EDTFPG, TFP growth adjusted for education of labor GDPG, GDP growth.

Conceptually the share of labor growth in GDP computed based on disaggregation of employment by education is more accurate. The difference between the two is the aggregation error. TFP growth can then be restimated based on the share of labor growth in GDP growth with decomposition of education (EDSLG). The result is given in Table 8 for the comparison between the unadjusted TFP for business fluctuation. TFP growth adjusted for education of labor is much lower, and almost all rates are negative. What is considered as productivity in the unadjusted TFP growth is actually the share of better education of labor.

Table 8. TFP growth adjusted for business fluctuation and decomposition of employment by education (%).

Year	EDSLG	BFSKG	EDBFTFPG	GDPG
1989	1.1299	5.2500	1.6901	8.07
1990	2.0350	5.3700	0.4550	7.86
1991	2.1242	5.5900	−0.1342	7.58
1992	0.9704	4.4900	1.6496	7.11
1993	1.6243	1.6900	3.8257	7.14
1994	1.6979	9.4900	−4.1079	7.08
1996	2.1796	1.3000	4.2004	7.68
1997	1.3387	0.6400	2.5613	4.54
1998	0.8786	−1.5400	−12.4686	−13.13
1999	0.9246	4.6000	−5.5146	0.01
2000	0.7726	8.9000	−4.9026	4.77

EDSLG, share of labor growth in GDP growth adjusted for decomposition of labor by education; BFSKG, share of capital growth in GDP growth adjusted for business fluctuation; EDBFTFPG, TFP growth adjusted for business fluctuation and decomposition of labor by education; GDPG, GDP growth.

Table 8 presents the results of estimation of TFP growth adjusted for both business fluctuation and education of labor. As mentioned above, business fluctuation adjustment caused TFP growth to increase but adjustment of education of labor caused a decrease in TFP growth. The results are better able to show fluctuation in TFP growth. It declined and became negative in 1991 and 1994 and culminated during the crisis in 1998−2000.

DECOMPOSITION OF CAPITAL BY ECONOMIC SECTOR

Data Needs

Different types of capital contribute differently to output. Land, buildings, machinery, transportation equipment, computers, etc. are production factors used to produce output and services. They are used in combination and the contribution of each type of capital to production is not the same. Several types of capital are more productive than others. A study by BPS-Statistics Indonesia tried to decompose capital stock into different types for 1980−94. These data are potentially useful for decomposing capital in the study of productivity. However, estimation of TFP growth needs the capital income share of each type of capital. Currently these data are not available and there are no existing data enabling the estimation of income shares.

Fortunately the BPS-Statistics Indonesia study also decomposed capital into economic sectors. Judging that different economic sectors need different combinations of capital, these sectoral capital stocks are useful for productivity measurement. Even if in every sector all types of capital goods are utilized, they are employed in different combinations. The agricultural sector, for example, employs more land but fewer building, machinery, and equipment stocks; in manufacturing industries, more machinery and equipment are combined with less land; in transportation the main capital equipment stocks are vehicles; and in services there are more computers and communication apparatus stocks. These different combinations of capital in the different sectors cause different levels of productivity.

Disaggregation of capital can therefore be performed employing sectoral capital stocks. Theoretically, sectoral breakdown will not produce sharp differences in productivity compared with the differences in the types of capital, but for practical reasons they are more useful. Investment in capital stock is never made based on their types, but always in a combination involving all the different types of capital to make the production process optimally operational. In this case, classification by economic sector is the most practical for policy analysis.

Estimating Sectoral Labor and Capital Income Shares

Fortunately, sectoral capital income shares needed for productivity study can be estimated using data on wages/salaries available from the NLFS. The distribution of wages and salaries by sector can be used as proxy for the sectoral labor income shares. However, the estimates must be controlled, such that the aggregated labor income share from the sectoral labor income share is consistent with the direct estimate of the total labor income share. The results of the estimates are given in Table 9.

Table 9. Labor income share decomposed by sectoral distribution of labor, 1989–2000.

Sector	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Agriculture	0.1086	0.1066	0.1134	0.0973	0.0931	0.093	0.0899	0.0588	0.0849	0.0712	0.073
M&Q	0.0043	0.0052	0.0055	0.0048	0.0045	0.0066	0.0051	0.0042	0.0044	0.0041	0.003
Manufacturing	0.035	0.0401	0.0383	0.0353	0.0394	0.0454	0.0465	0.0354	0.0349	0.034	0.036
E,G&W	0.0011	0.0011	0.0012	0.0013	0.0012	0.0012	0.0011	0.0013	0.0009	0.001	0
Construction	0.0109	0.0117	0.0142	0.0166	0.0136	0.0173	0.0178	0.0141	0.0137	0.0113	0.012
T,H&R	0.0607	0.064	0.0662	0.0621	0.0635	0.0671	0.0752	0.0555	0.0651	0.0567	0.058
Transportation	0.0159	0.0164	0.0182	0.0172	0.0207	0.0207	0.0231	0.0167	0.0206	0.0173	0.019
Finance	0.0041	0.0056	0.0059	0.0054	0.0051	0.0051	0.0067	0.0039	0.0045	0.0034	0.005
Services	0.0582	0.0545	0.0565	0.056	0.0576	0.0578	0.0623	0.0492	0.0574	0.052	0.041
Total	0.3914	0.3963	0.401	0.384	0.3733	0.3803	0.3971	0.3953	0.3434	0.3002	0.300

M&Q, mining and quarrying; E,G&W, electricity, gas, and water supply; T,H&R, trade, hotel, and restaurant.

Sectors with the largest labor income shares are agriculture, trade, and services, since they are labor intensive and employ numerous people. However, the average incomes in these sectors are low. In agriculture and services, the labor income shares are decreasing along with the use of more machinery and equipment. Agriculture, as a safety valve, was able to employ more people during the financial crisis to absorb those discharged from other sectors. This is indicated by the increase in labor income share in

1998. The rapid development of the trade, hotel, and restaurant sector, with the construction of starred hotels and prestigious restaurants, has made its proportion of labor income increase. The income share of labor in manufacturing is still small but increasing. This is believed to be caused by the increase in wages and salaries during the period of rapid industrialization. Accordingly, capital income shares are easily estimated by subtracting the sectoral labor income share from the sectoral value added. The results are given in Table 10. The level and development of sectoral capital income shares do not only depend on labor income share but also on the development of output of the sector compared to GDP growth in general. A particular sector may experience increases in both labor income share and capital income share if the share of value added of the sector in GDP increases. Both labor income share and capital income share in the manufacturing sector have increased, but capital income share increased faster due to the use of more capital. Similarly, before the financial crisis, construction and transportation sectors experienced increases in both labor and capital income, although the share of capital increased faster. On the other hand, agriculture has experienced a decrease in both, due to the decreasing share of value added of the sector.

Table 10. Capital income share decomposed by sectoral distribution of capital, 1989–2000 (%).

Sector	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Agriculture	0.0954	0.0875	0.0709	0.0874	0.0828	0.0742	0.0639	0.0900	0.0841	0.1009	0.0945
M&Q	0.1508	0.1470	0.1513	0.1397	0.1341	0.0872	0.0855	0.0848	0.0952	0.0923	0.0915
Manufacturing	0.1498	0.1538	0.1612	0.1703	0.1716	0.1876	0.2003	0.2131	0.2183	0.2267	0.2278
E,G&W	0.0047	0.0052	0.0056	0.0058	0.0061	0.0092	0.0106	0.0113	0.0141	0.0151	0.0167
Construction	0.0439	0.0462	0.046	0.0461	0.0525	0.0556	0.0616	0.0675	0.0460	0.0474	0.0482
T,H&R	0.1007	0.0972	0.0927	0.0981	0.1001	0.1007	0.0922	0.1142	0.0946	0.1019	0.1023
Transportation	0.0382	0.0388	0.0375	0.0404	0.0387	0.0504	0.0485	0.0567	0.0510	0.0532	0.0543
Finance	0.0626	0.0629	0.0644	0.067	0.0699	0.082	0.0836	0.0851	0.0707	0.0655	0.0636
Services	0.0553	0.0563	0.0509	0.0494	0.0455	0.0388	0.026	0.0383	0.0395	0.0459	0.0549
Total	0.6086	0.6037	0.599	0.616	0.6267	0.6197	0.6029	0.6047	0.6566	0.6998	0.6998

M&Q, mining and quarrying; E,G&W, electricity, gas, and water supply; T,H&R, trade, hotel, and restaurant.

Estimating Sectoral Capital Stock Growth

As the data are only available until 1994, the sectoral capital stock must be estimated for 1995–2000. This is done using time series regression functions based on the COR for 1980–94 (Table 11 in the Appendix). Not all relationships of COR and time are linear. In mining, the function is quadratic sloping downward, caused by increasing investment in the beginning years and then decreasing after production. In transportation, the function is quadratic sloping upward, with more investment in later years to catch up with industrialization. For manufacturing and finance, truncated linear regressions are used to capture the increasing investment in later years.

These COR estimates are then used for estimating the sectoral capital stocks for 1995–2000. This is possible since data on sectoral output for 1995–2000 are available from the national accounts. These capital stocks for the years 1980–2000 can be produced and the results are presented in Tables 11 and 12 in the Appendix, and accordingly the sectoral capital growth rates are computed and presented in Table 11. Investment in agriculture rapidly increased during the 1980s during the oil boom period, aimed at self-sufficiency in rice supply. However, the growth decreased during the period of rapid industrialization. Investment in manufacturing increased during the 1980s and continued during the early 1990s before the financial crisis. It decreased sharply during the crisis in 1998, caused by negative capital growth. However, in 1999 and 2000 it increased again.

Table 11. Capital growth by economic sector, 1989–2000 (%).

Sector	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Agriculture	15.39	9.42	6.56	6.48	9.00	9.56	8.02	9.53	26.32	8.01	2.16
M&Q	4.18	6.43	5.27	5.37	6.99	5.62	22.07	22.67	37.58	13.25	13.15
Manufacturing	7.50	8.67	7.30	6.88	7.30	8.95	8.88	5.85	5.42	1.60	−0.60
E,G&W	6.19	6.34	4.00	2.75	3.30	19.12	9.80	13.99	22.80	6.10	1.95
Construction	18.76	20.07	17.83	18.26	16.44	20.24	16.90	15.04	−19.43	3.37	6.36
T,H&R	13.98	14.60	16.07	13.31	15.89	14.19	12.10	13.66	3.78	4.41	5.38
Transportation	8.55	8.98	8.86	9.01	9.17	19.14	7.96	9.85	3.11	−0.95	4.37
Finance	7.08	5.44	8.57	6.41	8.85	15.29	6.12	3.76	−12.56	−9.39	−1.88
Services	15.77	16.63	13.97	13.09	11.38	3.27	7.18	11.01	21.88	6.21	1.84
Total	9.31	9.91	9.51	8.99	9.88	10.20	11.16	10.83	5.36	3.40	4.29

M&Q, mining and quarrying; E,G&W, electricity, gas, and water supply; T,H&R, trade, hotel, and restaurant.

TFP Growth Adjusted for Sectoral Capital Stock

With the data on sectoral capital growth and capital income shares, the share of capital in GDP growth by sectors are computed and presented in Table 12. The data clearly show a rapid structural shift in the Indonesian economy. The share of the agricultural sector was only 1.5% and decreased sharply to only 0.6% in the period 1989–97. Similarly, the share of the service sector declined due to the reduction in the informal activities in this sector. On the other hand, the contribution of manufacturing, public works, and construction in GDP growth increased along with industrialization. The share of other sectors (services, trade, and transportation) decreased due to a decrease in informal activities.

Table 12. Share of capital growth in GDP growth by economic sector, 1989–2000 (%).

Sector	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Agriculture	1.4683	0.8234	0.4651	0.5660	0.7454	0.7093	0.5126	0.8574	2.213	0.8085	0.2042
M&Q	0.6298	0.9452	0.7970	0.7497	0.9369	0.4896	1.8871	1.9224	3.577	1.2224	1.203
Manufacturing	1.1238	1.3341	1.1764	1.1719	1.2526	1.6794	1.7778	1.2474	1.1843	0.3619	−0.136
E,G&W	0.0289	0.0329	0.0225	0.0160	0.0201	0.1759	0.1037	0.1584	0.3211	0.0918	0.0326
Construction	0.8226	0.9267	0.8202	0.8410	0.8624	1.1260	1.0411	1.0151	−0.894	0.1597	0.3065

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T,H&R	1.4075	1.4188	1.4893	1.3055	1.5907	1.4285	1.1152	1.5594	0.3578	0.4496	0.5503
Transportation	0.3267	0.3489	0.3323	0.3642	0.3552	0.9638	0.3866	0.558	0.1586	−0.05	0.2373
Finance	0.4434	0.3418	0.5516	0.4295	0.6189	1.2538	0.5114	0.3202	−0.887	−0.615	−0.12
Services	0.8717	0.9369	0.7111	0.6462	0.5178	0.1270	0.1866	0.4222	0.8649	0.2855	0.1009
ESSKG	7.1228	7.1086	6.3655	6.0900	6.9000	7.9533	7.5222	8.0605	6.8951	2.7141	2.3785
SKG	5.4200	5.7000	5.4400	5.3000	5.9000	6.0200	6.3800	6.5500	1.8400	2.3800	3.0000

M&Q, mining and quarrying; E,G&W, electricity, gas, and water supply; T,H&R, trade, hotel, and restaurant; SKG, share of capital growth in GDP growth; ESSKG, share of capital growth adjusted for distribution of capital by economic sector.

The effect of sectoral disaggregation on the share of capital in GDP growth can be seen in the last two rows of Table 12. The sectoral disaggregation of capital increased its share in GDP growth compared with the share before disaggregation. The disaggregation was thus able to capture the impact of the sectoral shift. Capital growth increased more rapidly in the high-growth sectors. In the slowly growing agriculture sector with numerous informal activities, capital stock grew much more slowly. This resulted in giving more weight to the capital income share in the rapidly growing sector, and resulted in a higher contribution of capital growth to GDP growth. Only in 2000 was the share of capital growth in GDP growth adjusted for distribution of capital by economic sector lower than the share of capital growth in GDP growth, due to the negative share of manufacturing and finance.

The increase in the share of capital growth in GDP growth adjusted for distribution of capital by economic sector resulted in a decline in TFP growth adjusted for distribution of capital, as can be seen in Table 13. Except in the early 1990s, growth rates were low, culminating in the worst crisis year of 1998. However, an increase was seen in 2000, with positive growth of GDP.

Table 13. TFP growth adjusted for sectoral distribution of capital, 1989−2000 (%).

Year	SLG	ESSKG	ESTFPG	GDPG
1989	1.2300	7.1228	−0.2828	8.07
1990	1.0600	7.1086	−0.3086	7.86
1991	0.8100	6.3655	0.4045	7.58
1992	0.7800	6.0900	0.2400	7.11
1993	0.8500	6.9000	−0.6100	7.14
1994	0.8000	7.9533	−1.6733	7.08
1996	0.8700	7.5222	−0.7122	7.68
1997	0.6000	8.0605	−4.1205	4.54
1998	0.0300	6.8951	−20.0551	−13.13
1999	0.3900	2.7141	−3.0941	0.01
2000	0.3400	2.3785	2.0515	4.77

SLG, share of labor growth in GDP growth; ESSKG, capital growth share in GDP growth adjusted for sectoral distribution of capital; ESTFPG, TFP growth adjusted for sectoral distribution of capital; GDPG, GDP growth.

The simultaneous impact of both decomposition of labor by education and capital by sectoral shift can be seen in Table 14. This decomposition further depressed TFP. In all years it became negative, except in 1992 and 2000 when it was positive but very small.

Table 14. TFP growth adjusted for education of labor and sectoral distribution of capital, 1989–2000 (%).

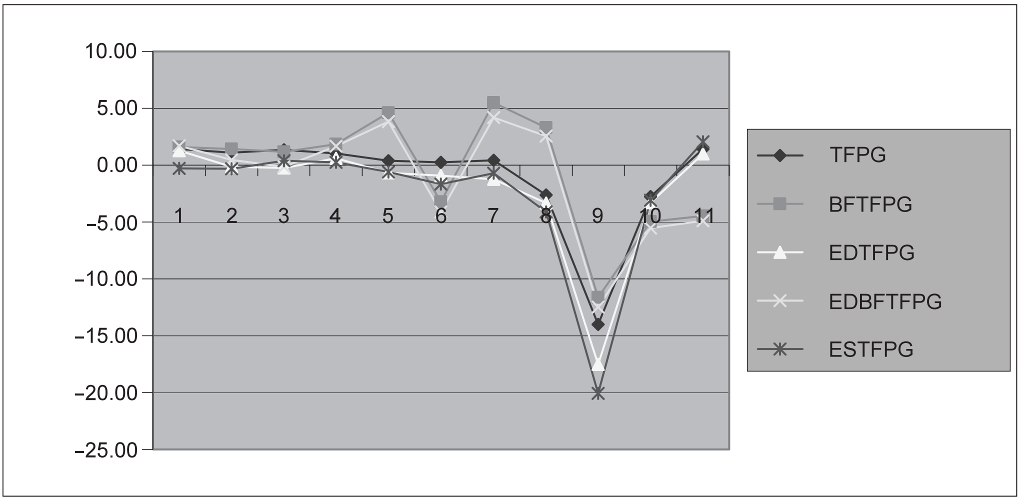
Year	EDSLG	ESSKG	EDESTFPG	GDPG
1989	1.1299	7.1228	-0.1827	8.07
1990	2.0350	7.1086	-1.2836	7.86
1991	2.1242	6.3655	-0.9097	7.58
1992	0.9704	6.0900	0.0496	7.11
1993	1.6243	6.9000	-1.3843	7.14
1994	1.6979	7.9533	-2.5712	7.08
1996	2.1796	7.5222	-2.0218	7.68
1997	1.3387	8.0605	-4.8592	4.54
1998	0.8786	6.8951	-20.9037	-13.13
1999	0.9246	2.7141	-3.6287	0.01
2000	0.7726	2.3785	1.6189	4.77

EDSLG, labor growth share in GDP growth adjusted for education; ESSKG, capital growth share in GDP growth adjusted for sectoral distribution of capital; EDESTFPG, TFP growth share adjusted for both education and sectoral distribution of capital; GDPG, GDP growth.

Figure 1 further compares the different levels of productivity. The simple unadjusted and aggregated productivity (TFP growth) serves as the base. The business fluctuation adjustment generally increased TFP growth due to smaller growth of capital caused by low-intensity use of capital. But the effect fluctuates, since the adjustment caused a business fluctuation in the growth of capital. The increases in the used capital in 1991 and 1994 reduced the level of productivity. The increasing idle capital during the financial crisis caused productivity to decline in 1999 and 2000. Adjustment for business fluctuation amplifies the fluctuation in productivity. Productivity (as measured by TFP growth adjusted for business fluctuation and that for both education of the labor force and business fluctuation) hit the lowest levels in 1994 and 1998 and the highest levels in 1993 and 1996. After reaching the bottom in 1998, productivity started to increase even though the levels were still negative.

As mentioned previously, the decomposition by education and economic sector consistently reduced productivity levels, since the decomposition increased the role of labor and capital in GDP growth. Only for the year 2000 did productivity after sectoral decomposition increase, due to faster growth of the traditional sector in the recovery period. This reduced the role of capital due to slower economic growth in the sectors with large capital stock.

Figure 1. Comparison of TFP growth, TFP growth adjusted for business fluctuation, TFP growth adjusted for education of the labor force, TFP growth adjusted for both education of the labor force and business fluctuation, and TFP growth adjusted for sectoral distribution of capital.



FACTORS INFLUENCING PRODUCTIVITY

An attempt was made to identify factors influencing the level of productivity. The effects of the education of labor and sectoral shift of capital on productivity have been deleted by disaggregation of employment and capital stock. The effects of business fluctuation have been taken into account in the measurement of productivity by weighing the intensity of use of capital stock. Due to data limitations, only three variables can be explored: exports, domestic demand, and proportion of the formal economy. Exports are suspected to be the driving force for productivity increase, since international markets are highly competitive. Domestic demand is an indicator of the size of the market. A larger market creates possibilities for innovation and efficiency, resulting in increased productivity, while the formal economy reflects the proportion of the modern sector, which is believed to be more productive.

Another factor that may influence productivity is FDI. Unfortunately, only data on approved FDI are available. Data on realized investment are not available. How much the approved FDI is realized varies greatly from year to year. Therefore the data on approved FDI cannot be used as a proxy.

Regressions were made with two dependent variables as an alternative: TFP growth adjusted for business fluctuation and decomposed by the education of labor; and TFP growth decomposed for the sectoral shift of capital. For the independent variables both the levels and growth of the variables are employed, and in addition to a linear function the use of a double log function is also attempted. Since the number of observations is small (only 11), only one independent variable is taken into account at a time. The results show that none of the regressions and coefficients are significant and the coefficients of determination iare small. The largest coefficient of determination is only 0.4. Statistically this is caused by the small sample size. Unfortunately, longer series are not possible, since data on wages and salaries are only available beginning in 1989. The nonsignificance of the regression may also be caused by the fact that the effects of important factors have been deleted during the decomposition of labor and capital as well as adjustment for business fluctuation. In this case, long- and short-term factors have been removed from TFP growth. Exports, domestic demand, and proportion of the informal sector are reflected in the structural shift. Therefore the influences of the three variables on TFP growth have been accounted for through the sectoral shift. Only their direct effect on productivity remains, which was found not to be significant. To determine the direct effect of the variables on productivity, the correlation matrix shown in Table 15 was produced.

Table 15. Pearson correlation of dependent and independent variables.

	EDBFTFPG	EDESTFPG	EX	DD	PFS
EDBFTFPG	1	0.998	−0.505	−0.319	−0.202
EDESTFPG	0.998	1	−0.505	−0.329	−0.203
EX	−0.505	−0.505	1	9.797	0.289
DD	−0.319	−0.329	0.797	1	0.447
PFS	−0.202	−0.203	0.289	0.447	1

EDBFTFPG, TFP growth adjusted for education of labor and business fluctuation; EDESTFPG, TFP growth adjusted for education and economic sector; EX, exports; DD, domestic demand; PFS, proportion of informal sector (ratio of employees and employers to total employment).

All correlations between the dependent and independent variables are very low, negative, and not significant. This is because after adjustment for the education of labor and sectoral shift, the growth of productivity became negative, while exports, domestic demand, and proportion of the formal economy grew positively. In this case, it is not relevant to explore which factors cause productivity growth.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

Estimating TFP for the national economy of Indonesia employing an accounting method encountered several problems. No problems were encountered in the methodology, since it is simple and straightforward. All of the problems are related to the availability and accuracy of data. The results of TFP estimation depend heavily on the accuracy of data. Therefore researchers undertaking the calculations must clearly understand how the data are prepared. It is important to explore this with the data producers, since not all the explanations behind data preparation are provided in publications.

Data on capital stock imposed more problems. If the PIM with the level of depreciation can be accepted, the accuracy of investment data, which are the total of capital formation and change in inventory, must be evaluated further. Before 1983, change in inventory was not given separately, as it was included in the consumption expenditure component, which is calculated as a residual of GDP minus their expenditure components. Starting in 1983, private consumption expenditure was estimated separately. This defines inventory as the balance between GDP and expenditure components.

If the value of underutilized capital stock is not taken into account, capital formation tends to be overestimated. In normal economic conditions with normal use of capital, capital growth will not be markedly affected. But during economic crises, especially in 1998, the amount of underutilized capital was very large, which may offset capital formation. Consequently, shares of capital growth are also overestimated and TFP growth is underestimated. Unfortunately, data on underutilization of capital are not available. Adjustment of capital to business fluctuation must be undertaken and TFP must be reestimated. This is done by using the percentage of stable workers as the indicator of capital utilization. Approximation using regression of GDP on capital cannot be employed since a proportion of GDP is produced in the informal sector without capital.

Careful interpretation must also be made of data on employment. In Indonesia, more than 75% of the labor force is still in the informal sector, which contributed only about 20% of output. With a large percentage of the labor force in the informal sector, the unemployment rate is very low (around 3%). Therefore almost all the labor force is employed. The growth of employment is determined more by labor force and population growth, not by the growth of capital and output. With large employment and relatively low labor force growth, the share of labor growth in GDP growth is bound to be low.

In the formal sector, where almost all capital is invested, the growth of employment is dynamic depending on capital investment and growth of output. With higher labor growth and labor income share, as well as high GDP growth, the estimation of TFP for the total economy will underestimate TFP in the formal sector. Since capital formation and technological progress occur mostly in the formal sector, TFP for the national economy will not give an accurate picture of the level and growth of technology in the formal economy in Indonesia. It is therefore suggested that TFP should be estimated separately for the formal sector.

Another problem concerns the data on labor income share. The data in the input-output table are underestimates, since they include only employee income calculated from the household surveys. For the calculation of TFP, labor income for all employment is estimated conservatively by assuming the average income per worker from the surveys. However, the labor income share of around 40% in Indonesia is reasonable compared with the figures for more developed countries of almost 50%. The problem is whether the level of income is equal to the marginal product of labor. The marginal product indicates the real contribution of labor to output growth. Income in a labor-surplus economy such as Indonesia is believed to be lower than labor productivity. The accounting method using the real income paid may underestimate the share of labor, resulting in overestimation of the share of capital and underestimating TFP growth.

Reestimation of TFP growth by decomposing employment according to the level of worker education can be done conveniently, since good data on education are available. But data on different types of capital are not available. Consequently, decomposition of capital can only use a proxy. One method is to use the sectoral distribution of capital. But in this case it can also be intepreted as the effect of a structural shift. Decomposition by sectoral distribution of capital has two meanings, capital decomposition and sectoral shift.

A more refined estimation of TFP growth by decomposition seems to produce reasonable results. In this way, the effect of other factors on TFP growth can be removed. In this case, two methods are attempted: decomposition of capital by economic sector; and decomposition of labor by level of education. In this way, the effect of changes toward more productive capital and changes toward better education of labor can be accounted for, so that the estimate of TFP growth is cleaner.

Attempts to explain the factors affecting productivity do not produce acceptable results for various reasons. Regression analysis cannot be implemented due to statistical problems. The number of observations is not sufficient even for a simple regression. Correlation analysis between TFP growth and the explanatory factors produce unreasonable results. The volume of exports, domestic demand, and percentage of the modern sector in output are negatively and nonsignificantly correlated with productivity. Unfortunately, data on realized FDI are not available.

Policy Implications

In general, TFP growth in Indonesia has been very low or even negative in many years. The growth of the economy is mostly driven by capital accumulation. This dependence on investment, especially on FDI, has made the economy vulnerable to external factors. Economic growth without productivity increase only enlarges the hardware and not the software. More capital and labor will produce more output. But for more rapid growth and a better economic structure, it must be accompanied by greater efficiency, a good work ethic, and a conducive environment to increase productivity and make the economy stronger.

The economic crisis experienced by Indonesia since 1997 gives a valuable lesson on depending only on capital (which is inefficiently used) to drive the growth of the economy, even though the economy was growing rapidly. For a better and stronger economic structure, GDP growth must be accompanied by increased productivity. It is therefore necessary to compute productivity (TFP growth, for example) as an indicator of economic growth. Increased productivity must be a target in addition to the growth of GDP. Consequently, better data should be made available to measure TFP growth.

Education has a major influence on economic growth. Taking account of the education of labor significantly increases the share of labor in GDP growth and decreases TFP growth. How much education affects the increase in labor share and how it increases productivity conceptually depend on the performance of labor and level of wages. If labor performance surpasses the increase in wages, then education will also increase productivity. Therefore higher wages to compensate for higher labor education must be accompanied by better management and better labor performance.

Decomposition of capital by economic sector confirms that structural change and better composition of capital increase the share of capital, for the obvious reason that better and more productive capital is used. More productive capital generally enjoys higher returns, causing the capital share to increase. Removing the contribution results in lower TFP growth. However, similar to better education, better capital also contributes to productivity growth. This is true if their performance surpasses the returns on capital. Therefore structural changes must be accompanied by better management of the capital used.

To achieve increases in productivity at the macro level, a productivity campaign should be undertaken at the micro level. The notion of productivity should become part of corporate culture, especially for the strategic companies in the country. In totality, productivity at company level will contribute to national productivity. In the past, increasing productivity has not received sufficient attention at either the macro or micro level. In Indonesia, no formal instituion is responsible for improving productivity. Only a small working unit whithin the Department of Manpower is assigned responsibility for productivity. Logically, this working unit concentrates more on labor productivity and has difficulties in coordinating various aspects related to productivity. It is necessary therefore to establish a national body or institution in charge of productivity, such as in Malaysia, Singapore, Thailand, and many other countries.

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APPENDIX. DATA USED FOR TFP GROWTH ESTIMATION.

Appendix Table 1. Adjustment of GDP, 1975−2000 (all in billion rupees except for columns 1 and 6 in %).

Year	GDP current prices	GDP constant73, 83 & 93prices	Adjusted GDP current prices	GDP constant 93 prices	GDP growth (official)
(1)	(2)	(3)	(4)	(5)	(6)
1975	12642.5	7630.8	12870.1	93124.9	
1976	15466.7	8156.3	15884.3	100418.2	7.54
1977	19010.7	8870.9	19695.1	110173.1	9.27
1978	21967.4	9471.2	22955.9	118650.6	7.41
1979	32025.4	10164.9	33754.8	128437.5	7.93
1980	45445.7	11169.2	48217.9	142332.5	10.27
1981	54027.0	12054.6	57916.9	154915.9	8.47
1982	59362.6	12325.4	64171.0	159725.9	3.06
1983*	71214.7	12842.2			
1983**	77622.8	77622.8	77622.8	167805.0	4.93
1984	89885.1	83037.4	90711.9	181160.0	7.66
1985	96996.9	85081.9	98780.6	187310.7	3.34
1986	102682.6	90080.4	105514.5	200104.7	6.61
1987	124816.9	94517.9	129406.3	211839.9	5.70
1988	142104.8	99981.4	148635.8	226070.7	6.50
1989	167184.7	107436.6	176404.7	245063.1	8.07
1990	195597.2	115217.3	208181.7	265099.9	7.86
1991	227450.2	123225.2	244174.3	285973.1	7.58
1992	259884.5	131184.9	281381.8	307053.2	7.11
1993*	302017.8	139707.1			
1993**	329775.9	329775.9	329775.9	329775.9	7.14
1994	377354.3	353973.2	377354.3	353973.2	7.08
1995	454514.1	383792.3	454514.1	383792.3	8.09
1996	532630.8	414418.9	532630.8	414418.9	7.68
1997	627695.5	433245.9	627695.5	433245.9	4.54
1998	955753.5	376374.9	955753.5	376374.9	−13.13
1999	1109979.5	379557.7	1109979.5	379557.7	0.08
2000	1290684.2	397666.3	1290684.2	397666.3	4.77

Columns 2 and 3: 1983*, in 1973 prices; 1983**, in 1983 prices; 1993*, in 1983 prices; 1993**, in 1993 prices.

Appendix Table 2. Unpublished Central Bureau of Statistics estimates of capital stock, 1993 prices (columns 2 and 3, in billion rupees; columns 4 and 5, in %).

Year	Capital stock	Investment	Implicit depreciation rate	Capital growth rate
(1)	(2)	(3)	(4)	(5)
1980	31223.0	31223.0		
1981	60185.4	34700.0	18.400	1.93
1982	96379.0	39208.8	5.010	1.60
1983	149737.3	57818.7	4.628	1.55
1984	201913.4	56251.4	2.722	1.35
1985	261476.1	64357.6	2.375	1.29
1986	323684.5	68540.0	2.421	1.24
1987	389022.7	70105.8	1.473	1.20
1988	450040.3	64765.9	0.010	1.16
1989	517705.7	72736.6	1.127	1.15
1990	593031.9	80652.6	1.030	1.15
1991	674970.7	88371.4	1.080	1.14
1992	764838.2	97426.2	1.120	1.13
1993	864112.8	109575.5	1.350	1.13
1994	978330.1	126482.8	1.420	1.13

Appendix Table 3. Estimates of level and growth of capital stock (all in billion rupees except for capital stock growth in %).

Year	GDFCF constant 60, 73, 83 & 93 prices	GDFCF current prices	GDFCF constant 93 prices	Capital stock 93 prices	Capital stock growth
1975	1650.2	2571.7	14635.06	162005.4	
1976	1749.2	3204.9	15513.05	172658.3	6.37
1977	2027.5	3826.4	17981.2	185459.7	7.15
1978	2332.9	4670.7	20689.69	200585.6	7.84
1979	2436	6704.3	21604.05	216172.1	7.48
1980	2896	9485.2	25683.63	235370.6	8.51
1981	3218.5	11553.4	28543.77	256853.3	8.73
1982	3636.7	13467.1	32252.64	281400.3	9.13
1983*	3921.2	17187.7			
1983**	19467.9	19467.9	34775.77	307734.1	8.95

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1984	18296.5	20136.1	37019.2	335521.2	8.64
1985	19615.8	22366.9	39688.53	365144.1	8.46
1986	21421.7	24781.9	43342.4	397532.2	8.5
1987	22596.8	30980.2	45719.97	431326.2	8.16
1988	25200.9	36802.6	50988.83	469375.2	8.45
1989	28568.1	45659.8	57801.67	513095.7	8.91
1990	32731.5	55633.4	66225.45	563928.2	9.45
1991	34867.2	63893.9	70546.6	617557	9.08
1992	36589.4	70820.2	74031.11	673061.4	8.61
1993*	38671.2	78243.2			
1993**	86667.3	86667.3	86667.3	739536.8	9.42
1994	97582.8	104220.7	97582.8	814933.5	9.71
1995	118386.4	129217.5	118386.4	908871.9	10.91
1996	128698.6	157652.7	128698.6	1010304	10.58
1997	139725.5	177686.1	139725.5	1119720.4	10.84
1998	93604.7	243043.4	93604.7	1179733.5	5.36
1999	75467.9	240322.2	75467.9	1219809.4	3.40
2000	88984.5	313915.2	88984.5	1272199	4.29

For column 2 only: 1983*, in 1973 prices; 1993*, in 1983 prices; 1983**, in 1983 prices; 1993**, in 1993 prices.

Appendix Table 4. Sources and adjustment of employment data (columns 3 and 5 in 1000 persons; columns 4, 6, and 7 in %).

Source	**Year**	**Labor force**	**LFPR**	**No. of employed**	**Employment rate**	**Employment growth**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
NLFS (Sept.-Dec.)	1976	48430.9	54.90	47306.2	97.68	 2.17 3.77
Pop. census (Sept.)	1980	52421.2 56355.7	50.23 54.00	51553.1 54856.6	98.34	 5.89 3.60
NLFS (average)	1982	59598.6 60702.3	54.00 55.00	57802.8 58875.1	97.86	 2.61 3.26
Intercensal pop. survey (Sept.)	1985	63825.6 66234.1	53.00 55.00	62457.0 64816.0	97.86	 4.13 3.17

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NLFS (average)	1989	75508.1	56.81	73424.9	97.24	
Population census (Sept.)*	1990	73913.7	54.73	71569.9	96.83	3.30 2.71
NLFS (average)	1990	77802.3 77354.5	57.33 57.00	75850.6 75412.9	97.49	 0.75 1.34
NLFS (average)	1991	78455.5	57.14	76423.2	97.41	 2.74
NLFS (average)	1992	80704.0	57.30	78518.4	97.29	 2.30
NLFS (average)	1993	82631.3	57.92	80323.0	97.21	 2.14
NLFS (average)	1994	85775.6	58.03	82038.1	95.64	
Intercensal pop. survey (Sept.)*	1995	86361.3	56.62	80110.1	92.76	2.21
NLFS (average)	1996	90109.6	58.30	85701.8	95.11	 1.52
NLFS (average)	1997			87004.5	95.11	
NLFS (average)	1998	92314.9	57.10	85843.8	92.99	

LFPR, labor force participation rate; NLFS, national labor force survey; Pop., population.
*Data from these sources were omitted.
Numbers in italic are revised figures.

Appendix Table 5. Input-output (I-O) table and survey data on employment income and estimates of their share in value added (columns 2, 3, 5, and 6 in billion rupees; columns 4, 7, and 9 in %; column 8 in thousand rupees).

Year	GVA from I-O table	Wages & salaries	Share of wages & salaries in GVA	Employee income from survey data	Wages & salaries adjusted for all employment	Share of employment income in GDP	Average employment income	Growth of average employment income
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1975	15466.7	3408.5	22.04					
1976				2098.3	6358.5	40.03		
1980	45445.7	11667.4	25.67					
1985	97645.9	27076.9	27.73					
1989				18992.3	69771.5	39.55	950	1.16
1990	207801.3	56977.8	27.42	22692.0	80615.2	38.72	1069	1.16
1991				29295.9	99002.5	40.54	1287	1.16
1992				33473.4	111578.0	39.65	1421	1.16
1993				36926.9	123089.7	37.33	1532	1.16
1995	535564.8	163376.4	30.51	61031.2	177340.0	39.02	2115	1.16

GVA, gross value added.

Appendix Table 6. Estimates of labor income share in GDP (column 2 in thousand rupees; columns 3 and 7 in %; columns 4 in thousand persons; columns 5 and 6 in billion rupees).

Year	Employment income/ worker	Growth of average employment income	No. of employed	Estimated employment income	GDP current prices	Employment income share
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1975	115.6		45522.8	5263.0	12870.1	40.89
1976	134.4	1.1626	47306.2	6358.5	15884.3	40.03
1977	156.3	1.1626	49089.6	7671.1	19695.1	38.95
1978	181.7	1.1626	50940.3	9254.6	22955.9	40.31
1979	211.2	1.1626	52860.8	11165.1	33754.8	33.08
1980	245.6	1.1626	54856.6	13470.6	48217.9	27.94
1981	285.5	1.1626	56831.4	16224.7	57916.9	28.01
1982	331.9	1.1626	58875.1	19541.2	64171.0	30.45
1983	385.9	1.1626	60788.5	23456.9	77622.8	30.22
1984	448.6	1.1626	62764.2	28157.3	90712.0	31.04
1985	521.6	1.1626	64816.7	33806.2	98781.6	34.22
1986	606.4	1.1626	66864.9	40545.1	105516.6	38.43
1987	705.0	1.1626	68977.8	48627.3	128261.8	37.91
1988	819.6	1.1626	71157.5	58320.5	148641.6	39.24
1989	950.2	1.1594	73424.9	69771.5	176413.3	39.55
1990	1069.0	1.1250	75412.9	80615.2	208193.7	38.72
1991	1286.7	1.2037	76943.8	99002.5	244190.5	40.54
1992	1421.0	1.1044	78518.4	111578.0	281379.2	39.65
1993	1532.4	1.0784	80323.0	123089.7	329775.9	37.33
1994	1781.6	1.1626	82038.1	146159.7	377354.3	39.15
1995	2115.1	1.1872	83842.9	177340.1	454514.1	39.02
1996	2511.1	1.1872	85701.8	215208.1	532630.8	40.40
1997	2773.3	1.1044	87004.5	241293.0	624337.1	38.65
1998	2773.3	1.0000	85843.8	238074.1	951385.9	25.02

Appendix Table 7. Estimates of TFP, 1980−2000 (%).

Year	LIS	ALS	AKS	LG	KG (mid-year)	SLG	SKG	TFP	GDPG
1980	27.94	0.3051	0.6949	3.71	8.51	1.13	5.91	3.22	10.27
1981	28.01	0.2798	0.7203	3.54	8.73	0.99	6.29	1.19	8.47
1982	30.45	0.2923	0.7077	3.53	9.13	1.03	6.46	−4.43	3.06

Continued...

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1983	30.22	0.3034	0.6967	3.2	8.95	0.97	6.24	−2.28	4.93
1984	31.04	0.3063	0.6937	3.2	8.64	0.98	5.99	0.69	7.66
1985	34.22	0.3263	0.6737	3.22	8.46	1.05	5.7	−3.41	3.34
1986	38.43	0.3633	0.6368	3.11	8.5	1.13	5.41	0.07	6.61
1987	37.91	0.3817	0.6183	3.11	8.16	1.19	5.05	−0.53	5.7
1988	39.55	0.3873	0.6127	3.11	8.45	1.2	5.18	0.12	6.5
1989	38.72	0.3914	0.6087	3.14	8.91	1.23	5.42	1.42	8.07
1990	40.54	0.3963	0.6037	2.67	9.45	1.06	5.7	1.1	7.86
1991	39.65	0.401	0.5991	2.01	9.08	0.81	5.44	1.33	7.58
1992	37.33	0.3849	0.6151	2.03	8.61	0.78	5.3	1.03	7.11
1993	37.33	0.3733	0.6267	2.27	9.42	0.85	5.9	0.39	7.14
1994	38.73	0.3803	0.6197	2.11	9.71	0.8	6.02	0.26	7.08
1995	39.02	0.3888	0.6113	2.18	10.91	0.85	6.67	0.57	8.09
1996	40.4	0.3971	0.6029	2.19	10.58	0.87	6.38	0.43	7.68
1997	38.65	0.3953	0.6048	1.51	10.83	0.6	6.55	−2.61	4.54
1998	30.02	0.3434	0.6566	0.77	5.36	0.03	1.84	−14	−13.13
1999	30.02	0.3002	0.6998	1.31	3.4	0.39	2.38	−2.76	0.01
2000	30.02	0.3002	0.6998	1.13	4.3	0.34	3	1.43	4.77

Except for 1996−2000, capital growth is end year.

LIS, labor income share; ALS, average labor income share; AKS, average capital income share; LG, labor growth; KG, capital growth; SLG, share of labor growth; SKG, share of capital growth; GDPG, GDP growth.

Appendix Table 8. Hours worked, employment rates, and growth of capital and GDP.

Year	LT 10 h	LT 25 h	25 − 34 h	ER	KG	GDPG
1980	0.0311	0.2016	0.2776	98.34	8.51	10.27
1982	0.0256	0.2071	0.2272	97.86	9.13	3.06
1989	0.0242	0.1959	0.2626	97.24	8.91	8.07
1990	0.0261	0.1990	0.2602	97.49	9.45	7.86
1991	0.0256	0.1934	0.2598	97.41	9.08	7.58
1992	0.0286	0.2085	0.2557	97.29	8.61	7.11
1993	0.0260	0.2115	0.2390	97.21	9.42	7.14
1995	0.0231	0.1866	0.2612	92.76	10.91	8.09
1997	0.0286	0.2132	0.2189	95.11	10.83	4.54
1998	0.0323	0.2248	0.2029	92.99	5.36	−13.13
1999	0.0282	0.2193	0.2091	93.64	3.4	0.01
2000	0.0243	0.1967	0.2260	93.86	4.3	4.77

LT, less than; ER, employment rate; KG, capital growth (%) GDPG, GDP growth (%).

Appendix Table 9. Distribution of employment by education, 1986−2000 (thousands).

Education	1986	1987	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No school	12917	12383	11937	11306	10242	10429	9840	9371	9683	8537	8469	7947	7570	7148
Not finish ES	20830	20889	20574	20240	18807	19770	19439	19553	19618	17283	18799	16642	15860	14323
ES	22954	24085	26195	27952	29008	29164	29746	30737	26732	32947	30843	32861	32949	34341
GJHS	4511	4998	5554	6346	8378	7343	7480	8205	8267	9669	10159	10760	11831	13933
VJHS	890	934	933	948		1161	1129	1148	747	1016	1429	1439	1544	
GSHS	2526	2882	3543	3965	8445	4727	5311	5951	7048	7802	8576	8999	9678	16078
VSHS	2830	3068	3453	3716		4250	4341	4863	5146	5482	5513	5545	5565	
DIP I/II	173	179	237	262	294	294	321	331	460	500	517	695	746	868
DIP III	401	519	503	552	568	634	684	894	862	983	970	958	1018	1102
UNIV	305	464	497	562	680	747	911	987	1546	1483	1775	1827	2054	2032
Total	68338	70402	73425	75851	76423	78519	79201	82038	80110	85702	87050	87672	88817	89824

ES, elementary school; GJHS, general junior high school; VJHS, vocational junior high school; VSHS, vocational senior high school; DIP I/II/III, college diploma course; UNIV, university.

Appendix Table 10. Average wages and salaries by education of employees, 1986−2000 (rupees).

Education	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
No school	37730	42194	51821	56121	65039	72577	92110	101478	120650	162105	206206
Not finish ES	46211	50784	61387	64791	74682	93823	122432	135422	160883	191721	232009
ES	59575	64865	74501	90372	101393	113232	145735	173368	199395	239708	286264
GJHS	86037	106424	102586	112801	161437	148261	186729	210850	247680	298710	363817
VJHS	97657	103128	117822	126362	159413	171353	209329	242760	275450	358469	
GSHS	110609	130433	141960	159249	199121	204979	256274	300950	345360	426735	511645
VSHS	111972	122275	137915	154344	201541	210485	263449	310351	358358	455437	
DIP I/II	138594	143613	160229	203299	231052	278548	333171	360353	436738	551219	564076
DIP III	169182	224594	249516	269031	310536	367738	419001	472345	528036	640050	755404
UNIV	208120	251680	272500	295246	355650	396041	487463	543759	610807	701651	935328
Total	77164	89676	101651	115951	143493	157343	207108	240732	282251	346950	430197

ES, elementary school; GJHS, general junior high school; VJHS, vocational junior high school; VSHS, vocational senior high school; DIP I/II/III, college diploma course; UNIV, university.

Appendix Table 11. Estimates of capital stock by sector, 1980−2000 (billion rupees).

Year	Agriculture	M&Q	Manufacture	E,G&W	Construct.	T,H&R	Transport.& commun.	Banking & finance	Service	Total
1980	9115	62046	61662	4986	18748	17591	35457	13406	12358	235371
1981	11522	63473	64632	6136	19025	18729	38690	22158	12487	256853
1982	13122	64868	73649	6832	20647	19983	41549	27138	13612	281400
1983	14810	61256	82245	6416	24087	23545	40181	40293	14901	307734
1984	16712	62067	90651	6671	26536	25550	42316	48132	16887	335521
1985	17215	63067	105421	7007	28952	27533	44794	53605	17549	365144
1986	17886	65569	119533	7781	31292	29857	49798	56385	19433	397532
1987	19370	66297	131348	8401	34689	34320	53542	62617	20742	431326
1988	21556	69649	141295	9113	39133	39783	57936	67485	23425	469375
1989	24874	72559	151892	9677	46474	45345	62893	72265	27118	513096
1990	27216	77225	165067	10290	55802	51966	68541	76193	31629	563928
1991	29001	81294	177114	10702	65749	60319	74612	82721	36046	617557
1992	30880	85657	189305	10996	77755	68349	81335	88022	40764	673061
1993	33660	91640	203120	11359	90538	79212	88792	95811	45404	739537
1994	36876	96787	221302	13531	108862	90450	105788	110462	46888	814934
1995*	41339	103560	255118	15650	129755	99879	128308	125119	48541	947269
1996	44684	126493	277942	17195	151778	112036	138615	132858	52060	1053660
1997	47320	150029	284465	18951	168814	123116	147217	133289	55878	1129078
1998	48788	168483	244783	18994	111024	104291	123897	95132	55588	970980
1999	52271	189259	246681	19989	113834	108014	121733	85504	58565	995850
2000	55337	221920	254096	21118	125462	117954	131661	86936	61804	1076287

*Figures for 1995–2000 are estimated using the estimated capital output ratio, 1980−94.

M&Q, mining and quarrying; E,W&G, electricity, water, and gas supply; Construct., construction; T,H&R, trade, hotel, and restaurant; Transport. & commun., transportation and communication.

Appendix Table 12. Capital output ratio, 1980–2000.

Year	Agriculture	M&Q	Manufacture	E,W&G	Construct.	T,H&R	Transport.& commun.	Banking & finance	Service	Total
1980	0.21	4.71	2.84	5.02	2.30	0.75	4.57	1.94	0.76	1.65
1981	0.25	4.62	2.68	5.31	2.06	0.71	4.45	2.92	0.70	1.66
1982	0.28	5.33	2.99	5.00	2.10	0.71	4.47	3.29	0.73	1.76
1983	0.39	1.76	3.84	9.45	2.42	0.95	4.54	3.95	0.79	1.83
1984	0.28	5.33	2.99	5.00	2.10	0.71	4.47	3.29	0.73	1.76
1985	0.41	1.85	3.57	8.82	2.92	1.01	4.53	4.44	0.83	1.95
1986	0.41	1.81	3.67	8.15	3.06	1.00	4.80	4.21	0.86	1.99
1987	0.43	1.81	3.61	7.58	3.22	1.07	4.84	4.43	0.86	2.04
1988	0.45	1.94	3.44	7.34	3.29	1.12	4.92	4.58	0.90	2.08
1989	0.50	1.91	3.35	6.89	3.47	1.15	4.74	4.42	0.98	2.09
1990	0.53	1.91	3.21	6.16	3.63	1.22	4.68	4.20	1.08	2.13
1991	0.55	1.81	3.10	5.47	3.82	1.33	4.68	4.12	1.17	2.16
1992	0.54	1.93	3.00	5.06	4.04	1.39	4.60	3.96	1.26	2.19
1993	0.58	2.00	2.92	4.71	4.16	1.47	4.53	3.87	1.34	2.24
1994	0.62	2.92	2.68	3.66	4.22	1.52	4.21	3.58	1.37	2.30
1995*	0.67	2.92	2.78	3.65	4.44	1.56	4.70	3.65	1.37	2.36
1996	0.70	3.37	2.72	3.55	4.61	1.62	4.67	3.55	1.42	2.41
1997	0.73	3.89	2.64	3.46	4.78	1.67	4.63	3.46	1.47	2.45
1998	0.77	4.50	2.57	3.36	4.94	1.73	4.59	3.36	1.52	2.50
1999	0.80	5.18	2.49	3.27	5.11	1.79	4.55	3.27	1.58	2.54
2000	0.83	5.93	2.42	3.18	5.27	1.85	4.50	3.18	1.63	2.59

*Figures for 1995–2000 are estimated using regression analysis based on capital output ratio 1980 = 1994.
M&Q, mining and quarrying; E,W&G, electricity, water, and gas supply; Construct., construction; T,H&R, trade, hotel, and restaurant; Transport. & commun., transportation and communication.

ISLAMIC REPUBLIC OF IRAN

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INTRODUCTION

An essential element in any successful strategy for growth and raising the level of well-being in a country is a sustained increase in productivity. During the past, in many nations productivity increase meant an increase in the volume of production aided by capital, labor, and cost reductions and therefore the contribution of productivity increase was limited. However, when the economy grows to a certain level, the growth rate usually slows and at that stage the emphasis shifts from labor or capital productivity toward total factor productivity (TFP) increase. The significance of unquantifiable factors such as technology and management innovation, labor relations, labor and capital quality, competitiveness, etc. also becomes more apparent.

The focus on the role of productivity in enhancing competitiveness while generating wealth and cultural well-being has shifted over time from the micro (labor, capital, personnel, teams) to the meso (organizational design and performance) and macro (large-scale and complex systems) levels. Likewise, the essential thinking about productivity matters has emerged through systemic, strategic, humanistic, and now integral patterns and organizing paradigms. We now also recognize that micro-scale solutions depend heavily on both meso-scale and macro-scale insights and that all three must be meshed in applications.

TFP includes all technological and managerial factors in addition to labor and capital. The measurement of productivity based on only one factor of production like labor or capital can only give a partial picture of technological efficiency. TFP is the ratio of output to an aggregate measure of inputs which combines the quantities of all the factors of production.

The Asian Productivity Organizaiton (APO) initiated a survey in 1998 to estimate and compare TFP based upon an agreed methodology in selected member countries in Asia and the findings were published. A second survey on the topic was organized by the APO in 2001. This report is the preliminary report of the second survey for estimating TFP and determining factors of its growth in the Islamic Republic of Iran during the period 1980–99. It should be noted that due to the special circumstances in Iran during the period of analysis and also problems with information and data, the results in some parts of the analysis, such as decomposition of labor and different factors affecting TFP growth, were not as desirable as expected.

ESTIMATION OF TFP GROWTH

Theory and Methodology

Measurement of TFP is based on the economic theory of production. The theory consists of a production function with a constant return to scale together with the necessary conditions for production equilibrium. Quantities of output and input entering the production function are identified with real product and real factor input as measured for social accounting purposes. In this survey, growth accounting, a statistical technique for dividing the growth rate of output into two sources of growth, was used for a variety of inputs and TFP growth. If Q represents output and K and L represent capital and labor inputs in physical units, respectively, then the aggregate production function can be written as:

$$Q = F(K, L; t) \qquad \text{(Eq. 1)}$$

The variable for time (t) appears in F to allow for technical change. Technical change represents any type of shift in the production function. Thus slowdowns, speedups, improvements in the education of the labor force, and other factors will appear as "technical change."

It is convenient to start with the special case of neutral technical change (Solow) in which shifts in the production function leave rates of substitution untouched, but simply increase or decrease the output from given inputs. In this case, the production function can be written in its special form:

$$Q_t = A(t), f(K_t, L_t) \qquad \text{(Eq. 2)}$$

where

Q_t = output during period t, K_t *and* L_t = factor inputs (capital and labor) during period t, and $A(t)$ = technical progress, giving TFP as a function of time or cumulative effect of shift over time.

By differentiating equation Eq. 2 with respect to time, we have:

$$Q' = \frac{dQ}{dt} = A'.f(K_t, L_t) + A\frac{\partial f}{\partial k}k' + A\frac{\partial f}{\partial L}.L' \qquad \text{(Eq. 3)}$$

Dividing the whole equation by Q, we have:

$$\frac{Q'}{Q} = A'.f(K_t, L_t)/Q + A\frac{\partial f}{\partial k}\bullet\frac{K'}{Q} + A\frac{\partial f}{\partial L}\bullet\frac{L'}{Q} \qquad \text{(Eq. 4)}$$

$$\frac{Q'}{Q} = \frac{A'}{A} + A\frac{\partial f}{\partial K}\bullet\frac{K'}{Q} + A\frac{\partial f}{\partial L}\bullet\frac{L'}{Q} \qquad \text{(Eq. 5)}$$

where $\frac{Q'}{Q}$ is the proportionate rate of change in output.

Solow assumed that:

$$S_l = \frac{\partial Q}{\partial L} \cdot \frac{L}{Q}$$

$$S_k = \frac{\partial Q}{\partial K} \cdot \frac{K}{Q} \qquad \text{(Eq. 6)}$$

where

S_l = share of labor and S_k share of capital, and this assumption means that factors are paid their marginal products under competitive equilibrium conditions. We can now write Eq. 7 as:

$$\frac{Q'}{Q} = \frac{A'}{A} + S_k \frac{K'}{K} + S_l \frac{L'}{L} \qquad \text{(Eq. 7)}$$

or as:

$$Q_{tg} = TFPG + S_k K_{tg} + S_l L_{tg} \qquad \text{(Eq. 8)}$$

where Q_{tg}, $TFPG$, K_{tg}, and L_{tg} are the growth rate of output, TFP growth, capital growth, and labor growth over time, respectively, and TFP growth can be obtained from this equation.

Assuming a constant return to scale, where percentage change in input will bring the same percentage change in output, we also have:

$$S_k + S_l = 1 \qquad \text{(Eq. 9)}$$

Since the rate of change of total factor productivity given in Eq. 2 is an instantaneous rate of change for the discrete time, we take the average of two consecutive periods, and therefore:

$$TFPG = (\ln Q_t - \ln Q_{t-1}) - \frac{1}{2}(Sk_t + Sk_{t-1})(\ln k_t - \ln k_{t-1}) -$$

$$\frac{1}{2}(S_{lt} + S_{lt-1})(\ln L_t - \ln L_{t-1}) \qquad \text{(Eq. 10)}$$

This is the equation used in the estimation of TFP growth. It should be noted that other participants in this survey project refer to Eqs. 8 and 10 as Eqs. 2 and 5, respectively.

Data

Main Producers of Data in Iran

The Iran Statistic Center (ISC) and the Central Bank of Iran are the main producers of statistics and information in Iran. The ISC is a subsidiary of the Iran Management and Planning Organization and was established in 1965. The statistical system in Iran is a centralized system according to its regulations and technical measures, but it is decentralized in relation to operational aspects. Therefore other institutions can produce their own statistics and information based on the approved regulations and measures. The ISC uses a special framework for conducting statistical surveys of different economic, social, and cultural sectors. It uses this framework to conduct general population and housing censuses by visiting all sites and registering all their current activities every 10 years. The first general census of population and housing was conducted in 1956.

The Central Bank of Iran as the second main producer of statistics conducts statistical surveys mostly in relation to economic sectors. The Central Bank also releases various publications, the most important of which is the yearly "balance sheet and economic report" which contains statistical tables on: productions, costs, and national income; agriculture; fuel and power; mining and industry; buildings and housing; social affairs; government budgets and financial plans; conditions of foreign economies; banking, monetary, and credit policies; capital markets; and price trends.

The Bureau of Macro Economics of the Iran Management and Planning Organization also engages in the collection of statistics and every few years it publishes a statistical time series in relation to economic and social affairs. The most recent publication covers statistics up to 1986.

Description of Data

Measures of Output GDP at factor cost at constant prices is used as the measure of output in this analysis. The official estimates from the time series tables published by the Iran Management and Planning Organization were the main reference for this purpose. The figures also correspond to the national account figures.

Capital Stock Official estimates for capital stock were not published by any official organization, although the estimates were submitted to the author by the Economic Bureau of the Central Bank of Iran. They were estimated by the perpetual inventory method in current and constant prices and differentiated according to "structures" or buildings and "machinery." The capital stock includes inventory as well as fixed assets, and the official depreciation figures were also mentioned in the estimates, in current and constant prices.

Employment The official employment figures were taken from the time series published by the Iran Management and Planning Organization and were compared with those in other publications and the national accounts published by the ISC.

Income Share of Labor and Capital Figures for labor compensation were only officially available in the national accounts for 1991–98 and were used to calculate the relevant labor share and then to estimate the labor share figures for 1980–90 and 1999. The labor share figures for 1980–90 were assumed to be fixed and calculated as the average figure for 1991–98. This appeared preferable to the estimation of labor compensation with the present information.

According to the definitions provided by the ISC, compensation of labor is the total cash or noncash wages and salaries payable by a company or organization to compensate the work performed by an employee in one accounting period. Labor compensation does not include voluntary work performed without pay like the work done by the owning family of the organization. It also does not include any payable taxes that the employee must pay on wages and salaries. To be counted as employees (either employed or independent workers), they should be performing an activity that is defined in the framework of production. The relation between employer and employee can be established through formal or informal agreements. Independent workers are individuals who either as partners or alone are the owners of the workplace. According to the ISC, the labor compensation of independent workers is included in the total labor compensation figures only if they have been registered in their accounts and statistics in this category.

The labor share of income is calculated as the ratio of compensation of labor (current) to GDP at factor cost (current). The capital share is simply 1 minus the labor share. For both the labor share of income and capital share of income, the two-year moving average was used. The complete set of the above data is given in the Appendix.

Period of Analysis The period of analysis is from 1980 to 1999 (20 years).

Results of TFPG Estimation

Year-to-year TFP Growth

TFP growth has been calculated year to year for 1980 to 1999. The relevant data and the results are in Table 1 of the Appendix. Histograms and/or graphs of the data and the results are illustrated in Figures 1-10. Data for periodic TFP growth for the following period and the resultant TFP growth are shown in Table 3 in the Appendix. The resulting year-to-year TFP growth and population are listed in Tables 1 and 2, respectively.

Table 1. Year-to-year TFP growth.

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.1774	−0.0515	0.0977	0.0632	−0.0526	−0.0139	−0.0460	0.0007	−0.0320
−0.2295		0.0494						

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0.0289	0.1076	0.0518	0.0259	0.0303	0.0043	0.0223	0.0252	0.0104	0.0006	−0.0008
0.1530								0.0958		

Table 2. Population (thousands) in national censuses.

	1956	1966	1976	1986	1991	1996	2001*
Total	18,955	25,789	33,708	49,445	55,837	60,055	65,698
Population 10 years and older	12,784	17,000	23,002	32,874	38,655	65,401	52,381

*Estimated.

Figure 1. GDP at factor price (constant price).

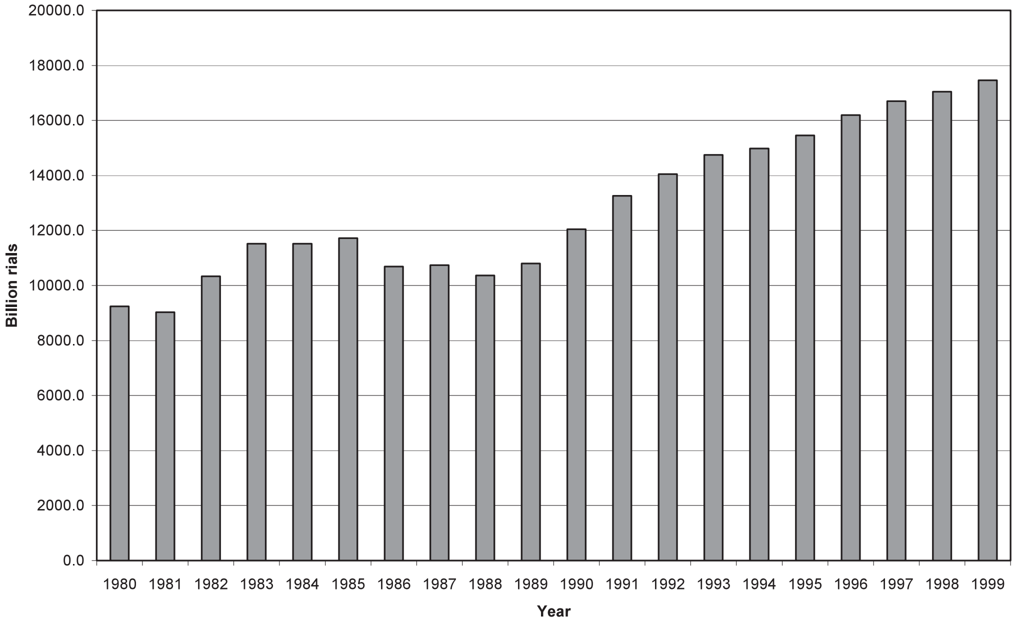


Figure 2. Labor input.

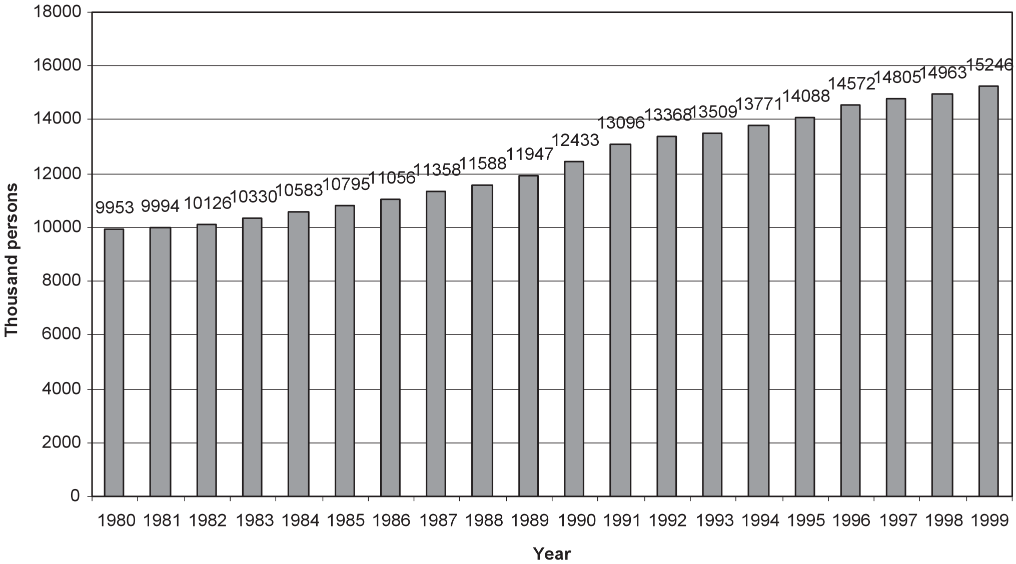


Figure 3. Capital input (constant prices, 1990 = base year).

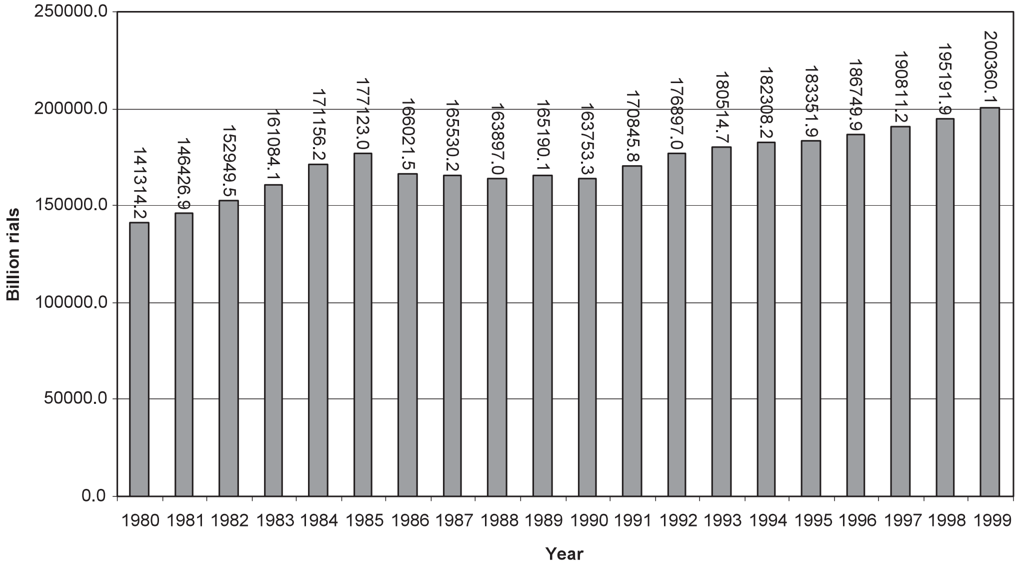


Figure 4. Labor compensation.

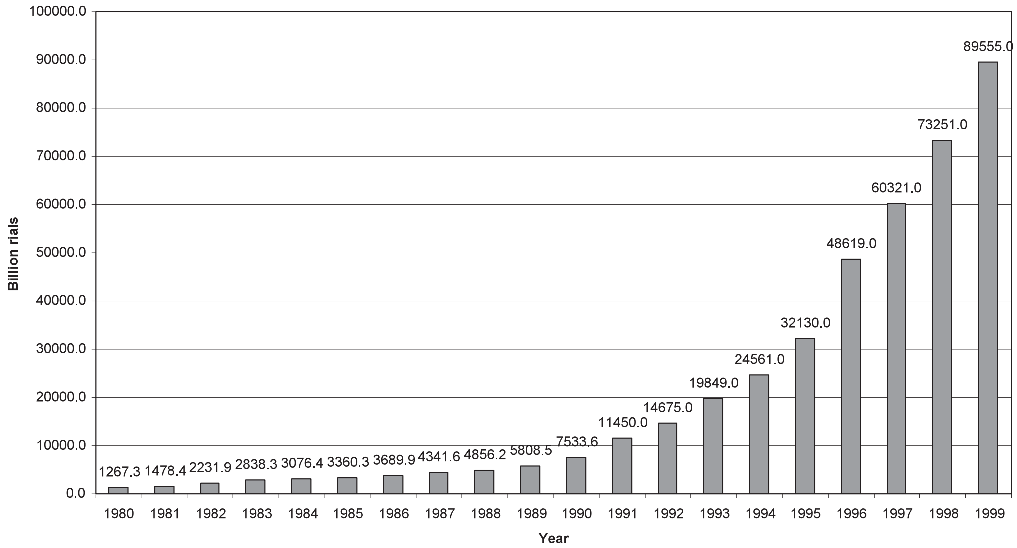


Figure 5. Labor share.

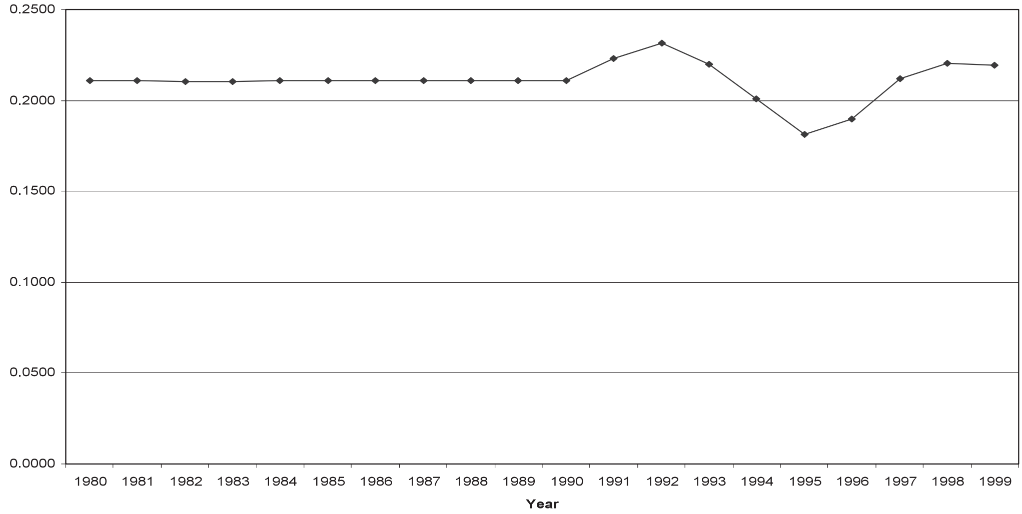


Figure 6. Total factor productivity (TFP) growth.

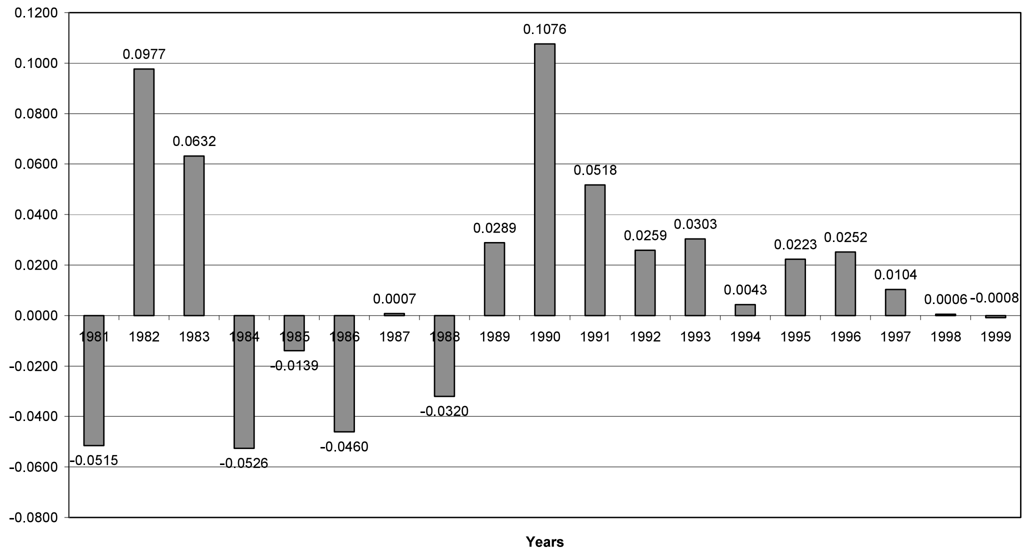


Figure 7. Comparative histogram of GDP (factor cost at constant price), capital (at constant price), labor, and TFP growth in various years.

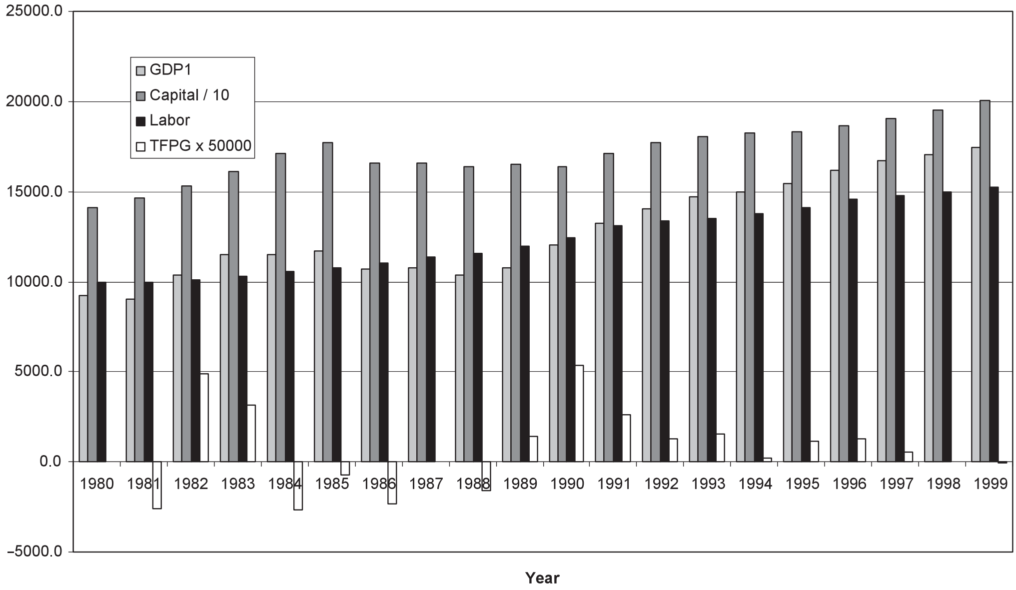


Figure 8. Comparative graph of GDP (factor cost at constant price), capital (at constant price), labor and TFP growth.

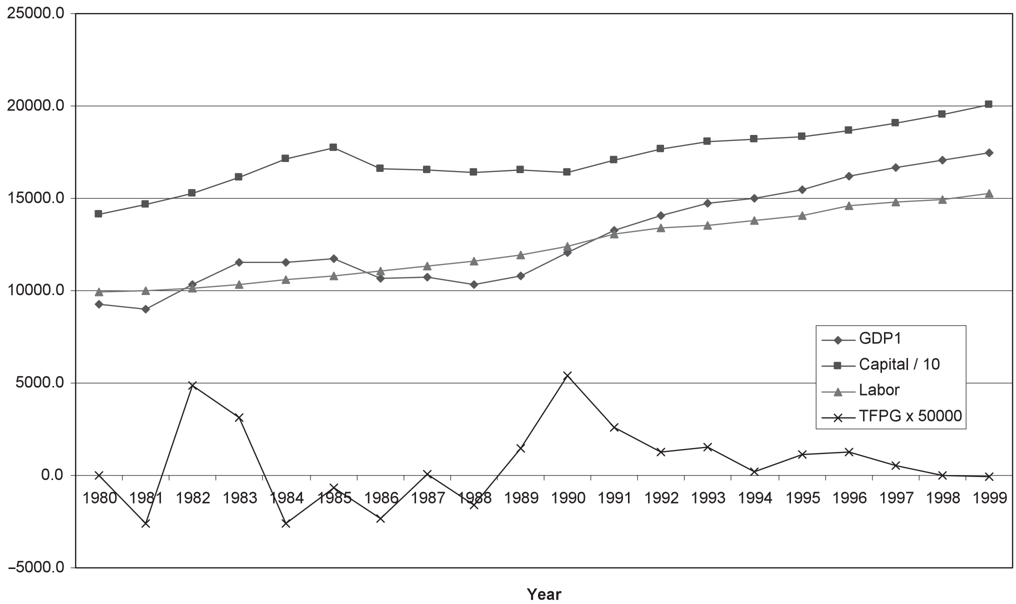


Figure 9. TFP growth periodicity.

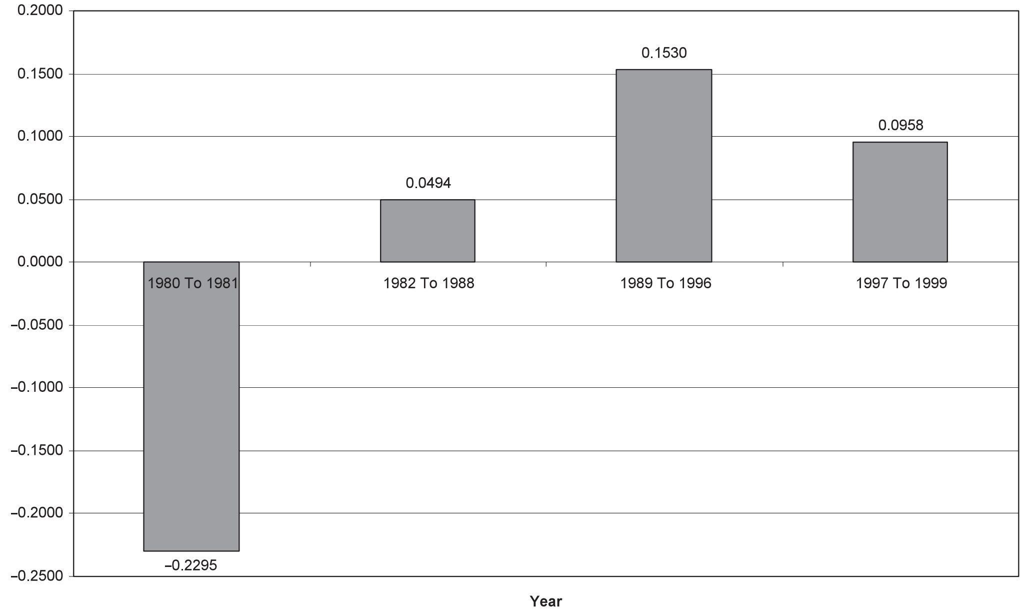
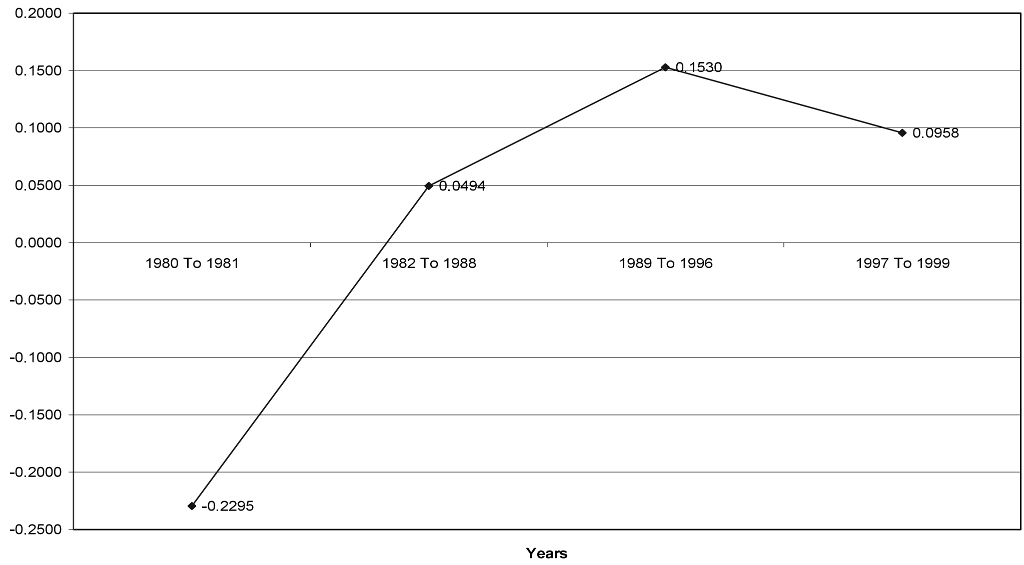


Figure 10. TFP growth changes over time.



As can be seen from Figures 1−10 and Table 2, the number of the labor force has been steadily increasing, from 9.953 million in 1980 to 15.246 million in 1999. It should be kept in mind that the population of Iran increased during the above period, although the rate has decreased sharply now.

The trends in capital input at constant prices are as follows. Capital input increased up to 1986 (immediately after Iran's Islamic Revolution and the first four years of the Iraq-Iran War). It then decreased from 1990 to 1989, the first year after the war. It started increasing once again from 1990, and the slope also increased from 1994 with the effects of foreign loans and higher oil prices.

Labor compensation can be explained as follows. From 1991 to the present the trend can be divided into two different periods: from 1991 to 1994, with a smaller slope; and from 1994 to the present, with a higher slope. The overall labor share, after calculating the two-year moving averages, was around 20–23% for the above period. The figures were controlled and confirmed with the relevant authorities in the ISC.

Overall Analysis of TFP Growth

Economic Background

The period of analysis (1980–99) can be divided into four economic periods:
1) the Revolution period (1979–81);
2) the Iran-Iraq War period (1982–88);
3) the reconstruction period (1989–96); and
4) the political development period (1997–99).

Year-to-year TFP Growth

The year-to-year TFP growth rates show many ups and downs. The best years were 1982 (0.0977%) and 1990 (0.1076%). In 1982, the effects of the 1979 Revolution were decreasing and the Iraq-Iran War was just beginning; 1990 was the year after the end of the war. During 1984 to 1988, TFP growth rates were negative. GDP also decreased in those years due to economic sanctions, mismanagement and waste of inputs as the consequence of the Revolution, war, and trying to do more than was possible.

TFP Growth Periodicity

Other than the years right after the Revolution, even during the war period, there was a small positive TFP growth. During the reconstruction period, TFP growth increased and during the political development period there was a decrease.

ADJUSTMENT FOR BUSINESS FLUCTUATION

Based on Unemployment Rate

Data

To adjust TFP growth based on the unemployment rate, the following formula was used:

GDP (potential) = *GDP*/(1-unemployment rate)

where *GDP (potential)* is the theoretical full employment level of GDP. For GDP data, GDP at factor cost at constant price was used, drawn from the official figures from the Central Bank of Iran.

Results

The results of *GDP (potential)* and TFP growth adjusted (*TFPG***) for the effect of business fluctuations (using the unemployment rate method) are shown in Table 3.

Table 3. Adjustment for business fluctuation using the unemployment method.

Year	Unemployment rate (%)	GDP** (billion rials)	TFPG**	TFPG	Impact on TFPG
1980	12.8	10594.2	—	−0.1774	—
1981	12.1	10275.0	−0.0595	−0.0515	−0.155
1982	12.0	11744.8	0.0965	0.0977	0.012
1983	12.4	13147.9	0.0677	0.0632	−0.072
1984	13.0	13243.8	−0.0457	−0.0526	0.131
1985	13.6	13569.0	−0.0070	−0.0139	0.498
1986	14.2	12462.1	−0.0390	−0.0460	0.151
1987	13.6	12426.2	−0.0062	0.0007	9.422
1988	13.0	11908.7	−0.0389	0.0320	−0.216
1989	12.4	12328.7	0.0220	0.0289	0.238
1990	11.8	13656.7	0.1008	0.1076	0.063
1991	11.1	14918.0	0.0438	0.0518	0.153
1992	10.9	15764.9	0.0237	0.0259	0.087
1993	10.6	16490.2	0.0269	0.0303	0.111
1994	10.5	16740.3	0.0033	0.0043	0.253
1995	10.8	17330.0	0.0258	0.0223	−0.149
1996	9.1	17813.3	0.0062	0.0252	0.752
1997	12.1	18996.8	0.0440	0.0104	−3.212
1998	13.6	19730.0	0.0178	0.0006	−27.744
1999	15.8	20731.2	0.0250	−0.0008	32.171

TFPG, TFP growth.

Overall Analysis The unemployment trend, TFP growth, and TFPG** curves after adjustment for capital utilization using the unemployment rate method are shown in Figures 11 and 12. From 1980 through 1994 the effect was very small (either negative or positive). From 1995 to 1999, the effect increased. In those years, unemployment also rose and fell. The impact on TFP growth is calculated by the following relation:

$$Impact\ on\ TFPG = \frac{TFPG - TFPG^{**}}{TFPG}$$

Figure 11. Impact of unemployment rate on TFP growth.

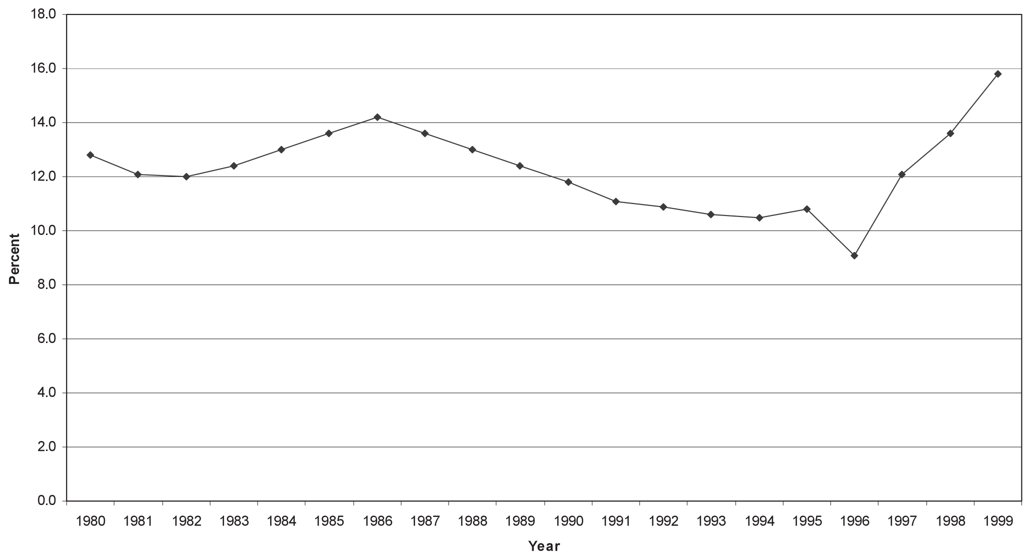
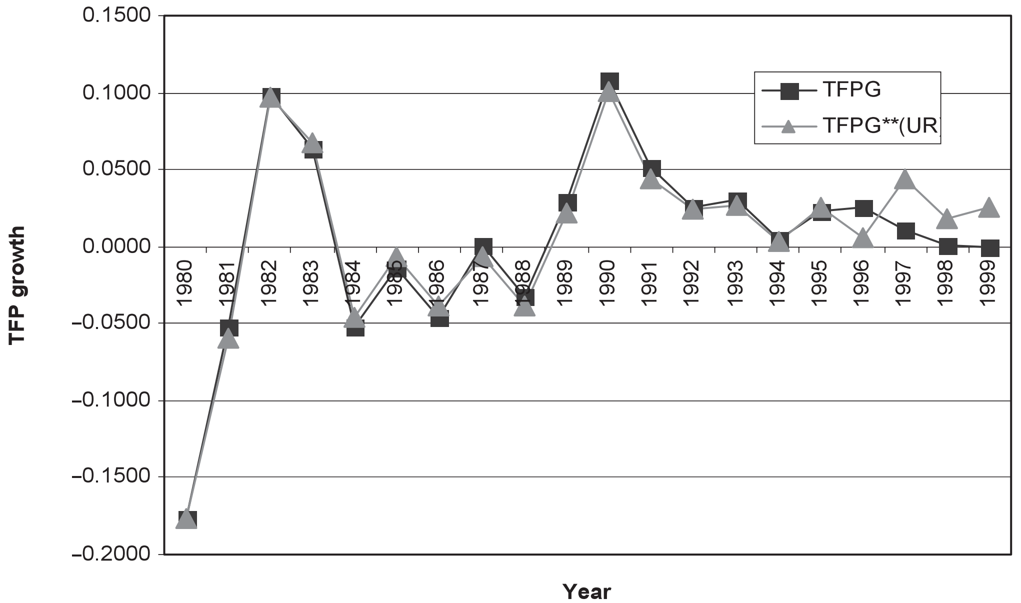


Figure 12. Comparative TFP growth and TFPG(UR): capital utilization based on the unemployment rate.**



Capital Utilization Based on Estimated Trend of Capital Output Ratio (Wharton Method)

Data and Methodology

The steps of the capital output ratio (COR) method are:

1) creating capital/output (K/Y) series using capital stock and GDP data used for TFP growth calculation and analysis;
2) fitting a linear trend to this K/Y series; and
3) drawing a line parallel to this trend line, passing through the lowest point on the K/Y series.

The potential capacity ratio $\left(K^{*}/Y^{*} \right)$ is given by the points on the lower line.

The potential output is given by:

$$Y^{*} = \frac{K}{\left(\dfrac{K^{*}}{Y^{*}} \right)} \quad \text{(Eq. 11)}$$

and Y/Y^{*} gives the capacity utilization.

Results

Data and results of TFPG** (COR) and the K/Y series curve (Figure 13) are shown in Table 4.

Figure 13. Capital utilization (COR).

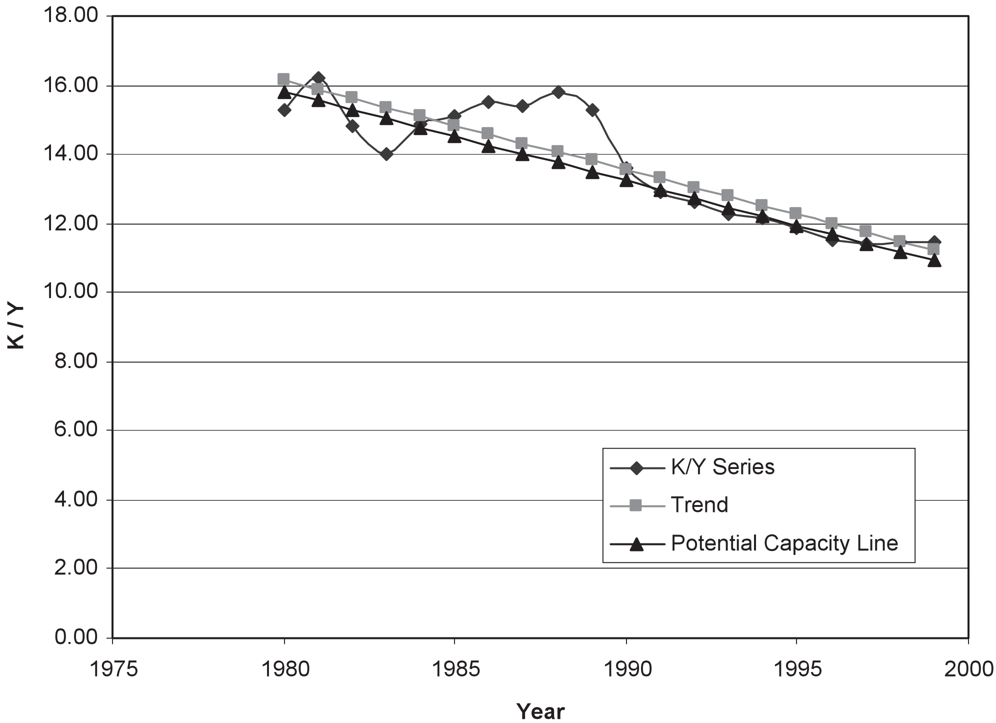


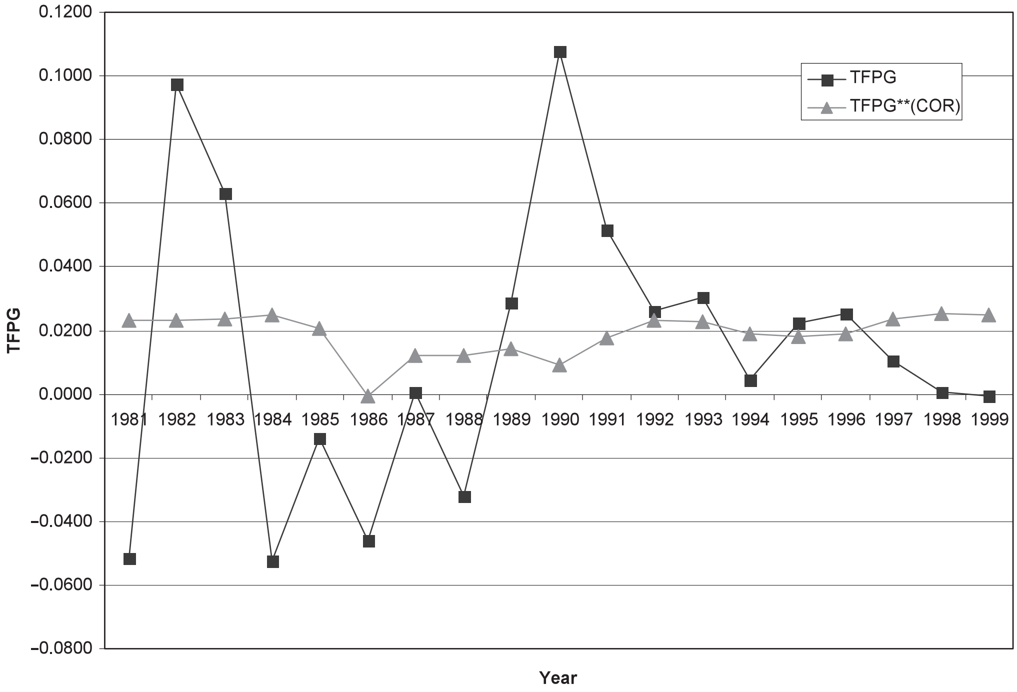
Table 4. Data and results of calculation of TFPG (COR).**

Year	K/Y	Potential capacity K*/Y*	Y*	Y/Y*	TFPG	TFPG** (COR)	Impact on TFPG
1980	15.30	15.81	8937.8	1.03	−0.1771	0.0000	1.00
1981	16.21	15.55	9414.7	0.96	−0.0515	0.0228	0.76
1982	14.80	15.30	9999.9	1.03	0.0977	0.0234	0.66
1983	13.99	15.04	10712.3	1.08	0.0632	0.0216	1.53
1984	14.85	14.78	11580.7	0.99	−0.0526	0.0277	2.43
1985	15.11	14.52	12197.3	0.96	−0.0139	0.0199	0.92
1986	15.53	14.26	11639.5	0.92	−0.0460	−0.0035	−13.84
1987	15.42	14.01	11818.7	0.91	0.0007	0.0110	1.23
1988	15.82	13.75	11921.6	0.87	−0.0320	0.0073	0.45
1989	15.30	13.49	12245.4	0.88	0.0289	0.0160	0.85
1990	13.59	13.23	12375.4	0.97	0.1076	0.0163	0.65
1991	12.88	12.97	13168.0	1.01	0.0517	0.0179	0.10
1992	12.59	12.72	13910.9	1.01	0.0260	0.0234	0.25
1993	12.24	12.46	14489.2	1.02	0.0302	0.0225	−3.35
1994	12.17	12.20	14942.5	1.00	0.0044	0.0192	0.19
1995	11.86	11.94	15352.5	1.01	0.0225	0.0183	0.25
1996	11.53	11.68	15982.1	1.01	0.0251	0.0188	−1.26
1997	11.43	11.43	16698.2	1.00	0.0104	0.0236	−39.59
1998	11.45	11.17	17475.9	0.98	0.0006	0.0252	0.76
1999	11.48	10.91	18362.6	0.95	−0.0008	0.0228	–

Slope = −0.25787157; intercept = 526.713; min. = 11.42705.

Overall Analysis The comparative TFP growth and TFPG** (COR) are shown in Fig. 14. There does not seem to be a close relation between the two curves.

Figure 14. Comparative TFP growth and TFPG(COR): capital utilization based on COR.**



STASTICAL DECOMPOSITION

Statistical decomposition is used when there are several kinds of labor or capital and allows us to measure the effect of quality of labor or capital on TFP growth. To decompose labor, the following formula for labor share is used:

$$SIL^{**} = \frac{w\,(L_1 + L_2)}{Q}\left(\frac{\frac{w_1}{w}\,dL_1 + \frac{w_2}{w}\,dL_2}{L_1 + L_2}\right) \qquad \text{(Eq. 12)}$$

where L_1 and L_2 are the number of workers in different educational or job (skill) categories, Q the output, w_1 and w_2 the wage rate for different categories of labor, and w the average wage rate given by the following formula:

$$W = \frac{W_1 I_1 + W_2 L_2}{L_1 + L_2} \qquad \text{(Eq. 13)}$$

and $\frac{1}{W}\,\frac{\frac{W_1}{W}\,dL_1 + \frac{W_2}{W}\,dL_2}{L_1 + L_2}$ is the growth rate of labor in efficiency units. The same method can be applied to calculate the quality of capital (different categories of capital).

Decomposition of Labor

Workforce educational qualifications are included in the statistics of the 10-year censuses in Iran and year-to-year statistics can be determined by extrapolating these figures (Appendix Table 2). However, the wage rate statistics for different categories of labor (by education) are not provided. Only statistics on government employees' wage rates for 1981 and 1983 for the following categories of education were available: lower than high school diploma and higher education.

To practice the calculation of the decomposition of labor in determining TFP growth adjusted for the quality of labor, the necessary figures were estimated using the same assumptions as in the preliminary report. However, because of deficiencies in the data, it was decided not to include the estimations in the final report. It should be mentioned that the results of decomposition of labor were positive in comparison to ordinary TFP growth.

Decomposition of Capital

Data

Official capital statistics differentiated by "structures" and "machinery" in current and constant prices were available through the Central Bank of Iran, as shown in Appendix Table 6.

Results

The following formula was used to determine the share of capital:

$$SK_t = \frac{W(K_{1t} + K_{2t})}{Q_t} \left(\frac{\frac{cp_1 (r + d_{1t} - cp_i\, g)}{w} dK_1 + \frac{cp_2 (r + d_{2t} - cp_i\, g)\, dK_2}{w}}{K_1 + K_2} \right)$$

(Eq. 14)

where K_1 and K_2 are capital (structures) and capital (machinery) in constant prices respectively; d_1 and d_2 are depreciation rates for structures and machinery, respectively, at time t; r is the interest rate taken at 24% (equivalent to the usual interest on bank loans in Iran); and cpi_t is the capital price index approximated by the wholesale price index change over time.

Using the above formula, Q as GDP at factor price at constant price, given labor figures, the two mentioned categories of capital (structures and machinery), and determining $SL_t = 1 - SK_t$, TFP growth (adjusted) was calculated as shown in Table 5 and Figure 15. The capital rate of return in the table is simply the total of the depreciation rate and interest rate, minus the capital price index. For capital share and labor share, two-year moving averages are used. It should be noted that since the capital rate of return for some years was negative, for each year the average of the whole period after that year was used in the formula.

Figure 15. Comparative TFP growth and TFPG(QK): quality of capital.**

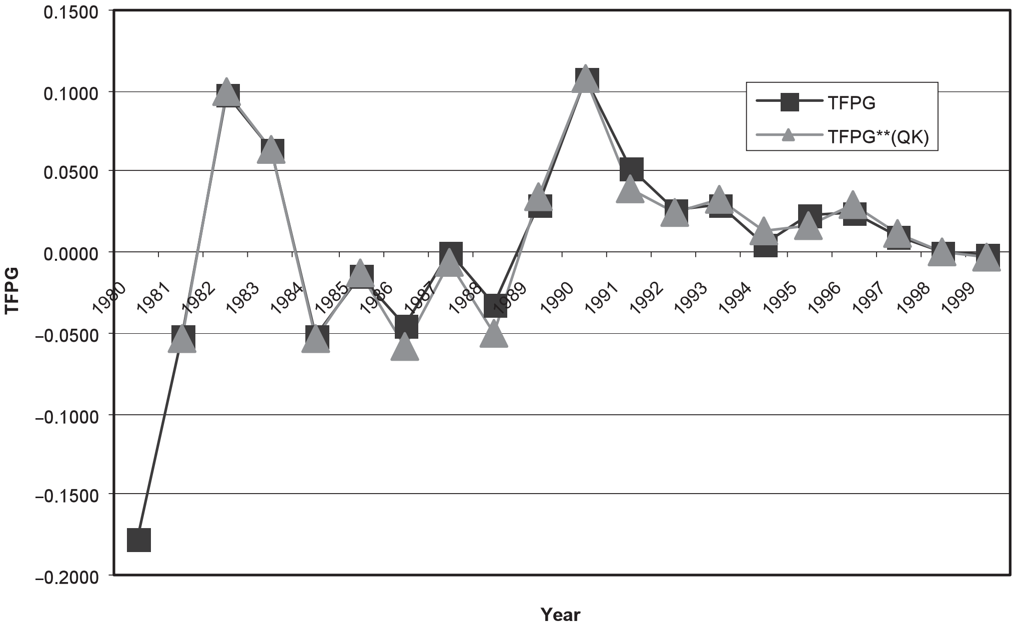


Table 5. Results of calculation of TFPG adjusted for the quality of capital.**

Year	TFPG	TFPG**(QK)	Impact on TFPG
1980	−0.1774		
1981	−0.0515	−0.0533	−0.04
1982	0.0977	0.0999	−0.02
1983	0.0632	0.0631	0.00
1984	−0.0526	−0.0530	−0.01
1985	−0.0139	−0.0131	0.06
1986	−0.0460	−0.0581	−0.26
1987	0.0007	−0.0057	8.70
1988	−0.0320	−0.0501	−0.57
1989	0.0289	0.0342	−0.18
1990	0.1076	0.1073	0.00
1991	0.0518	0.0391	0.24
1992	0.0259	0.0250	0.03
1993	0.0303	0.0331	−0.09
1994	0.0043	0.0125	−1.89
1995	0.0223	0.0162	0.27

Continued...

...Continued

1996	0.0252	0.0293	−0.16
1997	0.0104	0.0119	−0.15
1998	0.0006	−0.0002	1.30
1999	−0.0008	−0.0023	−1.90

TFPG, TFP growth.

REGRESSION ANALYSIS

For the available data, regression analysis was performed on the independent variables of R&D spending, foreign direct investment (FDI), exports, and education level of the workforce. The relevant data are shown in Appendix Tables 2 and 3 and the trends of each are shown in Figures 16−19, respectively. The dependent variable in the regression analysis is TFP growth with no adjustment.

Figure 16. R&D spending.

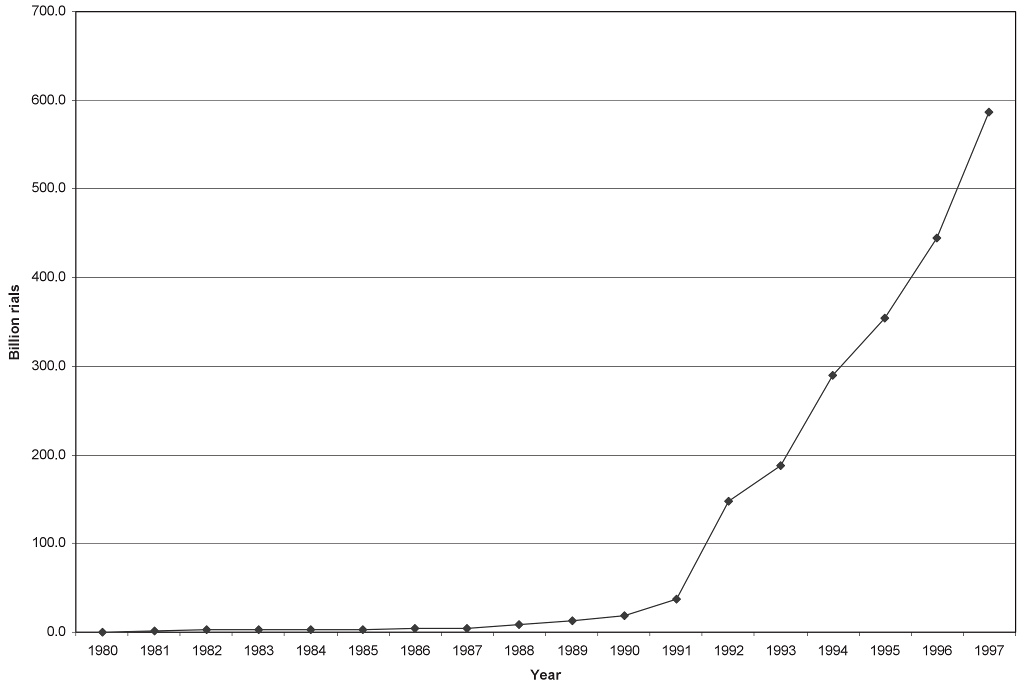


Figure 17. Regression analysis of FDI.

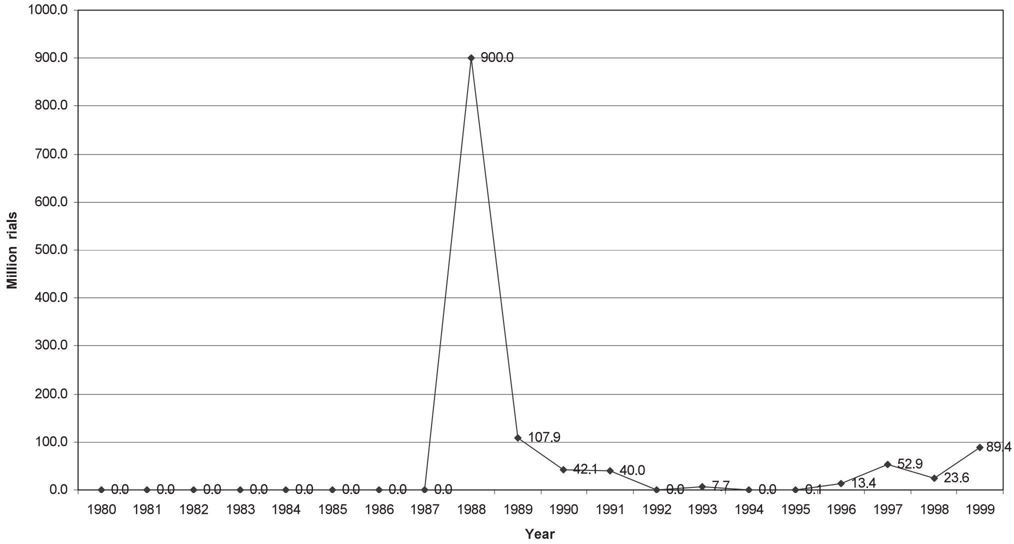
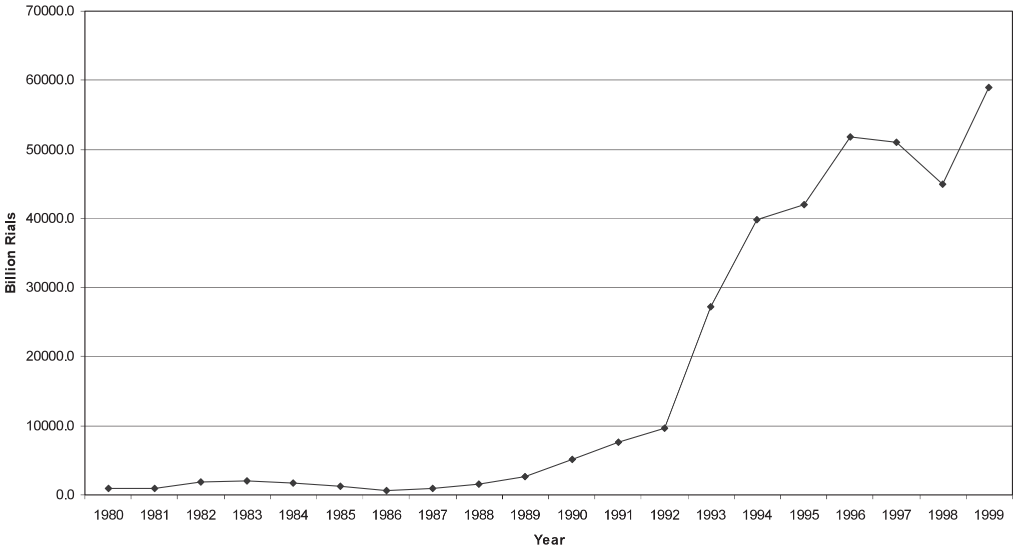


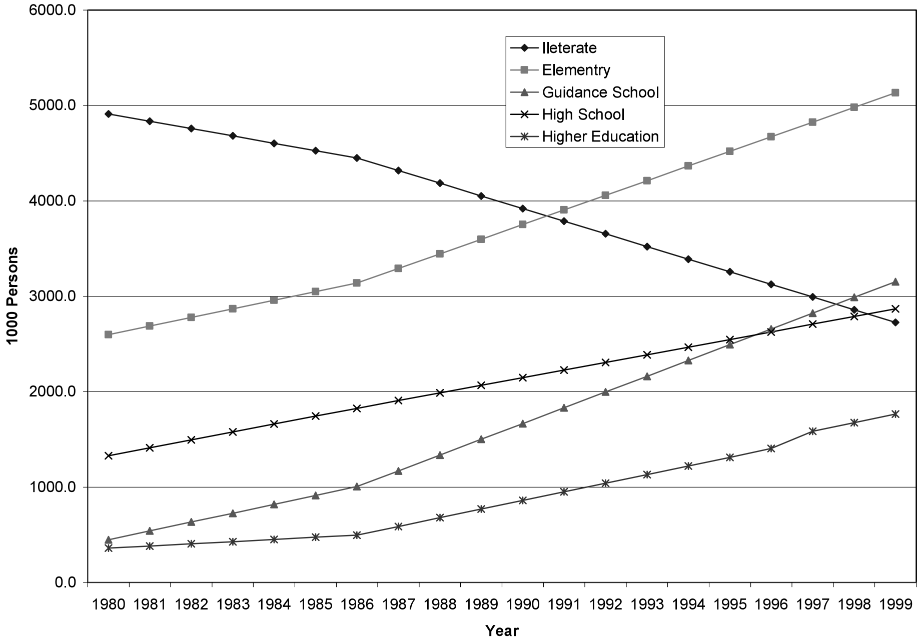
Figure 18. Regression analysis of exports.



R&D Spending

The data on R&D spending by the government sector were taken from official sources (Central Bank of Iran). Unfortunately, until 1996 the R&D figures were combined with higher education budget figures and were only separated from 1996 on. Also before 1996, the main research areas were social research. Experience shows that private-sector spending on R&D has been insignificant and therefore the above figures could be used as an approximation. The R&D figures for years before 1996 were extrapolated.

Figure 19. Regression analysis of education of the workforce.



The scatter diagram of TFP growth versus the rate of R&D spending to GDP at factor prices at constant price is shown in Figure 20. The correlation between TFP growth and R&D spending is 0.0488, and as seen from the figure there is no significant correlation between them. Nevertheless, the linear relation between the two shows a slight increase with respect to GDP. This was expected due to the small amounts of R&D spending.

FDI

During the period of analysis, Iran experienced many difficulties, which resulted in problems in attracting FDI. This remains an economic concern. The scatter diagram of TFP growth versus the rate of FDI to GDP at factor cost at constant prices is shown in Figure 21. The correlation between TFP growth and FDI is -0.1086. As can be seen from the figure, there is no correlation between them and the linear relation is negative, but since there has not been any significant FDI in Iran, this result is not reliable.

Exports

The data for exports were also taken from official sources (Central Bank of Iran), as shown in Appendix Table 2. The scatter diagram of TFP growth versus the rate of exports to GDP at factor cost at constant prices is shown in Figure 22, and as can be seen from the figure and the correlation coefficient (0.1469), there is no strong correlation between TFP growth and exports, but the linear relation shows a positive slope, i.e., for an increase in exports, there is an increase in TFP growth.

As a trial, Figure 23 shows the correlation and the regression of TFP growth versus FDI/GDP by eliminating FDI in 1988, which is different from all other years.

**Figure 20. TFP growth versus R&D spending/GDP (scatter diagram).
Correlation = 0.0488
y = (0.2902) x + 0.0029**

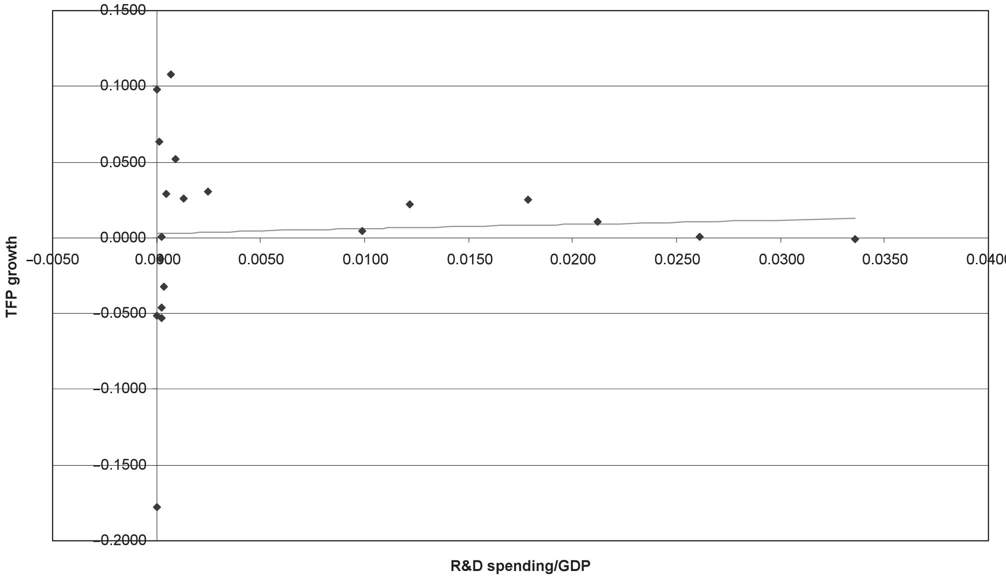


**Figure 21. TFP growth versus FDI/GDP (scatter diagram).
Correlation = -0.1086
y = (-0.3452) x + 0.0067**

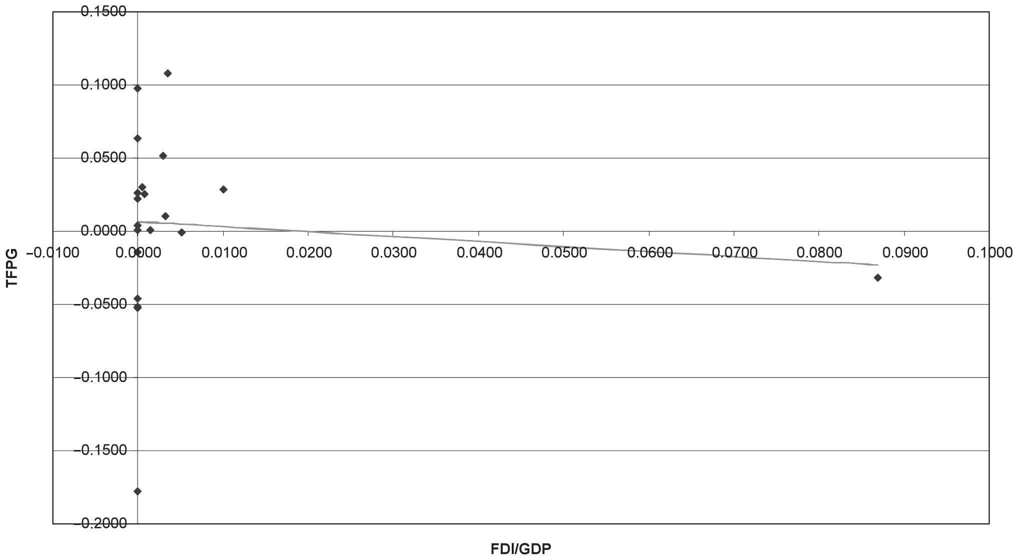


Figure 22. TFP growth versus exports/GDP.
Correlation = 0.1469
y = (0.0070) x - 0.0031

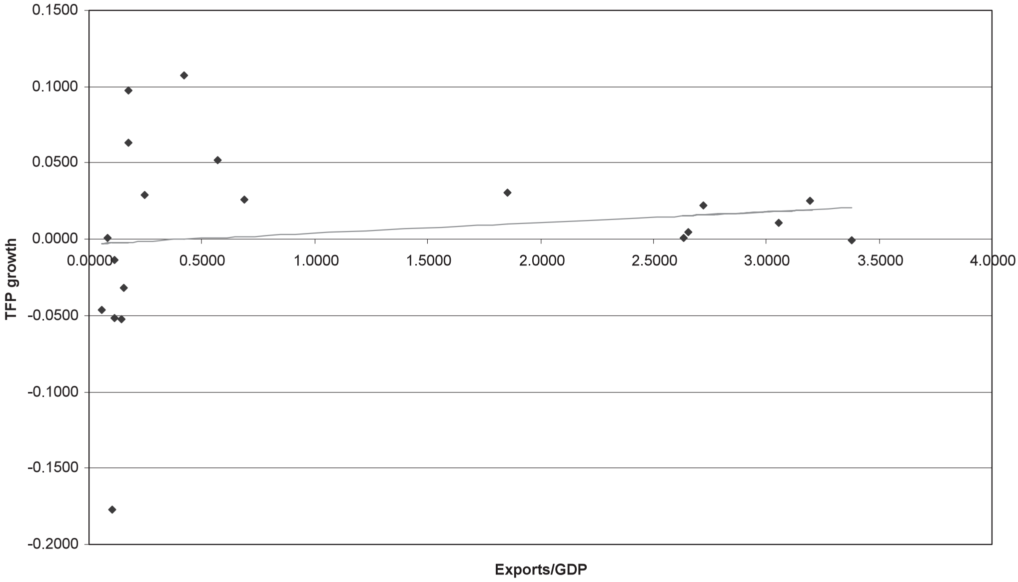
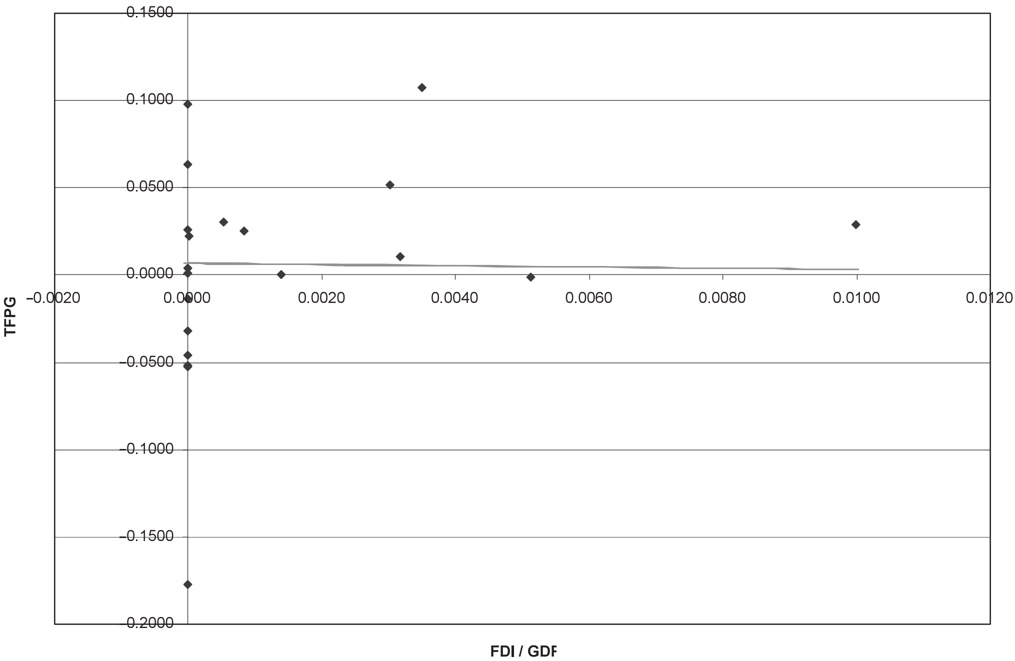


Figure 23. TFP growth versus FDI/GDP (scatter diagram): special.
Correlation = 0.2564
y = (6.18692853) x + -0.003785704



Labor Qualification

Labor statistics categorized by the following education levels were derived from the official sources of the ISC: illiterate; elementary (five years); guidance school (eight years); high school (12 years); and higher education (16 years or more). To perform regression analysis, first an index of education for each year was found as shown in Table 6.

Table 6. Indices of education per year, 1980−99.

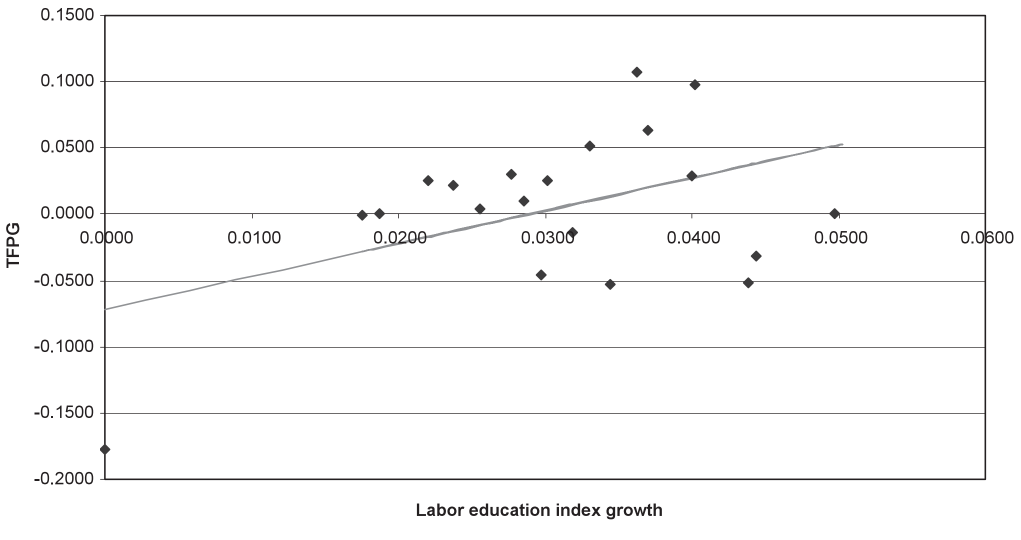
Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Index	3.97	4.14	4.31	4.47	4.62	4.77	4.91	5.15	5.38	5.60
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Index	5.80	5.99	6.17	6.34	6.51	6.66	6.81	7.00	7.13	7.26

Then a scatter diagram was drawn, as shown in Fig. 24. The correlation coefficient was 0.3399 and the regression line is shown in the figure. The regression equation is as follows:

$$TFPG = 0.0381(LE) - 0.2093 \quad \text{(Eq. 14)}$$

where LE is labor education in years and *TFPG* is TFP growth. As can be seen, an increase in labor qualification causes an increase in TFP growth.

Figure 24. TFPG versus labor education index growth.
Correlation =0.4554
y = (2.4737) x - 0.0713



Multiple Regression Analysis

Although it was intended to perform multiple regression analyses for the various factors already examined, there was no significant correlation between TFP growth and the factors affecting it. This was mainly due to the socioeconomic problems described above. Thus multiple regression analysis appeared meaningless.

CONCLUSIONS AND POLICY IMPLICATIONS

Summary

The APO survey on TFP was carried out by a number of national experts from Asian countries under the supervision of the chief expert of the survey. In the previous APO survey on TFP (in which Iran did not participate), TFP growth was estimated for each country. In the present survey in which the emphasis was more on "different adjustments to TFP growth" and "determining factors of TFP growth," the following calculations were carried out for Iran.

Results of general year-to-year TFP growth: Unfortunately, labor compensation data were only available from 1991 to 1998 and therefore labor share for the missing years was assumed to be the average labor share of the given years. The results were mentioned in the report and it was determined that: 1) the best years were 1982–83 and 1991–92; 2) the worst years were 1981 and 1984; 3) TFP growth figures were positive but decreasing from 1990 on; and 4) there was no relationship between TFP growth and GDP.

Results of TFP growth periodicity: The period of analysis was divided into four periods. During 1980–81 (Revolution period), TFP growth was negative and the lowest (-0.23); during 1982–88 (war period), TFP growth was positive but low (+0.05); during 1989–96 (reconstruction period), TFP growth was positive and the highest (+0.15); and during 1997–99 (political development period) TFP growth was positive (+0.10)

Adjustment for business fluctuation: Based on unemployment figures, the effect of business fluctuation on TFP growth was very slight, but in most years actual growth was less than the unadjusted growth. Based on the estimated trend of the COR (Wharton Business School method), it was not possible to note any trend since there was a fluctuation between TFP growth calculated here and the growth in terms of the COR.

Statistical decompositions: When statistical decomposition was performed for labor, unfortunately the wage rate statistics for different categories of labor (by educational level) were not available. Although the calculations were carried out using estimations and the results showed that the decomposition of labor based on quality had a positive effect on TFP growth, it was decided not to include this in the final report, because of the complexity and therefore the possibility of errors in the estimation.

Capital was decomposed into "structures" and "machinery." The resulting TFP growth (QK) rates, were in most cases (years) almost identical and in some cases smaller than the ordinary year-to-year TFP growth.

Regression analysis: There was almost no significant technological R&D in Iran during the period studied. The correlation between TFP growth and R&D was 0.049, which is a zero correlation. The equation of the regression line is: TFP growth = 0.29 (R&D) + 0.03.

There was also no significant FDI in Iran during the period studied. Nevertheless, regression analysis was performed and there is a correlation of -0.01 between TFP growth and FDI, which is nearly zero. The equation of the regression line is: TFP growth = −0.34 (FDI) + 0.007.

There was a small positive correlation of +0.15 between TFP growth and exports. The equation of the regression line is: TFP growth = 0.007(EXPORTS) −0.003.

In comparison with the other factors, there was a relatively good and positive correlation of 0.45 between TFP growth and the quality of labor. The equation of the regression line is: TFP growth = 2.47(LQ) - 0.07.

Policy Implications

TFP growth should be considered an important economic indicator to be measured on a national and sector basis yearly and included in official government statistics. This would mark a crucial decision for the Iranian economy and its analysis. The government and responsible authorities like the ISC, Iran Management and Planning Organization, and Central Bank of Iran should concentrate their efforts to overcome limitations on data availability and bottlenecks to facilitate the estimation of TFP growth with minimum errors.

According to the findings of this survey, there was no significant amount of R&D in the period studied, and thus it had no effect on TFP growth. Foreign collaboration (FDI) also had no effect since its amount was insignificant in this period. The education and upgrading of labor force qualifications had some effect on TFP growth, with a correlation of 0.45.

The government should take actions to facilitate the increase in factors affecting TFP growth. If the amounts of R&D, FDI, and nonoil exports are increased there will be better circumstances to measure the effects of these factors and better conclusions can be drawn.

Appendix Table 1. Statistics for TFP growth measurement.

Year	GDP1 (factor price at constant price) (billion rials)	GDP2 (factor price at current price) (billion rials)	K1 (constant price) (billion rials)	K2 (current price) (billion rials)	L (thousand persons)	LC (current price) (billion rials)	SL	SK	TFPG
1980	9238.1	6014.9	141314.2	25251.5	9953	1267.3	0.2107	0.7893	−0.1774
1981	9031.7	7016.7	146426.9	29438.9	9994	1478.4	0.2107	0.7893	−0.0515
1982	10335.4	10621.5	152949.5	34679.6	10126	2231.9	0.2105	0.7895	0.0977
1983	11517.6	13471.3	161084.1	40850.9	10330	2838.3	0.2105	0.7895	0.0632
1984	11522.1	14600.7	171156.2	46775.1	10583	3076.4	0.2107	0.7893	−0.0526
1985	11723.6	15948.2	177123.0	50930.9	10795	3360.3	0.2108	0.7892	−0.0139
1986	10692.5	17512.6	166021.5	55322.9	11056	3689.9	0.2108	0.7892	−0.0460
1987	10736.2	20605.4	165530.2	73143.2	11358	4341.6	0.2108	0.7892	0.0007
1988	10360.6	23048.2	163897.0	96063.9	11588	4856.2	0.2107	0.7893	−0.0320
1989	10799.9	27567.5	165190.1	117365.5	11947	5808.5	0.2107	0.7893	0.0289
1990	12045.2	35755.0	163753.3	163753.3	12433	7533.6	0.2108	0.7892	0.1076
1991	13262.1	48672.6	170845.8	218330.5	13096	11450.0	0.2230	0.7770	0.0518
1992	14046.5	64400.8	176897.0	288523.5	13368	14675.0	0.2316	0.7684	0.0259
1993	14742.2	93518.0	180514.7	419466.8	13509	19849.0	0.2201	0.7799	0.0303
1994	14982.6	129350.8	182308.2	574034.9	13771	24561.0	0.2011	0.7989	0.0043
1995	15458.4	186124.9	183351.9	817364.7	14088	32130.0	0.1813	0.8187	0.0223
1996	16192.3	235757.2	186749.9	1126837.3	14572	48619.0	0.1895	0.8105	0.0252
1997	16698.2	277664.8	190811.2	1302812.2	14805	60321.0	0.2118	0.7882	0.0104
1998	17046.7	327595.7	195191.9	1454022.8	14963	73251.0	0.2205	0.7795	0.0006
1999	17455.7	416696.7	200360.1	1756122.8	15346	89555.0	0.2193	0.7807	−0.0008

K, capital; L, labor; LC, labor compensation; SL, labor share; SK, capital share; TFPG, TFP growth.

Appendix Table 2. Statistics for TFP growth measurement: quality of labor and capital, R&D, FDI, unemployment rate, and exports.

Year	Educational level of labor (1000 persons)					Ed. index (year)	Category of capital (billion rials)				Dep. rate (%)		R&D spend.	FDI	Unem- ploy.	Exports (bil. rials)
	Illit.	Elem.	Guidance school	High school	Higher		Structure		Machinery							
							Current	Constant	Current	Constant	Struc.	Mach.	(bil. rials)	(mil.rials)	rate (%)	rate (%)
1980	4911.4	2597.4	447.0	1328.0	359.6	3.97	16247.9	91686.6	9003.6	49627.6	1.47	6.05	—	0.0	12.8	931.7
1981	4834.5	2687.5	540.0	1411.0	382.5	4.14	19451.3	96014.5	9987.5	50412.3	1.54	6.21	—	0.0	12.1	997.3
1982	4757.6	2777.6	633.0	1494.0	405.4	4.31	23220.2	101194.0	11459.4	51755.5	1.60	6.38	0.0	0.0	12.0	1821.3
1983	4680.7	2867.7	725.0	1577.0	428.3	4.47	28301.6	106484.6	12549.3	54599.4	1.62	6.38	1.8	0.0	12.4	1981.5
1984	4603.8	2957.8	819.0	1660.0	451.2	4.62	33331.4	112834.8	13443.7	58321.5	1.63	6.46	2.5	0.0	13.0	1656.6
1985	4526.9	3047.9	912.0	1743.0	474.1	4.77	36733.2	117410.9	14197.6	59712.1	1.69	6.84	2.5	0.0	13.6	1320.0
1986	4450.0	3138.0	1005.0	1826.0	497.0	4.91	39299.4	107914.8	16023.5	58106.7	1.96	7.30	2.8	0.0	14.2	583.6
1987	4317.0	3291.4	1170.3	1906.1	587.6	5.15	49902.9	110053.3	23240.3	55476.9	2.04	7.74	2.6	0.0	13.6	883.1
1988	4184.8	3444.8	1335.6	1986.2	678.2	5.38	66671.0	112222.0	29393.0	51675.0	2.09	8.43	3.8	900.0	13.0	1597.3
1989	4052.2	3598.2	1500.9	2066.3	768.8	5.60	81212.4	114434.0	36153.0	50756.1	2.14	8.59	4.8	107.9	12.4	2653.6
1990	3919.6	3751.6	1666.2	2146.4	859.4	5.80	113368.4	113368.4	50384.9	50384.9	2.23	8.66	8.6	42.1	11.8	5081.7
1991	3787.0	3905.0	1831.5	2226.5	950.0	5.99	145347.9	117268.5	72982.6	53577.3	2.22	8.40	12.3	40.0	11.1	7548.9
1992	3654.4	4058.4	1996.8	2306.6	1040.6	6.17	186233.8	121276.1	102289.7	55620.9	2.21	8.44	18.4	0.0	10.9	9683.9
1993	3521.8	4211.8	2162.1	2386.7	1131.2	6.34	272994.0	124998.0	146472.8	55516.7	2.19	8.62	36.6	7.7	10.6	27290.8
1994	3389.2	4365.2	2327.4	2466.8	1221.8	6.51	356511.8	128322.5	217523.2	53985.6	2.25	9.13	148.2	0.0	10.5	39781.4
1995	3256.6	4518.6	2492.7	2546.9	1312.4	6.66	510571.0	131303.7	306793.7	52048.1	2.27	9.24	188.1	0.1	10.8	42071.0
1996	3124.0	4672.0	2658.0	2627.0	1403.0	6.81	727235.2	134955.7	399602.1	51794.2	2.27	9.18	289.1	13.4	9.1	51747.0
1997	2991.4	4825.4	2823.3	2707.1	1584.2	7.00	823336.0	138157.9	479476.1	52653.3	2.25	9.07	354.6	52.9	12.1	51006.8
1998	2858.8	4978.8	2988.6	2787.2	1674.8	7.13	905913.6	140851.5	548109.3	54340.4	2.32	8.89	445.1	23.6	13.6	44884.8
1999	2726.2	5132.2	3153.9	2867.3	1765.4	7.26	1102862.2	144140.9	653260.6	56219.2	2.32	9.49	586.4	89.4	15.8	59002.2
	ILET.	El.=L1	Gs.=L2	Hs.=L3	He.=L4	LEI.	Cscur.	Cscon.	Cmcur.	Cmcon.	DPS.	DPM.	RD	FDI	UR	Exprt

Illit., illiterate; Elem., elementary school; Edu. index, education index; Dep. rate, depreciation rate; Struc., structures; Mach., machinery; R&D spend., R&D spending; bil., billion; mil., million; Unemploy. rate, unemployment rate.

Appendix Table 3. Statistics for TFP growth regression analysis: R&D, FDI, exports, and education index.

Year	TFPG	R&D spend. (billion rials)/GDP	FDI (million rials)/GDP	Exports (billion rials)/ GDP	Edu. index(year) growth
1980	−0.1774	0.0000	0.0000	0.1009	0.0000
1981	−0.0515	0.0000	0.0000	0.1104	0.0439
1982	0.0977	0.0000	0.0000	0.1762	0.0403
1983	0.0632	0.0002	0.0000	0.1720	0.0370
1984	−0.0526	0.0002	0.0000	0.1438	0.0344
1985	−0.0139	0.0002	0.0000	0.1126	0.0319
1986	−0.0460	0.0003	0.0000	0.0546	0.0297
1987	0.0007	0.0002	0.0000	0.0823	0.0497
1988	−0.0320	0.0004	0.0869	0.1542	0.0444
1989	0.0289	0.0004	0.0100	0.2457	0.0400
1990	0.1076	0.0007	0.0035	0.4219	0.0362
1991	0.0518	0.0009	0.0030	0.5692	0.0330
1992	0.0259	0.0013	0.0000	0.6894	0.0302
1993	0.0303	0.0025	0.0005	1.8512	0.0278
1994	0.0043	0.0099	0.0000	2.6552	0.0256
1995	0.0223	0.0122	0.0000	2.7216	0.0237
1996	0.0252	0.0179	0.0008	3.1958	0.0220
1997	0.0104	0.0212	0.0032	3.0546	0.0286
1998	0.0006	0.0261	0.0014	2.6330	0.0187
1999	−0.0008	0.0336	0.0051	3.3801	0.0175

TFPG, TFP growth.

Appendix Table 4. Statistics for periodicity of TFP growth measurement.

Period	GDP1 (factor price at constant prices) (bil. rials)	GDP2 (factor price at current prices) (bil. rials)	K1 (constant price) (bil. rials)	K1 (constant price) (bil. rials)	(thousand)	LC (current price) (bil. rials)	SL	SK	TFPG (periodic)
1980	9238.1	6014.9	141314.2	25251.5	9953.0	226.4	0.0376	0.9624	—
1981	9031.7	7016.7	146426.9	29438.9	9994.0	323.4	0.0461	0.9539	−0.0568
1980−81	9134.9	6515.8	143870.6	27345.2	9973.5	354.1	0.0544	0.9456	−0.2295
1982	10335.4	10621.5	152949.5	34679.6	10126.0	462.0	0.0435	0.9565	0.0926
1983	11517.6	13471.3	161084.1	40850.9	10330.0	660.0	0.0490	0.9510	0.0580
1984	11522.1	14600.7	171156.2	46775.1	10583.0	942.9	0.0646	0.9354	−0.0582
1985	11723.6	15948.2	177123.0	50930.9	10795.0	1347.1	0.0845	0.9155	−0.0159
1986	10692.5	17512.6	166021.5	55322.9	11056.0	1924.4	0.1099	0.8901	−0.0359
1987	10736.2	20605.4	165530.2	73143.2	11358.0	2749.1	0.1334	0.8666	0.0034
1988	10360.6	23048.2	163897.0	96063.9	11588.0	3927.3	0.1704	0.8296	−0.0302
1982−88	10984.0	16544.0	165394.5	56823.8	10833.7	1716.1	0.1037	0.8963	0.0494
1989	10799.9	27567.5	165190.1	117365.5	11947.0	5610.5	0.2035	0.7965	0.0294
1990	12045.2	35755.0	163753.3	163753.3	12433.0	8015.0	0.2242	0.7758	0.1075
1991	13262.1	48672.6	170845.8	218330.5	13096.0	11450.0	0.2352	0.7648	0.0516
1992	14046.5	64400.8	176897.0	288523.5	13368.0	14675.0	0.2279	0.7721	0.0260
1993	14742.2	93518.0	180514.7	419466.8	13509.0	19849.0	0.2122	0.7878	0.0302
1994	14982.6	129350.8	182308.2	574034.9	13771.0	24561.0	0.1899	0.8101	0.0044
1995	15458.4	186124.9	183351.9	817364.7	14088.0	32130.0	0.1726	0.8274	0.0225
1996	16192.3	235757.2	186749.9	1126837.3	14572.0	48619.0	0.2062	0.7938	0.0251
1989−96	13941.2	102643.4	176201.4	465709.6	13348.0	20613.7	0.2008	0.7992	0.1530
1997	16698.2	277664.8	190811.2	1302812.2	14805.0	60321.0	0.2172	0.7828	0.0104
1998	17046.7	327595.7	195191.9	1454022.8	14963.0	73251.0	0.2236	0.7764	0.0006
1999	17455.7	416696.7	200360.1	1756122.8	15246.0	89555.0	0.2149	0.7851	−0.0008
1997−99	17066.9	340652.4	195454.4	1504319.3	15004.7	74375.7	0.2183	0.7817	0.0958

K, capital; L, labor; LC, labor compensation; SL, labor share; SK, capital share; TFPG, TFP growth; bil., billion.

Appendix Table 5. Labor and wage data for decomposition of labor contribution to TFP growth.

Year	L1	L2	L3	W1	W2	W3
1980	7955800	1328000	359600	46782	59757	82533
1981	8062000	1411000	382500	48247	61708	90058
1982	8168200	1494000	405400	49712	63658	97582
1983	8273400	1577000	428300	51177	65609	105107
1984	8380600	1660000	451200	52642	67560	112631
1985	8486800	1743000	474100	54107	69510	120156
1986	8593000	1826000	497000	55572	71461	127680
1987	8778700	1906100	587600	57038	73412	135205
1988	8965200	1986200	678200	58503	75362	142729
1989	9151300	2066300	768800	59968	77313	150254
1990	9337400	2146400	859400	61433	79264	157778
1991	9523500	2226500	950000	62898	81214	165303
1992	9709600	2306600	1040600	64363	83165	172827
1993	9895700	2386700	1131200	65829	85116	180352
1994	10081800	2466800	1221800	67294	87066	187876
1995	10267900	2546900	1312400	68759	89017	195401
1996	10454000	2627000	1403000	70224	90968	202925
1997	10640100	2707100	1584200	71689	92918	210450
1998	10826200	2787200	1674800	73154	94869	217974
1999	11012300	2867300	1765400	74619	96820	225499

L, labor; W, wages.

Appendix Table 6. Data and results of TFPG calculation with decomposition of labor.**

Year	GDP1 (factor price at constant price) (bil. rials)	K1 (constant price) (bil. rials)	L (thousand)	W	Sl Lt** (LQ)	Lt**	Sl**	Sk**	TFPG** (LQ)	Impact on TFPG
1980	9238.1	141314.2	9953	49902	0.0154	0.0246	0.6133	0.3867	−0.1802	−0.0172
1981	9031.7	146426.9	9994	51797	0.0210	0.0241	0.7491	0.2509	−0.0367	0.2871
1982	10335.4	152949.5	10126	53709	0.0149	0.0237	0.7504	0.2496	0.1141	−0.1682
1983	11517.6	161084.1	10330	55638	0.0138	0.0231	0.6118	0.3882	0.0782	−0.2374
1984	11522.1	171156.2	10583	57582	0.0144	0.0229	0.6125	0.3875	−0.0379	0.2783
1985	11723.6	177123	10795	59541	0.0146	0.0224	0.6408	0.3592	−0.0079	0.4322
1986	10692.5	166021.5	11056	61513	0.0166	0.0220	0.7030	0.2970	−0.0869	−0.8883
1987	10736.2	165530.2	11358	63881	0.0321	0.0399	0.7792	0.2208	−0.0151	21.4499
1988	10360.6	163897	11588	66294	0.0346	0.0388	0.8489	0.1511	−0.0501	−0.5648
1989	10799.9	165190.1	11947	68749	0.0344	0.0376	0.9043	0.0957	0.0138	0.5220
1990	12045.2	163753.3	12433	71242	0.0320	0.0365	0.8958	0.1042	0.0741	0.3114
1991	13262.1	170845.8	13096	73769	0.0300	0.0354	0.8619	0.1381	0.0454	0.1212
1992	14046.5	176897	13368	76329	0.0293	0.0344	0.8496	0.1504	0.0349	−0.3426
1993	14742.2	180514.7	13509	78918	0.0288	0.0334	0.8565	0.1435	0.0364	−0.2041
1994	14982.6	182308.2	13771	81535	0.0292	0.0325	0.8805	0.1195	−0.0018	1.4094
1995	15458.4	183351.9	14088	84176	0.0292	0.0316	0.9112	0.0888	0.0103	0.5423
1996	16192.3	186749.9	14572	86840	0.0287	0.0308	0.9276	0.0724	0.0138	0.4483
1997	16698.2	190811.2	14805	90260	0.0423	0.0437	0.9503	0.0497	0.0146	−0.3934
1998	17046.7	195191.9	14963	92978	0.0288	0.0288	0.9846	0.0154	0.0096	−14.5496
1999	17455.7	200360.1	15246	95714	0.0289	0.0281	1.0150	–0.0150	0.0050	7.2009

K, capital; L, labor; W, wages; S1 Lt**, labor share over time.

Appendix Table 7. Data and results of TFP growth calculations with decomposition of capital.

Year	GDP1 (factor price at constant price) (bil. rials)	K1 (cap. structure at constant price) (bil. rials)	Dep. rate (%) of struc.	K2 (machinery at constant price) (bil. rials)	Dep. rate (%) of mach.	W (average capital rate of return) (%)	Rate of change in CPI (%)	L (thousand)	SKt*	SLt*
1979	10841.3	86205.8	1.38	49249.8	5.8	0	9.6		0.7893	0.2107
1980	9238.1	91686.6	1.47	49627.6	6.05	−0.0369	30.77	9953	0.7893	0.2107
1981	9031.7	96014.5	1.54	50412.3	6.21	0.0803	19.12	9994	0.7893	0.2107
1982	10335.4	101194	1.6	51755.5	6.38	0.1323	13.99	10126	0.7893	0.2107
1983	11517.6	106484.6	1.62	54599.4	6.38	0.1965	7.58	10330	0.7893	0.2107
1984	11522.1	112834.8	1.63	58321.5	6.46	0.1621	11.07	10583	0.7893	0.2107
1985	11723.6	117410.9	1.69	59712.1	6.84	0.2027	7.16	10795	0.7893	0.2107
1986	10692.5	107914.8	1.96	58106.7	7.3	0.0254	25.29	11056	0.7893	0.2107
1987	10736.2	110053.3	2.04	55476.9	7.74	−0.0175	29.7	11358	0.7893	0.2107
1988	10360.6	112222	2.09	51675	8.43	0.0627	21.82	11588	0.7893	0.2107
1989	10799.9	114434	2.14	50756.1	8.59	0.0962	18.5	11947	0.7893	0.2107
1990	12045.2	113368.4	2.23	50384.9	8.66	0.0430	23.91	12433	0.7893	0.2107
1991	13262.1	117268.5	2.22	53577.3	8.4	0.0156	26.6	13096	0.777	0.223
1992	14046.5	121276.1	2.21	55620.9	8.44	−0.0524	33.41	13368	0.7684	0.2316
1993	14742.2	124998	2.19	55516.7	8.62	0.0283	25.34	13509	0.7799	0.2201
1994	14982.6	128322.5	2.25	53985.6	9.13	−0.1408	42.37	13771	0.7989	0.2011
1995	15458.4	131303.7	2.27	52048.1	9.24	−0.0931	37.56	14088	0.8187	0.1813
1996	16192.3	134955.7	2.27	51794.2	9.18	0.0299	25.2	14572	0.8105	0.1895
1997	16698.2	138157.9	2.25	52653.3	9.07	0.1826	9.87	14805	0.7882	0.2118
1998	17046.7	140851.5	2.32	54340.4	8.89	0.1659	11.56	14963	0.7795	0.2205
1999	17455.7	144140.9	2.32	56219.2	9.49	0.0523	23.1	15246	0.7807	0.2193

Cap. struc., capital structure; Dep. rate, depreciation rate; mach., machinery; L, labor; SKt*, capital share over time; SLt*, labor share over time; bil., billion.

Appendix Table 7 *(continued)*.

Year	Capital rate of return on K1	Capital rate Of return on K2	SK1t* capital share of K1	SK2t* capital share of K2	KTg**	TFPG**(QK)	TFPG	Impact
1979	0.1578	0.2020	0.5776	0.4224				
1980	−0.0530	−0.0072	0.9315	0.0685	0.0484			
1981	0.0642	0.1109	0.5244	0.4756	0.0378	−0.0533	−0.0515	−0.0353
1982	0.1161	0.1639	0.5807	0.4193	0.0408	0.0999	0.0977	−0.0225
1983	0.1804	0.2280	0.6068	0.3932	0.0520	0.0631	0.0632	0.0021
1984	0.1456	0.1939	0.5923	0.4077	0.0611	−0.0530	−0.0526	−0.0073
1985	0.1853	0.2368	0.6061	0.3939	0.0333	−0.0131	−0.0139	0.0570
1986	0.0067	0.0601	0.1715	0.8285	−0.0494	−0.0581	−0.0460	−0.2621
1987	−0.0366	0.0204	1.3908	−0.3908	0.0052	−0.0057	0.0007	8.7028
1988	0.0427	0.1061	0.4664	0.5336	0.0130	−0.0501	−0.0320	−0.5663
1989	0.0764	0.1409	0.5501	0.4499	0.0011	0.0342	0.0289	−0.1847
1990	0.0232	0.0875	0.3737	0.6263	−0.0083	0.1073	0.1076	0.0034
1991	−0.0038	0.0580	−0.1674	1.1674	0.0586	0.0391	0.0518	0.2448
1992	−0.0720	−0.0097	0.9418	0.0582	0.0360	0.0250	0.0259	0.0341
1993	0.0085	0.0728	0.2082	0.7918	0.0166	0.0331	0.0303	−0.0935
1994	−0.1612	−0.0924	0.8057	0.1943	−0.0005	0.0125	0.0043	−1.8923
1995	−0.1129	−0.0432	0.8683	0.1317	0.0133	0.0162	0.0223	0.2741
1996	0.0107	0.0798	0.2589	0.7411	0.0133	0.0293	0.0252	−0.1630
1997	0.1638	0.2320	0.6494	0.3506	0.0196	0.0119	0.0104	−0.1450
1998	0.1476	0.2133	0.6420	0.3580	0.0236	−0.0002	0.0006	1.2993
1999	0.0322	0.1039	0.4428	0.5572	0.0281	−0.0023	−0.0008	−1.9011

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OVERVIEW OF THE JAPANESE ECONOMY DURING THE "LOST DECADE"

The Japanese economy has been experiencing the pain of serious recession for more than 10 years since the bursting of financial bubble in 1991. Things appear to be getting even worse. Macro statistics in 2001 show the evidence: -0.5% GDP growth rate (1.6% in 1995), 5.0% unemployment rate (3.0% in 1995), and 19,164 cases of firm bankruptcy (15,108 in 1995). Explanations could be made both from the supply and demand sides of the economy. While shrinking demand possibly lowers utilization of abundant resources accumulated during the bubble period, out-of-date economic and social structures might prevent resource reallocation from inefficient to efficient sectors.

Political instability seems to be a mirror of the economic turmoil in Japan. There have been eight prime ministers in the past 10 years. The Japanese political structure had been stable since 1957 under the "system of the year 1955" (when the two major conservative parties merged), which means a Gulliver-type of oligopolistic dominance in the Diet by the Liberal Democratic Party (LDP). A major change occurred in 1993, when a considerable number of politicians withdrew from the LDP and launched a new conservative party. The allied minority parties turned into a new majority and removed the leader of the LDP from the position of prime minister. Since then, the LDP has never recaptured an absolute majority in the Diet and has had to form a coalition government with at least one minority party.

Resource allocation appeared to be a minor issue during the high-growth period, because the total size of the economic pie was expanding and at least a small portion of the increase in output was attributable to everyone. The cessation of growth, however, would make some worse off if the government changed the rules of resource allocation, say, from a planned economy-oriented to a market economy-oriented system. LDP supporters mostly belong to traditional sectors of the Japanese economy such as agriculture, construction, and finance which have been highly protected by government regulations. In the face of globalization and marketization, these sectors will soon have to face severe competition in the global market. To receive stable votes from supporters, the government had to turn the economy away from a serious decline.

When the economic downturn occurred in 1991, however, the government at first considered it a temporary business shock that would be resolved shortly and tried to stand by its simple monetary policy. While the Bank of Japan made a 180-degree turn from a tight-money policy to calm the bubble economy to an easy-money policy to pull the economy up, the reduced budget principle was cited to maintain the soundness of national finance. (The official bank rate was continuously lowered from 4.5% in 1991 to 0.5% in 1995.) Just when the recovery process looked satisfactory, another blow came in 1997. The Hashimoto administration, criticized for passivity in its economic policy, was replaced by the Obuchi administration after the national election in 1998. Prime Minister Obuchi and his successor, Prime Minister Mori, drastically converted to a positive fiscal policy. Government bond issues increased by 46% in 1998, 32% in 1999, and 21% in 2000, and finally reached ¥90 trillion (US$0.75 trillion) in 2001. Both regional and central government loans soared to ¥666 trillion (US$5.5 trillion), which is ¥5.55 million per capita.

Considering the current situation of the Japanese economy, what can a survey of total factor productivity (TFP) contribute? TFP is one of the most convenient indicators to evaluate economic performance ex post facto. It is reasonable to view the Japanese economy during the period of drastic change in terms of TFP. Furthermore, TFP is expected to work as a buffer against economic fluctuations, especially during recession. If TFP gains during business booms are sufficient, companies accumulate them in the form of profits or capital gains and spend them during recession to maintain sound business conditions. In this sense, TFP can be interpreted as a shock absorber of business cycles. We should carefully watch TFP performance during bubble periods as well as after they burst.

REVISION FROM THE PREVIOUS SURVEY REPORT

A TFP study mainly involves the collection of data. The TFP derivation process itself is not very difficult once good data are obtained for sources of inputs and outputs. In other words, even with imprecise data we can calculate TFP indicators that could include both structural and stochastic errors, because the definition of TFP is a residual factor by subtracting input contributions from output growth.

Since TFP indices are convenient to evaluate the economic performance of nations, not only academic researchers but also government offices and commercial research institutes collect data and make their own calculations. There is usually insufficient information disclosure on how times series of input and output variables in those research papers were developed. Limited disclosure might cause duplication of work in collecting data, and as a result many types of TFP are reported for the Japanese economy.

A data processing procedure is laborious and time-consuming. Once an ideal database is constructed from the best sources, duplication of work may be inefficient unless the marginal productivity of an additional resource to upgrade the database is greater than the marginal cost. What we should do first is search for the best current TFP study in Japan and make full use of it. We can save resources by not doing the same work and allocate them to data extension or another analysis. The paper from Japan in the 2001 APO publication on TFP (*Measuring Total Factor Productivity: Survey Report*) is one candidate.

It is, unfortunately, difficult to say that the previous Japanese study (PJ study) was a good benchmark for us to extend the current TFP survey. It had serious problems concerning data sources, especially on capital stock. The capital stock data in the PJ study were basically from *The Gross Capital Stock of Private Enterprises 1955–1996 (GCSPE)* published by the Economic Planning Agency. Nomura (1998) pointed out four serious problems that the *GCSPE* has in the process of capital stock estimation. First, the *GCSPE* is based on the concept of gross capital stock, which ignores the depreciation of production capability in capital goods and assumes their sudden death at the end of life. Second, no classification of capital goods is considered in the *GCSPE*. (Nomura [1998] stated that an approximately 13% discrepancy exists between the simple summation of capital goods and the quality-adjusted aggregation of classified capital goods.) Third, the price (deflator) of capital stock is not available in the *GCSPE*. The fourth point is that information disclosure about the calculation process of capital stock is insufficient in the *GCSPE*, which would be an obstacle for outsiders to reproduce the *GCSPE* results.

Another problem exists in labor input data. Although the PJ study did not describe the details of how the labor input time series was developed, it is assumed that simple total man-hours were utilized. It is well known that in the process of economic growth after the Second World War the number of high school and college graduates increased greatly in Japan. The simple summation of man-hours is insufficient to capture the drastic quality change in labor input. We need classified labor inputs and their wages to make a labor index consistent with the economic aggregation theory. The Ministry of Labor provides detailed statistics on the number of employees, working hours, and wages for classified labor input categories.

KEIO ECONOMIC OBSERVATORY DATABASE

Masahiro Kuroda and his research group at Keio University, Tokyo, have been constructing a database for a neoclassical economic model and subsequent productivity study since the early 1970s (Kuroda et al., 1996). This has been carried out in parallel with Dale Jorgenson's research group at Harvard University, USA, to maintain mutual comparability. Kuroda calls this database the KEO Database (KDB) after the Keio Economic Observatory (KEO) where he is employed.

The KDB contains capital stock, labor, energy, and material (KLEM) inputs and their prices, and a single gross output index and its deflator for 42 industrial sectors. To be consistent with macroeconomic statistics, the KDB treats numbers in the system of national accounts (SNA) as the control totals, which means the summation of nominal variables in the KDB. For example, value added equals GDP in the SNA. This constraint prevents KDB variables from becoming unrealistic numbers, although it could reflect errors and output definition problems in the SNA (the output of the real estate industry in the SNA includes attributed rents for self-owned housing).

The KDB fundamentally follows the Jorgenson-Griliches (1967) approach, which carefully monitors the effect of qualitative and structural change in input and output as well as quantitative change. For example, consider the case where labor input is captured simply by the number of workers. It would include many types of workers such as males, females, high school graduates, college graduates, young people, senior citizens, etc.

Their quality might be different in the sense of suitability to jobs. Suppose a firm substitutes one college graduate for a high school graduate, expecting more advanced technological skills from the former. In this case it is inappropriate to consider the labor input unchanged, because the quality of labor is improved even though the number of workers is still the same.

How can the quality be captured in data? We usually use proxy variables for the quality index with the help of economic theory. A product with higher quality should be priced higher than the one with lower quality at the equilibrium, because the latter would not be utilized at all if the two were priced equally. The quality differences are reflected in price differentials. The KDB and Jorgenson approaches make use of price information for classified inputs/outputs and calculate their aggregates that are consistent with economic theory. It can be shown that under perfectly competitive market conditions the application of appropriate aggregation function formulae yields a precise quality-adjusted quantity index. In the case of a trans-log aggregation function, for example, the Theil-Törnqvist formula creates exact index numbers. The KDB takes into account quality changes for KLEM inputs, as summarized below (for more details, see Kuroda et al., 1996).

Labor Input

The labor force is classified by gender (male and female), age (11 classes), educational career (four for males and three for females), and employment status (employed, self-employed, family worker) for industrial sectors. Working hours are also taken into account as the utilization rate of the labor force. Since in the SNA the income of self-employed and family workers is defined as a part of business surplus, the KDB reallocates it to a labor compensation item.

Capital Input

Making capital stock time series is one of the most laborious processes in constructing databases. The KDB applies the double benchmark methodology, which utilizes the *Census of National Wealth* (CNW) for 1955 and 1970. The two-point availability of the CNW is useful for determining the depreciation rates of capital goods on the basis of the Hulten-Wykoff (1981) dual approach, because the rates can be estimated so that the theoretical values are equal to the observed values. Applying the perpetual inventory method, capital stock is annually accumulated using investment data and estimates of depreciation rates. Capital goods are classified into 78 commodities for 42 sectors and aggregated into a single capital input index.

Intermediary Input

Rich information about intermediary input is available in input/output (I/O) tables. Unfortunately, the most precise commodity-by-commodity basic tables (X-tables) are published by the Ministry of General Affairs every five years, so the KDB estimates time series of X-tables through the KEO-RAS method, which allows estimation of input coefficients of X-tables by minimizing the summation of squared deviations between estimated coefficients and those of the X-tables on the restriction of control totals given by the annual SNA. After the estimation of X-tables, the KDB estimates commodity-by-sector input tables (U-tables) from sector-by-commodity output tables (V-tables) of the SNA and estimated X-tables under the commodity-technology assumption.

Output

The KDB assumes separation between input and output and aggregates multiple outputs into a single index for 42 industrial sectors. Basic information on output is from V-tables in the SNA. One characteristic of the KDB is that it does not use I/O commodity deflators for the conversion from nominal to real values, but applies the wholesale price index published by the Bank of Japan (BOJ). The reason is that the BOJ index considers quality change in commodities. Shimpo (1999) showed how the two different output deflators lead to large discrepancies in the TFP index. While in case of the I/O deflator, the US automobile industry had an advantage in the level of TFP over the Japanese industry in the 1980s, the BOJ price index yields higher TFP of the Japanese auto industry than that in the USA (Urata et al., 1995). Considering the recent rapid technical change in high-tech commodities, a quality-adjusted price index is preferable.

INDUSTRY-LEVEL TFP GROWTH, 1960–95

Industry-level TFP growth rates from 1960 to 1995 were calculated using the Nomura-Kuroda (1999) method based on the KDB. The observation period covered by the KDB is divided into four subperiods: 1961–73 (high-growth period); 1974–85 (stable-growth period); 1986–91 (bubble economy period); and 1992–95 (post-bubble economy period).

Table 1 summarizes the results. (For the theoretical background of the TFP calculations, see the Appendix.) First the good performance of machinery-related industries in general can be noted. They maintained positive TFP growth except for general machinery during the final period, although the rates gradually declined. The communications industry made constant productivity progress against the background of an expanding telecommunications market. On the other hand, some traditional sectors such as agriculture, food, wood, publishing, leather products, water supply, and education had almost constant productivity declines throughout the observation period.

Examining the average annual growth rates from 1961 to 1995 in Tables 1 and 2, the differences in TFP performance among industries become more obvious. The ranking supports the understanding that TFP measured in the long term reflects the characteristics of industries. (See Nakajima [2001] for a more detailed explanation of the relationship between industrial characteristics and TFP growth.) Although air, railway, and water supply services are categorized as a network-based transportation industry, their TFP performance differs. The differences in their market conditions are obviously an influence. Water supply is still widely provided by local governments in Japan. However, we should also pay more attention to production and technological characteristics. The big difference exists in the burden of cost for building infrastructure. While railway and water supply services need huge amounts of investment to construct rails and lay pipes throughout the country, an air transportation service needs only an airport.

Table 1. TFP growth rate by industry (%).

	1961-1973	1974-1985	1986-1991	1992-1995	1961-1995		1961-1973	1974-1985	1986-1991	1992-1995	1961-1995
Agriculture	-2.24%	-1.97%	-0.35%	1.21%	-1.43%	Vehicle	2.47%	1.44%	0.66%	0.07%	1.53%
Coal mining	5.11%	-3.12%	0.46%	2.98%	1.25%	Other transportation machinery	1.06%	0.40%	0.60%	0.05%	0.64%
Other mining	5.45%	-1.24%	2.07%	-1.98%	1.73%	Precision machinery	3.39%	2.43%	0.44%	0.21%	2.19%
Building & construction	-0.94%	-0.03%	0.69%	-0.87%	-0.34%	Miscellaneous manufacturing products	2.28%	-0.08%	0.59%	-0.14%	0.90%
Foods	-0.08%	-0.09%	-1.11%	-0.33%	-0.29%	Railway transportation	0.67%	-2.57%	-1.40%	2.47%	-0.59%
Textile	-0.07%	1.81%	1.26%	2.24%	1.07%	Road transportation	0.98%	-0.22%	0.92%	-1.69%	0.25%
Apparel	1.29%	0.07%	-0.88%	-0.60%	0.28%	Water transportation	0.96%	3.16%	-2.36%	3.21%	1.40%
Woods	-0.31%	2.75%	-0.75%	-0.94%	0.59%	Air transportation	6.95%	1.42%	0.90%	-1.01%	3.11%
Furniture	0.82%	0.11%	0.87%	-3.00%	0.15%	Storage	-2.11%	4.79%	-2.32%	1.96%	0.69%
Paper & pulp	1.80%	-0.07%	1.68%	0.33%	0.97%	Communications	1.79%	2.97%	0.88%	1.56%	2.01%
Publishing	-2.32%	-1.63%	0.60%	-1.49%	-1.49%	Electricity	4.01%	-2.25%	3.10%	-2.96%	0.91%
Chemical	2.91%	0.44%	0.77%	2.56%	1.65%	Gas	2.86%	1.79%	3.18%	1.18%	2.36%
Petroleum	-2.13%	0.61%	2.70%	1.69%	0.08%	Water	-3.92%	-0.86%	-1.56%	-0.90%	-2.12%
Coal	-0.63%	-2.45%	0.07%	4.73%	-0.52%	Trade	4.54%	0.24%	2.79%	0.63%	2.32%
Rubber	2.11%	-0.14%	1.92%	-1.62%	0.88%	Finance	2.80%	0.82%	0.22%	-0.77%	1.27%
Leather	1.70%	-0.07%	-0.16%	-1.69%	0.39%	Real estate	1.75%	-0.79%	-0.07%	0.43%	0.42%
Stone & clay	1.65%	-0.56%	0.85%	-0.37%	0.52%	Education	2.32%	-3.76%	-0.55%	-0.92%	-0.63%
Iron & steel	0.95%	-0.11%	0.20%	1.22%	0.49%	Research	2.12%	1.61%	1.05%	-0.59%	1.45%
Non- ferrous products	0.93%	0.79%	0.40%	2.24%	0.94%	Medical service	0.25%	1.13%	-2.21%	-2.82%	-0.22%
Metal products	2.85%	-0.18%	1.32%	0.71%	1.31%	Other industries	-2.85%	-1.87%	-2.58%	0.77%	-2.05%
General machinery	0.54%	1.64%	0.65%	-0.72%	0.79%	Public services	3.91%	-1.05%	0.87%	1.89%	1.46%
Electric machinery	4.18%	2.23%	2.90%	1.05%	2.93%						

Table 2. Top 10 and worst 10 TFP performers.

	Top 10	Worst 10
1	Air transportation	Water supply
2	Electric machinery	Other industries
3	Gas	Publishing
4	Trade	Agriculture
5	Precision machinery	Education
6	Communications	Railway transportation
7	Other mining	Coal
8	Chemicals	Building & construction
9	Vehicles	Food
10	Public services	Medical services

In the short term, changes in market conditions as well as other features of the external environment could affect industry-level TFP performance. A good example is the financial sector, in which TFP growth rates decreased throughout the period. Even during the bubble economy period, which everyone believes caused unprecedented prosperity for financial institutes, the TFP growth rate was only 0.22%. This appears mysterious unless we consider the change in the market conditions of Japan's financial sector. The following interpretation may be true: the long-term regulations and protection provided by the Japanese government to financial institutes might have prevented them from making efforts to raise productivity, and the globalization and liberalization in financial markets with the bursting of the bubble economy finally led to negative TFP growth in the post-bubble period.

Next, we apply TFP (fixed-effect panel) regression analysis to industry-level TFP indices and attempted to determine the influential factors. Although various combinations of independent variables were tested, it was difficult to obtain satisfactory results. One result is shown in Table 3. The coefficients of public finance ratio and R&D-related variables are positive and significant. The effect of public subsidy is negative and significant at the 5% level only in the first column. To some extent, R&D activities and the public finance system might be effective in increasing TFP growth. Concerning other industrial policies, the results are too ambiguous to derive robust implications.

Table 3. Estimation results of TFP regression model (fixed-effect model).

	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Dependent	ln TFP	ln	TFP ln	TFP
number of observations	154	168	105	105
PF			0.461 [2.264]**	0.434 [2.164]**
R&D0	1.591 [4.754]**			
R&D1		0.153 [10.577]**	0.114 [7.662]**	
R&D2				0.768 [2.585]**
R&D3				0.052 [0.626]
R&D4				0.105 [4.885]**
subsidy	-5.062 [-1.960]*	-1.322 [-0.595]	2.756 [0.953]	3.165 [1.118]
tariff	-1.207 [-0.736]	0.839 [0.611]	1.499 [0.821]	2.010 [1.117]
const	0.973 [80.892]**	0.782 [39.429]**	0.771 [23.269]**	0.759 [22.837]**
sigma_u	0.093	0.209	0.144	0.156
sigma_e	0.114	0.102	0.070	0.069
rho	0.397	0.809	0.807	0.837

All independent variables are measured by logarithmic values
*,**: significant on 5% and 1% level respectively
PF: The ratio of public finance over total debt.
(source: *Basic Survey on Commercial and Manufacturing Structure and Activities*)
R&D0 : R&D expenditure based on I-O table over total production
R&D1 : R&D sales ratio (source: *Survey of Research and Development*)
R&D2 : R&D (basic reserch)/sales (source: *Survey of Research and Development*)
R&D3 : R&D (applied reserch)/sales (source: *Survey of Research and Development*)
R&D4 : R&D (development)/sales (source: Survey of Research and Development)
subsidy : subsidy production ratio (quoted from Urata et al.(1995))
tariff : tariff production ratio (quoted from Urata et al.(1995))
Eq.1 : 1965-1995
Eq.2 : 1960-1995
Eq.3, Eq.4 : 1970-1990

Finally, we tried to extract factors common to some industries by applying cluster analysis to industry-level TFP growth rates. The results are shown in Table 4. It appears difficult to specify the four factors based only on the industry types listed. One interesting interpretation, however, may be derived from group 2 in Table 4. This group is composed of Japan's typical traditional sectors, some of which have been or still are protected by government regulations. It is ironic as well as persuasive that the public sector is also classified in this group.

Table 4. Results of cluster analysis based on TFP growth rate by industry.

< 1 >	< 2 >	< 3 >	< 4 >
Other mining	Agriculture	Publishing	Petroleum products
Building & construction	Coal mining	Rubber products	Coal products
Apparel	Food	General machinery	Leather products
Wood	Textile	Electric machinery	Non-ferrous products
Furniture	Chemical	Water transportation	Other transportation
Paper & pulp	Stone & clay	Air transportation	
Vehicles	Iron & steel	Electricity	
Precision machinery	Metal products	Trade	
Railway transportation	Miscellaneous manufacturing products	Research	
Road transportation	Finance		
Storage	Medical services		
Communications	Public services		
Gas			
Water			
Real estate			
Education			
Other industries			

MACRO TFP GROWTH OF THE JAPANESE ECONOMY, 1960−2000

There are basically two ways to derive TFP growth for an entire country. One is to perform growth accounting by utilizing macro statistics on labor, capital, and value added. The other is to aggregate the industry-level input/output to the national level and calculate macro TFP. The differences in input, output, and TFP between the above two are defined as allocation bias by Nomura and Kuroda (1999). According to the definition, the bias is estimated as positive if a resource is reallocated from a lower-priced sector to higher-priced one and vice versa.

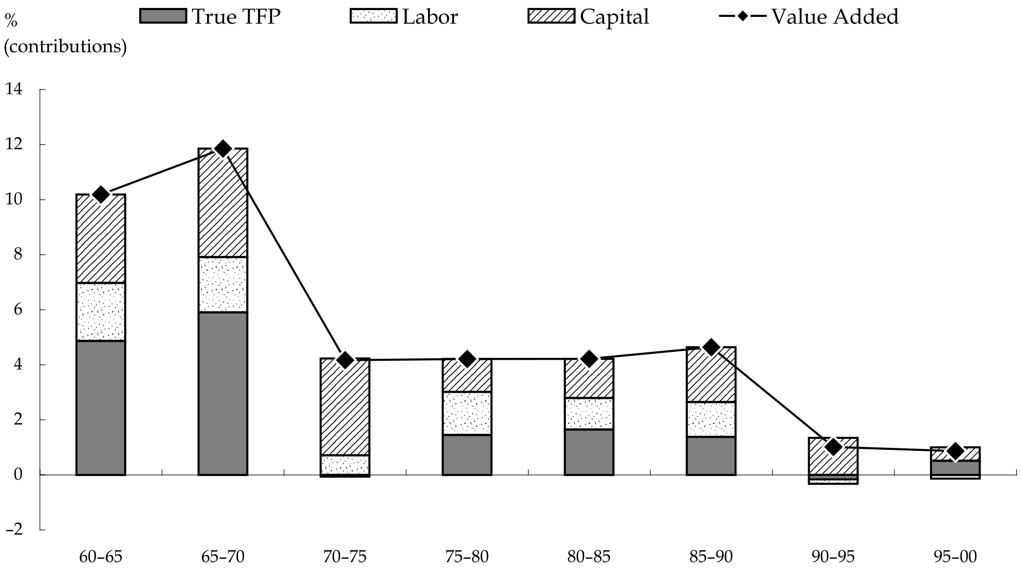
Table 5 shows the basic results. Column A explains the final nationwide growth accounting that reflects the quality change in input factors and allocation bias effects among industries. Columns B, C, and D illustrate factor decompositions of growth rates for output, input, and TFP, respectively, and correspond to the four panels in Figures 1 and 2. The row of "other bias" stands for the value of the cross-term that inevitably appears in the process of aggregation from industry level to macro level.

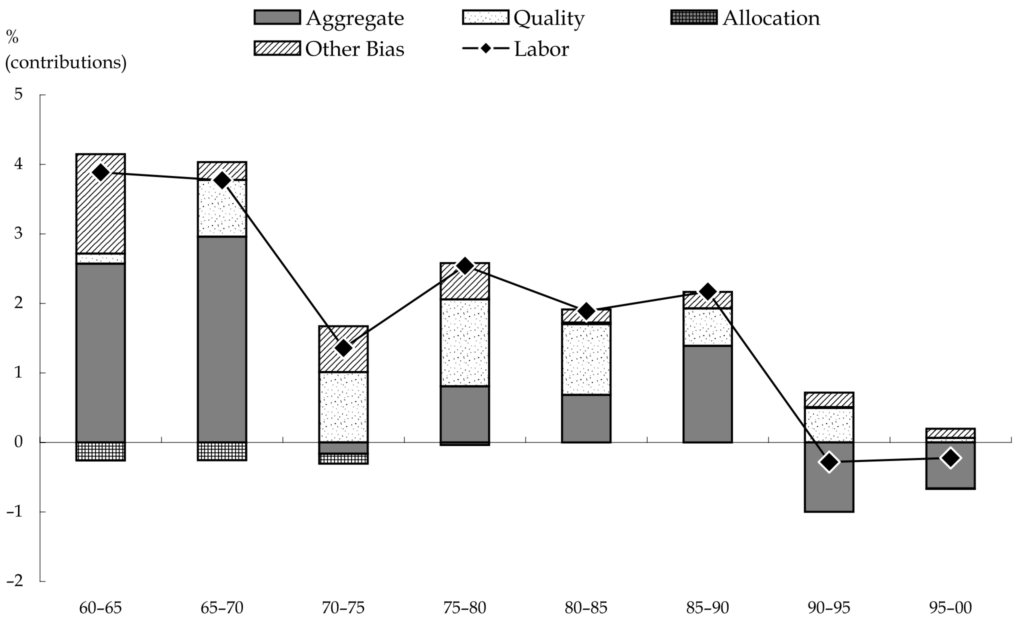
Table 5. Decomposition of sources of economic growth during 1960−2000 in Japan.

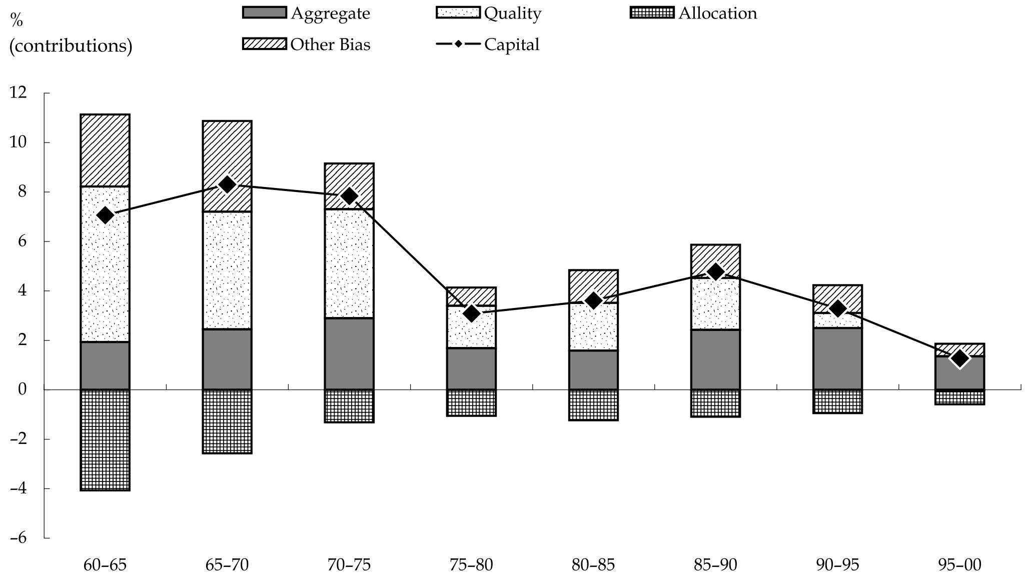
	A. Divisia aggregation														
a1	True TFP		4.867	5.903	−0.063	1.452	1.647	1.380	−0.160	0.514	4.542	0.832	1.259	0.124	1.942
a2	Output	Value added	10.187	11.857	4.167	4.211	4.218	4.639	1.018	0.866	10.095	3.704	4.463	0.649	5.146
a3	Input	Labor	3.885	3.772	1.359	2.541	1.890	2.170	−0.282	−0.223	3.417	1.655	1.900	−0.342	1.889
a4		Capital	7.061	8.306	7.836	3.085	3.610	4.778	3.289	1.275	7.980	4.393	5.024	1.841	4.905
a5	Contribution	Labor	2.105	2.008	0.712	1.565	1.145	1.265	−0.166	−0.137	1.832	0.991	1.107	−0.204	1.062
a6		Capital	3.214	3.946	3.519	1.195	1.427	1.994	1.344	0.490	3.721	1.795	2.097	0.729	2.141
	B. Output Decomposition														
b1	Value added	Aggregate	4.798	10.014	4.093	3.067	3.724	4.302	0.999	1.031	7.179	3.024	4.193	0.723	4.004
b2		Allocation	5.386	1.829	0.085	1.149	0.493	0.336	0.019	−0.165	2.921	0.682	0.269	−0.074	1.141
	C. Input decomposition														
c1		Aggregate	2.571	2.960	−0.162	0.807	0.684	1.388	−0.998	−0.660	2.310	0.437	1.168	−0.929	0.824
c2		Quality	0.146	0.816	1.012	1.250	1.018	0.537	0.495	0.065	0.560	0.882	0.512	0.269	0.667
c3		Allocation	−0.261	−0.259	−0.145	−0.038	0.022	0.002	0.011	−0.010	−0.265	−0.007	0.000	0.001	−0.085
c4		Other Bias	1.431	0.258	0.660	0.523	0.190	0.238	0.210	0.132	0.814	0.349	0.216	0.178	0.455
c5		Aggregate	1.931	2.447	2.895	1.684	1.585	2.421	2.497	1.354	2.398	2.188	2.677	1.700	2.102
c6	Capital	Quality	6.287	4.758	4.408	1.716	1.928	2.101	0.610	−0.037	5.460	2.117	2.174	0.037	2.722
c7		Allocation	−4.071	−2.571	−1.321	−1.058	−1.235	−1.095	−0.945	−0.551	−2.956	−1.144	−1.125	−0.690	−1.606
c8		Other Bias	2.917	3.669	1.848	0.740	1.325	1.346	1.124	0.509	3.076	1.226	1.290	0.795	1.685
	D. TFP decomposition														
d1	Aggregate TFP		2.538	7.255	2.952	1.917	2.682	2.482	0.578	0.918	4.818	1.873	2.394	0.614	2.665
d2	Aggregation	Bias in value added	5.386	1.829	0.085	1.149	0.493	0.336	0.019	−0.165	2.921	0.682	0.269	−0.074	1.141
d3		Bias in labor	−0.725	−0.416	−0.862	−1.066	−0.738	−0.453	−0.430	−0.113	−0.592	−0.736	−0.425	−0.270	−0.600
d4	bias	Bias in capital	−2.335	−2.784	−2.227	−0.543	−0.797	−0.980	−0.327	0.030	−2.601	−0.901	−0.976	−0.059	−1.245

Calculation is based on the Keio Economic Observatory Database.
Note : a1=a2−a5−a6
a2=b1+b2
a3=c1+c2+c3+c4
a4=c5+c6+c7+c8
a1=d1+d2+d3+d4

Figure 1. Macro Growth Accounting of Japan Labor Input Growth Accounting of Japan Capital Input Growth Accounting of Japan TFP Growth Accounting of Japan






%
(contributions)
Aggregate
Quality
Allocation
Other Bias
Capital
12
10
8
6
4
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60–65
65–70
70–75
75–80
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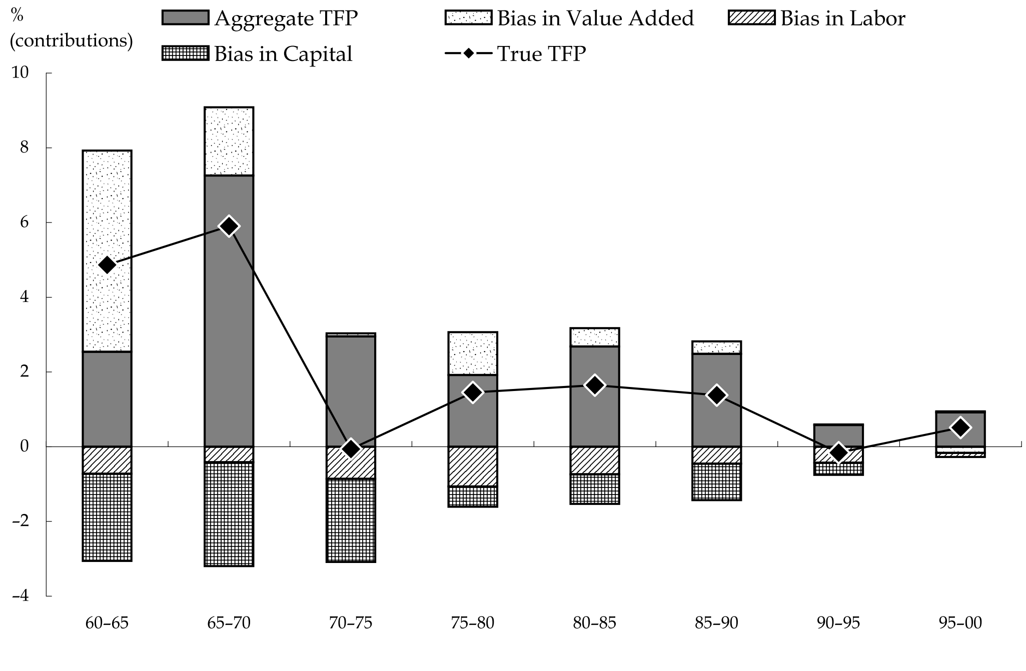
85–90
90–95
95–00


%
(contributions)
Aggregate TFP
Bias in Value Added
Bias in Labor
Bias in Capital
True TFP
10
8
6
4
2
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80–85
85–90
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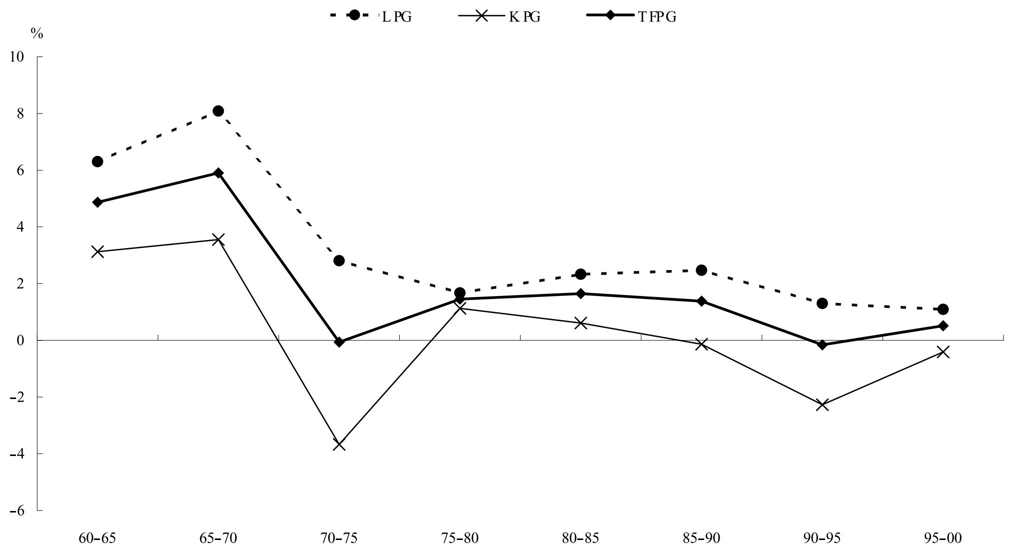
Figure 2. TFP, LP and KP growth rates



Column A

1) The contribution of TFP to value-added growth was strongly significant (mostly 50%) during the high-growth period.
2) The supply-side shock of the first oil crisis was perfectly absorbed by TFP growth from 1970 to 1975.
3) The bubble economy, which was praised as the second advent of high growth, had substantially different characteristics in terms of growth accounting from the high economic growth in the 1960s. While the latter was mostly attained by TFP growth, the former relied on a more than 70% contribution from input growth.

Column B

1) Allocation bias had a substantially large positive value during the high-growth period, which reflected rapid structural change in Japanese industries.
2) Only the post-bubble recession period (1995–2000) showed a negative value of bias, which indicates that some inefficiency might have occurred in output allocation among industries at that time.

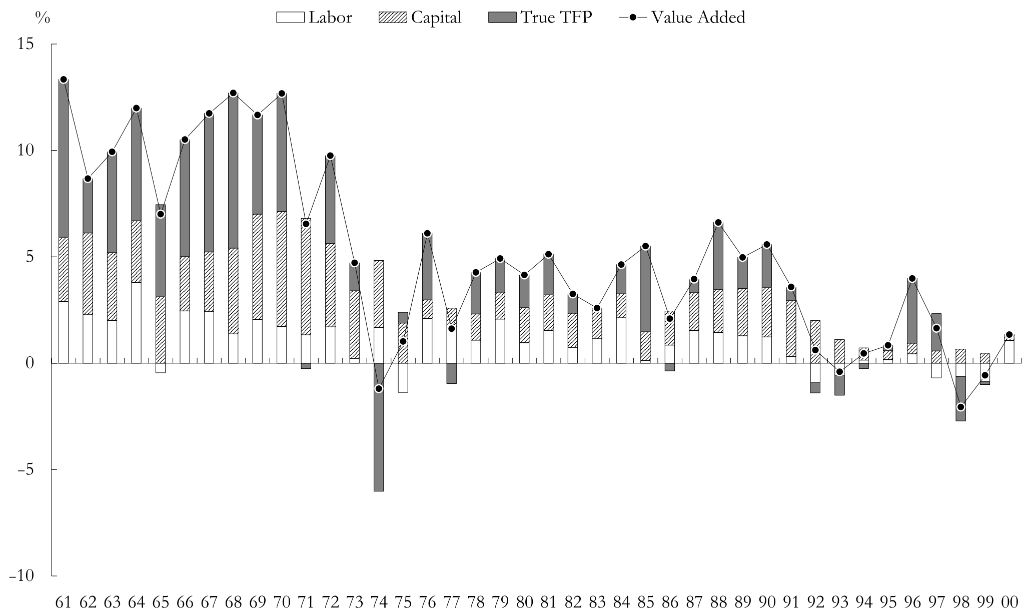
Column C

1) The positive and significant contribution of labor quality change was constant.
2) The contribution of capital stock to Japan's economic growth was constantly substantial.
3) The allocation bias of capital was constantly negative, which shows that capital goods were allocated to industries that have relatively small capital stock shares in the Japanese economy.

Figure 3 summarizes the macro growth accounting results and partial productivity indicators for the Japanese economy. The LP growth was stably larger than KP growth.

The KP growth rate was small and occasionally negative a result of a higher rate of capital accumulation than economic growth. The difference between LP and KP narrowed after the first oil crisis, but expanded again until the bubble economy period. This shows that capital accumulation-driven growth experiences setbacks at economic downturns.

Figure 3. Macro Growth Accounting of the Japanese Economy



CONCLUSIONS AND POLICY IMPLICATIONS

In TFP studies there is always a trade-off between data precision and availability of resources. The KDB is one of the finest data sources for TFP calculations but needs a huge amount of work to construct. We must accept a three-year-lag to obtain the complete version. The previous APO TFP publication sacrificed precision for the latest growth accounting numbers. In this paper, we chose the KDB in exchange for a three-year-lag. The reason for our choice is that a TFP indicator becomes meaningless if it contains measurement errors.

Figure 3 and Table 4 show that TFP growth has made a considerable contribution to the economic growth of Japan. Especially during the high-growth period, the contribution of TFP was nearly 50%, which must have worked as a shock absorber at the time of the economic recession after the first oil crisis in 1973. The bubble economy after the late 1980s raised TFP growth rates, but the gains at that time might not have been enough to absorb the downward shock of the sudden bursting of the bubble in 1992.

In a sophisticated economy like Japan, it is not easy to interpret macro TFP fluctuations because it has a complicated industrial structure and many other factors that jointly affect TFP measurement. Relatively longer time series of industry-level TFP indicators could present more interpretable results reflecting industrial characteristics. Table 1 shows that manufacturing industries, especially machinery-related ones, had better TFP performance throughout the observation period. Tertiary industries, on the other hand, had either positive or negative TFP growth rates depending on their production technologies and market structures. Although the TFP regression analysis results only show a significant effect of R&D expenditure on TFP growth, the cluster analysis based on industry-level TFP growth rates (group 2) pointed out industries that have been under government protection and regulations.

Our results based on the KDB unfortunately still seem to have uncorrected errors. We cannot say that the effect of the business cycle has been completely eliminated from our TFP fluctuations in Figures 1, 2, and 3. Since Griliches-Jorgenson (1967), great efforts have been made to select data sources to obtain "pure" TFP indicators. However, those efforts mainly focused on the input side of growth accounting. Less attention has been paid to the definition of output, that is, GDP, although a 1% error in output growth leads directly to the same amount of error in TFP growth.

The problem of output definition is more serious for a developed economy like Japan. In the early stage of economic development, the main actor is manufacturing that produces a visible and measurable output. As the economy becomes more mature, a structural change may occur from econdary to tertiary industry such as finance, retail, real estate, and many other service industries. How can we correctly define output for those industries? What should be their deflators? Consider the retail industry. The service output is defined as the trade margin, and traditionally the double deflation approach has been utilized to obtain the "real" output. When the trade margin decreases and the quality of a retail service increases as a result of more competition, "real output" will decrease under the traditional definition. The TFP number for trade is 92 to 95 in Table 1 and could reflect this situation. Considering the more than 40% contribution of the service industry to nominal GDP, we should pay more attention to the output definition issue in TFP analysis.

ACKNOWLEDGMENTS

We thank Noriyoshi Oguchi and other participants in the APO meeting in Kuala Lumpur for useful comments and suggestions. We are also grateful to Masahiro Kuroda and Kazushige Shimpo for allowing us to utilize the Keio Economic Observatory Database and to quote some of their results.

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APPENDIX. THEORETICAL BACKGROUND OF TFP

Choice of Index Formula

TFP is defined as the ratio of output to input. It is simple to calculate TFP in the case of a single-input/output technology such as a simple transportation service in which a worker carries baggage from one place to another. In more general cases of multiple-input/output technologies, we need to aggregate them into single input and output indices to calculate TFP. Although the choice of an appropriate aggregate function is basically left to a researcher according to the purpose of the study, economic theory gives guidelines on making the choice, especially when a TFP indicator with a specific calculation formula holds.

Diewert (1976) made a considerable contribution to the consistency of an index formula with a production technology (a form of production function). He proved that an input/output index based on the Theil-Törnqvist (T-T) formula is consistent with a trans-log production function. This implication is useful, because once a producer's rational choice of an input combination is assumed, it is not necessary to estimate the production function itself to obtain aggregated numbers. It is only needed to calculate an index using an exact (corresponding) formula. Since the trans-log production function satisfies the requirement for technological flexibility, Diewert called the T-T (trans-log) index the superlative index.

The TFP numbers referred in this paper were basically calculated using the T-T index to maintain the flexibility of production technologies. If we assume a constant cost share for an input factor, the production function is specified as a Cobb-Douglas type.

Adjustment of Capital Utilization

One of the most difficult tasks for TFP researchers is how to solve the problem of fixed-factor utilization. Because in the KDB the rate of return on capital stock is endogenously derived based on the neoclassical economic theory, it is impossible to show the difference in TFP results before and after the utilization adjustment. As Yoshioka (1987) explained, TFP occasionally has a procyclical movement with the business cycle. For the sake of the original definition of TFP, that is, a purely external technological shift factor of production technology, the mixture of business cycle effects might be an obstacle to be eliminated. There are actually a variety of methods to remove the effect of fixed-factor utilization from TFP. Oguchi (2001) presented a useful and appropriate method that could be applied to most APO member countries. In this paper, however, we apply another method to adjust capital utilization.

One of the most famous theories of microeconomics explains that a perfect allocation of nominal output to the compensation of input factors is guaranteed under the following conditions: perfect competition, linear-homogeneous production technology, perfect flexibility of input factors, and producer's rational behavior (profit maximization). In this ideal case, no capital utilization problem occurs because the optimal input level is obtained rapidly. One simple method for the utilization adjustment is to make use of this theorem.

Suppose the short-run production cost can be expressed using a variable cost function G as follows:

$$C = G(p, Y, K) + p_K K \qquad \text{(Eq. 1)}$$

where p stands for the price vector of variable inputs, Y for output, K for fixed input (capital stock), and pK for the user cost of capital. Taking a partial derivative in terms of Y, we obtain the following two different results depending on whether capital stock is adjustable (in the long term) or not (in the short term):

$$\frac{\partial G}{\partial Y} + \frac{\partial G}{\partial K}\frac{\partial K}{\partial Y} + p_K \frac{\partial K}{\partial Y} \rightarrow \text{Change in variable cost in the long term} \qquad \text{(Eq. 2)}$$

$$\frac{\partial G}{\partial Y} \rightarrow \text{Change in variable cost in the short term} \qquad \text{(Eq. 3)}$$

We define the optimal input level of K (unity capital stock utilization rate) as one that equalizes the long-run derivative and short-run derivative in terms of Y, that is,

$$p_K = -\frac{\partial G}{\partial K}. \qquad \text{(Eq. 4)}$$

Since it can be shown that the left-hand side corresponds to marginal productivity of capital, replacement of the user cost of capital with LHS in Eq. 4 gives utilization-adjusted growth accounting.

The marginal productivity of capital can be easily calculated if we assume that the four conditions mentioned above hold true. Applying Euler's theorem for a linear-homogeneous function to production function $Y = F(L, K)$, the following relation holds:

$$Y = \frac{\partial F}{\partial L} L + \frac{\partial F}{\partial K} K$$

$$= wL - \frac{\partial G}{\partial K} K, \qquad \text{(Eq. 5)}$$

where w means wage rate and it is assumed that the product price equals unity. Using Eq. 5, the marginal productivity can be calculated as:

$$-\frac{\partial G}{\partial K} = \frac{Y - wL}{K}. \qquad \text{(Eq. 6)}$$

Considering the discussion above, it is theoretically confirmed that utilization adjustment can be achieved using the estimated marginal productivity of capital instead of user cost.

REPUBLIC OF KOREA

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INTRODUCTION

The growth experience of the Republic of Korea and other East Asian countries has been a subject of lively and often contentious debate in social science. As each government throughout Asia seeks to cope with the aftereffects of the 1997 financial crisis, a growing number of skeptics have challenged the sustainability of the East Asian growth model. The recent crisis in Asian economies, however, does not diminish the need to understand the source of the past "miracle." Many reasons for the recent economic failure in Asian countries are likely to be found through a better understanding of the past.

Various studies analyzed the sources of economic growth in Korea and other East Asian countries, for example, Kim and Park (1985), Young (1992, 1995), Moon et al. (1991), Pyo and Kwon (1991), Lee (1998), Bosworth et al. (1995), Kim and Lau (1994), Sarel (1996), and Kim and Hong (1997). There has recently been a flood of research since the outbreak of the 1997 Asian financial crisis offering various reasons for causes of and lessons from the crisis. A common feature of these studies is that they look at economic growth in Korea and East Asia in terms of factor accumulation and technological progress, with some suggesting that low efficiency brought on the crisis in Korea (Kim 1998).

The purpose of this paper is to estimate total factor productivity (TFP) growth and its determinants in Korea for the period 1972–99. Academic and policy interest in TFP as a source of economic growth is based on the presumption in growth theories that productivity is the source of long-term economic growth. This paper provides estimates of TFP changes within the growth accounting framework with value added, labor, and capital input data.

GROWTH AND STRUCTURAL CHANGES IN THE KOREAN ECONOMY

Korea's GDP growth averaged 7.9% per year from 1972 to 1999 (Table 1). Since the early 1960s, the Korean economy has recorded sustained high economic growth, interrupted only in 1980 and in the financial crisis year of 1997, when output temporarily declined. Korea's real GDP growth was high at 7% to 8% during the 1970s, but somewhat slowed in the early 1980s owing to three factors: agricultural failure because of bad weather conditions; a severe recession caused by the second oil crisis; and domestic political instability. For the period 1972–99, the growth rate for capital and labor inputs rose at an annual average of 11.6% and 2.1%, respectively. The rise in capital input from 1975 to 1980 rose at an average 14.3% per year; this was the period of the heavy and chemical industry drive. Labor input remained constant throughout the period 1995 to 1999, registering an annual average growth rate of only 0.01%. The uneven growth rates of different sectors led to a dramatic transformation in Korea's production structure (Table 2). Since the manufacturing and service sectors became more important, their shares in GDP increased, while that of agriculture declined from 29.8% in 1972 to a low of 5.6% in 1999.

Table 1. Growth of the Korean economy (%).

Period	GDP growth	Capital growth	Employment growth
1972-75	8.99	11.99	3.53
1975-80	7.42	14.29	2.87
1980-85	6.62	11.23	1.76
1985-90	9.37	11.51	3.59
1990-95	8.04	12.05	2.25
1995-99	5.18	8.32	0.01
1972-99	7.88	11.57	2.10

Table 2. Production structure of the Korean economy (%).

Period	Gross value-added share		
	Agriculture	Mining & manufacturing	Service
1972-75	27.96	28.60	43.44
1975-80	23.39	31.97	44.64
1980-85	15.69	34.05	50.26
1985-90	11.45	34.84	53.71
1990-95	7.89	32.53	59.58
1995-99	6.04	33.25	60.72
1972-99	14.93	32.78	52.29

There has also been a sizable movement in the labor force across sectors (Figure 1 and Table 3). The employment share of agriculture, which employed about 40% of labor for the period 1972 to 1975, has steadily declined in the process of Korea's industrialization. For example, for the period 1995 to 1999, employment share in the agricultural sector was 12.3%. On the other hand, the share of employment in the service sector increased from 44.1% in 1972-75 to 71.1% in 1995-99, while employment share in the manufacturing industry was around 16.6% for the period 1995-99.

Figure 1. GDP shares of the three main sectors.

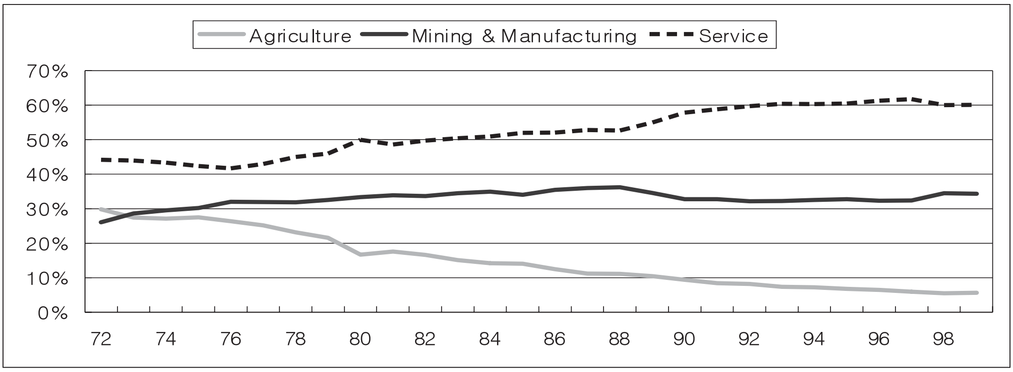


Table 3. Employment structure.

Period	Employment		
	Agriculture	**Mining &manufacturing**	**Service**
1972-75	40.00	15.95	44.05
1975-80	32.77	19.89	47.34
1980-85	25.58	20.53	53.89
1985-90	18.99	22.82	58.19
1990-95	14.11	22.66	63.23
1995-99	12.29	16.60	71.12
1972-99	21.72	20.02	58.26

ESTIMATION OF THE TRADITIONAL TFP GROWTH MODEL

Traditional Model

We assume a production function where output is a function of capital and labor. We measure output by the total amount of goods and services produced. This relationship is expressed mathematically by Eq. 1:

$$Q_t = A_t F(K_t, L_t) \qquad \text{(Eq. 1)}$$

where Q is output in terms of GDP, K the capital input, L the labor input, and A represents the level of efficiency. Output growth may be thought of as due to two factors: factor accumulation, which in turn may be broken into growth of capital input ($s_K K_t$) and growth of labor input ($s_L L_t$); and growth of TFP ($TFPG_t$). Hence we may write:

$$Q^g_t = TFPG_t + s_K K^g_t + s_L L^g_t \qquad \text{(Eq. 2)}$$

where Q^g_t is output growth rate, K^g_t capital growth rate, L^g_t labor growth rate, s_K the share of capital input, and s_L the share of labor input.

In estimating TFP growth, this paper applies the traditional growth accounting approach. Under constant returns to scale, the average rate of TFP growth between any two discrete points in time, for example, t and t-1, can be expressed as the difference between successive logarithms of output minus the weighted average of the differences between the successive logarithms of capital and labor input with weights given by their average value share. In particular, a trans-log growth accounting method is assumed, as follows:

$$TFPG_t = [\ln Q_t - \ln Q_{(t-1)}] - s_L * [\ln L_t - \ln L_{(t-1)}] - s_K * [\ln K_t - \ln K_{(t-1)}] \qquad \text{(Eq. 3)}$$

where $s_L = \_ * (s_{Lt} + s_{L(t-1)})$ and $s_K = \_ * (s_{Kt} + s_{K(t-1)})$

Applied to Korean data yields, this gives what is referred to in this paper as the unadjusted TFP growth (TFPG_UN).

Data

The data in this paper are estimated using the same methodology as that of Lee (2001).

Output

The national accounts data are used for gross output and value added. Value added at constant base year prices is used as output.

$$\text{GDP at factor cost} = \text{GDP at market price} - \text{net indirect taxes} \qquad \text{(Eq. 4)}$$

Output growth rate for the total economy is 7.9% per year for the period 1972 to 1999.

Capital Stock

Pyo's (1998) capital stock based on the National Wealth Survey of 1968, 1977, 1987, and 1998 is used in the estimation of TFP growth. With capital stock data for these years as a benchmark, capital stock is estimated from the investment data shown in the national accounts for 1969−76, 1978−86, and 1987−97. The polynomial benchmark method (Hulten and Wykoff, 1981) shown by Eq. (5) is used for estimation:

$$Ns^i_t = I^i_t + (1 - d_i) I^i_{t-1} + ... + (1 - d_i)^{s-1} I^k_{t-s+1} + . + (1 - d_i)^s NK^k_{t-s} \qquad \text{(Eq. 5)}$$

where NK^k_j stands for constant price net capital stock in the i-th sector at the end of year j, and I^i_j stands for constant price total fixed capital formation in the i-th sector at the end of year j. The capital input growth rate for the total economy is 11.6% per year for the period 1972 to 1999 (Figure 2).

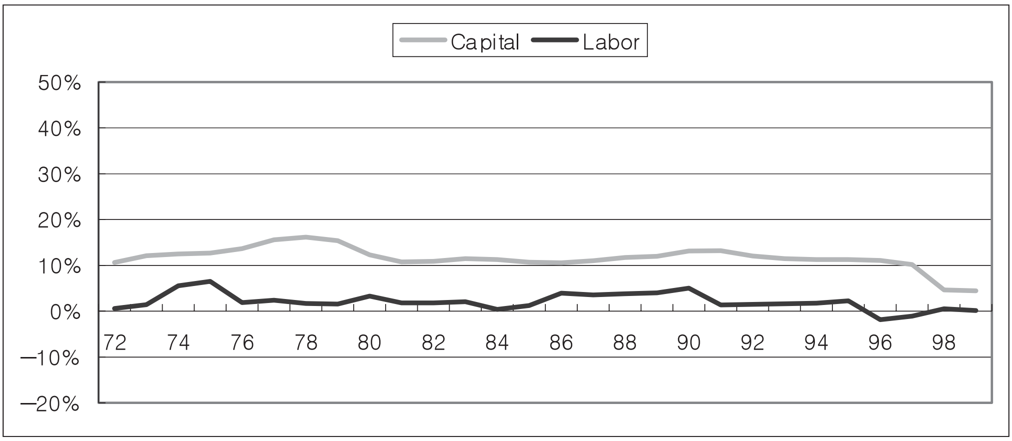
Labor input

Data on employees' compensation is available from the national accounts. Since there are no data related to labor input, we estimate this using the input-output tables. The input-output tables after 1970 provide employment tables for 1970, 1973, 1975, 1978, 1980, 1983, 1985, 1986, 1990, 1995, and 1998, as well as data on unpaid family workers and employees. Data for the years not available from the table are estimated based on the interpolation method (Figure 2).

The numbers of employees, unpaid family workers, and employed persons in all sectors are from the employment tables in the input-output tables, which in general are useful for TFP analysis. However, several steps were necessary to make the input-output table data consistent with the value-added data in the national accounts. First, industrial classification in the input-output tables had to be adjusted to that of the national accounts. Second, data for years not covered in the input-output tables during the period under study were estimated by interpolating average annual growth rates in each period. Third, the data for 1999 were extrapolated from the annual growth rate in 1998-99.

All workers were classified into three categories according to educational level attained: below high school graduate; high school graduate; and college and higher education graduate. Although a finer classification of educational attainment is desirable, classification was limited to these three categories to assure compatibility of the educational composition of workers and worker data by educational category. In any case, the composition of workers by educational category shows that the number of workers with relatively higher levels of education (i.e., high school graduates and above) increased steadily in relative terms during the period under study.

Figure 2. Growth rates of labor and capital input.



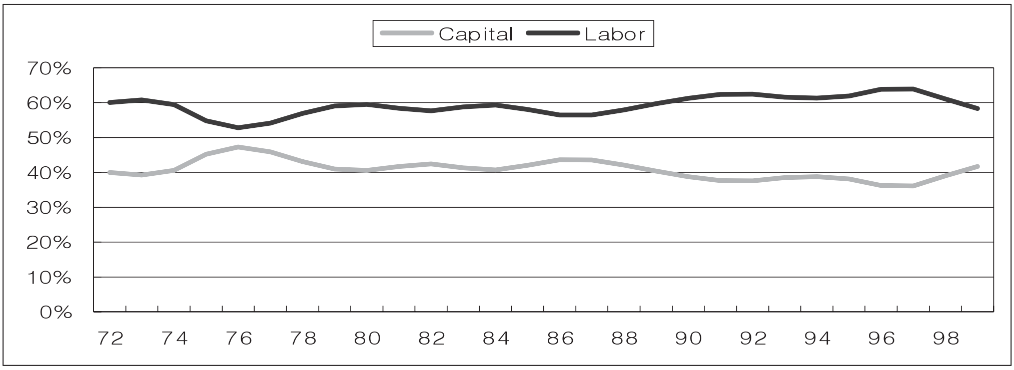
Factor Shares

The income share of labor is taken from the national accounts. For our purposes, the compensation of labor as a percentage of the value added is used. Value added here constitutes the sum of subsidies and the value added in the national accounts from which indirect taxes are subtracted. Compensation for labor is the sum of employees' compensation taken from the national accounts and that of the unpaid and family workers. The share of capital is measured as a residual of the labor share. That is, the labor share of income is the ratio of compensation for labor to GDP at factor cost and the capital share is simply 1 - labor share. Wages for unpaid and family workers are not included in the compensation of employees in the national accounts and were therefore estimated. First, the number of employed persons and unpaid and family workers is estimated from the input-output tables. Second, the per capita wage for employees is obtained from the value of the compensation of employees divided by their number. The value of the compensation of unpaid and family workers is estimated by the number of unpaid and family workers multiplied by the per capita wage for employees.

Figure 3 shows the share of labor for the period 1972 to 1999. This share in the case of the whole economy was 59.2%, while the capital share was 40.8% for the period under study. From 1987 to 1997, the share of labor increased slightly, but fell dramatically after the outbreak of the Asian financial crisis.

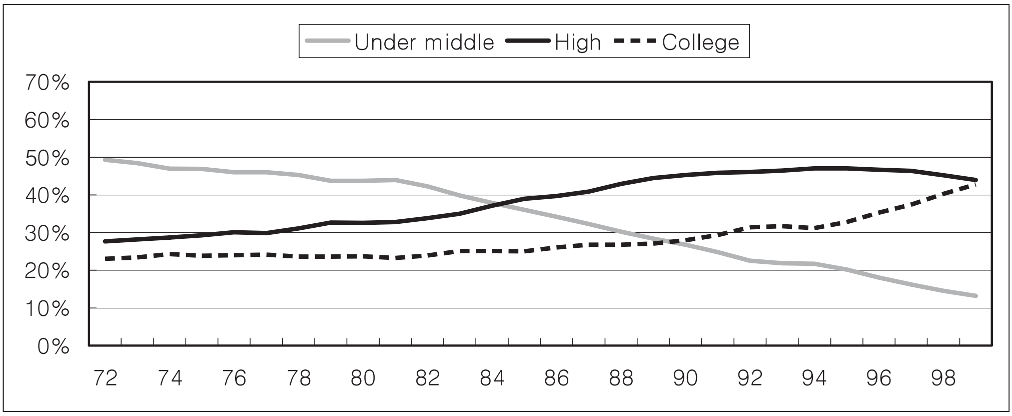
Data on wages and the number of workers by educational level and by sector were obtained from the Survey Report on Wage Structure published by the Ministry of Labor. The actual proportion of the three groups according to educational level was calculated from the Survey Report on Wage Structure, and this ratio was applied to the data in the input-output tables to obtain a more consistent number of workers for each educational category.

Figure 3. Labor and capital income share, 1972−99.



There have been sizeable changes in the educational structure of labor over the years. With more people completing high school and college education, the share of those who have at least high school certification increased from 34.8% for the period 1972−75 to 81.26% in 1995−99 (Figure 4).

Figure 4. Labor share by education level, 1972-99.



RESULTS AND COMPARISONS

Estimation Results and Comparisons

Estimation Results

Table 4 presents GDP growth (gGDP), TFP growth, the labor share (SL), and contribution to GDP growth of TFP growth (cTFPG) for the Korean economy for six subperiods during 1972 to 1999. As in previous studies, the contributions of capital and labor inputs were obtained by weighting the corresponding growth rates by the shares of individual input in value added. Taking into account Sarel's (1996) note that the growth rate of TFP is sensitive to the length of the time period, this paper uses a five-year demarcation period. This paper reports three types of TFP growth at the level of the whole economy. According to Table 4, TFP growth rates during 1972-99 averaged about 1.92% per annum under the standard assumption of constant returns to scale.

Table 4 shows that the relative contribution of capital input to output growth was 60.1%, while labor input and unadjusted TFP growth accounted for 15.4% and 24.4% of growth, respectively. The growth of GDP, the growth rate of the two primary factor inputs, the unadjusted TFP growth, and contributions to GDP growth by TFP growth for six subperiods are also presented in Table 4. Comparing the estimates for these six subperiods reveals the dynamic change in TFP growth. In particular, the growth rate of unadjusted TFP dropped sharply from the period of 1972-75 to that of 1975-80, and rises from the 1975-80 and 1980-85 periods.

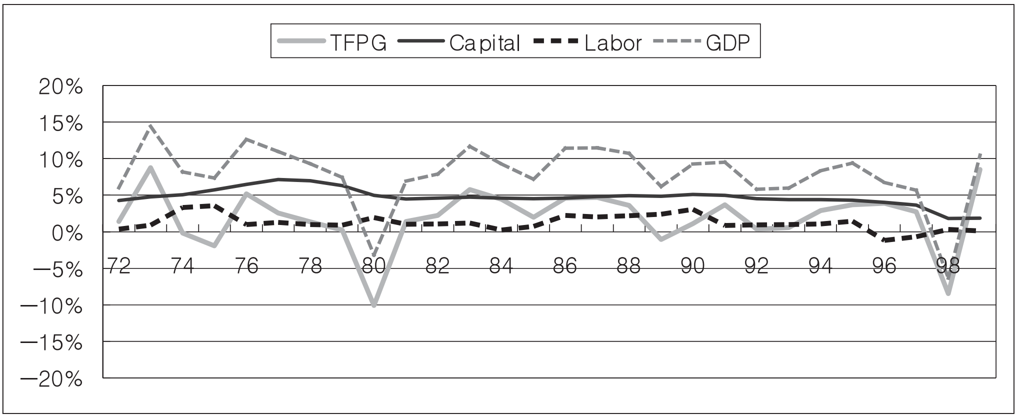
Table 4. GDP growth, TFP growth, and its contribution to output growth (%).

Year	gGDP	$S_K \cdot gK$	$S_L \cdot gL$	SL	Unadjusted TFPG	cTFPG
1972	6.01	4.25	0.37	60.04	1.39	23.10
1973	14.41	4.75	0.88	60.79	8.78	60.89
1974	8.18	5.06	3.31	59.44	-0.19	-2.29
1975	7.36	5.74	3.55	54.77	-1.93	-26.15
1976	12.61	6.46	0.98	52.76	5.17	41.03
1977	10.99	7.14	1.28	54.13	2.57	23.38
1978	9.31	6.98	0.97	56.90	1.36	14.61
1979	7.45	6.30	0.91	59.03	0.24	3.17
1980	-3.19	4.97	1.94	59.47	-10.10	316.75
1981	6.93	4.48	1.04	58.34	1.41	20.30
1982	7.89	4.61	1.06	57.61	2.22	28.08
1983	11.69	4.72	1.20	58.74	5.77	49.35
1984	9.25	4.59	0.22	59.33	4.43	47.95
1985	7.18	4.50	0.72	58.00	1.96	27.30
1986	11.43	4.59	2.24	56.41	4.60	40.27
1987	11.47	4.80	2.00	56.44	4.68	40.75
1988	10.71	4.93	2.18	57.89	3.59	33.53
1989	6.17	4.84	2.38	59.68	-1.06	-17.16
1990	9.25	5.08	3.06	61.23	1.11	11.95
1991	9.50	4.96	0.85	62.38	3.68	38.75
1992	5.81	4.51	0.93	62.41	0.37	6.30
1993	5.96	4.40	0.99	61.54	0.56	9.47
1994	8.35	4.37	1.07	61.26	2.91	34.82
1995	9.39	4.30	1.42	61.89	3.68	39.13
1996	6.73	4.01	-1.18	63.80	3.90	57.87
1997	5.68	3.66	-0.70	63.91	2.72	47.85
1998	-6.34	1.80	0.33	61.00	-8.47	133.50
1999	10.46	1.86	0.10	58.29	8.50	81.26
1972-75	8.99	4.95	2.03	58.76	2.01	22.38
1975-80	7.42	6.26	1.61	56.18	-0.45	-6.03
1980-85	6.62	4.65	1.03	58.58	0.95	14.30
1985-90	9.37	4.79	2.10	58.28	2.48	26.47
1990-95	8.04	4.61	1.39	61.79	2.05	25.48
1995-99	5.18	3.13	-0.01	61.78	2.06	39.82
1972-99	7.88	4.74	1.22	59.20	1.92	24.40

Unadjusted TFP growth rates then began to decrease again from the beginning of 1990. TFP growth was negative in 1998, but improved after the structural adjustment period of 1997−98. A tentative conclusion from the estimation of unadjusted TFP growth is that capital input was the most important factor in the growth of the Korean economy between 1972 and 1999, unadjusted TFP growth was the second most important factor, while labor input played the smallest role (Figure 5).

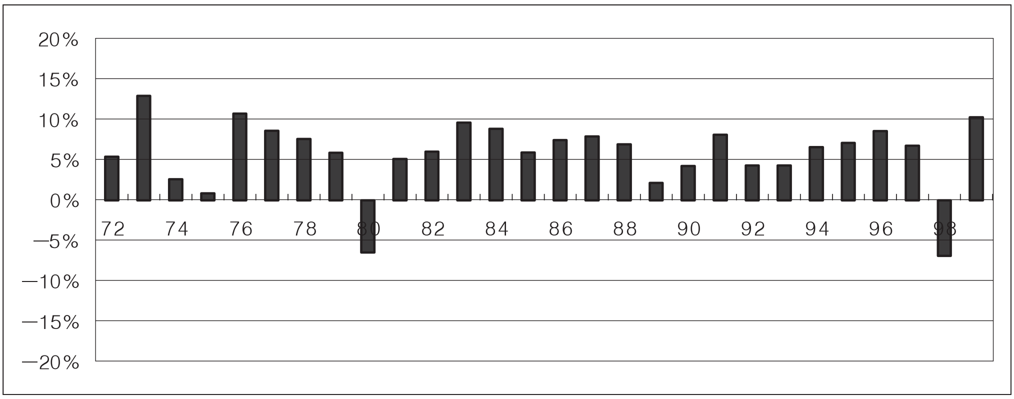
Recent debates over whether economic growth in Asian countries depends on technological change or simply the quantitative growth of the factors of production have heated up after Krugman's (1994) article, which argued that economic growth was achieved simply by the quantitative growth of the factors of production. Our findings clearly support the quantitative-growth hypothesis that economic growth in Korea relies on the quantitative increase in the factors of production. Currently, the Korean economy is undergoing drastic transformation from a capital-intensive production structure to a knowledge-based economy, as illustrated by the rapid growth of venture businesses in recent years.

Figure 5. Contribution of capital and TFP to economic growth.



The growth rate of capital input peaked between 1975 and 1980. The government-driven financial policy was largely responsible for the centralized investment of capital toward heavy and chemical industries during the late 1970s. Such high capital input growth, however, resulted in low capital productivity. The annual growth rate of labor productivity averaged 5.8% for the period under study. In general, growth in capital stock seems to have played a more important role in Korea's economic growth. An interesting point is that over the same period TFP growth did not decrease, despite the fall in capital productivity. This suggests that productivity growth may have been largely due to labor productivity growth from 1972 to 1999. Figure 6 shows the annual labor productivity growth rate from 1972 to 1999. It can be seen that there was considerable improvement in labor productivity growth, except for 1980 and 1998.

Figure 6. Labor productivity growth.



Comparisons

There are numerous estimates of Korean TFP growth, and some are compared in Table 5. Because of limitations due to the differences in the model used, analysis period, and the data utilized between the earlier studies and the present one, a direct comparison is difficult. Christensen and Cummings (1981) estimated very high TFP growth rates of 4.1% per annum for the period 1960 to 1973. On the other hand, annual TFP growth rates as low as 1.7% were reported in Pyo and Kwon (1991). Pyo and Kwon's estimates are adjusted by age and gender differences in the labor input structure. Pyo et al. (1993) estimated the annual TFP growth rate for the whole economy for the period 1970 to 1990 at 1.3%. Capital stock showed rapid growth, particularly because land and inventory are excluded from the estimates. The income share of labor is estimated at a discounted rate by assuming that the income of unpaid family workers is one-quarter that of employees. Capital and labor input data are estimated and are consistent with those in the national accounts in the present study, which resulted in a 7.9% annual output growth rate and a 1.9% annual TFP growth rate between 1972 and 1999. When we compare these results with those of Kim and Hong (1997), the contributions of labor inputs and TFP growth are much lower in this study, while that of capital inputs is much higher. The TFP growth estimates in the present study are similar to those of Lee (2001).

Table 5. Studies of TFP growth in the Korean economy (% per annum).

Researcher	Time period	Output growth	TFP growth	Contribution
Present study	1972–99	7.88	1.94	26.4
Lee (2001)	1971–96	7.85	2.00	25.4
Christensen & Cummings (1981)	1960–73	9.70	4.1	42.3
Kim & Park (1985)	1963–82	7.61	2.72	35.7
Pyo & Kwon (1991)	1960–89	8.59	1.65	19.2
Pyo et al. (1993)	1970–90	8.38	1.31	15.6

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Kim & Hong (1997)	1963–95	7.61	3.34	43.9
Young (1995)	1966–90	10.4	1.70	16.3

ESTIMATION OF MODIFIED TFP GROWTH MODEL

Modified Model

Three different types of modification are made to the unadjusted TFP growth to eliminate the effects of business fluctuations, quality of labor inputs, and interindustry movements of labor, respectively. These three adjustments are based on the method proposed by Oguchi (2001).

Labor Quality-adjusted TFP Growth

We assume that in the production function all types of labor have uniform marginal productivity. In reality this may not be true, because different types of labor input may have different marginal productivity, which implies that the corresponding TFP estimate may be unrealistic. The true TFP growth can be derived if labor inputs are disaggregated into their different types of labor quality. That is:

$$Q = Bf(L_1, L_2, \ldots L_n, K) \qquad \text{(Eq. 6)}$$

where Q is the output, L_1 is type 1 labor, L_2 is type 2 labor, etc., and K is the capital input. Equation 5 provides a methodology decomposing the effects of labor quality from TFP growth. We call it labor quality-adjusted TFP growth (*TFPG_LQ*). Oguchi (2001) wrote Eq. 7 in discrete form as:

$$Q^g_t = TFPG\_LQ + s_k K^g_t + s_l L^{g*}_t \qquad \text{(Eq. 7)}$$

where $s_l L^{g*}_t = 1/2*(s_{l1t} + s_{l1(t-1)})*(\ln L_{1t} - \ln L_{1(t-1)}) + 1/2*(s_{l2t} + s_{l2(t-1)})*(\ln L_{2t} - \ln L_{2(t-1)})\ldots + 1/2*(s_{l3t} + s_{l3(t-1)})*(\ln L_{3t} - \ln L_{3(t-1)})$.

To analyze the effects of labor on TFP growth, we denote L_1 as below high school graduates, L_2 as high school graduates, and L_3 as college and higher graduates.

Industry Shift-adjusted TFP Growth

Labor productivity differs from industry to industry. Hence as workers move from a less productive industrial sector to a more productive one, overall productivity improves even if overall employment remains constant. This improvement is reflected in the TFP growth rate. The effects of interindustry labor movement on TFP growth are estimabed using the same method as above. It is referred to as industry shift-adjusted TFP growth

(*TFPG_IS*). Labor according to sector is considered: L_A is the labor in agriculture; $L_{M\&M}$ labor in mining and manufacturing; and L_s labor in the service sector. Correspondingly, S_A denotes the labor share in agriculture, $S_{M\&M}$ the labor share in the mining and manufacturing sector, and S_S the labor share in the service sector.

Business Fluctuation-adjusted TFP Growth

A Cobb-Douglas production function is estimated to compute the theoretical value-added for each year, as shown in Eq. 8.

$$Q_t / L_t = A * (K_t / L_t)^a u_t \qquad \text{(Eq. 8)}$$

where the variables Q, K, L, A, and t stand for the real value added, capital stock, number of employees, technogical constant, and time subscript, respectively, and ut is the stochastic error term. Using the estimated parameters of the Cobb-Douglas production function, the theoretical value added for each year is computed. The estimated equation is:

$$\ln(GDP/L) = 4.602 + 0.428 * \ln(K/L) \; (75.79) \; (12.93) \qquad \text{(Eq. 9)}$$

where $R^2 = 0.861$, adjusted $R^2 = 0.855$, $F = 167.39$, and the sample period is 1972–99. ln(*GDP/L*) is a logarithm of GDP/labor, and ln(*K/L*) is a logarithm of capital stock/labor. A trans-log production function was also estimated but the t values were small and not statistically significant.

We take the ratio of the actual value (denoted by Q) to the theoretical value (denoted by Q^*) and call it V_t:

$$V_t = Q/Q^* \qquad \text{(Eq. 10)}$$

where V_t represents the capacity utilization rate. We compute the changing rate of capacity utilization which indicates the extent to which the growth rate of value added is affected by business fluctuations. We then compute business fluctuation-adjusted TFPG (*TFPG_BF*) as follows:

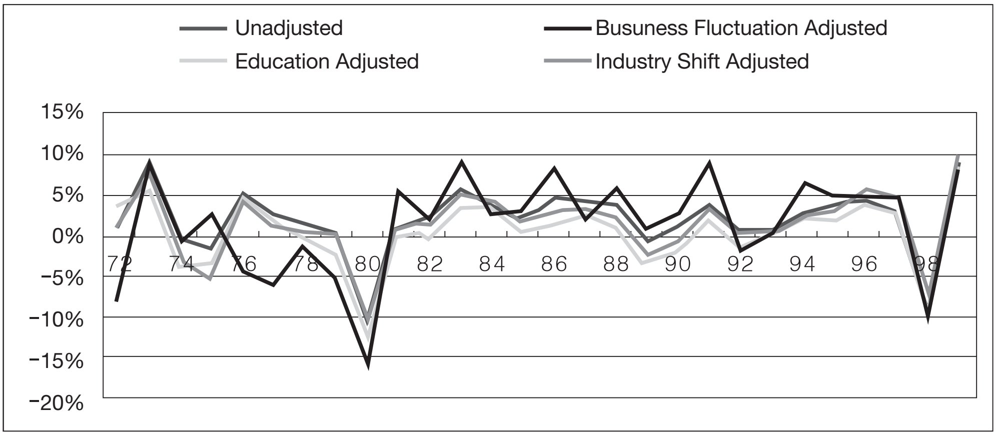
$$TFPG\_BF = Unadjusted\ TFP\ growth\ rate - GV_t \qquad \text{(Eq. 11)}$$

where $GV_t = \ln V_t - \ln V_{(t-1)}$ and thus *TFPG_BF* is the TFP growth corrected for the effects of business fluctuation.

Estimation Results

Figure 7 shows the results of adjusting for the effects of labor quality, business fluctuation, and labor movement across sectors on TFP growth. This figure shows that the unadjusted and adjusted TFP growth shows a similar trend. However, there was a difference in movement between the unadjusted and adjusted TFP growth. The annual growth rate of GDP and TFP in 1980 and 1998 decreased sharply.

Figure 7. Modified TFP growth trends.



The estimates of TFP growth adjusted for business fluctuation, labor quality, and labor movement across sectors during the period 1972 to 1999 are presented in Table 6. Since the unadjusted TFP growth is not adjusted for the quality effects of education of workers, it overstates the TFP growth in the economy.

Table 6. Modified TFP growth (TFPG) estimates (%).

Period	Output growth	Business fluctuation-adjusted TFPG	Education-adjusted TFPG	Industry shift-adjusted TFP
1972	1.39	-8.08	3.69	0.93
1973	8.78	8.89	5.56	7.96
1974	-0.19	-0.96	-3.78	-2.90
1975	-1.93	2.59	-3.17	-5.35
1976	5.17	-4.58	4.25	4.08
1977	2.57	-5.90	1.46	1.31
1978	1.36	-0.73	-0.46	0.37
1979	0.24	-5.58	-2.24	-0.17
1980	-10.10	-16.28	-12.84	-10.69
1981	1.41	5.34	0.20	0.84
1982	2.22	2.16	-0.31	1.56
1983	5.77	9.09	3.49	4.99
1984	4.43	2.67	3.55	4.40
1985	1.96	2.99	0.62	1.74

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1986	4.60	8.27	1.32	2.77
1987	4.68	2.00	2.38	3.25
1988	3.59	5.69	0.85	2.05
1989	-1.06	0.50	-3.57	-2.62
1990	1.11	2.57	-1.74	-0.81
1991	3.68	8.99	2.03	3.22
1992	0.37	-1.97	-1.55	-0.17
1993	0.56	0.34	0.16	0.00
1994	2.91	6.30	1.88	2.34
1995	3.68	4.90	1.99	2.94
1996	3.90	4.99	3.75	5.59
1997	2.72	4.62	2.50	4.47
1998	-8.47	-10.82	-9.72	-7.61
1999	8.50	8.73	8.00	10.15
1972-75	2.01	0.61	-0.46	0.16
1975-80	-0.45	-5.08	-2.17	-1.74
1980-85	0.95	0.99	-0.88	0.47
1985-90	2.48	3.67	-0.02	1.06
1990-95	2.05	3.52	0.46	1.25
1995-99	2.06	2.48	1.30	3.11
1972-99	1.92	1.31	0.30	1.24

The results show that TFP growth decreased slightly due to capacity utilization adjustment to output. The education-adjusted TFP growth (TFPG_LQ) is lower than the unadjusted TFP growth (TFPG_UN), which indicates the contribution of education to productivity growth in the economy (Table 7). The improvement in labor quality makes the education-adjusted growth rate of labor higher than the education-unadjusted growth rate of labor, resulting in low estimates of education-adjusted TFP growth. Industry shift-adjusted TFP growth is lower than the unadjusted TFP growth. A lower estimate after adjusting for industry shift means that labor movement across industries increased the adjusted growth rate of labor, meaning that labor moved from lower-productivity sectors to higher-productivity sectors.

Table 7. Effects of business fluctuation, education, and labor movement on TFP growth (%).

Period	Unadjusted TFPG/ business fluctuation-adjusted TFPG	Unadjusted TFPG/education-adjusted TFPG	Unadjusted TFPG/industry shift-adjusted TFPG
1972-75	1.40	2.48	1.85

Continued...

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1975-80	4.63	1.72	1.30
1980-85	-0.05	1.83	0.47
1985-90	-1.19	2.50	1.42
1990-95	-1.47	1.59	0.80
1995-99	-0.42	0.76	-1.05
1972-99	0.61	1.63	0.69

FACTORS INFLUENCING TFP GROWTH

Traditional theory on trade is clear about the effect of more trade: it increases competition and enhances efficiency. Markets grow not only from increased domestic demand but also from external demand. Thus foreign trade is also another important source of growth. In addition to its effects on economies of scale, exposure to foreign competition may improve productivity since it may increase entrepreneurial effort and improve technical efficiency. Tybout (1992) found that exposure to increased foreign competition was associated with improvements in the average level of technical efficiency and reduction in the cross-plant dispersion in technical efficiency. It was concluded that "export expansion leads to higher TFP growth through economies of scale and/ or through competitive incentive... [and that] import substitution leads to lower TFP growth." Foreign trade is expected to enhance TFP due to its effect on competition and its potential to provide technically superior foreign machinery and equipment.

Foreign investment plays an important role in several respects. Foreign firms may raise productivity by enhancing competition, introducing new capital goods and technology, and encouraging an increase in skilled workers. Multinational activity may lead to technology transfer to domestic firms. If foreign firms introduce new products or processes to the domestic market, domestic firms may benefit from the accelerated diffusion of new technology (Aitken and Harrison, 1999). Accordingly, this study includes foreign direct investment (FDI) in its analysis.

The time series of this variable during 1972 to 1999 is used as an explanatory variable. Using the growth rate of the ratio of exports to GDP and the ratio of imports to GDP, the ratio of FDI to GDP, and ratio of R&D expenditure to GDP in Korea and in the USA to represent the spillover effect, and the average years of schooling, the following equations for TFP growth are obtained:

$$TFGP = a_1 + b_1\,GEX + b_2\,RD\_KOR + b_3\,GFDI + b_4\,RD\_USA + b_5\,MAN$$

$$+ b_6\,DUM\_90 + u_i \qquad \text{(Eq. 12)}$$

$$TFGP = a_1 + b_1\,GIM + b_2\,RD\_KOR + b_3\,GFDI + b_4\,RD\_USA + b_5\,MAN + b_6\,DUM\_90 + u_i$$

(Eq. 13)

where *TFPG* = the unadjusted TFP growth or the adjusted TFP growth, *GEX* = the percentage change in exports, *GIM* = the percentage change in imports, *RD_KOR* = l*n*(R&D in Korea/GDP) (where l*n* = natural log), *GFDI* = the percentage change in FDI, *RD_USA* = l*n*(R&D in USA/GDP), *MAN* = the ratio of manufacturing output/GDP, and *DUM_*90 = dummy variable.

Four types of TFP growth are assigned as the dependent variables. The export and import data were obtained from the *Major Statistics of Korean Economy published* by the Korea National Statistical Office. Data on FDI were obtained from the Ministry of Finance and Economy. R&D data were obtained from the *Major Indicators of Industrial Technology* published by the Korea Industrial Technology Association.

Table 8 presents the regression results explaining TFP growth, where three asterisks indicate significance at the 1% level, two asterisks significance at the 5% level, and one asterisk significance at the 10% level. The results are almost the same when the dependent variable (*UN_TFPG*) is replaced by adjusted TFP growth (*TFPG_LQ*, *TFPG_IS*, *TFPG_BF*). The explanatory power of the equation, as measured by R^2 and F statistics, is relatively low and statistically significant.

First, the estimated coefficient on *GEX* is positive and statistically significant, implying that an increase in exports may improve TFP growth. Export expansion leads to higher TFP growth through economies of scale and through competitive incentives.

Second, the estimated coefficient on *GIM* is positive and statistically significant, implying that an increase in imports may enhance efforts to improve domestic TFP growth. Imports have positive effects on the innovative activity of domestic firms because this increases competition in the domestic market, and domestic firms must enhance efficiency to maintain their market position.

Third, R&D investment in Korea is found to have a positive impact on TFP growth. The results are inconsistent with the hypothesis that R&D growth leads to higher TFP growth. The estimated coefficient of the US R&D/GDP ratio positively affects TFP growth and is marginally significant. Kwack (1997) found that the increase in US R&D played an important role in improving TFP growth in the Korean economy.

Fourth, the estimated coefficient of inward FDI has a positive impact on TFP growth. Inward FDI may raise productivity by enhancing competition and introducing new capital goods and technology. FDI spillovers are likely generated through a variety of activities in the host economy, including labor and management training, technological "copying," direct licensing of technology, vertical linkages in production, and distribution value chains.

Finally, the ratio of gross value added of the manufacturing sector to GDP is negative and statistically insignificant. The estimated coefficient of the Dum_90 variable is statistically insignificantly negative. This implies that TFP growth after the 1990s decreased.

Table 8. Determinants of TFP growth, 1972–99.

Dependent variable	Unadjusted TFPG				Business fluctuation-adjusted TEPG				Education-adjusted TFPG				Industry shift-adjusted TFPG			
Equation no.	**EQ1**	**EQ2**	**EQ3**	**EQ4**	**EQ1**	**EQ2**	**EQ3**	**EQ4**	**EQ1**	**EQ2**	**EQ3**	**EQ4**	**EQ1**	**EQ2**	**EQ3**	**EQ4**
Constant	0.20	0.15	0.17	0.11	−0.18	−0.29	−0.12	−0.25	0.35	0.31	0.31	0.26	0.21	0.17	0.17	0.12
	(0.74)	(0.56)	(0.63)	(0.42)	(−0.37)	(−0.63)	(−0.28)	(−0.61)	(1.24)	(1.08)	(1.07)	(0.90)	(0.74)	(0.60)	(0.62)	(0.44)
GEX	0.14***	0.14**			0.09	0.09			0.12**	0.13**			0.13**	0.13**		
	(2.84)	(2.87)			(0.99)	(1.06)			(2.42)	(2.42)			(2.58)	(2.58)		
GIM			0.11***	0.13***			0.13**	0.16**			0.09**	0.10**			0.10**	0.11***
			(2.93)	(3.43)			(2.09)	(2.80)	0.08*	0.08*	(2.12)	(2.41)			(2.50)	(2.84)
RD−KOR	0.07	0.06	0.05	0.04	0.03	0.02	0.04	0.02	(1.91)	(1.76)	0.06	0.06	0.08*	0.07	0.05	0.05
	(1.65)	(1.48)	(1.22)	(1.09)	(0.45)	(0.23)	(0.60)	(0.41)	0.02	0.01	(1.46)	(1.34)	(1.72)	(1.57)	(1.31)	(1.18)
GFDI	0.01	0.00	0.02*	0.01	0.02	0.00	0.02	0.00	(1.42)	(0.93)	0.03**	0.02	0.02	0.01	0.03**	0.02
	(0.81)	(0.30)	(1.81)	(0.82)	(0.81)	(0.11)	(1.17)	(0.02)		0.12	(2.31)	(1.44)	(1.34)	(0.87)	(2.29)	(1.39)
RD−USA		0.15		0.25*		0.38		0.52**		(0.83)		0.21		0.12		0.22
		(1.04)		(1.83)		(1.55)		(2.37)	−1.35	−1.60		(1.34)		(0.81)		(1.44)
MAN	−0.76	−1.06	−0.62	−1.20	0.56	−0.21	0.35	−0.85	(−1.36)	(−1.53)	−1.17	−1.64	−0.84	−1.08	−0.68	−1.18
	(−0.80)	(−1.06)	(−0.66)	(−1.27)	(0.33)	(−0.12)	(0.22)	(−0.56)	(3.00)	−0.04	(−1.16)	(−1.56)	(−0.84)	(−1.03)	(−0.69)	(−1.14)
DUM_80	−0.03	−0.04	−0.03	−0.03	−0.00	−0.01	−0.00	−0.02	−0.03	(−1.22)	−0.03	−0.04	−0.03	−0.03	−0.02	−0.03
	(−1.09)	(−1.24)	(−0.85)	(−1.23)	(−0.01)	(−0.26)	(−0.05)	(−0.50)	(−1.11)	0.41	(−0.85)	(−1.10)	(−0.85)	(−0.97)	(−0.61)	(−0.89)
R2	0.37	0.40	0.38	0.47	0.19	0.28	0.30	0.44	0.39	2.45	0.36	0.41	0.40	0.42	0.39	0.45
F−Statistic	2.59	2.34	2.70	3.05	1.05	1.33	1.85	2.80	2.84	1.33	2.48	2.44	2.94	2.52	2.84	2.83

*10%, **5%, ***1% significance level.
Figures in parentheses are t values.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

Annual TFP growth during the period 1972–99 averaged about 1.92%. The relative contribution of capital input to output growth was highest at around 60.1%, while labor input and unadjusted TFP growth accounted for 15.4% and 24.4% of growth, respectively. High capital input growth resulted in low capital productivity, while the growth rate of labor productivity per annum reached 5.78% for the period under study. This clearly supports the quantitative growth hypothesis that economic growth in Korea still relies on the quantitative increase in factors of production.

The paper estimates adjusted TFP growth since the unadjusted TFP growth overstates the TFP growth in the economy. The education-adjusted TFP growth is lower than the unadjusted TFP growth, which suggests the contribution of education to productivity growth. The improvement in labor quality makes the education-adjusted growth rate of labor higher than the education-unadjusted growth rate of labor, resulting in low estimates of education-adjusted TFP growth. The industry shift-adjusted TFP growth is lower than the unadjusted TFP growth. A lower estimate after adjusting for industry shift means that labor movement across industries increased the adjusted growth rate of labor. That means that labor moved from lower-productivity sectors to higher-productivity sectors.

Regression results showed that import and export growth leads to improved TFP growth. Import liberalization has allowed for the increased flow of foreign goods and might have helped improve TFP growth enhancement efforts through increased competition in the domestic market. Export expansion leads to higher TFP growth through economies of scale and through competitive incentives. Growth in R&D investment plays a positive role in enhancing TFP growth in the Korean economy. The increase in US R&D also plays a positive role in improving TFP growth in the Korean economy.

Policy Implications

The role of TFP in enhancing overall economic growth has become even more important after the Asian financial crisis. The recent crisis in Korea reflected structural weaknesses, which induced a decline in the growth rate of TFP. To increase the TFP growth rate, the Korean government will have to make more rigorous efforts to enhance economic efficiency through economic restructuring, continued improvement in education and training quality, and attracting FDI and foreign R&D. Import and export growth leads to improved TFP growth. Firms operating in international markets are in a position to capture knowledge and technological spillovers from their international contacts and reach larger markets, allowing them to exploit economies of scale. From this perspective, an economic policy facilitating a deeper integration of the Korean economy into the global market could lead to dynamic productivity gains.

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APPENDIX. TABLES USED FOR CALCULATIONS.

Appendix Table 1. Variables and their definitions.

Variable	Definition
GDP	Gross domestic product
K	Capital stock
L	Labor force
Agri	Ratio of agricultural sector to GDP
M&M	Ratio of mining and manufacturing sector to GDP
Ser	Ratio of Service Sector to GDP
SK	Capital share of income
SL	Labor share of income
SM	Labor share of less high school graduates
SH	Labor share of high school graduates
SC	Labor share of college graduates
SA	Labor share of agricultural sector
SM&M	Labor share of mining and manufacturing sector
SS	Labor share of service sector
BFf	Business fluctuation estimates
cCap	Contributions to capital input (capital growth*capital share)
cLab	Contributions to labor input (labor growth*labor share)
gGDP	Growth rate of GDP
gK	Growth rate of capital input
gL	Growth rate of labor input
TFPG-UN	Unadjusted TFP growth
TFPG-LQ	Labor quality (education)-adjusted TFP growth
TFPR-IS	Industry shift-adjusted TFP growth
TFPG-BF	Business fluctuation-adjusted TFP growth
gLP	Growth rate of labor productivity
EX	Export growth rate
IM	Import growth rate
RD-KOR	Ratio of R&D in Korea to GDP
FDI	Ratio of foreign direct investment to GDP
RD-USA	Ratio of R&D in USA to GDP
MAN-GDP	Ratio of manufacturing output to GDP

Appendix Table 2. Basic database for TFP growth estimation.

Year	GDP	K	L	Agri	M&M	Ser	S_K	S_L	S_M	S_H	S_C	S_A	$S_{M\&M}$	S_S
1970	40,838,261	85,139	10,759,400	0.3009	0.2525	0.4466								
1971	44,671,436	95,781	10,783,336	0.3050	0.2509	0.4440	0.3902	0.6098				0.4375	0.1548	0.4077
1972	47,440,196	106,541	10,849,989	0.2982	0.2603	0.4415	0.3996	0.6004	0.4933	0.2765	0.2302	0.4198	0.1595	0.4206
1973	54,795,678	120,277	11,008,590	0.2745	0.2863	0.4392	0.3921	0.6079	0.4844	0.2818	0.2338	0.4051	0.1716	0.4233
1974	59,469,011	136,273	11,638,535	0.2710	0.2953	0.4336	0.4056	0.5944	0.4697	0.2872	0.2431	0.3738	0.1930	0.4332
1975	64,012,862	154,713	12,417,570	0.2748	0.3019	0.4233	0.4523	0.5477	0.4689	0.2927	0.2384	0.3510	0.2060	0.4430
1976	72,618,105	177,378	12,650,277	0.2633	0.3200	0.4167	0.4724	0.5276	0.4598	0.3005	0.2397	0.3507	0.2201	0.4292
1977	81,051,982	207,229	12,953,890	0.2517	0.3188	0.4295	0.4587	0.5413	0.4600	0.2989	0.2411	0.3444	0.2349	0.4207
1978	88,958,502	243,647	13,176,512	0.2316	0.3183	0.4502	0.4310	0.5690	0.4525	0.3110	0.2365	0.3270	0.2402	0.4328
1979	95,835,256	284,142	13,381,281	0.2152	0.3255	0.4593	0.4097	0.5903	0.4374	0.3263	0.2362	0.3165	0.2404	0.4431
1980	92,827,209	321,245	13,824,560	0.1666	0.3338	0.4995	0.4053	0.5947	0.4371	0.3259	0.2370	0.3199	0.2401	0.4400
1981	99,483,814	357,722	14,072,869	0.1755	0.3388	0.4857	0.4166	0.5834	0.4393	0.3278	0.2329	0.3112	0.2493	0.4395
1982	107,650,297	398,859	14,333,995	0.1659	0.3365	0.4975	0.4239	0.5761	0.4226	0.3382	0.2392	0.2898	0.2553	0.4548
1983	121,004,904	447,204	14,630,530	0.1510	0.3447	0.5043	0.4126	0.5874	0.3985	0.3502	0.2513	0.2670	0.2564	0.4766
1984	132,730,645	500,643	14,685,777	0.1418	0.3489	0.5093	0.4067	0.5933	0.3784	0.3710	0.2506	0.2551	0.2625	0.4824
1985	142,605,123	557,237	14,868,934	0.1405	0.3400	0.5195	0.4200	0.5800	0.3604	0.3895	0.2501	0.2490	0.2642	0.4868
1986	159,873,380	619,120	15,470,270	0.1244	0.3548	0.5208	0.4359	0.5641	0.3422	0.3971	0.2608	0.2435	0.2653	0.4911
1987	179,309,591	691,215	16,028,116	0.1122	0.3600	0.5279	0.4356	0.5644	0.3232	0.4090	0.2678	0.2263	0.2784	0.4953
1988	199,579,699	777,160	16,644,497	0.1112	0.3623	0.5265	0.4211	0.5789	0.3026	0.4294	0.2680	0.2067	0.2907	0.5025
1989	212,271,292	876,262	17,322,798	0.1044	0.3458	0.5498	0.4032	0.5968	0.2842	0.4447	0.2711	0.1918	0.2855	0.5227
1990	232,848,571	999,007	18,211,719	0.0942	0.3278	0.5780	0.3877	0.6123	0.2680	0.4525	0.2795	0.1725	0.2670	0.5605
1991	256,047,706	1,139,900	18,462,842	0.0842	0.3277	0.5882	0.3762	0.6238	0.2477	0.4589	0.2934	0.1519	0.2553	0.5928
1992	271,372,726	1,285,386	18,740,460	0.0817	0.3215	0.5969	0.3759	0.6241	0.2251	0.4611	0.3138	0.1388	0.2505	0.6107
1993	288,028,273	1,441,104	19,045,868	0.0737	0.3224	0.6039	0.3846	0.6154	0.2185	0.4644	0.3170	0.1366	0.2452	0.6182
1994	313,099,898	1,613,314	19,380,516	0.0718	0.3252	0.6031	0.3874	0.6126	0.2174	0.4706	0.3120	0.1361	0.2412	0.6227
1995	343,941,473	1,806,029	19,829,804	0.0679	0.3274	0.6047	0.3811	0.6189	0.2021	0.4702	0.3278	0.1215	0.2482	0.6303
1996	367,887,882	2,017,761	19,466,986	0.0643	0.3226	0.6130	0.3620	0.6380	0.1806	0.4667	0.3527	0.1080	0.2572	0.6348
1997	389,373,412	2,233,150	19,254,783	0.0591	0.3239	0.6170	0.3609	0.6391	0.1622	0.4638	0.3741	0.1064	0.2551	0.6384
1998	365,447,594	2,338,596	19,357,758	0.0546	0.3451	0.6002	0.3900	0.6100	0.1456	0.4519	0.4025	0.1054	0.2548	0.6398
1999	405,745,501	2,445,447	19,389,909	0.0560	0.3432	0.6008	0.4171	0.5829	0.1323	0.4396	0.4281	0.1033	0.2666	0.6301

Appendix Table 3. Basic database for TFP growth estimation *(continued)*.

Year	BFf	cCap	cLab	gGDP	gK	gL	TFPG_UN	TFP_BF	TFPG_LQ	TFPG_IS	gLP
1970											
1971											0.0875
1972	0.0947	0.0425	0.0037	0.0601	0.1065	0.0062	0.0139	−0.0808	0.0369	0.0093	0.0540
1973	−0.0011	0.0475	0.0088	0.1441	0.1213	0.0145	0.0878	0.0889	0.0556	0.0796	0.1296
1974	0.0077	0.0506	0.0331	0.0818	0.1249	0.0556	−0.0019	−0.0096	−0.0378	−0.0290	0.0262
1975	−0.0451	0.0574	0.0355	0.0736	0.1269	0.0648	−0.0193	0.0259	−0.0317	−0.0535	0.0088
1976	0.0976	0.0646	0.0098	0.1261	0.1367	0.0186	0.0517	−0.0458	0.0425	0.0408	0.1076
1977	0.0847	0.0714	0.0128	0.1099	0.1555	0.0237	0.0257	−0.0590	0.0146	0.0131	0.0862
1978	0.0209	0.0698	0.0097	0.0931	0.1619	0.0170	0.0136	−0.0073	−0.0046	0.0037	0.0760
1979	0.0582	0.0630	0.0091	0.0745	0.1538	0.0154	0.0024	−0.0558	−0.0224	−0.0017	0.0590
1980	0.0618	0.0497	0.0194	−0.0319	0.1227	0.0326	−0.1010	−0.1628	−0.1284	−0.1069	−0.0645
1981	−0.0394	0.0448	0.0104	0.0693	0.1076	0.0178	0.0141	0.0534	0.0020	0.0084	0.0515
1982	0.0006	0.0461	0.0106	0.0789	0.1089	0.0184	0.0222	0.0216	−0.0031	0.0156	0.0605
1983	−0.0332	0.0472	0.0120	0.1169	0.1144	0.0205	0.0577	0.0909	0.0349	0.0499	0.0965
1984	0.0177	0.0459	0.0022	0.0925	0.1129	0.0038	0.0443	0.0267	0.0355	0.0440	0.0887
1985	−0.0103	0.0450	0.0072	0.0718	0.1071	0.0124	0.0196	0.0299	0.0062	0.0174	0.0594
1986	−0.0366	0.0459	0.0224	0.1143	0.1053	0.0396	0.0460	0.0827	0.0132	0.0277	0.0747
1987	0.0268	0.0480	0.0200	0.1147	0.1102	0.0354	0.0468	0.0200	0.0238	0.0325	0.0793
1988	−0.0210	0.0493	0.0218	0.1071	0.1172	0.0377	0.0359	0.0569	0.0085	0.0205	0.0694
1989	−0.0156	0.0484	0.0238	0.0617	0.1200	0.0399	−0.0106	0.0050	−0.0357	−0.0262	0.0217
1990	−0.0146	0.0508	0.0306	0.0925	0.1311	0.0500	0.0111	0.0257	−0.0174	−0.0081	0.0425
1991	−0.0531	0.0496	0.0085	0.0950	0.1319	0.0137	0.0368	0.0899	0.0203	0.0322	0.0813
1992	0.0234	0.0451	0.0093	0.0581	0.1201	0.0149	0.0037	−0.0197	−0.0155	−0.0017	0.0432
1993	0.0022	0.0440	0.0099	0.0596	0.1144	0.0162	0.0056	0.0034	0.0016	0.0000	0.0434
1994	−0.0340	0.0437	0.0107	0.0835	0.1129	0.0174	0.0291	0.0630	0.0188	0.0234	0.0660
1995	−0.0122	0.0430	0.0142	0.0939	0.1128	0.0229	0.0368	0.0490	0.0199	0.0294	0.0710
1996	−0.0109	0.0401	−0.0118	0.0673	0.1109	−0.0185	0.0390	0.0499	0.0375	0.0559	0.0858
1997	−0.0190	0.0366	−0.0070	0.0568	0.1014	−0.0110	0.0272	0.0462	0.0250	0.0447	0.0677
1998	0.0236	0.0180	0.0033	−0.0634	0.0461	0.0053	−0.0847	−0.1082	−0.0972	−0.0761	−0.0687
1999	−0.0023	0.0186	0.0010	0.1046	0.0447	0.0017	0.0850	0.0873	0.0800	0.1015	0.1029

Appendix Table 4. Basic database for TFP growth estimation *(continued)*.

Year	GEX	GIM	RD_KOR	GFDI	RD_USA	MAN
1970						0.2118
1971				−0.4737		0.2114
1972	0.5212	0.0533	0.29	2.0500	2.35	0.2228
1973	0.9857	0.6813	0.29	1.6066	2.36	0.2491
1974	0.3830	0.6159	0.5	−0.5189	2.23	0.2574
1975	0.1391	0.0617	0.42	0.3529	2.2	0.2587
1976	0.5185	0.2061	0.7	−0.6184	2.21	0.2738
1977	0.3021	0.2322	0.81	0.0633	2.15	0.2673
1978	0.2652	0.3849	0.76	0.7738	2.14	0.2663
1979	0.1845	0.3584	0.71	0.2819	2.19	0.2769
1980	0.1627	0.0960	0.77	−0.2513	2.29	0.2816
1981	0.2142	0.1723	0.81	0.0699	2.37	0.2835
1982	0.0282	−0.0720	1.02	0.2353	2.51	0.2788
1983	0.1186	0.0801	1.11	0.4233	2.56	0.2889
1984	0.1964	0.1695	1.29	0.5688	2.59	0.2967
1985	0.0355	0.0165	1.58	0.2607	2.69	0.2917
1986	0.1463	0.0144	1.73	−0.3327	2.8	0.3059
1987	0.3620	0.2988	1.81	1.9944	2.76	0.3119
1988	0.2837	0.2631	1.87	0.2079	2.71	0.3188
1989	0.0277	0.1863	1.9	−0.1511	2.68	0.3062
1990	0.0423	0.1363	1.88	−0.2633	2.73	0.2883
1991	0.1054	0.1672	1.94	0.7385	2.8	0.2901
1992	0.0662	0.0031	2.09	−0.3596	2.73	0.2874
1993	0.0731	0.0248	2.22	0.1678	2.61	0.2881
1994	0.1675	0.2231	2.45	0.2615	2.52	0.2903
1995	0.3025	0.3202	2.5	0.4784	2.61	0.2937
1996	0.0372	0.1126	2.6	0.6451	2.66	0.2886
1997	0.0497	−0.0381	2.69	1.1764	2.71	0.2889
1998	−0.0283	−0.3550	2.55	0.2700	2.74	0.3086
1999	0.0860	0.2838	2.47	0.7556	2.84	0.3074

MALAYSIA

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INTRODUCTION

Malaysia, as one of the fastest developing economies in this region, enjoyed rapid growth as reflected in GDP, which grew at an average of 6.7% during 1971–90 (Outline Perspective Plan [OPP1]) and 7.0% in 1991–2000 (OPP2). The economy grew at an average growth of 7.0% per annum and achieved the target set in OPP2, although the economy was affected by the Asian financial crisis in 1997–98 which saw GDP register negative growth of 7.5%. In 2001, the Malaysian economy registered a lower growth of 0.4% due to the slowdown of the world economy as compared to growth of 8.5% in 2000. Under OPP3, it is envisaged that GDP will grow at an average 7.5% per annum. The years after the economic crisis saw better economic performance due to demand from domestic consumption emerging from the recovery in private-sector activities and the impact of government measures to consolidate for future growth. In addition, the manufacturing sector continued to maintain its position as the leading sector, contributing 31.5% of GDP in 2001.

ECONOMIC OVERVIEW

Sources of Economic Growth and Development

In the past, Malaysian economic growth was stimulated by investment, with capital accumulation contributing more than 50% to productivity growth. Both the Seventh Malaysia Plan (1996–2000) and Eighth Malaysia Plan (2001–05) stipulated a shift in national development strategy from one that is input driven to productivity driven. This strategy is further emphasized in OPP3 (2001–10), which focuses on achieving sustainable growth through productivity improvement with the emphasis on increasing the contribution of total factor productivity (TFP) to output. Table 1 depicts the contributions to economic growth by labor, capital, and TFP for different OPP periods.

Table 1. Contribution of factors of production, TFP, and GDP growth to economic growth (%).

Period	Labor	Capital	TFP	GDP growth
OPP1 (1971–90)				

Continued...

...Continued

% Contribution	2.4	3.4	0.9	6.7
% of Total	36.1	50.9	13.0	100.0
OPP2 (1991−2000)				
% Contribution	1.7	3.5	1.8	7.0
% of Total	24.3	50.2	25.5	100.0
OPP3 (2001−10)				
% Contribution	1.6	2.7	3.2	7.5
% of Total	20.9	36.6	42.5	100.0

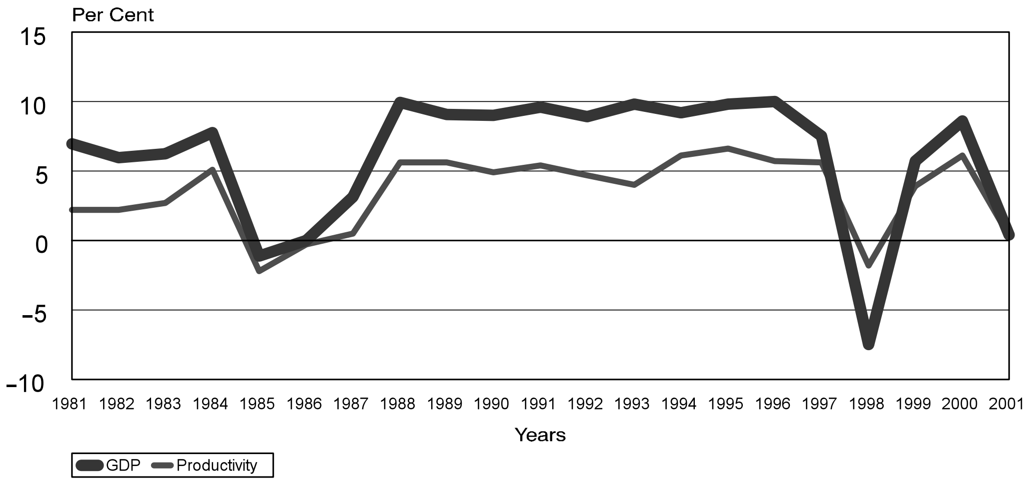
Source: Third Outline Perspective Plan (2001−10).

Trends in Productivity and GDP Growth

Productivity and GDP growth were plotted to illustrate the relationship between them, and the results are presented in Figure 1.

There is a positive relationship between productivity and GDP growth in Malaysia. The improvement in productivity after 1985 was the result of government efforts to create a favorable investment climate, and capital investment recorded double-digit growth and more job opportunities were created. The increasing productivity trend was also due to productivity improvements arising from initiatives taken by both the public and private sectors. In this context, several measures were undertaken to raise the productivity of labor and TFP. This steady growth in productivity enabled the economy to achieve higher growth in the 1990s.

Figure 1. Growth rate of GDP and productivity.



Growth and Structural Change in the Malaysian Economy

The Malaysian economy has been in a turnaround stage since 1986 in the effort to industrialize. Outward-oriented industralization approaches were thus the major thrust. The switch to a liberalized, export-oriented industralization strategy, especially after the recession period of 1986, gave fresh impetus to industrial growth. Since then, the manufacturing and service sectors have become more important and their shares in GDP have increased, while that of agriculture declined from 23% in 1981 to as low as 8.15% in 2001 (Table 2). The manufacturing sector share in GDP grew from 19.7% in 1981 to 29.79% in 2001.

Table 2. Production structure of the Malaysian economy (% share of GDP), 1981−2001.

Sector	1981	1990	1995	2001
Agriculture	23.0	18.4	13.23	8.15
Manufacturing	19.7	26.5	32.35	29.79
Transport	6.1	6.6	7.11	7.88
Commerce/trade	12.3	11.0	11.84	14.33
Finance	8.5	9.6	10.43	12.44

Source: Economic Report, Economic Planning Unit, Prime Minister's Office.

There is evidence of a sizable movement of the labor force among sectors (Table 3). The employment share of agricuture declined from 37.2% in 1981 to 17.42% in 2001. On the other hand, the share of employment in the service and manufacturing sectors increased. The share of employment in the manufacturing sector increased from 15.5% in 1981 to as high as 24.5% in 2001.

Table 3. Employment structure of the Malaysian economy (% share of employment), 1981−2001.

Sector	1981	1990	1995	2001
Agriculture	37.2	27.8	18.13	17.42
Manufacturing	15.5	19.5	25.71	24.50
Transport	3.9	4.3	5.01	5.05
Commerce/trade	14.9	18.7	16.85	17.47
Finance	2.9	3.5	4.81	4.94

Source: Economic Report, Economic Planning Unit, Prime Minister's Office.

METHODOLOGY

Estimation of TFP

The measurement of TFP is related to the specification and estimation of the production function. The model used here attempts to estimate TFP based on the growth accounting framework pioneered by Solow (1957). TFP is the residual and is considered to represent the rate of technical change. Growth accounting is a statistical technique for dividing the growth of output into two sources: the growth of a variety of inputs, such as investment in physical capital or increases in size of labor; and the growth of TFP on the other. TFP is the economic and technical efficiency with which resources such as capital and labor are converted into output. Based on this framework, the mathematical presentation of the model used is given below. The equations used to compute the sources of economic and productivity growth are derived using a production function:

$$Q = f(K, L) \qquad \text{(Eq. 1)}$$

where Q = output or GDP, K = capital, and L = number of workers.

By including a time variable (t, assumed due to technical progress), the resulting shifts of the production function can be represented by:

$$Q_t = f(K_t, L_t, t) \qquad \text{(Eq. 2)}$$

thus implying that the same input quantities yield a different outputs at different points of time.

Assuming that technical progress is both neutral and disembodied (Solow, 1957), the production function in Eq. 2 can be expressed as:

$$Q_t = A(t),.f(K_t, L_t) \qquad \text{(Eq. 3)}$$

where Q_t, K_t, and L_t = output and factor inputs during period t, and A(t) = technical progress or TFP as a function of time.

Differentiating Eq. 3 with respect to time and denoting the derivatives by putting a dot over the variable,

$$dQ/dt = \dot{Q} \text{ we have}$$

$$\dot{Q} = \dot{A}.f(K_t, L_t) + A.\frac{\partial f}{\partial K}.\dot{K} + A.\frac{\partial f}{\partial L}.\dot{L} \qquad \text{(Eq. 4)}$$

Dividing throughout by Q leads to an expression for the proportionate rate of change in output:

$$\frac{\dot{Q}}{Q} = \dot{A}.f(K_t, L_t)/Q + \dot{A}.\frac{\partial f}{\partial K}.\frac{\dot{K}}{Q} + A.\frac{\partial f}{\partial L}.\frac{\dot{L}}{Q} \qquad \text{(Eq. 5)}$$

$$\frac{\dot{Q}}{Q} = \dot{A}.f(K_t, L_t)/Q + \dot{A}.\frac{\partial f}{\partial K}.\frac{K}{Q}.\frac{\dot{K}}{K} + A.\frac{\partial f}{\partial L}.\frac{L}{Q}.\frac{\dot{L}}{L} \qquad \text{(Eq. 6)}$$

Solow (1957) assumed that factor inputs are paid the value of their marginal products under competitive equilibrium conditions, so that:

$$\frac{\partial Q}{\partial K} = A.\frac{\partial f}{\partial K} = \frac{r}{p}$$

$$\frac{\partial Q}{\partial L} = A.\frac{\partial f}{\partial L} = \frac{w}{p} \qquad \text{(Eq. 7)}$$

where p = prices of output, r = prices of capital inputs, and w = prices of labor inputs.

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + \frac{rK}{pQ}.\frac{\dot{K}}{K} + \frac{wL}{pQ}.\frac{\dot{L}}{L} \qquad \text{(Eq. 8)}$$

In Solow's notation, the shares of capital and labor are denoted by $w_K = r.K/p.Q$ and $w_L = W.L/p.Q$, respectively, and thus with this assumption Eq. 8 becomes:

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + w_k.\frac{\dot{K}}{K} + w_L.\frac{\dot{L}}{L} \qquad \text{(Eq. 9)}$$

Further, assuming constant returns to scale, where a percentage change in inputs leads to the same percentage change in output, the following holds:

$W_K + W_L = 1$

Therefore Eq. 9 becomes:

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + w_k.\frac{\dot{K}}{K} + (1 - w_k).\frac{\dot{L}}{L} \qquad \text{(Eq. 10)}$$

where

$\dot{Q}/Q$ = proportionate rate of change in output,
$\dot{A}/A$ = proportionate rate of change in technical progress or TFP,
$\dot{K}/K$ = proportionate rate of change in capital, and
$\dot{L}/L$ = proportionate rate of change in labor.

Sources of TFP Growth

TFP growth is defined as the residual of output growth. Hence it includes the effects of various elements. In this study, the sources of TFP growth were based on Denison's method and those of Professor Noriyoshi Oguchi. The estimation of the sources of TFP growth are outlined below.

Education and Training

In the estimation, education level was used as a proxy to indicate the effect of change in education level on TFP. Basically, Denison assumed that, on the average, the ratio of the actual wage rates of workers in the various labor subgroups are proportional to the ratio of their respective marginal productivity, thus using the wage ratio as the weight to arrive at the total employment figure. In this paper, the figures at national level were collected for the three categories of primary, secondary, and tertiary education. Based on the model, the wage rate of each category was computed to reflect changes in worker efficiency.

Economic Restructuring

Productivity growth of the sector depends on the maturity and resource availability. As workers move from lower-productivity to higher-productivity sectors, the overall productivity of the country will improve. In this respect, the marginal productivity of each sector is reflected in the wage rates. The wage rate ratio in each sector was compiled against employment in each sector. The wage rate ratio of each sector was then compared with that in the manufacturing sector and the relative productivity of labor in each sector was derived. The weighted sum of employment using the wage rate ratio as the weight gives employment in efficiency units. The computation of the TFP growth rate uses this employment efficiency unit, and thus we obtain the difference in two TFP growth rates. This difference then gives the effects of the shift of employment from sector to sector.

Demand Intensity

Business fluctuation affects the capacity utilization of machinery and equipment. A high fluctuation of demand intensity indicates increased capacity utilization due to high demand for output. A recession may result in underutilization of machinery and equipment. To compute demand intensity, the following steps were taken.

First, boom years when the economy was operating at full capacity were identified. Using data from those years, the estimated production function provides the level of full capacity utilization. Second, the theoretical value of the production function and the actual values of factor inputs were estimated. The ratio of the actual production level to the theoretical value of production is taken as the rate of capacity utilization. Finally, the rate of change in the rate of capacity utilization represents the effect of business fluctuation. Subtracting this rate of change from TFP growth yields the technical change.

Capital Structure

Capital structure relates to the proportion of investment in productive capital inputs. Investment in machinery and equipment, which are productive capital inputs, yields immediate output as compared with infrastructure, plant, and buildings that have longer lag times. In this paper, the different types of capital figure were compiled, consisting of structures, transport equipment, and plant and machinery. The user cost approach of Denison was adopted in analyzing changes in the efficiency of capital composition. The data were derived similarly as those for education and training by computing the relative efficiency of these capital inputs.

Technical Progress

Other qualitative factors not captured by either changes in education and training or capital structure are defined as technical progress, that is, the "residual." By deducting TFP growth from education and training, capital structure, economic restructuring, and demand intensity technical progress can be computed. In general, technical progress indicates the effective and efficient utilization of technology, innovation, management, and organizational effectiveness.

Data Sources

Output

This study uses various published data. GDP was obtained from the Department of Statistics (DOS) and was used as output in computing TFP at the national level. The data were adjusted to cover GDP for 1981 to 2001 using 1987 prices.

Employment

The national employment figures were from the Economic Planning Unit, Prime Minister's Office, and the DOS.

Capital Stock

Capital stock data are not available for Malaysia. However, data on gross fixed capital formation are published by the Ministry of Finance in the economic reports. Data for decomposition were obtained from the DOS and Central Bank Report for the overall computation.

Labor Share of Income

The share of labor income was computed from the national accounts statistics. The data on compensation were divided by the number of employed persons to obtain compensation per worker. The growth rate series were used to interpolate per-worker compensation data series for years when data were not available. The per-worker compensation was then multiplied by the number of employed to derive the total labor income. The ratio of total labor income to national income is the share of labor income (Appendix Table 1).

Capital Share

The capital share is computed by taking 1 minus the labor share (Appendix Table 1).

RESULTS

TFP Growth of the Malaysian Economy

TFP growth for Malaysia during 1981−2001 is presented in Table 4. TFP growth was negative during the early 1980s due to the input-driven economy. This is reflected by the capital stock, which was growing at double digits, registered more than 13.0 %, and was at its peak in 1981 at 13.70%. However, after the second half of the 1980s, TFP growth was positive, with the highest growth of 5.9% achieved in 1988, mainly due to the industrial programs initiated by the government.

Table 4. Output, capital stock, employment, and TFP growth, 1981−2001 (1987 prices).

Year	Rate of growth (%)				
	Output	Productivity	Capital stock	Employment	TFP
1981	6.94	2.2	13.70	4.63	−1.0

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1982	5.94	2.2	12.74	3.71	-1.0
1983	6.25	2.7	12.09	3.98	-0.7
1984	7.76	5.1	10.91	2.02	2.6
1985	-1.12	-2.2	8.36	1.51	-5.1
1986	-0.02	-0.3	5.57	1.93	-3.3
1987	3.14	0.5	4.82	3.87	-1.1
1988	9.94	5.6	5.65	3.19	5.9
1989	9.06	5.6	6.12	3.48	4.6
1990	9.01	4.9	7.92	4.63	3.2
1991	9.55	5.4	9.39	3.07	3.9
1992	8.89	4.7	9.57	2.97	2.9
1993	9.89	4.0	10.51	4.24	3.4
1994	9.21	6.1	11.20	2.78	3.4
1995	9.83	6.6	12.68	6.36	2.29
1996	10.00	5.7	12.06	5.21	2.5
1997	7.54	5.6	11.67	1.50	2.6
1998	-7.50	-1.8	4.49	-0.45	-8.4
1999	5.74	3.9	3.75	3.08	2.6
2000	8.60	6.1	5.07	4.62	3.9
2001*	0.4	0.3	5.36	-0.80	-0.6

*Estimated.
Source: National Productivity Corporation; Economic Planning Unit, Prime Minister's Office; economic reports of the Ministry of Finance, various years.

The actual turnaround for rapid economic growth can be traced to the implementation of the Industrial Master Plan (IMP) 1986 sponsored by UNIDO. The IMP has been an important program in Malaysian industralization. Reflected by the increasing trend in GDP, productivity, capital, and labor inputs after the inception of the IMP, further TFP growth was recorded after 1986 except in 1998 and 2001 when negative growth rates of -8.4% and -0.6%, respectively, were recorded due to the recession and worldwide economic slowdown (Figure 2). Slower growth rates recorded during the second half of the 1990s were mainly due to the lower demand affecting capacity utilization.

Our estimates clearly show that, throughout the period under study, the growth in output was driven by input growth, especially by that of capital.

Estimates of TFP Growth in Other Studies

Table 5 lists various estimates of TFP growth at the national level obtained from other studies. The results vary with the different sources of data and methods of computation adopted.

Figure 2. Growth rate of GDP, employment, TFP, productivity, and capital.

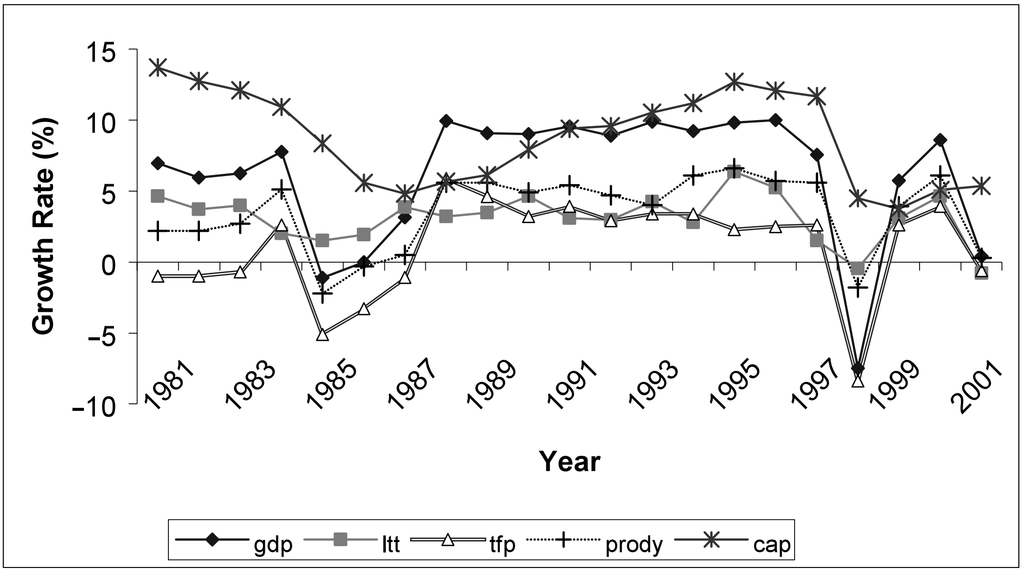

Table 5. Summary of the results of selected studies on TFP growth (TFPG) for Malaysia.

Author	Period of study	Method	Conclusion
Syrquin (1991) as reported in Toh & Lim (1992)	1960–89	Growth accounting	TFPG of 3% for 1960–70 and 0.5% for 1980–89
Thomas & Wang (1992)	1960–87	Econometric estimation of Cobb–Douglass production function	TFPG of 2%. Government interventions implemented more efficiently in East Asia than in other regions during this period
World Bank (1993)	1960–90	Econometric estimation of Cobb–Douglass production function	TFPG –1.3%. Rapid growth of East Asia attributed to more efficient accumulation of physical & human capital
Gan & Robinson (1993)	1975–91	Econometric estimation of production function	TFP was negative during first half of 1980s; made positive contributions to economic growth after 1985
Zarina & Shariman (1994)	1978–92	Econometric estimation of production function	Negative value of TFPG
Kawai (1994)	1970–90	Growth accounting	TFP 2.5% 1970–80 & 0.7% 1980–90. Capital accumulation explains rapid growth of developing countries

Continued...

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Gan & Soon (1996)	1974–95	Growth accounting with factor shares estimated econometrically	TFPG 1.6% 1974–95 & 2.2% 1990–95
Ab. Wahab	1980–97	Growth accounting	TFPG 1.3% 1990–97

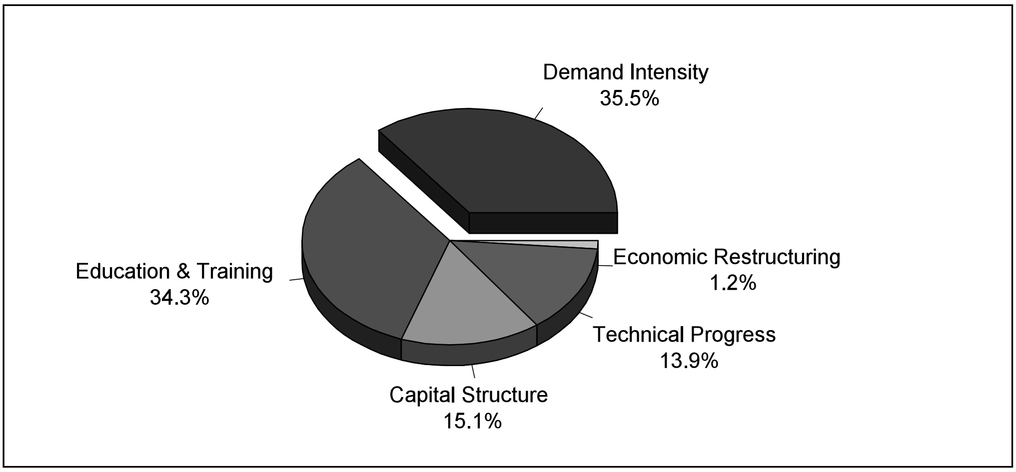
Source: APO, 2001.

Sources of TFP Growth

Sources of TFP Growth at National Level

The main contributors to TFP growth were decomposed by capital structure, education and training, demand intensity, economic restructuring, and technical progress. During 1991–2001, the main contributor to TFP growth was registered by demand intensity (35.5%), followed by education and training (34.3%), capital structure (15.1%), technical progress (13.9%), and economic restructuring (1.2%) (Figure 3).

Figure 3. Sources of TFP growth at national level, 1991–2001.



Source: National Productivity Corporation.

Demand intensity indicates the extent of productive capacity of the economy. A slowdown in demand intensity indicates lower capacity utilization and is reflected in sales performance. Implementation of the first IMP (IMP1) in 1986 marked the beginning of emphasis on the development of an industrialized nation focusing on the manufacturing sector as the engine of growth. This resulted in the expansion of the manufacturing sector and a significant increase in the export of Malaysian manufactured products. The manufacturing sector alone constituted 58.8% of total exports in 1990, valued at RM46,841 million. This share expanded to 85.2% in 2000, valued at RM317,937 million (Table 6).

Table 6. Merchandise trade.

Sector	Value (RM million)		% of Total	
	1990	2000	1990	2000
Manufacturing	46,841	317,937	58.8	85.2
Agriculture & forestry	15,621	22,914	19.6	6.1
Mining	14,573	26,801	18.3	7.2
Other	2,611	5,657	3.3	1.5
Total	79,646	373,307	100.0	100.0

Source: OPP3.

Analysis of demand intensity showed that it was the main contributor to TFP growth from 1991 to 2001. Demand intensity recorded positive growth during those years, except during the recession in 1998. On average, the growth in demand intensity was 0.56% in those years (Appendix Table 2).

Education and training of the workforce enable skill upgrading and expansion in knowledge. More highly skilled workers are able to produce better-quality products and services, thus enabling increases in TFP growth. The present results showed that the second most important contributor to TFP growth in Malaysia from 1991 to 2001 was education and training. On average, the growth in education and training was 0.54%.

In line with the IMP and government initiatives to achieve industrialization, increasing the level of education and skills of the workforce was emphasized to enable them to participate actively in the economy. The educational structure has changed significantly over the years, with those in the lower and middle secondary category, which accounted for 57.4% in 1990, expanding to 58.8% in 2000. More profoundly, those with tertiary-level education almost doubled from 8.8% in 1990 to 14.0% in 2000 (Table 7). The databases consulted also showed that Malaysia received a positive contribution in terms of education and training over the period 1991 to 2001, except in 1998 (Appendix Table 2).

Table 7. Changes in educational structure.

Level of education	1990	%	2000	%
Primary	2,380.2	33.8	2,604.3	27.2
Lower & middle secondary	4,042.1	57.4	5,624.5	58.8
Tertiary	619.7	8.8	1,343.7	14.0

Source: OPP3.

Capital structure reflects the productive capital investment in machinery and equipment which will improve production efficiency. The contribution of capital structure to TFP growth during the period 1991 to 2001 was the third largest. This study showed that the contribution of capital structure was negative for 1991, 1992, and 1993. The negative results were mainly due to the gestation period or lag time required for capital investment to be realized. On average, the growth in terms capital structure from 1991 to 2001 was 0.24% (Appendix Table 2).

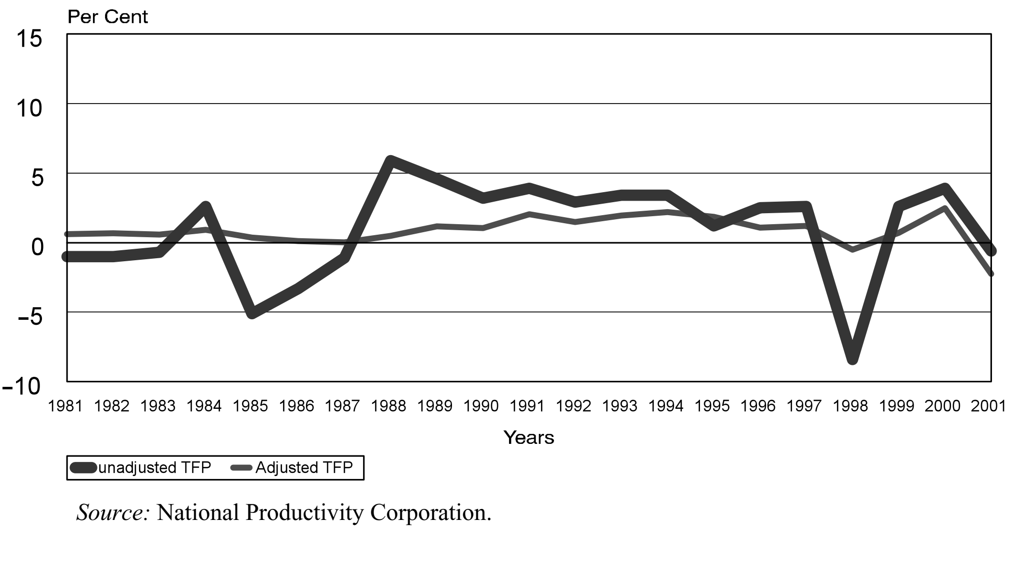
Technical progress indicates the effective and efficient utilization of technology, innovation, management, and organizational effectiveness. Technical progress contributed significantly to TFP growth during the early 1990s. However, it was negative during 1994 to 1997 and during the worldwide slowdown in 2001. The contribution of technical progress was positive for other years. On average, the technical progress growth rate was 0.22% from 1991 to 2001 (Appendix Table 2).

Economic restructuring refers to the movement of resources from less productive to more productive sectors of the economy. Economic restructuring contributed the least to TFP growth over the period 1991 to 2001. On an average, the growth rate was 0.02% over the period analyzed. The contribution from economic restructuring was negative in 1995 and from 1999 to 2001 (Appendix Table 2).

ADJUSTED TOTAL FACTOR PRODUCTIVITY GROWTH

The adjusted TFP growth was derived by taking the existing TFP growth known as unadjusted TFP discounted by the growth in demand intensity. In the case of Malaysia, the unadjusted TFP and adjusted TFP were plotted to determine the trend in terms of the "true" TFP growth (Figure 4). Over the period 1981 to 2001, it was found that the trend in unadjusted and adjusted TFP showed a similar trend, except that the actual TFP was smaller in value terms. Being a small and open economy, Malaysia is dependent on exports and the demand for its products, especially from the manufacturing sector. Therefore emphasis should be given to increasing TFP growth by increasing other factors such as capital structure, quality of labor, and technical progress.

Figure 4. Unadjusted and adjusted TFP growth (without business fluctuation).



Source: National Productivity Corporation.

FACTORS AFFECTING TFP GROWTH : EMPIRICAL RESULTS

Regression analysis was undertaken to examine possible determinants of TFP in Malaysia from 1981 to 2000. The regression analysis was computed to establish whether there is a statistically significant relationship between the unadjusted TFP growth which can be explained by differences in tertiary education, share of manufacturing GDP, number of quality control circles (QCCs), and share of exports in GDP during that period. The following formulae were used:

$TFPG = f(xi)$ where $I = 1, \ldots\ldots n$; and xi is in terms of growth rate

$= a + b1x1 + b2x2 + \ldots.. t\, bnXn + e$

and thus

$$\hat{TFPG} = a + b1\hat{x}1 + b2\hat{x}2 + \ldots\ldots bn\hat{X}n$$

The independent variables are $X1$ = growth in ratio of tertiary education/number of employees, $X2$= growth in the share of manufacturing/GDP, $X3$ = growth in the number of QCCs, $X4$ = growth in share of exports/GDP, and $TFPG$ is the dependent variable, so that:

TFPG = f(tertiary education [+], *share of manufacturing in GDP* [+], *number of QCCs* [+], *and share of exports in GDP* [+])

where the expected signs on the coefficients of the explanatory variables are shown in brackets.

We established two regression equations for different periods. The first covers the period from 1981 to 2001 and the second that from 1984 to 2001. The reason for having two period regression equations is to determine whether any of the productivity initiatives undertaken by the National Productivity Corporation such as QCCs, which only started during the late 1980s, had any impact on TFP growth. Tables 8 and 9 (both in series form) list the results of the regression analysis.

Table 8 (series). Summary of regression analysis results: Factors affecting TFP growth at national level, where the dependent variable is unadjusted TFP growth, 1981–2001.

(i) Independent variables: MFGGDP_G, EDULTT_G, FDIGDP_G
Model summary

Model	R	R square	Adjusted R square	SE of the estimate	Durbin-Watson
1	0.598	0.358	0.245	3.073	1.313

MFGGDP_G, EDULTT_G, FDIGDP_G.
Dependent variable, unadjusted TFP growth.

Continued...

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ANOVA

Model		Sum of squares	Df	Mean square	F	P
1	Regression	89.507	3	29.836	3.160	0.052
	Residual	160.520	17	9.442		
	Total	250.027	20			

Predictors (constant), MFGGDP_G, EDULTT_G, FDIGDP_G.
Dependent variable, unadjusted TFP growth.

Coefficients

		Unstandardized coefficients	SE	Standardized coefficients	t	P
Model		B		Beta		
1	(Constant)	−0.421	0.925		−0.455	0.655
	FDIGDP_G	7.071E−04	0.018	0.008	0.039	0.970
	EDULTT_G	1.562E−02	0.045	0.069	0.349	0.731
	MFGGDP_G	.432	0.152	0.583	2.847	0.011*

Dependent variable, unadjusted TFP growth.

Residual statistics

	Minimum	Maximum	Mean	SD	n
Predicted value	−3.208	4.016	1.067	2.115	21
Residual	−6.256	3.191	3.595E−16	2.833	21
Std. predicted value	−2.021	1.394	0.000	1.000	21
Std. residual	−2.036	1.038	0.000	0.922	21

Std., standard.
Dependent variable, unadjusted TFP growth.
Source: National Productivity Corporation.
*Significant at 5% level.
Edultt_G, growth in ratio of education/number of employees; MFGGDP_G, growth in share of manufacturing GDP/GDP; FDIGDP_G, growth in ratio of FDI/GDP.

(ii) Independent variables: MFGGDP_G, EDULTT_G,
Model summary

Model	R	R square	Adjusted R square	SE of the estimate	Durbin-Watson
1	0.598	0.358	2.986	2.986	1.325

Predictors (constant), MFGGDP_G, EDULTT_G.
Dependent variable, unadjusted TFP growth.

Continued...

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ANOVA

Model		Sum of squares	df	Mean square	F	P
1	Regression	89.493	2	44.746	5.017	0.019
	Residual	160.534	18	8.919		
	Total	250.027	20			

Predictors (constant), MFGGDP_G, EDULTT_G.
Dependent variable, unadjusted TFP growth.

Coefficients

		Unstandardized coefficients	SE	Standardized coefficients	t	P
Model		B		Beta		
1	(Constant)	−0.414	0.880		−0.470	0.644
	EDULTT_G	1.542E−02	0.043	0.068	0.357	0.725
	MFGGDP_G	0.433	0.141	0.585	3.070	0.007*

Dependent variable, unadjusted TFP growth.

Residual statistics

	Minimum	Maximum	Mean	SD	n
Predicted value	−3.203	4.027	1.067	2.115	21
Residual	−6.222	3.254	0.000	2.833	21
Std. predicted value	−2.018	1.400	0.000	1.000	21
Std. residual	−2.083	1.090	0.000	0.949	21

Std., standard.
Dependent variable, unadjusted TFP growth.
Source: National Productivity Corporation.
*Significant at 5% level.
Edultt_G, growth in ratio of education/number of employees; MFGGDP_G = growth in share of manufacturing GDP/GDP.

(iii) Independent variables: MFGGDP_G
Model summary

Model	R	R square	Adjusted R square	SE of the estimate	Durbin-Watson
1	0.594	0.353	0.319	2.917	1.328

Predictors (constant), MFGGDP_G.
Dependent variable, unadjusted TFP growth.

Continued...

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ANOVA

Model		Sum of squares	df	Mean square	F	P
1	Regression	88.356	1	88.356	10.384	0.004
	Residual	161.670	19	8.509		
	Total	250.027	20			

Predictors (constant), MFGGDP_G.
Dependent variable, unadjusted TFP growth.

Coefficients

		Unstandardized coefficients	SE	Standardized coefficients	t	P
Model		B		Beta		
1	(Constant)	−0.267	0.759		−0.351	0.729
	MFGGDP_G	0.440	0.137	0.594	3.222	0.004*

Dependent variable, unadjusted TFP growth.

Residual statistics

	Minimum	Maximum	Mean	SD	n
Predicted value	−3.150	4.135	1.067	2.102	21
Residual	−6.357	3.103	1.269E−16	2.843	21
Std. predicted value	−2.006	1.460	0.000	1.000	21
Std. residual	−2.179	1.064	0.000	0.975	21

Std., standard.
Dependent variable, unadjusted TFP growth.
Source: National Productivity Corporation.
*Significant at 5% level.
MFGGDP_G, growth in share of manufacturing GDP/GDP.

The results in the Table 8 series show that over the period 1981 to 2001, there was a positive relationship between the share of manufacturing in GDP and TFP growth. The transfer of resources including labor from an activity with low marginal productivity to a higher one should increase overall output. In Malaysia, there has been a shift of labor away from the agricutural sector, which has lower productivity, to other sectors such as manufacturing. The inclusion of the ratio of the manufacturing sector to GDP in the regression analysis confirmed that labor movement toward the manufacturing sector increased efficiency and was favorable to TFP growth.

Table 9 (series). Summary of regression analysis results: Factors affecting TFP growth at national level with the dependent variable of unadjusted TFP growth, 1984–2001.

(i) Independent variables : LAG_EXP2, QCC_PERC, MFGGDP_G

Model summary

Model	R	R square	Adjusted R square	SE of the estimate	Durbin-Watson
1	0.769	0.592	0.504	2.626	1.897

Predictors (constant), LAG_EXP2, QCC_PERC, MFGGDP_G.
Dependent variable, unadjusted TFP growth.

ANOVA

Model		Sum of squares	df	Mean square	F	P
1	Regression	139.916	3	46.639	6.765	0.005
	Residual	96.513	14	6.894		
	Total	236.429	17			

Predictors (constant), LAG_EXP2, QCC_PERC, MFGGDP_G.
Dependent variable, unadjusted TFP growth.

Coefficients

		Unstandardized coefficients	SE	Standardized coefficients	t	P
Model		B		Beta		
1	(Constant)	2.009	1.128		1.782	0.096
	QCC_PERC	−8.216E−02	0.027	−0.516	−3.013	0.009*
	MFGGDP_G	0.426	0.139	0.562	3.070	0.008*
	LAG_EXP2	6.716E−03	0.059	0.021	0.114	0.911

Dependent variable, unadjusted TFP growth.

Residual statistics

	Minimum	Maximum	Mean	SD	n
Predicted value	−7.121	4.408	1.394	2.869	18
Residual	−4.745	3.653	−2.035E−16	2.383	18
Std. predicted value	−2.968	1.051	0.000	1.000	18
Std. residual	−1.807	1.391	0.000	0.907	18

Std., standard.
Dependent variable, unadjusted TFP growth.
Source: National Productivity Corporation.
*Significant at 5% level.
QCC_PERC, growth in number of QCCs; MFGGDP_G, growth in share of manufacturing GDP/GDP; LAG_EXP2, lag growth in share of exports in GDP.

The results in the Table 9 series show that from 1984 to 2001, there was a positive relationship between the share of manufacturing to GDP in total GDP and TFP growth. However, there was also a significant relationship between QCC initiatives and TFP growth. Although the result is negatively significantly related, it is assumed that the inconsistency in the number of QCCs during the early years after their introduction had a negative effect.

PRODUCTIVITY CHALLENGES

Based on the results of this study, the following are the major challenges in creating a sustainable, resilient Malaysian economy.

Productivity- and Quality-driven Growth

Transforming the economy from investment-driven to a productivity- and quality-driven one will require enhancement of the efficiency of labor and capital as well as improvement in management and innovation.

Shifts to Higher Value-added Activities

Accelerating to higher value-added activities that are labor saving and acquiring more capital- and technology-intensive production processes require integration of human resources and technology development policies and programs as well as concerted efforts to venture into new frontiers of development.

Science and Technology and R&D

Strengthening science and technology and enhancing R&D activities to harness the nation's technological capabilities as well as taking advantage of advances in information technology will enable the development of a knowledge-based society.

POLICY IMPLICATIONS

Continous improvements in productivity can be achieved by improving human resources development and intensifying R&D and other initiatives. For example, in the area of human resources development Malaysia should:

1) increase investment in science and technological education and develop technical and research manpower;
2) emphasize developing scientists, researchers, technologist, and educators, while fostering creativity and innovativeness and raising the general science and technology awareness level;
3) increase the human resources development fund to stimulate private investment in the training and retraining of workers; and
4) encourage small and medium enterprises to utilize innovative technologies to improve their operations and increase their information technology literacy.

In the area of R&D, the country should seek to:
1) increase funding for R&D;
2) establish centers of excellence within and among R&D agencies and internationally;
3) encourage close working relationships among R&D agencies to improve technology innovation activities and ensure that the knowledge and skills are industry related;
4) promote cofinancing and joint programs in research among the public and private sectors and internationally; and
5) extend the intensification of research in priorities areas to the private sector.

In terms of management and organization, qualitative improvements in economic entities are crucial to increase TFP. There should be structural changes and increased investment in human resources development at firm level to ensure efficient utilization and management of new technologies and systems. Management is responsible for raising the productivity and competitiveness of firms. This requires worker cooperation. It is vital for management to implement productivity- and quality-related programs such as total quality management, total preventive maintenance, or benchmarking in the quest to increase productivity and quality.

Finally, machinery and equipment are essentials in the production process. Firms should invest in new technologies and acquire the appropriate technical know-how to improve productivity. Investment in more advanced technologies will result in long-term cost savings due to fewer defective products. In addition, higher investment will led to higher capital-labor ratios, thus enabling firms to produce higher output.

CONCLUSIONS

This paper analyzes TFP growth and its sources in the Malaysian economy from 1981 to 2001. In addition, it attempted to identify the factors affecting TFP growth at the national level. On average, the growth rate of GDP in Malaysia was 6.6% from 1991 to 2001. During that period, the economy recorded an annual employment growth of 1.9% and capital stock growth of 3.1%. TFP growth at the national level during this period was 1.5% per annum. Such growth was mainly due to demand intensity (which contributed about 35.5%), followed by education and training (34.3%), capital structure (15.1%), technical progress (13.9%), and economic restructuring (1.2%).

Over the period from 1981 to 2001, the trends in unadjusted and adjusted TFP were similar trend, except that the actual TFP was smaller in value terms. Being a small and open economy, Malaysia depends very heavily on exports and demand for its products, especially from the manufacturing sector. Therefore emphasis should be given to increasing TFP growth by increasing other factors such as capital structure, quality of labor, and technical progress.

In terms of factors affecting TFP growth in Malaysia, the share of manufacturing in GDP growth showed a positive relationship with TFP growth throughout the period from 1981 to 2001. The implementation of the IMP positively affected economic performance as activities changed from traditional to manufacturing-based activities. The transfer of resources including labor from sectors with low marginal productivity to those with higher activity increased overall output. In Malaysia, there has been a shift of labor away from the agricutural sector, which has lower productivity, to other sectors such as manufacturing and this had a positive impact on TFP growth.

In efforts to create a sustainable economy, a productivity-driven strategy was formulated which emphasizes productivity and quality initiatives. This saw greater efforts such as QCC activities. The results of regression analysis from 1984 to 2001 confirmed that QCC activities significantly affected TFP growth.

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APPENDIX. DATA USED TO COMPUTE TFP GROWTH.

Appendix Table 1. Share of labor and capital.

Year	Labor share	Capital share
1981	0.36	0.64
1982	0.36	0.64
1983	0.39	0.61
1984	0.40	0.60
1985	0.37	0.63
1986	0.36	0.64
1987	0.41	0.59
1988	0.41	0.59
1989	0.37	0.63
1990	0.34	0.66
1991	0.33	0.67
1992	0.34	0.66
1993	0.35	0.65
1994	0.34	0.66
1995	0.34	0.66
1996	0.33	0.67
1997	0.41	0.59
1998	0.41	0.59
1999	0.41	0.59
2000	0.41	0.59
2001	0.41	0.59

Appendix Table 2. Sources of TFP growth (TFPG).

Year	TFPG	Education & training	Capital structure	Demand intensity	Economic restructuring	Technical progress
1981	−1.0	8.7	NA	−1.60	0.44	0.20
1982	−1.0	0.08	NA	−1.68	1.30	−0.72
1983	−0.7	0.07	NA	−1.27	0.15	0.40
1984	2.6	0.09	NA	1.67	0.01	0.77
1985	−5.1	0.26	NA	−5.46	0.13	−0.03
1986	−3.3	0.36	NA	−3.40	0.26	−0.48
1987	−1.1	−0.15	NA	−1.12	0.07	0.12
1988	5.9	−0.13	0.11	5.40	−0.13	0.61

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1989	4.6	0.45	−3.26	3.44	0.22	3.77
1990	3.2	0.43	−3.69	2.16	0.31	3.98
1991	3.9	1.20	−3.36	1.86	0.11	0.89
1992	2.9	1.36	−1.44	1.43	0.23	0.57
1993	3.4	0.07	−0.96	1.44	0.05	0.79
1994	3.4	0.37	0.80	1.21	0.15	−0.04
1995	2.29	0.21	1.85	0.44	−0.18	−0.22
1996	2.5	0.29	1.43	1.41	0.03	−0.12
1997	2.6	1.76	1.00	1.39	0.04	−0.52
1998	−8.4	−2.75	0.82	−7.98	0.27	0.82
1999	2.6	1.32	0.71	1.89	−0.02	0.36
2000	3.9	1.02	0.59	1.43	−0.01	0.23
2001	−0.6	1.12	1.18	1.66	−0.47	−0.35

NA, not available.

NEPAL

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INTRODUCTION

Growth alone is not adequate. It must be sustainable. Growth generated only by increasing inputs will not be sustainable. Only when total factor productivity (TFP) growth can be generated will real efficiency result. Growth strategies should thus encompass generation of TFP growth. Higher productivity will result in sustained growth and enable a nation to compete globally. Growth not accompanied by productivity growth will not be sustainable.

There is increasing concern over the growth pattern of East and Southeast Asian economies. High growth in those economies was mainly achieved through investment in inputs rather than through productivity growth. It is estimated that growth will not be sustainable in the long run in those economies. Studies by Krugman (1994) and Kim and Lau (1994) showed that growth was the result of increased employment and education levels and massive injections of capital and that TFP growth was at a very low level. Young (1992) showed that incredible growth of 8.5% per annum on average in Singapore from 1966 to 1990 was mainly contributed by an increase in employed persons from 27% to 51%, an increase in education level, and more importantly, an increase in the share of investment in output from 11% to 40% during the period. Similarly, in Hong Kong, only 35% of the output growth is explained by TFP growth. Young estimated that the return on capital fell from 37% in the mid-1960s to 13% in the late 1980s. Similarly, return on capital is estimated to have fallen from 26% in the 1980s to 18% in the 1990s.

No effort has been made so far in Nepal to measure TFP. Nepal appears to be generating growth only from additional investments and resource use. No efforts are visible to generate growth from other available factors. Without these, faster and sustained growth will not be feasible. Hence, an attempt has been made, despite profound data limitations, to compute TFP in Nepal.

METHODOLOGY

Traditional approaches to measuring TFP are based on the works of Tinbergen (1942), Stigler (1947), Solow (1957), and Kendrick (1961), among others. Productivity is basically computed using the production function assuming the existence of an aggregate economywide function. The function further assumes a constant return on scale and perfect competition. The traditional production function is measured by the ratio change in the output of capital and labor in terms of inputs. Mathematically it can be expressed as:

$$Q_t = A_t F(K_t, L_t) \qquad \text{(Eq. 1)}$$

where Q reflects output in terms of GDP, K is the capital input, L is the labor input, and A represents the level of efficiency. Factor productivity is the function of growth in the inputs of capital ($s_k K_t$) and labor (s_l, L_t)and total factor productivity ($TFPG_t$). The equation may be written as

$$Q^g_t = TFPG_t + s_k K^g_t + s_l L^g_t \qquad \text{(Eq. 2)}$$

where $Q^g t$ is output growth rate, $K^g t$ capital growth rate, and $L^g t$ labor growth rate. This gives the factor productivity at a discrete point of time. Taking the average of two consecutive periods we derive:

$$TFPG_1 = (\ln Q_t - \ln Q_{t-1}) - S_{lqt}(\ln L_t - \ln L_{t-1}) - S_{kqt}(\ln K_t - \ln K_{t-1}) \qquad \text{(Eq. 3)}$$

When S_{jq} are the average value shares:

$$S_{jqt} = 1/2\left(S_{jq}(t) + S_{jq}(t-1) \right) \qquad \text{(Eq. 4)}$$

TFP growth is explained as the residue of the difference in the value added of two periods and difference in labor input *(l)* and capital input *(k)* during the same period. If there are many types of labor and many types of capital, we should start with a production function given by Eq. 5 where the whole spectrum of capital and labor are lined up as an independent argument.

$$Qtg = BtH(K1t, K2t, \ldots\ldots Kmt, L1t, L2t, \ldots\ldots\ldots Lnt) \qquad \text{(Eq. 5)}$$

$$Qtg = TFPG^{**} + SkKtg^{**} + SlLtg^{**} \qquad \text{(Eq. 6)}$$

where $L_{tg}^{**} = \tfrac{1}{2}(Sl1t + Sl1t\text{-}l)(\ln L1t - \ln L1t\text{-}l) + \tfrac{1}{2}(Sl2t + Sl2t\text{-}l)(\ln L2t - \ln L2t\text{-}l)$

$+\ldots\ldots\ldots + \tfrac{1}{2}(Slnt + Slnt\text{-}1)(\ln Lnt - \ln Lnt\text{-}l)$

and $Ktg^{**} = \tfrac{1}{2}(Sk1t + Sk1t\text{-}l)(\ln K1t - \ln K1t\text{-}l) + \tfrac{1}{2}(Sk2t + Sk2t\text{-}l)(\ln K2t - \ln K2t\text{-}l)$

$+\ldots\ldots\ldots + \tfrac{1}{2}(Skmt + Skmt\text{-}l)(\ln Kmt - \ln Kmt\text{-}l)$

where *TFPG*** is the true growth rate of TFP and *TFPG* includes an error of aggregation. The process of decomposition by partly aggregating labor and capital using proper formulae as given in Eq. 6 is a process of deriving *TFPG* in Eq. 6 part by part. The difference between TFP growth and *TFPG*** given by *TFPG* – *TFPG*** is the part that should not be included in true TFP growth.

DATA SOURCES AND LIMITATIONS

For TFP growth calculation, there is a need for the aggregate data on output, capital stock, and employment.

GDP

GDP figures were taken from the Economic Surveys and GDP at factor cost is used in this study. The present GDP series was adjusted in 1994–95. Readjustments have been made for earlier periods.

Capital Stock

Recently, the Central Bureau of Statistics has estimated capital stock in Nepal. It used sectorwise capital stock formation and estimated depreciation of sectoral assets using viable depreciation rates for each sector (Karmacharya, 2002). It estimated capital stock net of depreciation for each year from 1974–75 to the present. This paper estimates TFP in Nepal using the same data.

Employment Data

Employment data are available from different sources including the census and other surveys. However, wholly satisfactory data are not available in any of these sources. In this survey, the economically active population is taken from the census figures. Annual data are computed by interpolating two census figures. From these, unemployed people have been deducted. Unemployment data are available from 1977–78, 1984–85, 1995–96, and 1998–99 surveys. Interpolation has been done to calculate unemployment rates annually. Net employed data have been computed by deducting the estimated unemployed segment from the economically active population and the growth rate was computed from that.

Labor and Capital Share of Income

Nepal's national account data are not based on income and hence there is no information on income share by input segment. The labor share of value addition was estimated from the share of remuneration in the community and the share of remuneration in manufacturing value added estimated by the manufacturing census from 1977–78 to 1996–97. The labor share of GDP in the manufacturing sector and community and social services sector are available from national accounting data from the Central Bureau of Statistics. These two sectors contributed 30.48% of nonagricultural GDP. The average of these two sectors is taken as the representative labor share in the nonagriculture sector. For the agriculture sector, the wage rate is used as estimated by the Nepal Rashtra Bank (the central bank) and employed persons on a time-series basis in various sectors as estimated by the Central Bureau of Statistics.

Wages

Wage rates for a number of years are available from various surveys and the Nepal Rashtra Bank. For the gaps, wages were calculated by interpolating available data.

Factors Affecting TFP Growth

The following factors have been included to test their effect on TFP growth.

Exports

Total export figures are available from a number of sources. For the present study, data from various economic surveys of Nepal were used. Export data were converted at the constant prices of 1984/85.

Total Trade

Total trade data from economic surveys were used and constant value was calculated at 1984/85 prices.

Total Investment

Total investment was obtained from economic surveys and adjusted to 1984/85 prices.

Deficit Financing

Deficit financing, the difference between public revenue and expenditure, was computed in relative terms as a percentage of GDP.

Limitations

This exercise may be termed a crude attempt to estimate TFP growth in the absence of vital data like total capital stock, income contribution of labor and capital, level of skill and education of the workforce, wage rates, etc. Decomposition was further restricted due to the lack of data. However, it is expected to make a useful contribution from the perspective that no such attempt has so far been made in Nepal. The TFP growth and TFPG** estimates thus are expected to give valuable insight on the situation of factor productivity in Nepal.

NEPALESE ECONOMY

Nepal achieved an average growth rate of around 4% during past three decades or so. However, poverty has remained rampant and deprivation widespread. Nepal appears to be infusing capital to achieve growth. Nepal is a basically agrarian economy, but there is a definite shift in the economy with pronounced growth in the secondary sector (Figure 1). The service sector has a greater share than the agriculture sector in the economy. In the total inputs, the share of capital and labor is more or less equal, although the share of the former is slightly higher.

Share of Labor and Capital

Figure 2 illustrates the share of labor and capital stock in economic growth, and Figure 3 illustrates the growth of GDP, capital stock, and labor.

Figure 1. Contribution of various sectors to Nepal's economy.

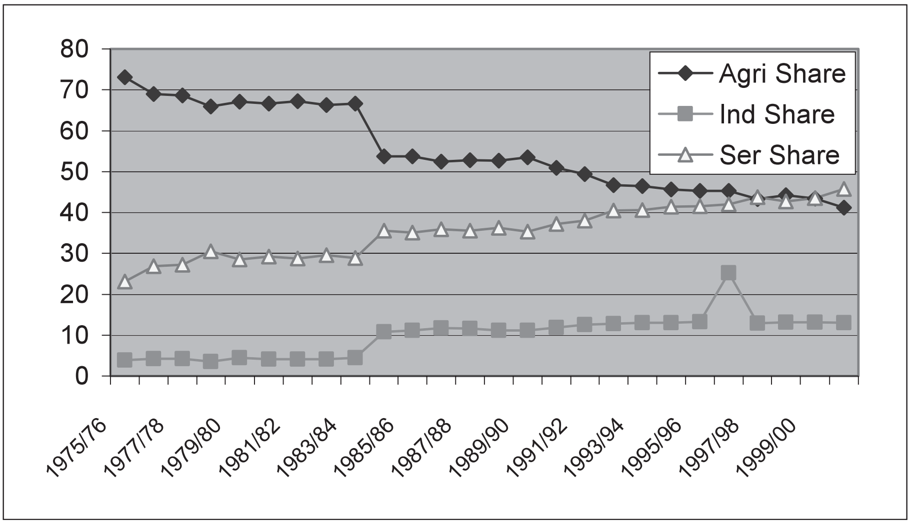


Figure 2. Share of labor and capital in economic growth.

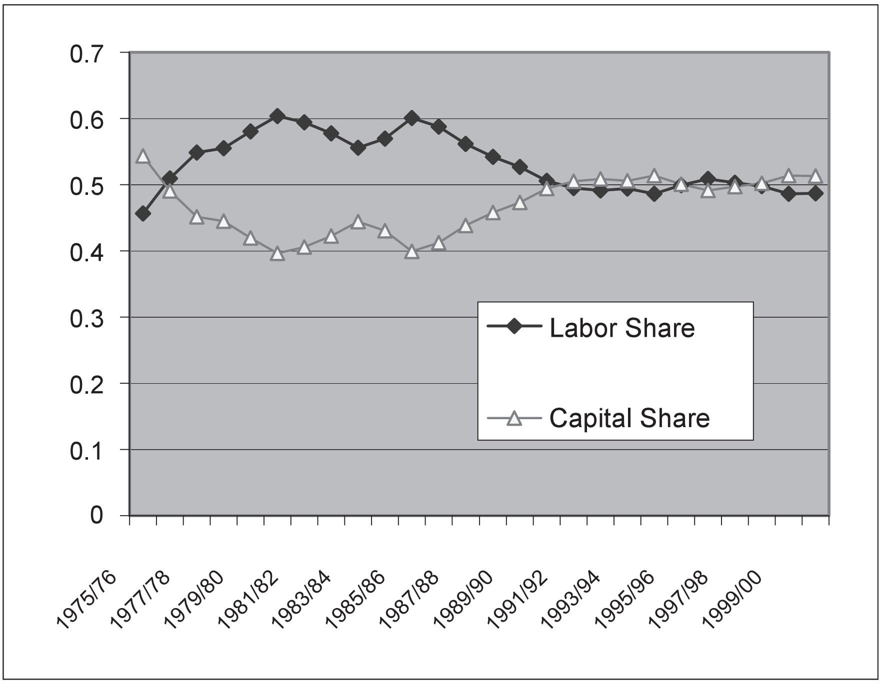
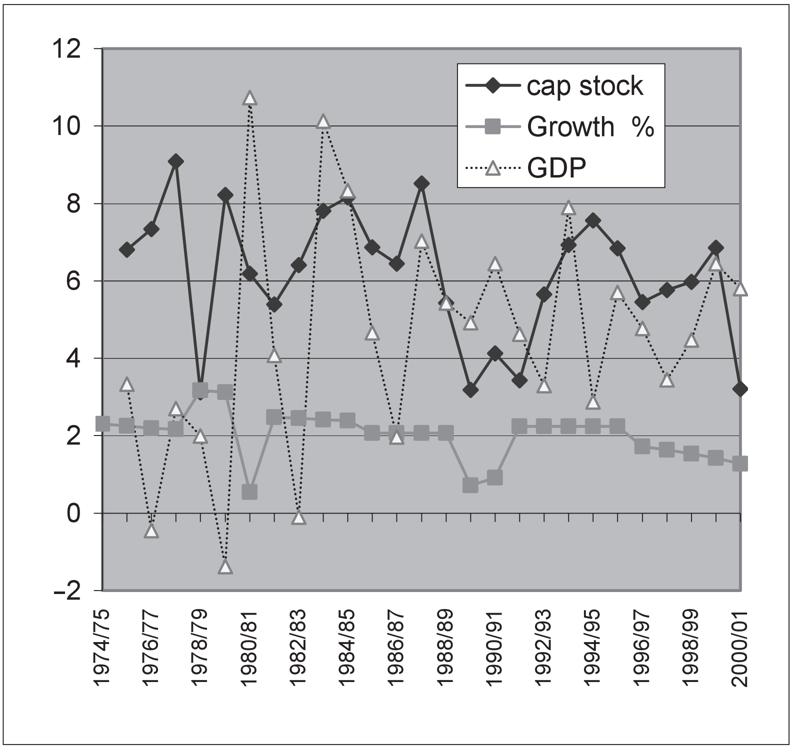


Figure 3. Growth of GDP, capital stock, and labor.



ESTIMATION OF TFP GROWTH

Table 1 gives the estimated TFP growth of Nepal. It was negative for 10 of 26 years. High TFP growth occurred in 1980‒81, 1983‒84, 1984‒85, 1988‒89, 1989‒90 and 2000‒01. In the rest of the period, TFP growth was less than 3% and in most cases less than 2%. High TFP growth needs to be interpreted in the light of negative growth in the preceding years. TFP grew at an average negative rate of 0.83% in the period 1974‒75 to 1983‒84. It grew at 1.54% in the period 1984‒85 to 1989‒90. In 1990‒91 to 2000‒01, it grew at 1.35% per annum. During the 26-year period, TFP grew by only 0.69%.

Table 1. TFP growth of the Nepalese economy.

Year	TFP growth	Average TFP growth
1974/75	0	
1975/76	1.40021	
1976/77	‒5.16435	
1977/78	‒2.58678	
1978/79	‒1.15687	
1979/80	‒6.64279	

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1980/81	7.965884	
1981/82	0.419583	
1982/83	−4.21717	
1983/84	5.317644	−0.82945
1984/85	3.458665	
1985/86	0.676038	
1986/87	−1.90877	
1987/88	2.133099	
1988/89	1.824079	
1989/90	3.036058	1.536528
1990/91	3.940489	
1991/92	1.781392	
1992/93	−0.6881	
1993/94	3.286655	
1994/95	−2.1065	
1995/96	1.159314	
1996/97	1.213595	
1997/98	−0.2502	
1998/99	0.70745	
1999/00	2.235456	
2000/01	3.530142	1.346335
		0.690924

TFP growth explained only about 15.2% of total growth in Nepal. This indicates that growth has been mainly generated by additional investments rather that by improving productivity. Proper use of available factors and efforts to generate higher productivity will help to further growth rates substantially.

ADJUSTMENT FOR BUSINESS FLUCTUATION

The Nepalese economy experienced large fluctuations and the above TFP growth estimates show large fluctuations as well. To remove the effect of business fluctuations from the estimates of TFP growth, we adjusted our estimate using the Wharton method (for the detailed methodology, see the paper by Oguchi in this volume). The results are given in Table 2.

Table 2. TFP growth adjusted for business fluctuation (TFPG*) (%).

Year	TFPG*
1974/75	
1975/76	0.77
1976/77	1.03
1977/78	2.18
1978/79	−1.21
1979/80	1.15
1980/81	2.43
1981/82	0.47
1982/83	0.75
1983/84	1.90
1984/85	2.05
1985/86	1.50
1986/87	1.07
1987/88	2.22
1988/89	0.50
1989/90	0.00
1990/91	0.33
1991/92	−0.76
1992/93	0.19
1993/94	0.96
1994/95	0.89
1995/96	0.79
1996/97	0.40
1997/98	0.49
1998/99	0.63
1999/00	1.08
2000/01	−0.58

It is clear that the fluctuation in the estimates of TFP growth adjusted for business fluctuation is much smaller. In Table 2, we can see consistently positive growth in TFP.

DECOMPOSITION

Decomposition was done only on the basis of the industry shift of labor. Reduction in the labor force in the agriculture sector and resulting wage impacts have been adjusted in TFP growth to compute TFPG **, as shown in Table 3.

Table 3. Decomposed TFP growth for Nepal (%).

Year	TFPG**	Average
1974/75		
1975/76	−5.37321	
1976/77	−6.18405	
1977/78	−5.23626	
1978/79	−1.20646	
1979/80	−4.28965	
1980/81	−3.80391	
1981/82	−2.70181	
1982/83	−2.91996	
1983/84	−4.02105	−3.97071
1984/85	−8.09551	
1985/86	−3.27031	
1986/87	−2.42574	
1987/88	−4.52215	
1988/89	−3.13569	
1989/90	−1.94703	−3.8994
1990/91	−1.35608	
1991/92	−0.6084	
1992/93	−1.99964	
1993/94	−3.49218	
1994/95	−3.04629	
1995/96	−3.20576	
1996/97	−2.75331	
1997/98	−1.64357	
1998/99	−3.03529	
1999/00	−3.13232	
2000/01	−1.12542	−2.30893
		−3.2512

Decomposition Based on Industry Shift

Decomposition based on industry shift was computed on the basis of the shift of labor from the agricultural sector to the nonagricultural sector. The shift was calculated by adjusting the shift based on estimated wage rates. Differential values were adjusted to TFP growth. Table 3 shows significant changes in TFPG**. The average TFP growth for the period on a decomposed basis was −3.25%. Thus the average TFP growth decreased from 0.69% to −3.25%. Output change was mainly the result of a shift from agricultural activities to nonagricultural activities in Nepal.

FACTORS AFFECTING TFP GROWTH

To identify factors influencing TFP growth, regression analyses were computed. The model is as follows:

$$TFPG = \alpha + b1EX/GDP + b2IMP/GDP + TI/GDP + DF/GDP + ... + ut \quad \text{(Eq. 7)}$$

where *EX/GDP* is the ratio of exports to GDP, *IMP/GDP* the ratio of imports to GDP, *TI/GDP* the ratio of lack of investment as a percentage of GDP, *DF/GDP* deficit financing as a percentage of GDP, α is a constant term, and ut is an error term. The regression results are listed in Table 4.

Table 4. Regression results (%).

Variable	Estimated coefficient	T ratio
Import/GDP	0.28575	0.8618
Export/GDP	−0.29007	−1.631
Investment/GDP	0.57935***	2.054
Deficit financing/GDP	0.42835	1.353
Constant	−11.279**	−2.431
R^2 = 0.2642	Adjusted R^2 = 0.1171	
F = 1.796	DW = 2.2791	

**Significant at the 5% level.
***Significant at the 10% level.

The first regression model based on a linear model using variables as a ratio of GDP did not give satisfactory results, as shown by poor R^2 and F values. The regression model used the data for the period 1975/76 to 2000/01. Among individual variables, only the constant and investments were significant. As a result, a second model was tested based on the annual growth rate of variables (Table 5). Due to the use of annual growth, the regression was computed for the period 1976/77 to 2000/01. The regression model used was:

$$TFPG = \alpha + b1Ex_{t-(tt-1)} + b2IM_{t-(tt-1)} + TI_{t-(tt-1)} + DF/GDP + ... + ut \quad \text{(Eq. 8)}$$

where α is the constant term, $E_{xt-(tt-1)}$ is export growth, $IM_{t-(tt-1)}$ is import growth, $TI_{t-(tt-1)}$ is the growth in investment, *DF/GDP* is the ratio of deficit financing to GDP, and U_t is the error term.

Table 5. Results based on annual growth.

Variable	Estimated coefficient	t ratio
Exports	−0.0470	−1.018
Imports	0.0812*	3.666
Deficit financing	27.030	1.120
Investment	0.0965***	2.027
Constant	−2.1540	1.804
$R^2 = 0.5082$	Adjusted $R^2 = 0.4098$	
F = 5.166	DW = 1.8598	

*Significant at the 1% level.
***Significant at the 10% level.

The results in Table 5 show that the model was significant with a satisfactory F value, and R^2 was relatively higher at 0.5082. Imports were significant at the 1% level and investment at the 10% level. Thus imports and investment influenced factor productivity.

POLICY IMPLICATIONS AND CONCLUSIONS

The government should compute TFP growth and sources of growth on a regular basis, for which it should upgrade its database. GDP should be computed on an income basis and information should be collected on the nature of changes in capital stock. Similarly, information should be collected on labor employed, categories of labor, wage rates, etc.

TFP growth should also be decomposed in some possible areas, such as industry shift, business fluctuation, changes in quality and capital, etc. to remove biases and give an accurate estimation of TFP growth. Such calculations should be used to formulate development strategies that will include selection of labor and capital and their mix to maximize growth with minimum inputs. Such calculations would also help in making better and more efficient utilization of factors of production. This would help to generate higher growth and minimize wastage and unproductive or less productive use of the factors of production. Development strategies should be periodically reviewed based on the analysis of sources of growth.

TFP in Nepal is growing only at a slow pace. The experience of the 1990s is not encouraging compared with that in the 1980s. In other words, growth has been mainly generated by the additional use of inputs, both labor and capital, rather than by improving factor productivity. Thus growth in Nepal, which in itself is not high, is not sustainable. Hence efforts must be made to improve factor productivity growth. Such strategies so far do not seem to have been initiated in Nepal. Further, factors affecting TFP growth-TFPG** need to be attended to, particularly exports, the nonagriculture sector, and public-sector investment. There is also a need to improve the database to ensure better calculation of TFP growth/TFPG** and devise more productive strategies if Nepal is to pursue a path of steadier and faster growth to alleviate poverty and find the path of sustainable growth.

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APPENDIX. DATA USED FOR CALCULATIONS

Appendix Table 1. GDP in Nepal 1974−75 to 2000−01.

Year	Nominal GDP at factor cost	GDP at constant prices (1984−85 = 100)	GDP growth rate
1974/75	16051	30449	
1975/76	16231	31462	3.33
1976/77	15784	31321	−0.45
1977/78	17541	32167	2.70
1978/79	19850	32806	1.99
1979/80	20428	32352	–1.38
1980/81	22938	35827	10.74
1981/82	26056	37288	4.08
1982/83	32219	37251	−0.10
1983/84	37671	41024	10.13
1984/85	44441	44441	8.33
1985/86	53215	46512	4.66
1986/87	61140	47427	1.97
1987/88	73170	50761	7.03
1988/89	85831	53518	5.43
1989/90	99702	56151	4.92
1990/91	116127	59768	6.44
1991/92	144933	62531	4.62
1992/93	165350	64586	3.29
1993/94	191596	69686	7.90
1994/95	209974	71685	2.87
1995/96	239388	75773	5.70
1996/97	269570	79388	4.77
1997/98	289798	82116	3.44
1998/99	329960	85789	4.47
1999/00	365465	91317	6.44
2000/01	392532	96612	5.80

Source: Economic surveys, various years.

Appendix Table 2.
Gross capital formulation and change in stock (Rs million, current prices).

Year	Total investment	Gross capital formulation	Change in stock
1974/75	1434	1255	179
1975/76	1596	1407	189
1976/77	1627	1439	188
1977/78	2852	2639	213
1978/79	3514	3263	251
1979/80	4270	3681	589
1980/81	4808	4299	509
1981/82	5314	5465	-151
1982/83	6628	6576	52
1983/84	7351	6907	444
1984/85	10184	10184	798
1985/86	10599	10599	1168
1986/87	12898	12898	1073
1987/88	15237	15237	1823
1988/89	19415	19415	3023
1989/90	19076	19076	2074
1990/91	25074	25074	2294
1991/92	31619	31619	2342
1992/93	39653	39653	2375
1993/94	44644	44644	2612
1994/95	55231	55231	6861
1995/96	68017	68017	11936
1996/97	71084	71084	10290
1997/98	74728	74728	9353
1998/99	70003	70073	4734
1999/00	92383	92383	17438
2000/01	105015	105015	21336

Appendix Table 3. Employed labor.

Year	Economically active	Unemployment rate	Employed			% Growth	Source
			total	Agri-popul		Non agri	
1974/75	5391233	4.33	5157793	4867409	8538	2.3053	
1975/76	5535055	4.7232	5274177	4908677	9328	2.2565	

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1976/77	5682714	5.1521	5389935	4981378	10187	2.1948	
1977/78	5834311	5.62	5506423	5071416	10955	2.1612	Survey
1978/79	5989953	5.1621	5680746	5214357	10959	3.1658	
1979/80	6149747	4.7415	5858157	5358456	11613	3.123	
1980/81	6157862	4.3552	5889675	5368439	12638	0.538	Census
1981/82	6287177	4.0003	6035671	5438743	13202	2.4788	
1982/83	6419208	3.6744	6183341	5507502	13565	2.4466	
1983/84	6554011	3.375	6332813	5576042	14810	2.4173	
1984/85	6691645	3.01	6484204	5643851	21680	2.3906	Survey
1985/86	6832170	3.1261	6618590	5695297	23136	2.0725	
1986/87	6975645	3.1525	6755738	5746431	24214	2.0722	
1987/88	7122134	3.1791	6895714	5798606	26026	2.072	
1988/89	7271699	3.2059	7038576	5850464	27258	2.0718	
1989/90	7333145	3.2329	7088739	5824817	28377	0.7127	
1990/91	7394590	3.2602	7153512	5810798	31396	0.9137	Census
1991/92	7562447	0.32877	7313816	5833500	34461	2.2409	
1992/93	7734114	3.3154	7477697	5856532	36690	2.2407	
1993/94	7909679	3.3434	7645227	5879180	39669	2.2404	
1994/95	8089229	3.3716	7816493	5902234	41768	2.2402	
1995/96	8272854	3.4	7991577	5925754	44534	2.2399	Survey
1996/97	8460648	3.9173	8129182	5918857	46859	1.7223	
1997/98	8652705	4.5133	8262182	5906634	49649	1.6356	
1998/99	8849121	5.2	8388967	5889055	52028	1.5345	
1999/00	9049996	5.9912	8507793	5864422	55878	1.4165	
2000/01	9255431	6.9027	8616556	5831685	59759	1.2784	Census

Source: Central Bureau of Statistics, 1995 and 2001.

Appendix Table 4. Total capital stock at 1984−85 prices and rate of change.

Year	Capital stock	Change (%)
1974/75	46128	
1975/76	49267	6.803151
1976/77	52881	7.335723
1977/78	57684	9.08323
1978/79	59481	3.115438
1979/80	64367	8.213612
1980/81	68346	6.183081
1981/82	72029	5.387966
1982/83	76642	6.404519

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1983/84	82626	7.807926
1984/85	89366	8.156466
1985/86	95497	6.861352
1986/87	101651	6.443988
1987/88	110310	8.518122
1988/89	116295	5.426151
1989/90	120001	3.186668
1990/91	124951	4.124922
1991/92	129237	3.430005
1992/93	136540	5.650665
1993/94	145998	6.926674
1994/95	157040	7.563715
1995/96	167787	6.843042
1996/97	176945	5.45825
1997/98	187136	5.759191
1998/99	198321	5.977165
1999/00	211907	6.85074
2000/01	218706	3.208038

Source: Karmacharya, 2002; Central Bureau of Statistics, various years.

Appendix Table 5. Income share of labor and capital.

Year	Agriculture labor share	2-Year average labor share	Capital share	Nonagriculture			Labor share
				Labor share	2-year average labor share	Capital share	
1974/75	0.413954		0.586946	0.494815			0.45661501
1975/76	0.469148	0.441550824	0.530852	0.4899045	0.49235975	0.5100955	0.50954622
1976/77	0.571217	0.520182338	0.428783	0.485055	0.48747975	0.514945	0.5483052
1977/78	0.596039	0.583628152	0.403961	0.4747695	0.47991225	0.5252305	0.55483707
1978/79	0.598935	0.59748719	0.401065	0.464867	0.46981825	0.535133	0.58042442
1979/80	0.696670	0.647802634	0.303330	0.4553265	0.46009675	0.5446735	0.60366598
1980/81	0.677283	0.686976549	0.322717	0.44628	0.45080325	0.55372	0.59454126
1981/82	0.679272	0.678277519	0.320728	0.437259	0.4417695	0.562741	0.57772319
1982/83	0.634875	0.657073797	0.365125	0.441071	0.439165	0.558929	0.55596198
1983/84	0.604092	0.619483588	0.395908	0.4459855	0.44352825	0.5540145	0.56988145
1984/85	0.730007	0.667049214	0.269993	0.489752	0.46786875	0.510248	0.60082859
1985/86	0.700350	0.715178482	0.299650	0.480833	0.4852925	0.519167	0.58739851
1986/87	0.704173	0.702261947	0.295827	0.473734	0.4772835	0.526266	0.56180599

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1987/88	0.665812	0.684992758	0.334188	0.4157256	0.4447298	0.5842744	0.54224926
1988/89	0.634500	0.650156019	0.365500	0.460861	0.4382933	0.539139	0.52663819
1989/90	0.602094	0.618297098	0.397906	0.412993	0.436927	0.587007	0.5056802
1990/91	0.599600	0.600847187	0.400400	0.426366	0.4196795	0.573634	0.4949282
1991/92	0.569040	0.58432018	0.430960	0.417863	0.4221145	0.582137	0.49155719
1992/93	0.580858	0.574949063	0.419142	0.438443	0.428153	0.561557	0.49439731
1993/94	0.563160	0.572008775	0.436840	0.4328965	0.43566975	0.5671035	0.48626388
1994/95	0.594590	0.578874897	0.405410	0.406963	0.41992975	0.593037	0.49957811
1995/96	0.685935	0.640262589	0.314065	0.394823	0.400893	0.605177	0.50884408
1996/97	0.670196	0.67806541	0.329804	0.387922	0.3913725	0.612078	0.50264464
1997/98	0.668806	0.669500875	0.331194	0.3991425	0.39353225	0.6008575	0.4978261
1998/99	0.639808	0.654307086	0.360192	0.3934285	0.3962855	0.6065715	0.48626468
1999/00	0.631753	0.635780665	0.368247	0.3894485	0.3914385	0.6105515	0.48698123
2000/01	0.664331	0.648042114	0.335669	0.3858635	0.387656	0.6141365	

Appendix Table 6. Computation of TFP growth.

Year	Computation of TFPG	Labor growth rate	Labor share	Capital growth	Capital share	ProdLabor	ProdCapital	TFPG	Average TFPG
1974/75		2.3053	0		1	0	0	0	
1975/76	3.326874	2.2565	0.456615	6.803151	0.543385	1.030352	3.69673	−1.40021	
1976/77	−0.44816	2.1948	0.509546	7.335723	0.490454	1.118352	3.597833	−5.16435	
1977/78	2.701063	2.1612	0.548305	9.08323	0.451695	1.184997	4.102848	−2.58678	
1978/79	1.986508	3.1658	0.554837	3.115438	0.445163	1.756503	1.386878	−1.15687	
1979/80	−1.38389	3.123	0.580424	8.213612	0.419576	1.812665	3.446231	−6.64279	
1980/81	10.74122	0.538	0.603666	6.183081	0.396334	0.324772	2.450565	7.965884	
1981/82	4.07793	2.4788	0.594541	5.387966	0.405459	1.473749	2.184598	0.419583	
1982/83	−0.09923	2.4466	0.577723	6.404519	0.422277	1.413458	2.70448	−4.21717	
1983/84	10.12859	2.4173	0.555962	7.807926	0.444038	1.343927	3.467016	5.317644	−0.82945
1984/85	8.329271	2.3906	0.569881	8.156466	0.430119	1.362359	3.508247	3.458665	
1985/86	4.660111	2.0725	0.600829	6.861352	0.399171	1.245217	2.738856	0.676038	
1986/87	1.967234	2.0722	0.587399	6.443988	0.412601	1.217207	2.658799	−1.90877	
1987/88	7.029751	2.072	0.561806	8.518122	0.438194	1.164062	3.73259	2.133099	
1988/89	5.431335	2.0718	0.542249	5.426151	0.457751	1.123432	2.483824	1.824079	
1989/90	4.91984	0.7127	0.526638	3.186668	0.473362	0.375335	1.508447	3.036058	1.536528
1990/91	6.441559	0.9137	0.50568	4.124922	0.49432	0.46204	2.039031	3.940489	
1991/92	4.622875	2.2409	0.494928	3.430005	0.505072	1.109085	1.732399	1.781392	
1992/93	3.28637	2.2407	0.491557	5.650665	0.508443	1.101432	2.87304	−0.6881	

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1993/94	7.896448	2.2404	0.494397	6.926674	0.505603	1.107648	3.502145	3.286655	
1994/95	2.868582	2.2402	0.486264	7.563715	0.513736	1.089328	3.885753	-2.1065	
1995/96	5.702727	2.2399	0.499578	6.843042	0.500422	1.119005	3.424408	1.159314	
1996/97	4.770829	1.7223	0.508844	5.45825	0.491156	0.876382	2.680852	1.213595	
1997/98	3.436288	1.6356	0.502645	5.759191	0.497355	0.822126	2.864365	-0.2502	
1998/99	4.472941	1.5345	0.497826	5.977165	0.502174	0.763914	3.001576	0.70745	
1999/00	6.443717	1.4165	0.486265	6.85074	0.513735	0.688794	3.519467	2.235456	
2000/01	5.798482	1.2784	0.486981	3.208038	0.513019	0.622557	1.645784	3.530142	1.346335

ProdLabor, labor productivity; ProdCapital, capital productivity.

Appendix Table 7. Variables used.

Year	GDP	IM	EX	TRA	INV	PUB	PVT	DEF
1975	15723	1185.8	1981.7	3167.5	2632	632	1811	438
1976	15070	1164.7	2008	3172.7	2768	689	1891	614.9
1977	16934	1046.2	2469.6	3515.8	3507	1113	2181	626.3
1978	20286	1396.8	2884.7	4181.5	3514	1138	2125	609.4
1979	20167	1150.5	3480.1	4630.6	4270	1466	2215	785.1
1980	23271	1608.7	4428.1	6036.9	4808	1823	2476	804.2
1981	26372	1491.5	4930.3	6421.8	5314	2487	2978	1688.5
1982	28794	1132	6314	7446	6628	2941	3635	3047.5
1983	33863	1703.9	6514.3	8281.2	7351	3139	3768	3151.4
1984	42352	2740.6	7742.1	10482.7	10184	3629	5757	3554.8
1985	50478	3078	9341.2	12419.2	10599	3909	5522	3979.8
1986	58407	3011.4	10905.2	13916.6	12898	4727	7089	4253
1987	69613	4114.6	13869.6	17984.2	15237	5483	7921	4677.8
1988	80909	4195.3	16263.7	20459	19415	7902	8490	8547.5
1989	94330	5156.2	18324.9	23481.1	19076	7968	9034	8406.4
1990	108667	7387.5	23226.5	30614	25074	8683	14097	10655.1
1991	131869	13706.5	31940	45646.5	31619	10331	18945	11261.7
1992	150228	17266.5	39205.6	56472.1	39653	11769	25509	11956
1993	173458	19293.4	51570.8	70864.2	44644	13380	28652	11623
1994	187673	17639.2	63679.5	81318.7	55231	15070	33300	10547.7
1995	214206	19881.1	74454.5	94335.6	68017	17624	38457	13824.2
1996	240090	22636.5	93553.4	116190	71084	19392	41402	14361.9
1997	260079	27513.5	89002	116516	74728	22573	42802	17777.8
1998	299415	35676.3	87525.3	123202	70003	23888	41381	17991.4
1999	329350	51623	106967	158590	92383	26436	44611	17667

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2000	350653	325104	69307.9	101809	105015	31322	47141	23940

GDP, gross domestic product; IM, imports; EX, exports; INV, investment; PUB, public investment; PVT, private investment; DEF, fiscal deficit; TRA, total trade.

Appendix Table 8. Ratios to GDP.

Year	EX	IM	TRA	INV	PUB	PVT	DEF
1975	7.5	12.6	20.1	15.5	4.0	11.5	2.8
1976	7.7	13.3	21.1	17.1	4.6	12.5	4.1
1977	6.2	14.6	20.8	19.5	6.6	12.9	3.7
1978	6.9	14.2	20.6	16.1	5.6	10.5	3.0
1979	5.7	17.3	23.0	18.3	7.3	11.0	3.9
1980	6.9	19.0	25.9	18.5	7.8	10.6	3.5
1981	5.7	18.7	24.4	20.7	9.4	11.3	6.4
1982	3.9	21.9	25.9	22.8	10.2	12.6	10.6
1983	5.0	19.2	24.5	20.4	9.3	11.1	9.3
1984	6.5	18.3	24.8	22.2	8.6	13.6	8.4
1985	6.1	18.5	24.6	18.7	7.7	10.9	7.9
1986	5.2	18.7	23.8	20.2	8.1	12.1	7.3
1987	5.9	19.9	25.8	19.3	7.9	11.4	6.7
1988	5.2	20.1	25.3	20.3	9.8	10.5	10.6
1989	5.5	19.4	24.9	18.0	8.4	9.6	8.9
1990	6.8	21.4	28.2	21.0	8.0	13.0	9.8
1991	10.4	24.2	34.6	22.2	7.8	14.4	8.5
1992	11.5	26.1	37.6	24.8	7.8	17.0	8.0
1993	11.1	29.7	40.9	24.2	7.7	16.5	6.7
1994	9.4	33.9	43.3	25.8	8.0	17.7	5.6
1995	9.3	34.8	44.0	26.2	8.2	18.0	6.5
1996	9.4	39.0	48.4	25.3	8.1	17.2	6.0
1997	10.6	34.2	44.8	25.1	8.7	16.5	6.8
1998	11.9	29.2	41.1	21.8	8.0	13.8	6.0
1999	15.7	32.5	48.2	21.6	8.0	13.5	5.4
2000	92.7	19.8	29.0	22.4	8.9	13.4	6.8

IM, imports; EX, exports; INV, investment; PUB, public investment; PVT, private investment; DEF, fiscal deficit; TRA, total trade.

Appendix Table 9. Share of sectors in GDP.

Year	Agr	Ind	Ser	GDP	Agri share	Ind share	Serv share
1975	11495	603	3625	15723	73.10946	3.835146	23.0554

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1976	10389	636	4045	15070	68.93829	4.220305	26.84141
1977	11616	707	4611	16934	68.59572	4.175032	27.22924
1978	13365	724	6197	20286	65.88287	3.568964	30.54816
1979	13520	889	5758	20167	67.04021	4.408192	28.55159
1980	15510	953	6806	23271	66.64948	4.095226	29.2467
1981	17715	1068	7589	26372	67.17352	4.04975	28.77673
1982	19082	1199	8513	28794	66.27075	4.164062	29.56519
1983	22570	1520	9773	33863	66.65092	4.488675	28.86041
1984	22761	4561	15030	42352	53.74244	10.76927	35.48829
1985	27136	5622	17720	50478	53.75807	11.13753	35.1044
1986	30623	6821	20963	58407	52.43036	11.67839	35.89125
1987	36755	8118	24740	69613	52.79905	11.66161	35.53934
1988	42572	9052	29285	80909	52.61714	11.18788	36.19498
1989	50470	10507	33353	94330	53.50366	11.13856	35.35779
1990	55368	12902	40397	108667	50.95199	11.87297	37.17504
1991	65156	16563	50150	131869	49.40964	12.56019	38.03017
1992	70090	19260	60878	150228	46.65575	12.82051	40.52374
1993	80589	22497	70372	173458	46.46024	12.96971	40.57005
1994	85569	24326	77778	187673	45.59473	12.96191	41.44336
1995	96896	28317	88993	214206	45.23496	13.21952	41.54552
1996	108785	60551	100754	240090	45.31009	25.22013	41.9651
1997	112495	33687	113897	260079	43.25417	12.9526	43.79323
1998	132373	39313	127729	299415	44.21054	13.12994	42.65952
1999	142908	43109	143333	329350	43.39092	13.08911	43.51996
2000	144420	45862	160371	350653	41.18602	13.07903	45.73496

Appendix Table 10. Annual growth rates.

Year	EX	IM	TRA	INV	PUB	PVT	DEF
1975							
1976	−1.8	1.3	0.2	5.6	9.0	4.4	40.4
1977	−10.2	23.0	10.8	27.7	61.5	15.3	1.9
1978	33.5	16.8	18.9	−0.9	2.2	−2.6	−2.7
1979	−17.6	20.6	10.7	12.8	28.8	4.2	28.8
1980	39.8	27.2	30.4	16.8	24.4	11.8	2.4
1981	−7.3	11.3	6.4	27.1	36.4	20.3	110.0
1982	−24.1	28.1	15.9	20.3	18.3	22.1	80.5
1983	50.5	3.2	11.2	5.0	6.7	3.7	3.4

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1984	60.8	18.8	26.6	35.9	15.6	52.8	12.8
1985	12.3	20.7	18.5	0.5	7.7	−4.1	12.0
1986	−2.2	16.7	12.1	25.3	20.9	28.4	6.9
1987	36.6	27.2	29.2	13.4	16.0	11.7	10.0
1988	2.0	17.3	13.8	22.3	44.1	7.2	82.7
1989	22.9	12.7	14.8	3.7	0.8	6.4	−1.7
1990	43.3	26.7	30.4	34.0	9.0	56.0	26.7
1991	85.5	37.5	49.1	28.5	19.0	34.4	5.7
1992	26.0	22.7	23.7	27.3	13.9	34.6	6.2
1993	11.7	31.5	25.5	12.8	13.7	12.3	−2.8
1994	−8.6	23.5	14.8	15.1	12.6	16.2	−9.3
1995	12.7	16.9	16.0	15.9	16.9	15.5	31.1
1996	13.9	25.7	23.2	8.4	10.0	7.7	3.9
1997	21.5	−4.9	0.3	7.5	16.4	3.4	23.8
1998	29.7	−1.7	5.7	−0.2	5.8	−3.3	1.2
1999	44.7	22.2	28.7	8.9	10.7	7.8	−1.8
2000	529.8	−35.2	−35.8	10.4	18.5	5.7	35.5

IM, imports; EX, exports; INV, investment; PUB, public investment; PVT, private investment; DEF, fiscal deficit; TRA, total trade.

Appendix Table 11. Wage rates.

Year	Wages in agriculture	Wages in nonagriculture
1974/75	4501.477	29404.08
1975/76	4509.143	25521.37
1976/77	4242.647	24933.53
1977/78	4182.61	25184.05
1978/79	4189.695	23498.48
1979/80	3870.34	23239.82
1980/81	4319.498	24246.28
1981/82	4428.613	22116.43
1982/83	4300.716	20071.05
1983/84	4701.172	19570.07
1984/85	4032.885	25798.69
1985/86	4104.439	25058.13
1986/87	4039.551	23990.71
1987/88	4265.68	23722.37
1988/89	4488.533	22942.29
1989/90	4768.219	22451.54

Continued...

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1990/91	4882.634	23382.49
1991/92	4811.863	23279.48
1992/93	4763.228	22631.88
1993/94	5105.644	22462.02
1994/95	5068.759	21819.41
1995/96	5271.734	21557.51
1996/97	5495.824	21200.05
1997/98	5496.701	21077.47
1998/99	5732.838	20811.93
1999/00	6043.051	21138.91
2000/01	6319.443	21458.45

Source: Nepal Rashtra Bank for agricultural wages.
The nonagricultural wages were computed as the average wage rate in the manufacturing and community and public service sector. Data for these two were provided by the Central Bureau of Statistics.

PHILIPPINES

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INTRODUCTION

A series of articles that appeared in the recent World Bank Economic Review highlighted the important role of total factor productivity (TFP) growth in the process of economic growth. While the articles did not downplay the critical role of factor accumulation in economic growth, "Major empirical regularities of economic growth emphasize the role of something else besides factor accumulation." It is therefore important to understand the forces that underlie "residual" determinants of growth and income. This is the basic motivation of the present paper. It attempts to quantify TFP growth in the Philippines and its contribution to overall economic growth. Furthermore, the paper attempts to understand the possible factors that might have caused changes in TFP growth over time.

LITERATURE REVIEW

Research has been done in the past to quantify TFP growth and its contribution to Philippine economic growth. Cororaton and Cuenca (2001) updated the TFP growth estimates of Cororaton and Caparas (1999) from 1980–96 to 1980–98, using the growth accounting method in trans-log form at the level of the economy and major sectors of the economy. Some insights were drawn from the estimates. At the sectoral level, the results are mixed. Some sectors showed improving TFP growth in the 1990s, while others had declining rates, especially the nontradable service sectors like real estate. Because of this, the economy as a whole saw declining TFP growth in the 1990s. The decline may have been due to movement of capital toward the nontradable sectors during the period when foreign capital inflow surged, which in turn was aggravated by the prolonged real appreciation of the local currency.

de Silva (2001) also applied the growth accounting method to estimate TFP growth. Her estimation period was much longer, from 1971 to 1998. The major finding of the work was: "From 1990 to 1997, the average TFP growth is estimated at –0.8%, only a slight improvement from the average rate estimated for the 1980s." On the whole, the paper implied that "The movements of total factor productivity (TFP) indicate that it did not drive the growth of real output during the past 25 years."

Austria (1998), using a macrodynamic model with output and inflation interaction, showed that the TFP growth for an extended period of time, 1967 to 1997, declined by

–0.47%. Lim (1998), using a Cobb-Douglas production function, showed negative TFP growth for industry and services, sectors that account for 75% of GDP. However, Cororaton and Abdula (1997) showed slightly positive TFP growth for the manufacturing sector. In the TFP study conducted on specific industries within the manufacturing sector by Cororaton et al. (1996), it was observed that the number of manufacturing units with negative TFP growth increased from 1956 to 1992, while the average TFP growth for the entire manufacturing sector was slightly above zero.

There seems to be one general conclusion from the various studies on TFP conducted in the Philippines: TFP growth has not been encouraging. Estimates seem to suggest negative TFP growth, and therefore it has not been a source of economic growth.

GROWTH PERFORMANCE AND POLICIES

The last 35 years saw "roller coaster" Philippine economic growth performance. Growth was highest during the 1973–82 period, averaging 5.5% per year (Table 1). This was the peak period of the Marcos regime. This was not sustained, however, as dissatisfaction among Filipinos with martial law mounted and eventually led to a political uprising in the following period, 1983–85. The political crisis triggered an economic crisis that resulted in an economic collapse. The economy contracted by –4.1% per year during that period. The Marcos administration was finally forced out in early 1986, which gave way to the Aquino government. Thus in the subsequent period, 1986–90, the political euphoria brought about economic recovery under the new government. Growth averaged 4.5% per annum. However, toward the end of the Aquino administration, a political tug-of-war led to a series of military coup attempts. Although the attempts failed, they created political uncertainty and instability. This, together with a series of natural calamities and an energy crisis, brought the economy to a halt in the 1991–93 period. The economy contracted again by –0.1% per year during the period.

Table 1. The Philippine economy.

Year	GDP growth (%)	Employment growth (%)	Export/ GDP (%)	Import/ GDP (%)
1967–72	4.8	3.3	13.6	17.4
1973–82	5.5	3.1	16.0	22.8
1983–85	–4.1	3.2	15.4	20.4
1986–90	4.5	2.1	17.4	23.0
1991–93	–0.1	3.7	19.5	30.2
1994–97	4.9	3.3	24.5	39.3
1998–2000	3.5	–0.3	45.8	43.2

Sources: National Income Accounts, Philippine Statistical Yearbook.

The leadership of the Ramos administration revived the economy with growth averaging 4.9% per year from 1994 to 1997. However, the Asian financial crisis, the El

Nino effects on agricultural production in 1998, and the political scandals that wreaked havoc on the Estrada administration took a heavy toll on the economy. Growth slid to 3.5% per year in the 1998-2000 period. The past 35 years were thus marked by boom-and-bust growth cycles. Economic growth could not be sustained. Political as well as weak economic fundamentals were believed to be the major forces behind such performance.

Employment performance was not as generally disappointing. Employment growth was averaging more than 3% per year over the years, except from 1998-2000 when it contracted by -0.3% per year.

Major economic policy shifts occurred when the Aquino government took over in 1986. Structural reforms like trade liberalization, foreign exchange liberalization, investment reforms, banking reforms, and privatization, among others, were implemented. Those reforms intensified in the 1990s and are still being pursued at present.

One of the major results of the reforms was the increasing share of foreign trade in the Philippine economy. From a 13.6% export-to-GDP ratio in the 1967-72 period, the share increased to 45.8% in 1998-2000. Similarly, the import-to-GDP ratio increased from 17.4% to 43.2% over the same period. The rise in the trade sector is mainly attributed to the recent surge in the demand for semiconductors in the world market. To date, almost 60% of the country's exports are highly raw material- and import-dependent semiconductors.

However, in spite of the reforms and the dramatic rise in foreign trade, apparent signs of structural weaknesses prevail in the economy. These are seen in the stagnating share of industry in general and of manufacturing in particular in the past 35 years (Table 2). The share of industry picked up from 31.7% in the 1967-72 period to 37.4% in 1983-85. It declined thereafter and continued its descent to 30.9% in 1998-2000. A similar dismal record for the manufacturing sector was observed over the same period. The drop in the share of agriculture was compensated for by the increasing share of the service sector. The disappointing and stagnating share of the industry and manufacturing sectors is also observed in the structure of employment. Employment share in industry is about 15%, while that in manufacturing is 10%. These shares have stagnated compared with the rising employment share in the service sector (Table 3). Wage rates also stagnated (Table 4).

Table 2. Production structure.

Year	Gross value-added shares (%)			
	Agriculture	Industry	Manufacturing	Services
1967-72	29.3	31.7	24.7	39.0
1973-82	27.9	36.8	25.6	35.3
1983-85	23.9	37.4	24.7	38.7
1986-90	23.1	34.7	25.0	42.2
1991-93	21.5	33.2	24.4	45.4
1994-97	20.7	32.2	22.8	47.0
1998-2000	17.2	30.9	21.9	52.0

Sources: National Income Accounts, Philippine Statistical Yearbook.

Table 3. Employment structure.

Year	Employment share (%)				Quality of labor (%)	
	Agriculture	Industry	Manufacturing	Services	Unskilled*	Skilled**
1967-72	55.1	15.5		29.4	79.6	20.4
1973-82	52.5	14.7		32.7	71.9	28.1
1983-85	50.0	14.6	9.9	35.5	68.6	31.4
1986-90	46.9	15.0	10.0	38.0	64.3	35.7
1991-93	45.3	15.9	10.4	38.9	61.0	39.0
1994-97	43.0	16.2	10.1	40.7	58.3	41.7
1998-2000	38.4	16.3	9.8	45.3	54.5	45.5

Sources:Philippine Statistical Yearbook.
*From no formal schooling to those who have not finished high school.
**At least high school graduate.

Table 4. Wages.

Year	Growth in real Minimum wage (%)	Growth in real sectoral wage rate (%)			
		Total	Agriculture	Industry	Services
1967-72					
1973-82	3.9	-3.3	-7.6	-0.1	-3.3
1983-85	-1.9	-8.8	-0.9	-10.4	-11.8
1986-90	4.6	6.3	3.6	3.1	8.0
1991-93	-0.3	-4.3	-6.4	-6.3	-1.6
1994-97	-1.4	3.1	-2.0	-1.0	3.8
1998-2000	0.7	5.2	7.3	4.1	3.1

Sources: Philippine Statistical Yearbook and selected Philippine economic indicators.

The contrasting performance of the foreign trade sector and the industrial sector in general and the manufacturing subsector in particular in terms of output and employment generation in the midst of policy reforms indicates the absence of trickle-down effects. Considering that these policy reforms have been pursued for quite some time, the lack of concrete trickle-down effects strongly implies a high degree of duality between the local and foreign sectors. These structural defects need to be identified and addressed appropriately. Perhaps one good starting point is the assessment of the productivity performance of the country.

METHODOLOGY

Output growth (Q^*_t) may be due to two broad factors: factor accumulation, which in turn may be broadly divided into growth of capital input ($s_K K_t^*$), and growth of labor input ($s_L L_t^*$); and growth of total factor productivity ($TFP\ growth_t^*$). That is:

$$Q^*_t = TFP\ growth_t^* + s_K K_t^* + s_L L_t^* \quad \text{(Eq. 1)}$$

In estimating Eq. 1 using actual data, the traditional growth accounting approach to measuring TFP growth was used. In particular, it uses a trans-log-based growth accounting formula

$$TFP\ growth_t = [\ln Q_t - \ln Q_{(t-1)}] - v_L^*[\ln L_t - \ln L_{(t-1)}] - v_K^*[\ln K_t - \ln K_{(t-1)}] \quad \text{(Eq.2)}$$

where $v_L = \frac{1}{2} * (v_{Lt} + v_{L(t\text{-}1)})$ and $v_K = \frac{1}{2} * (v_{Kt} + v_{K(t\text{-}1)})$; ln is natural logarithm operator; Q output, L employment, K capital input, and v_L and v_K are average factor shares. The application of this formula to Philippine data yielded unadjusted TFP growth.

Six different refinements were applied to the unadjusted TFP growth to identify the effects of business fluctuation: two types of labor input; three types of capital input; and sectoral movement of labor. The last three adjustments were based on the method that utilizes factors in efficiency units to decompose TFP growth proposed by Oguchi (2001).

Business Fluctuation Adjustment

Unadjusted TFP growth estimates derived using Eq. 2 are usually sensitive to business cycles, making it difficult to determine which part is driven by the business cycle and which part is due to real change in TFP. There is no standard way of determining the effects of business fluctuations on TFP growth. The approach applied in the paper is that of Oguchi (2001), which involves the estimation of a production function using actual output data and the computation of "theoretical" output level that is compared with the actual output. In particular, the following steps were applied: 1) estimate the Cobb-Douglas production function; 2) compute the "theoretical" value of output using the estimated production function; 3) take the ratio of the actual output to the theoretical value of output, which will yield an indicator of capacity utilization rate; and 4) take the rate of change of the estimated capacity utilization and subtract it from the estimated TFP growth to obtain the adjusted TFP growth. Furthermore, to smooth the kinks in the estimates, a three-year moving average was applied to the adjusted TFP growth. The estimated equation for the Cobb-Douglas production function is:

$$\begin{aligned} lg\,dpl = \; & \underset{(t=4.709)}{0.869} + \underset{(t=13.228)}{0.627} * lkstockl - \underset{(t=-8.757)}{0.011} * trend - \underset{(t=-6.530)}{0.139} * d85\_87 \\ & - \underset{(t=-2.302)}{0.059} * d92\_93 + \underset{(t=3.090)}{0.114} * d2000 \end{aligned} \quad \text{(Eq. 3)}$$

and R^2 = 0.889, R^2bar = 0.870, DW = 1.361, F = 46.487, *OLS*, sample: 1966–2000, *lgdpl* is l*n* of GDP/labor, *lkstockl* is l*n* of capital stock/labor. Other variables in the equation are dummy variables that capture turbulent years.

Decomposition of TFP Growth

Consider the production function (which is similar to Eq. 1, except that Eq. 1 is in the form of growth of variables):

$$Q = A * f(L, K) \qquad \text{(Eq. 4)}$$

where Q is output, L is simple aggregation of labor (aggregate of all types of labor skills), K is simple aggregation of capital (aggregate of all types of capital), and A is TFP (or *TFP_A*). The basic assumption in this formulation is that all types of labor have the same marginal productivity. Similarly, all marginal productivity of all types of capital is the same. In reality this may not be true. Different types of factor inputs may not have uniform marginal productivity. This means that the corresponding TFP estimate, A, may also not be true. "True" TFP can be derived if factor inputs are disaggregated into their different types. That is, if the entire spectrum of labor and capital is lined up as independent arguments in the production function, then the true production function should take the following form:

$$Q = B f(l_1, l_2, ..., k_1, k_2 ...) \qquad \text{(Eq. 5)}$$

where Q is the same output as in Eq. 4, l_1 is type 1 labor, l_2 is type 2 labor, etc., and k_1 is type 1 capital, k_2 is type 2 capital, etc. The parameter B in Eq. 5 is the "true" TFP (or *TFP_B*).

Equations 4 and 5 provide an opportunity for capturing and decomposing the effects of the quality of factor inputs from TFP growth. That is, if TFP growth computed using Eqs. 4 and 5 then the difference, which is

$$TFP\ growth\_A - TFP\ growth\_B \qquad \text{(Eq. 6)}$$

may give indications of the effects of changes in the quality of factor inputs on TFP growth.

The above framework was utilized to analyze the separate effects on TFP growth of: 1) skilled and unskilled labor; 2) sectoral labor movement; and 3) structures, durable equipment, and other capital. In using the framework, factor inputs must be converted into efficiency units. Oguchi (2001) showed that in terms of growth in variables, Eq. 4 in discrete form can be written as

$$Q_g^{\,t} = TFP\ growth^{t\,**} + s_k K_g^{\,t\,**} + s_l L_g^{\,t\,**} \qquad \text{(Eq. 7)}$$

where $s_l L_g^{t**} = 0.5(s_{l1}^{\,t} + s_{l1}^{\,t-1}) * (\ln L_1^{\,t} - \ln L_1^{\,t-1}) +$

$0.5(s_{l2}^{\,t} + s_{l2}^{\,t-1}) * (\ln L_2^{\,t} - \ln L_2^{\,t-1}) + \ ...$

$0.5(s_{ln}^{\,t} + s_{ln}^{\,t-1}) * (\ln L_n^{\,t} - \ln L_n^{\,t-1})$

and $s_l K_g^{t**} = 0.5(s_{k1}^t + s_{k1}^{t-1}) * (\ln K_1^t - \ln K_1^{t-1}) +$

$0.5(s_{k2}^t + s_{k2}^{t-1}) * (\ln K_2^t - \ln K_2^{t-1}) + \ldots$

$0.5(s_{kn}^t + s_{kn}^{t-1}) * (\ln K_n^t - \ln K_n^{t-1})$

Assuming two types of labor, $s_l L_g^{t**}$ can be written as

$$s_l L_g^{t\,**} = \frac{w * (L_1 + L_2)}{Q} * (w1/w) * \frac{dL_1 + (w_2/w_1) * dL_2}{(L_1 + L_2)} \quad \text{(Eq. 8)}$$

or

$$= \frac{w * (L_1 + L_2)}{Q} * \frac{(w_1/w) * dL_1 + (w_2/w) * dL_2}{(L_1 + L_2)}$$

where $w = \dfrac{w_1 * L_1 + w_2 L_2}{L_1 + L_2}$ (average wage)

and $\dfrac{dL_1 + (w_2/w_1)\, dL_2}{L_1 + L_2}$ (Eq. 9)

is the growth rate of labor in efficiency units ($dL_1 + (w_2/w_1)\ dL_2$) is the efficiency-weighted increase in labor.

In applying this method to analyze the effects of skilled and unskilled labor on TFP growth, L_1 is considered unskilled and L_2 skilled. Skilled labor is defined as those who are at least high school graduates. w_1 is the minimum wage, i.e., the wage rate for unskilled labor, while w_2 is the wage for skilled labor, which is computed residually.

A similar method was applied to analyze the effects of sectoral labor movement on TFP. Three sectoral labor types were considered: L_a agricultural labor; L_i industrial labor; and L_s service-sector labor. w_a is agricultural wage, w_i industry wage, and w_s service-sector wage, which is computed residually.

In the analysis of the effects of types of capital on TFP, Eq. 6 was used for the three types of capital: K_1 is durable equipment; K_2 structures; and K_3 other capital, and their respective capital prices.

Determinants of TFP Growth

TFP growth as a residual could be due to a host of factors. In the literature, in giving a theoretical sense to the residual, Grossman and Helpman (1991), Romer (1990), and Aghion and Howitt (1998) attempted to determine the role of technology, i.e., better instructions for combining raw materials into useful products and services. Romer (1986), Lucas (1988), and others tried to incorporate the critical role of externalities, including spillovers, economies of scale, and various complementarities in explaining TFP growth. However, in the present paper the possible determinants of TFP growth in the Philippines are investigated using regression analysis. No formal theorizing was attempted to sort the possible determining factors, but rather ad hoc regression specifications were experimented with using Philippine data. The possible factors analyzed include: foreign trade indicators (exports and imports); availability of credit; foreign direct investment

(FDI); macroeconomic fundamentals and stability (budget deficit and price changes); economic structure; expenditure on R&D; and structure of the national government budget. These factors were tested for statistical significance using standard tests in regression analysis.

DATA

The Appendix describes in detail the data requirements for the analysis as well as the sources of economic information. There are no official data series on capital stock. Thus studies of TFP growth in the Philippines use various methodologies for capital estimation. In the present work, the estimation of the capital stock made use of official data on investment going back to 1946.

Labor data used are based on employment numbers. Output data are GDP at factor cost. Factor prices, which are key in the analysis of TFP based on the quality of factor inputs, were either constructed from existing official available information or other variables served as proxies.

RESULTS AND ANALYSIS

TFP Growth Adjusted for Business Fluctuation

Annual TFP growth estimates from 1967 to 2000 are presented in Table 5, while the three-year moving average of business fluctuation-adjusted TFP growth is shown in Figure 1. In most of the past 35 years, TFP growth fell below zero. Positive estimates are seen in the second half of the 1980s and around 2000.

Figure 1. Three-year moving average business fluctuation-adjusted TFP growth.

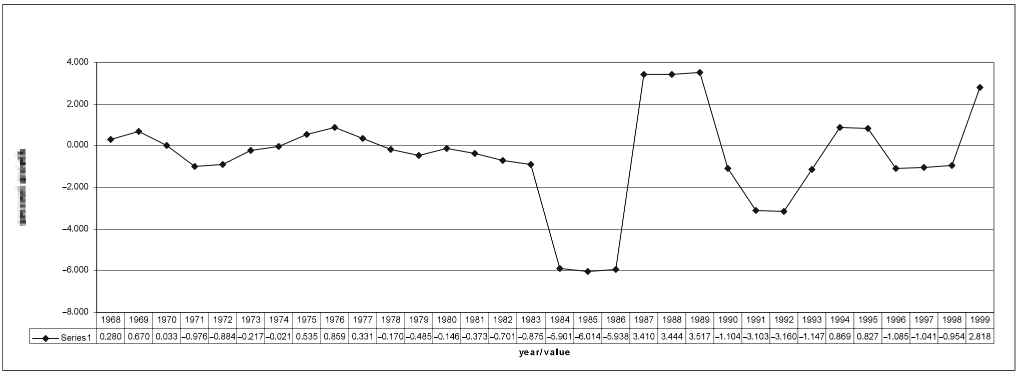
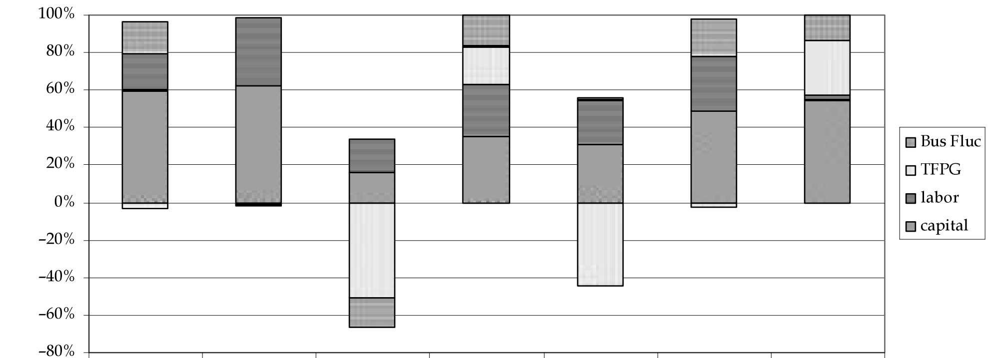


Table 5. Estimated Philippine TFP growth(TEPG) (%).

Year	Unadjusted TFPG	Business fluctuation adjustment factor	Business fluctuation-adjusted TFPG	3-Year moving average-adjusted TFPG
1967	-5.11	-3.8206	-1.293	
1968	1.13	1.1588	-0.032	0.280
1969	6.79	4.6197	2.166	0.670
1970	0.67	0.7964	-0.125	0.033
1971	-4.71	-2.7647	-1.943	-0.976
1972	-0.15	0.7088	-0.859	-0.884
1973	5.53	5.3769	0.151	-0.217
1974	-1.95	-2.0102	0.056	-0.021
1975	-4.32	-4.0452	-0.272	0.535
1976	7.07	5.2500	1.822	0.859
1977	1.01	-0.0134	1.027	0.331
1978	-7.45	-5.5928	-1.855	-0.170
1979	0.98	0.6572	0.318	-0.485
1980	3.72	3.6401	0.083	-0.146
1981	-1.69	-0.8533	-0.840	-0.373
1982	-0.76	-0.3997	-0.360	-0.701
1983	-4.20	-3.3004	-0.902	-0.875
1984	-8.77	-7.4009	-1.364	-5.901
1985	-8.36	7.0756	-15.438	-6.014
1986	1.78	3.0208	-1.239	-5.938
1987	1.23	2.3696	-1.136	3.410
1988	6.28	-6.3261	12.606	3.444
1989	1.51	2.6487	-1.138	3.517
1990	0.69	1.6101	-0.916	-1.104
1991	-4.92	-3.6642	-1.258	-3.103
1992	-3.50	3.6341	-7.134	-3.160
1993	-1.22	-0.1330	-1.089	-1.147
1994	0.56	-4.2166	4.781	0.869
1995	1.35	2.4392	-1.086	0.827
1996	1.60	2.8100	-1.214	-1.085
1997	1.06	2.0206	-0.956	-1.041
1998	-1.36	-0.4103	-0.954	-0.954
1999	2.50	3.4493	-0.951	2.818
2000	4.74	-5.6227	10.360	

Interesting results are observed in the analysis of the decomposition of output growth in Figure 2, in which TFP growth is considered as one of the contributing factors during the different critical subperiods over the past 35 years. While it may be true that the contribution of TFP growth to overall economic growth has been negative, in terms of the trend over an extended period it has improved. For example, from a −4.26% contribution to GDP growth in 1983−85, it improved to +0.93% in 1998−2000. This may be due to the effects of various economic policy reforms pursed in the past decade. Through the years, the largest contributor to growth has been capital.

Figure 2. Decomposition of output.



	1967–72	1973–82	1983–85	1986–90	1991–93	1994–97	1998–2000
Bus Fluc	0.88	−0.05	−1.34	0.58	0.08	0.90	0.41
TFPG	−0.18	−0.04	−4.26	0.67	−2.47	−0.11	0.93
labor	1.06	1.93	1.46	0.94	1.28	1.31	0.08
capital	3.07	3.33	1.38	1.18	1.73	2.22	1.71

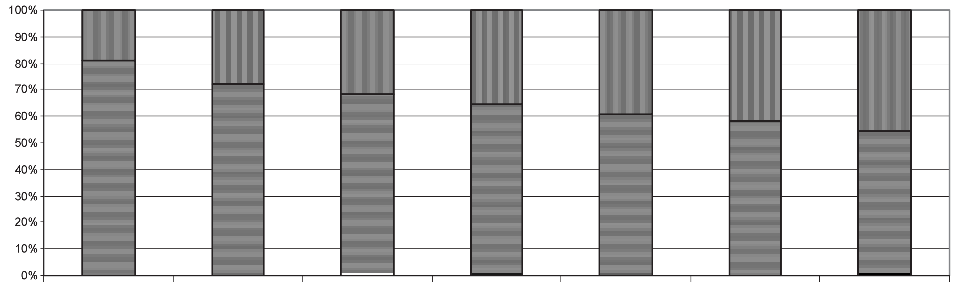
Decomposition of TFP Growth

There have been major changes in the structure of labor quality over the years. The share of skilled workers, loosely defined as those who have at least finished high school, increased from 19% in 1967−72 to 45% in 1998−2000 (Figure 3).

The structure of capital has not changed as much over the years. The share of capital structure hovered at around 47% (Figure 4). The share of durable equipment, on the other hand, improved from 30% in 1967−72 to 39% in 1998−2000.

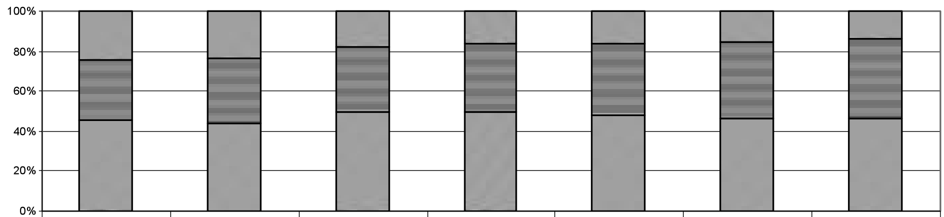
There were noticeable movements of labor across sectors (Figure 5). Agriculture, which employed 56% of labor in 1967−72, had a declining employment share. In 1998−2000, its employment share dropped to 38%. Labor moved to the service sector and not to the industrial sector. The share of service-sector employment increased from 29% in 1967−72 to 45% in 1998−2000. The employment share in industry hovered at around 16%.

Figure 3. Changes in the structure of labor quality.



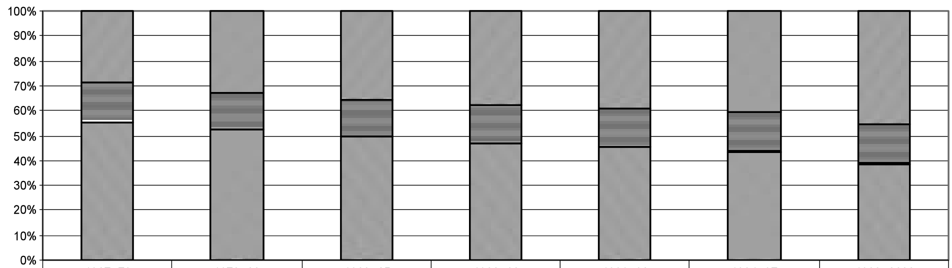
	1967-72	1973-82	1983-85	1986-90	1991-93	1994-97	1998-2000
skilled	0.19	0.28	0.31	0.36	0.39	0.42	0.45
unskilled	0.81	0.72	0.69	0.64	0.61	0.58	0.55

Figure 4. Types of capital.



	1967-72	1973-82	1983-85	1986-90	1991-93	1994-97	1998-2000
Others	0.24	0.24	0.18	0.17	0.16	0.15	0.14
Durable	0.30	0.32	0.33	0.34	0.36	0.38	0.39
Structure	0.46	0.44	0.49	0.50	0.48	0.47	0.47

Figure 5. Movements of labor.



	1967-72	1973-82	1983-85	1986-90	1991-93	1994-97	1998-2000
Services	0.29	0.33	0.35	0.38	0.39	0.41	0.45
Industry	0.16	0.15	0.15	0.15	0.16	0.16	0.16
Agri	0.56	0.53	0.50	0.47	0.45	0.43	0.38

What were the effects of these factor changes on TFP growth? Table 6 presents the results of decomposing the effects of labor quality on TFP growth using Eq. 7. The results are presented by period. The second column is unadjusted TFP growth rates, which are period averages of the same estimates in Table 5. The third column presents the results for TFP growth adjusted for the quality of labor. The last two columns compare the estimates by taking the difference and the ratio. A higher difference implies a larger contribution of labor quality to TFP growth. In terms of ratio, the further it deviates from 1, the larger the TFP growth.

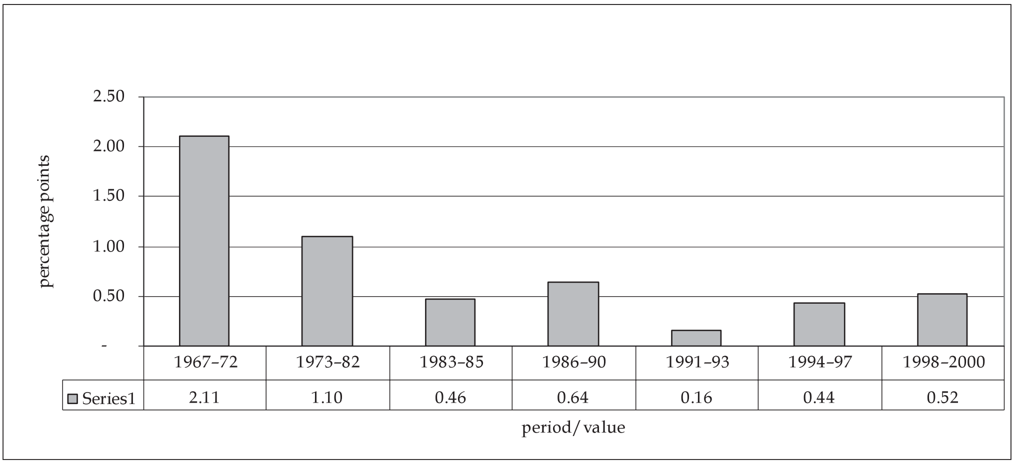
Table 6. Effects of labor quality on TFP growth (TFPG) (%).

Period	Unadjusted TFPG	TFPG adjusted for labor quality	Difference (unadjusted− adjusted)	Ratio (unadjusted/ adjusted)
1967−72	(0.23)	(2.34)	2.11	0.10
1973−82	0.21	(0.89)	1.10	(0.24)
1983−85	(7.11)	(7.57)	0.46	0.94
1986−90	2.30	1.66	0.64	1.39
1991−93	(3.21)	(3.38)	0.16	0.95
1994−97	1.14	0.71	0.44	1.61
1998−2000	1.96	1.44	0.52	1.36

In spite of the increasing ratio of skilled labor to total employment its contribution to TFP growth declined. The drop is evident in Figure 6. From a 2.11% contribution to TFP growth, it declined to 0.16% in 1991−93. It started to recover thereafter, although it remained far below the contribution in earlier periods. This decline may imply a number of things. First, it may be true that skilled labor, as loosely defined in terms of level of schooling, may not have captured the actual skill development of labor. Second, the quality of education that could have produced the necessary skills to improve productivity may have declined over time. There are available facts that may support this. Cororaton (1998) observed that while the Philippines has one of the highest numbers of college graduates in the region, it has the fewest graduates specializing in science, technology, and engineering. Third, the results may imply that the marginal productivity of workers with higher education, as well as the efficiency of education itself, has deteriorated. Fourth, the increasing (massive) number of Filipinos working abroad may have resulted in a brain drain, with losses in productivity in the domestic economy.

There could be other reasons, but the results indicate that the drive to improve education in the country should somehow be reflected in productivity improvement; otherwise the whole exercise could become frustrating if it only results in a situation wherein trained Filipinos seek employment elsewhere. Structural incentives, particularly labor incentives, must be examined. The structure of incentives could include the structure of relative factor wages to address the problems related to graduates specializing in science and technology. The efficiency of the educational system, including the curriculum, books and manuals, and training of teachers and professors, should also be examined.

Figure 6. Contribution of labor quality to TFP growth.



The effects of incorporating different types of capital into TFP growth are negligible, as presented in Table 7 and Figure 7. Although nil, the effects through the years varied.

Figure 7. Contribution of capital types to TFP growth.

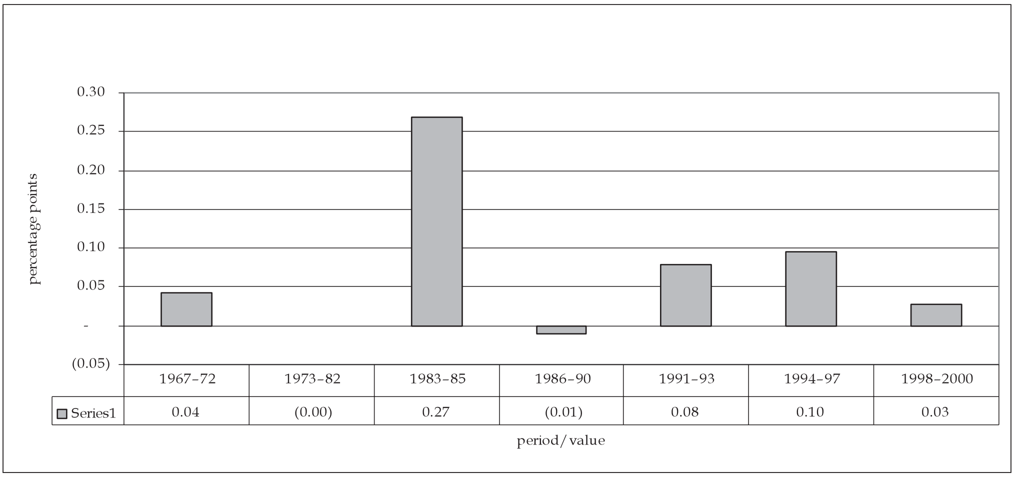


Table 7. Effects of capital type on TFP growth (TFPG) (%).

Period	Unadjusted TFPG	TFPG adjusted for capital type	Difference (unadjusted−adjusted)	Ratio (unadjusted/ adjusted)
1967-72	(0.23)	(0.27)	0.04	0.84

Continued...

...Continued

1973-82	0.21	0.21	(0.00)	1.00
1983-85	(7.11)	(7.38)	0.27	0.96
1986-90	2.30	2.31	(0.01)	1.00
1991-93	(3.21)	(3.29)	0.08	0.98
1994-97	1.14	1.05	0.10	1.09
1998-2000	1.96	1.93	0.03	1.01

Finally, the effects of the movement of labor across sectors on TFP growth improved over the years, indicating efficiency effects, however small, from labor movement out of agriculture (Table 8 and Figure 8). Except for 1991-93, the effect on TFP growth increased over time. One wonders whether labor movement to industry in general, or to the manufacturing sector in particular, instead of the service sector could have contributed to higher TFP growth.

Figure 8. Contribution of sectoral labor movement to TFP growth.

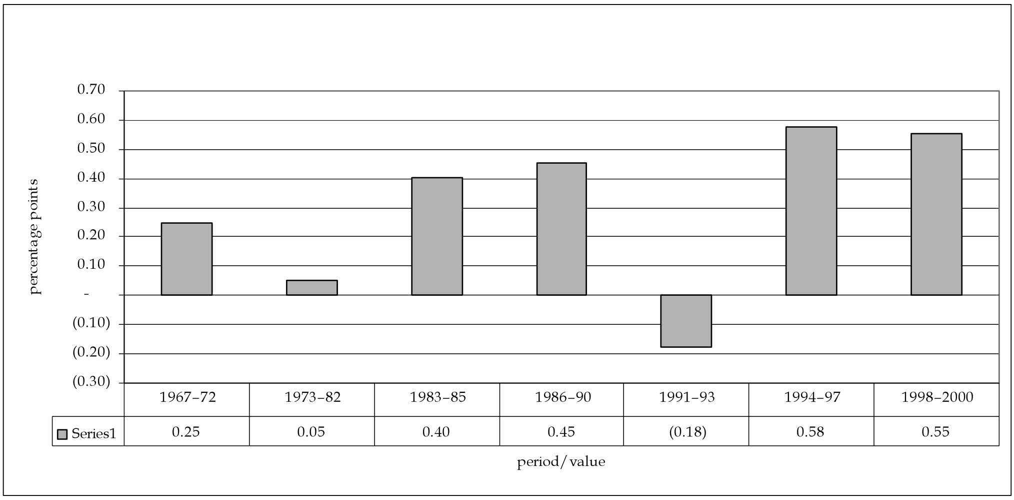


Table 8. Effects of sectoral labor movement on TFP growth (TFPG) (%).

Period	Unadjusted TFPG	TFPG adjusted for sectoral labor movement	Difference (unadjusted-adjusted)	Ratio (unadjusted/adjusted)
1967-72	(0.23)	(0.48)	0.25	0.48
1973-82	0.21	0.16	0.05	1.31
1983-85	(7.11)	(7.51)	0.40	0.95
1986-90	2.30	1.85	0.45	1.25

Continued...

...Continued

1991-93	(3.21)	(3.04)	(0.18)	1.06
1994-97	1.14	0.57	0.58	2.02
1998-2000	1.96	1.40	0.55	1.40

Determining Factors of TFP Growth

A number of regression experiments were conducted on the computed TFP growth and the various determining factors listed earlier (Table 9). Only two regression factors resulted in better results. These are presented in Table 10.

Table 9. Estimated Philippine TFP growth (TFPG), unadjusted and adjusted (%).

Year	Unadjusted TFPG	Business fluctuation-adjusted TFPG	Labor quality-adjusted TFPG	Capital type-adjusted TFPG	Sectoral labor movement-adjusted TFPG
1967	−5.01	−3.82	−6.10	−5.04	−4.78
1968	0.17	1.16	−0.76	0.13	0.29
1969	3.78	4.62	2.81	3.76	3.22
1970	−0.20	0.80	−1.26	−0.21	−1.24
1971	−4.05	−2.76	−5.16	−4.07	−4.86
1972	−0.34	0.71	−1.46	−0.35	0.65
1973	4.53	5.45	3.36	4.54	4.21
1974	−2.91	−2.08	−4.15	−2.90	−1.35
1975	−4.99	−4.05	−6.17	−5.01	−6.56
1976	4.84	5.25	3.70	4.85	4.52
1977	−0.54	−0.01	−0.11	−0.53	−0.84
1978	−7.01	−5.59	−7.51	−7.01	−6.99
1979	−0.07	0.66	−0.57	−0.08	−0.24
1980	2.38	3.64	2.12	2.33	2.66
1981	−2.12	−0.85	−2.11	−2.20	−1.62
1982	−1.94	−0.40	−2.29	−2.00	−1.78
1983	−4.63	−3.30	−4.56	−4.68	−4.90
1984	−8.82	−7.40	−9.06	−8.86	−9.27
1985	−7.81	7.09	−7.89	−7.82	−7.68
1986	2.30	3.02	2.28	2.29	2.60
1987	1.26	2.37	0.88	1.27	0.75
1988	6.29	−6.33	6.14	6.29	5.79
1989	1.51	2.65	1.38	1.49	0.99
1990	0.13	1.61	−0.05	0.11	−0.08

Continued...

1991	−4.63	−3.66	−4.65	−4.65	−4.53
1992	−3.41	3.64	−3.52	−3.43	−3.34
1993	−1.26	−0.13	−1.22	−1.29	−1.08
1994	0.47	−4.20	0.42	0.44	0.28
1995	2.09	3.33	1.91	2.05	1.56
1996	0.91	1.91	0.67	0.88	0.73
1997	0.48	1.82	0.47	0.46	−0.20
1998	−2.02	−0.76	−2.30	−2.04	−2.60
1999	2.61	4.01	2.51	2.59	2.50
2000	4.27	−5.62	4.10	4.26	3.70

Table 10. Determinants of TFP growth (TFPG).

Dependent variable: 3−year moving average of TFPG						
Regression no.	**Regression no. 1**			**Regression no. 2**		
Method	**OLS**			**OLS**		
Sample	**1975−99**			**1976−99**		
	Coefficient	**SE**	**t value**	**Coefficient**	**SE**	**t value**
Variable:						
Constant	−89.4	17.1	−5.2	−86.3	16.6	−5.2
Exports				26.2	6.9	3.8
Imports(−1)				8.7	8.1	1.1
Exports+imports	18.7	4.9	3.8			
FDI (−1)	304.8	54.3	5.6	325.0	53.8	6.0
R&D (−2)	1943.2	766.4	2.5	2193.8	754.5	2.9
Price changes	−6.7	3.1	−2.2	−7.8	3.0	−2.6
Share of manufacturing	300.0	61.0	4.9	289.9	58.9	4.9
D83	9.0	2.2	4.1	8.9	2.1	4.3
D87	7.1	1.4	5.0	6.8	1.4	5.0
D91	−4.7	1.4	−3.3	−4.5	1.4	−3.2
R square	0.849			0.870		
Adjusted R square	0.769			0.787		
DW	2.122			2.226		
Fvalue	10.576			10.447		

Definition of variables

Exports,	exports/GDP
Imports(−1),	one-year lag of imports/GDP
Exports+imports,	(exports+imports)/GDP
FDI (−1),	one-year lag of foreign direct investment/GDP
Share of manufacturing,	manufacturing GVA/GDP
R&D (−2),	two-year lag of R&D expenditure/GDP
Price changes,	annual change in GDP deflator
D83, D87, D91,	dummy variables

The results of regression analysis showed that trade indicators, in this case exports and imports combined, are positive determinants of TFP growth. The reason for combining these variables is because exports and imports generally grow in the same direction, as shown in Table 1. This is because exports are highly dependent on imports. This can create multiple colinearity problems, as found in the second regression analysis.

The coefficient of the combined trade indicator is statistically significant. The positive effect of exports on TFP growth implies that exports can bring about economies of scale with larger export markets. It can also expose local producers to international best practices in production. Furthermore, foreign competition in the export market can translate into improved efficiency in the operations of local producers. On the other hand, the positive effect of imports on TFP growth indicates the transfer of modern technology into the domestic economy since imports are one major vehicle for acquiring appropriate foreign technology. Therefore a higher volume of imports necessarily decreases the technological gap between domestic and foreign technology in terms of modern equipment, production processes, and management.

FDI lagged one year not only positively affected TFP growth but was also highly statistically significant. FDI is another major vehicle for transferring foreign technology.

Price changes, an indicator of economic stability and fundamentals, is negatively related to TFP growth. This means high and unstable prices create economic uncertainties that discourage investors from investing in productivity improvement projects.

The share of gross value added of manufacturing to total GDP was included to capture externalities and spillover effects of production technology to the rest of the economy. The shares of the agriculture and service sectors were found to be statistically insignificant. The positive and highly statistically significant coefficient of the share of manufacturing indicates that this sector has far greater spillover effects to the rest of the economy than other sectors. Its development therefore is an important factor affecting TFP growth.

Expenditure on R&D lagged two years is positive and statistically significant, indicating that it is also another important factor determining TFP growth.

CONCLUSIONS AND POLICY IMPLICATIONS

The following insights can be drawn from the results reported in this paper.

1) Although the last 35 years saw mostly negative TFP growth in the Philippines, there is an underlying trend that is encouraging. The contribution of TFP growth to overall economic growth consistently improved from −4.26% in the mid-1980s to +0.93% in 1998−2000. It is important to note that during this period major economic policy reforms were pursued.
2) In spite of the increasing ratio of skilled labor to the total, loosely defined as those who have at least finished high school, its contribution to TFP growth declined over time. This could imply a number of things, including: deterioration in the quality of education necessary for productivity improvement; deterioration in the marginal productivity of workers with higher education and in the efficiency of education itself; and a brain drain due to the surge in the number of Filipinos working abroad. These are critical issues in the Philippines which need to be examined closely.

3) Efficiency improvements seem to have been gained from the movement of labor out of agriculture.
4) Sound macroeconomic fundamentals, price stability, and opening up of the economy to foreign trade and investments are critical factors affecting TFP growth. Spillover effects on TFP from manufacturing seem to be far more significant than those from the service and agriculture sectors. Expenditure on R&D is also another important factor affecting TFP.

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APPENDIX

The paper attempts to estimate and analyze TFP in the Philippine as far back as possible to obtain a good historical perspective of its changes. Assembling the database for analysis required information dating to early 1946.

Output

Output is indicated by GDP at factor cost. In particular, this is computed as

GDP at factor cost = Nominal GDP - indirect taxes + subsidies.

This is expressed in 1985 prices using the implicit price deflator of GDP of the National Income Accounts (NIA). The latest base year for the price deflator is 1985. Nominal GDP, indirect taxes, and subsidies were all sourced from the official NIA.

Labor Input

The employment data were supplied directly by the staff of the National Statistics Office as part of the ongoing work on institutionalizing TFP estimation under an interagency technical working group on productivity indicators and monitoring systems. Labor input is indicated by employment data from the Department of Labor and Employment (DOLE). It is broken down into two employment categories: by major sector and by skill level. The sectoral breakdown includes employment in the agriculture, industry, and service sectors. On the other hand, skilled labor is defined in an ad hoc way, which includes employed people with at least a high school diploma.

Employment data by major sector are available from 1956 to 2000, except for 1979. For 1979, the overall available employment data were broken down into sectoral employment using the interpolated employment share derived as the average of the 1978 and 1980 employment share for agriculture and industry employment. Service-sector employment was derived as a residual.

Data on employment by highest grade completed are available for 1976 to 2000, except for 1979. For that year, data are interpolated using the average share in 1978 and 1980. However, data are available for 1965 and 1961 on employment by highest grade completed. The employment series in this category was interpolated until 1961 using a geometric growth formula on the shares of unskilled labor, which is defined as those without education up to the third year of high school. Data for skilled labor were derived residually for those years for which data were unavailable.

Investment

There is no available official capital stock series. The capital stock series is therefore a calculated one. Investment is indicated by the gross capital formation (GCF) of the NIA, which is available officially starting in 1946. Aside from the GCF, four of its components were utilized in the estimation: investment in durable equipment; construction; breeding stock and orchard development; and changes in stock. Investment in breeding stock and orchard development refers to expenditures on animals, as a form of capital formation, which are used as producing units on livestock and poultry farms and raised as breeding stock, draft animals, dairy animals, and egg layers, less the disposal of those animals. Transfer costs incurred in the purchase of these animals are also included as part of fixed capital formation on animals. Expenditures on orchard development cover the outlays and expenditures on the cultivation of plantations and the planting of permanent crops until they become productive.

For the present research, the last two categories of investment were lumped under the heading of others. Data series on investment are expressed in 1985 prices using the implicit price deflator, which is available for each of the components of the GCF.

Initial Capital Stock

Apart from the overall total initial capital stock, three more types of capital stock, as well as their respective initial capital stocks, were estimated: machinery and equipment; structures; and others. The first two were estimated using historical data on investment, while the last one was derived residually. Historical data on investment in durable equipment were used to estimate the initial capital for machinery and equipment, while historical data on construction were utilized to estimate initial capital stock for structures.

The procedure for estimating the overall initial capital stock is shown in Appendix Table 1. This procedure is different from the one developed in de Silva (2001). In the present procedure, an assumed depreciation was used to calculate the initial stock, while in de Silva (2001), the initial capital stock was calculated as the simple sum of real investment from 1946 to 1960. Other studies have also applied 5% (Austria and Martin, 1992). If a depreciation rate of 5% is assumed, then the average life span of capital is 20 years (i.e., 1/0.05 = 20 years). If the 5% depreciation rate is indeed true, then the amount invested in 1946 would have zero value in 1966. Thus the value of investment in 1946 of P14,377 million in 1985 prices will be zero in 1966, as shown in the table. Similarly, the investment in 1947 of P25,371 million will have a remaining value of P1,269 million in 1966, while a 1948 investment will have a remaining value of P3,103 million in 1966. If one continues this process until 1966, then one arrives at the value of the overall capital stock in 1966, which is P449,935 million in 1985 prices.

A similar procedure was used to estimate initial capital stock for structures. A 5% depreciation rate was assumed on investment in construction. This yielded the value of P212,068 million in 1985 prices of initial capital stock for structure in 1966.

However, using a similar procedure, a 6% depreciation rate was assumed for investment in durable equipment to arrive at the initial capital stock for machinery and equipment. This generated an estimate of P90,684 million in 1985 prices for the initial capital stock of machinery and equipment in 1963. To be consistent with the first two, the value for 1966 was considered in the analysis. The initial capital stock for others was derived residually.

Appendix Table 1. Estimation of initial capital stock.

	GCF	1946	1947	1948	1949	1950	1951	…	1964	1965	1966
1946	14,377	14,377	13,658	12,939	12,220	11,502	10,783	…	1,438	719	0
1947	25,371		25,371	24,102	22,834	21,565	20,297	…	3,806	2,537	1,269
1948	31,030			31,030	29,479	27,927	26,376	…	6,206	4,655	3,103
1949	23,286				23,286	22,122	20,957	…	5,822	4,657	3,493
1950	22,197					22,197	21,087	…	6,659	5,549	4,439
1951	22,553						22,553	…	7,894	6,766	5,638
…	…								…	…	…
1964	56,589								56,589	53,760	50,930
1965	60,145									60,145	57,138
1966	60,184										60,184
	K0 = K66										449,935

Capital Stock

The series on capital stock was derived using the common perpetual capital inventory method. That is,

$$K_t = K_{t-1}(1-\delta) + I_t$$

where K_t is capital stock in year t, K_{t-1} is the capital stock in the previous year, δ is the depreciation rate, and I_t is investment. The method was applied to derive the capital stock series for the overall total, structures, and machinery and equipment. To be consistent with the estimation of the initial capital stock, the depreciation rate for the overall total is 5%, for structures 5%, and for machinery and equipment 6%.

Factor Shares

The share of labor was computed using data on labor compensation and a derived labor income from household operating surplus. The former is readily available officially, while the latter was derived using the following assumption:

Labor income from household operating surplus = (total household operating surplus) × (labor compensation/GDP at factor cost)

Total labor income was calculated as the sum of labor compensation plus the derived labor income from household operating surplus. The share of capital is 1 minus the total share of labor income.

Price of Capital

The analysis that allows for differences in marginal productivity of the different types of capital input requires their respective capital prices. However, there are no official records on these prices. Proxy indicators were therefore devised utilizing information on interest rates, depreciation rates, and a price deflator. For example, the following relationship was used to obtain proxy indicators for the rental price of capital type 1:

Rental price of capital type 1 = (interest rate + depreciation rate of capital type 1 - rate of change of the price of capital type 1)* (price of capital type 1).

However, since there are no official records on the various prices of capital, the same price was used for all types of capital considered in the analysis. The share of capital type 1 was computed as:

S_{k1} = (rental price of capital 1)*K_1/[(rental price of capital 1)*K_1 + (rental price of capital 2)*K_2 + (rental price of capital 3)*K_3].

The shares of capital for the other types were similarly computed.

Appendix Table 2. Database TFP computations.

	GDP Nominal Pmillion	GDP Real Pmillion	GDP at factor cost nominal Pm	GDP at factor cost (Pm 85prices)	Gross Cap form ation (Pm 85prices)	Investment in Construction (Pm 85prices)	Investment in Durable Equip (Pm 85prices)	Total Capital* Stock (Pm 85prices)	Bulding &* Structure (Pm 85prices)	Durable* Equipment (Pm 85prices)	Employment (000)	Employment unskilled	Employment skilled	Employment Agriculture
1946			4,481		14,377	9,046	1,024							
1947			5,574		25,371	15,058	4,516							
1948			6,081		31,030	18,121	5,297							
1949			6,368		23,286	12,737	5,276							
1950			6,735		22,197	11,816	4,004							
1951			7,498		22,553	13,642	3,305							
1952			7,847		21,780	12,513	3,523							
1953			8,320		27,438	14,687	5,137							
1954			8,610		29,522	12,398	6,807							
1955			9,173		31,458	12,598	7,697							
1956			10,023		31,153	15,103	9,311							
1957			10,936		36,866	18,084	11,230				8,217			4,979
1958			11,552		36,733	16,664	11,442				8,855			5,369
1959			12,594		41,862	18,537	13,811				8,910			5,495
1960	13,478	212,211	12,497	196,765	37,335	16,638	11,768				9,187			5,620
1961	14,682	224,130	13,558	206,971	43,507	20,388	12,544				9,474	8,384	1,090	5,664
1962	16,421	234,828	15,189	217,210	43,095	19,057	11,991				9,761	8,384	1,090	5,959
1963	19,126	251,408	17,665	232,203	50,936	23,542	13,884			90,684	10,401	8,558	1,203	6,182
1964	20,677	260,074	19,134	240,666	56,589	26,936	17,231			102,474	10,661	9,036	1,365	6,240
1965	22,617	273,769	21,122	255,673	60,145	29,680	17,163			113,489	10,631	9,177	1,484	6,102
1966	24,878	285,886	23,153	266,063	60,184	28,119	17,919	449,935	212,068	124,599	11,124	9,068	1,563	6,327
1967	26,717	301,107	24,709	278,476	66,489	31,058	23,278	493,928	232,523	140,401	12,287	10,163	2,124	7,051
1968	29,835	315,998	27,945	295,980	66,953	28,011	26,511	536,184	248,908	158,488	12,586	10,251	2,335	7,262
1969	33,062	330,712	30,906	309,146	69,986	30,004	26,283	579,361	266,466	175,261	11,329	9,087	2,242	6,378
1970	39,506	343,162	37,083	322,115	67,236	24,668	26,909	617,629	277,811	191,655	11,453	9,046	2,407	6,151
1971	47,648	361,791	44,097	334,828	71,102	24,395	31,270	657,850	288,316	211,425	12,689	9,869	2,820	6,494
1972	53,515	381,497	49,480	352,732	73,684	28,345	29,309	698,641	302,245	228,049	13,328	10,208	3,120	7,226
1973	68,123	415,229	62,932	383,588	82,415	29,915	30,271	746,124	317,048	244,637	13,373	10,086	3,287	7,075
1974	93,545	430,314	85,940	395,330	99,568	32,968	38,175	808,386	334,163	268,134	13,781	10,235	3,546	7,847
1975	107,950	454,260	96,960	408,022	123,546	50,693	45,635	891,513	368,148	297,681	14,639	10,707	3,932	7,833
1976	127,211	494,265	116,179	451,401	146,854	71,396	44,264	993,791	421,137	324,084	14,357	10,340	4,017	7,562
1977	145,451	521,954	132,332	474,876	148,282	75,834	43,183	1,092,383	475,914	347,822	14,454	10,473	3,981	7,536
1978	167,249	548,950	149,486	490,648	160,283	78,709	49,659	1,098,047	530,827	376,612	16,236	11,679	4,557	8,473
1979	202,900	579,909	182,192	520,723	167,265	77,249	55,473	1,305,410	581,535	409,488	16,683	11,906	4,777	8,661
1980	243,749	609,768	223,617	559,405	161,071	79,758	60,077	1,401,210	632,216	444,996	16,795	11,891	4,904	8,674
1981	281,596	630,642	259,962	582,192	165,633	91,095	66,704	1,496,783	691,700	485,000	17,632	12,495	5,137	9,049
1982	317,177	653,467	292,623	602,879	179,577	92,881	73,793	1,601,521	749,996	529,693	17,991	12,483	5,508	9,307
1983	369,077	665,717	339,557	612,471	191,070	111,496	71,108	1,712,515	823,992	569,019	18,898	13,171	5,727	9,631
1984	524,481	616,962	486,115	571,831	120,398	83,318	45,043	1,747,287	866,111	579,921	19,238	13,158	6,080	9,553
1985	571,883	571,883	531,027	531,027	82,047	51,242	33,261	1,741,970	874,047	578,387	19,747	13,368	6,379	9,738
1986	608,887	591,423	565,399	549,182	90,301	47,753	37,827	1,745,172	878,098	581,511	20,488	13,834	6,654	10,197
1987	682,764	616,923	623,139	563,048	108,085	51,745	40,124	1,765,998	885,938	586,744	20,770	13,510	7,260	10,013
1988	799,182	658,581	742,446	611,827	123,960	58,454	49,635	1,801,659	900,095	601,174	21,205	13,574	7,631	9,969
1989	925,444	699,448	848,947	641,632	149,310	67,370	65,760	1,860,886	922,460	630,864	21,908	13,819	8,089	9,901
1990	1,077,237	720,690	989,352	661,893	172,951	77,443	76,976	1,940,792	953,780	669,988	21,894	13,561	8,333	9,750
1991	1,248,011	716,522	1,133,784	650,941	143,047	60,733	69,922	1,986,800	966,824	699,711	22,914	14,148	8,766	10,290
1992	1,351,559	718,941	1,217,554	647,659	154,252	63,518	76,094	2,041,712	982,001	733,822	23,695	14,318	9,377	10,726
1993	1,474,457	734,156	1,324,038	659,260	166,397	70,258	82,292	2,106,023	1,003,159	772,085	24,382	14,844	9,538	11,139
1994	1,693,865	766,368	1,512,232	684,190	180,797	72,858	91,658	2,181,519	1,025,859	817,418	25,032	15,073	9,959	11,286
1995	1,905,266	802,866	1,697,688	715,394	187,131	78,627	93,701	2,259,574	1,053,193	862,074	25,676	15,093	10,583	11,147
1996	2,171,922	849,121	1,951,740	763,040	210,440	91,115	102,654	2,357,035	1,091,648	913,003	27,186	15,519	11,667	11,645
1997	2,421,306	892,860	2,167,979	799,445	235,052	104,404	112,065	2,474,236	1,141,470	970,288	27,715	15,806	11,909	11,314
1998	2,678,187	887,905	2,425,252	804,049	196,794	98,831	91,837	2,547,318	1,183,228	1,003,908	27,910	15,402	12,508	10,933
1999	2,976,905	918,160	2,704,040	834,001	192,894	98,571	87,269	2,612,846	1,222,637	1,030,942	27,742	15,150	12,592	10,774
2000	3,302,589	954,962	3,053,727	883,002	197,254	94,890	90,422	2,679,458	1,256,395	1,059,508	27,453	14,751	12,702	10,181

/1/ computed in itial K-stock in 1966, and inventory method for the rest of the years. dep=0.05 dep=0.05 dep=0.06

*Calculation in k-stock.xls.

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	Industry	Service	Labor Share	Capital Share	minimum wage (pesos/day)	interest rate	dep rate building	dep rate dur.Equip	IPI-GCF	IPI-const	IPI-durequip	total laborincome	total laborincime	Industry	Services	Industry		
																Agriculture	Industry	Services
1946									0,0698	0,0633	0.0684							
1947									0,0636	0,0632	0.0419							
1948									0,0564	0,0633	0,0400							
1949									0,0572	0,0634	0,0402							
1950					2,63				0,0584	0,0677	0,0362							
1951					2,83				0,0617	0,0660	0,0466							
1952					3,03				0,0607	0,0655	0,0494							
1953					3,11				0,0589	0,0669	0,0469							
1954					3,08				0,0535	0,0640	0,0419							
1955					3,17				0,0520	0,0629	0,0404							
1956					3,22				0,0581	0,0646	0,0410							
1957	1,291	1,947			3,18				0,0593	0,0654	0,0424							
1958	1,397	2,089			3,20				0,0601	0,0662	0,0435							
1959	1,280	2,135			3,23				0,0611	0,0681	0,0447							
1960	1,415	2,152	57,045	42,955	3,23		0.05	0,06	0,0672	0,0727	0,0537	7,129						
1961	1,431	2,379	57,337	42,663	3,31		0.05	0,06	0,0700	0,0731	0,0592	7,774	1,977	2,194	3,603	349	1,533	1,514
1962	1,411	2,391	56,661	48,808	3,41		0.05	0,06	0,0775	0,0771	0,0747	8,606	2,305	2,256	4,045	387	1,599	1,692
1963	1,661	2,558	57,194	48,422	3,59		0.05	0,06	0,0830	0,0813	0,0799	10,103	2,657	2,777	4,669	430	1,672	1,825
1964	1,660	2,761	56,815	48,633	3,63		0.05	0,06	0,0860	0,0842	0,0829	10,871	2,979	2,901	4,990	477	1,748	1,807
1965	1,583	2,946	56,943	47,917	3,88		0.05	0,06	0,0881	0,0862	0,0848	12,028	3,259	2,912	5,857	534	1,839	1,988
1966	1,721	3,076	56,286	48,730	4,17	22,2	0.05	0,06	0,0918	0,0897	0,0874	13,032	3,730	3,289	6,013	590	1,911	1,955
1967	1,836	3,400	55,961	49,401	4,36	22,2	0.05	0,06	0,0946	0,0919	0,0909	13,827	4,562	3,623	5,643	647	1,973	1,660
1968	1,853	3,471	55,658	48,836	4,85	22,2	0.05	0,06	0,1006	0,0990	0,0960	15,554	5,198	3,806	6,549	716	2,054	1,887
1969	1,734	3,217	55,780	48,868	5,08	22,2	0.05	0,06	0,1057	0,1016	0,1028	17,239	5,106	3,748	8,384	801	2,162	2,606
1970	1,891	3,411	55,696	48,651	5,64	25,1	0.05	0,06	0,1254	0,1176	0,1291	20,654	5,970	5,130	9,554	971	2,713	2,801
1971	2,070	4,125	59,534	46,099	6,02	22,8	0.05	0,06	0,1409	0,1306	0,1431	26,253	7,727	7,127	11,399	1,190	3,443	2,763
1972	2,038	4,064	59,547	46,157	6,38	22,8	0.05	0,06	0,1507	0,1382	0,1520	29,464	10,539	8,904	10,021	1,459	4,369	2,466
1973	2,056	4,242	59,640	46,094	6,38	18,0	0.05	0,06	0,1803	0,1616	0,1820	37,532	12,472	11,238	13,822	1,763	5,466	3,258
1974	1,902	4,032	61,951	44,458	8,36	19,2	0.05	0,06	0,2532	0,2497	0,2237	53,241	17,253	13,423	22,565	2,199	7,058	5,596
1975	2,225	4,581	61,380	46,496	8,89	14,9	0.05	0,06	0,2696	0,2512	0,2657	59,515	16,849	17,165	25,501	2,151	7,715	5,567
1976	2,115	4,680	60,892	45,743	10,65	14,2	0.05	0,06	0,2846	0,2680	0,2822	70,744	15,849	17,762	37,132	2,096	8,398	7,934
1977	2,110	4,808	62,102	45,000	13,03	13,8	0.05	0,06	0,3004	0,2590	0,2921	82,181	15,894	19,922	46,365	2,109	9,442	9,643
1978	2,389	5,374	61,727	46,533	13,57	11,7	0.05	0,06	0,3212	0,3132	0,3099	92,273	17,557	24,759	49,957	2,072	10,364	9,296
1979	2,516	5,506	61,300	46,583	17,67	14,0	0.05	0,06	0,3740	0,3636	0,3648	111,683	17,684	28,708	65,290	2,042	11,410	11,858
1980	2,595	5,526	52,192	53,464	25,45	14,5	0.05	0,06	0,4402	0,4674	0,4009	116,710	23,162	43,264	50,283	2,670	16,672	9,099
1981	2,533	6,050	53,001	52,372	27,07	17,1	0.05	0,06	0,4669	0,5047	0,4019	137,783	25,861	52,034	59,889	2,858	20,542	9,899
1982	2,557	6,127	52,804	52,580	27,10	18,2	0.05	0,06	0,4923	0,5421	0,4251	154,517	28,317	56,704	69,497	3,043	22,176	11,343
1983	2,729	6,538	50,472	54,844	29,07	19,3	0.05	0,06	0,5717	0,5982	0,5296	171,381	34,608	65,128	71,645	3,593	23,865	10,958
1984	2,879	6,806	47,225	57,309	41,36	26,7	0.05	0,06	0,8864	0,9045	0,8414	229,567	54,710	81,677	93,180	5,727	28,370	13,691
1985	2,814	7,195	39,483	64,325	48,86	28,2	0.05	0,06	1,0000	1,0000	1,0000	209,665	45,923	72,369	91,372	4,716	25,718	12,699
1986	2,789	7,502	40,283	63,578	48,86	17,3	0.05	0,06	1,0274	1,0359	1,0334	227,762	48,701	77,034	102,026	4,776	27,621	13,600
1987	2,969	7,788	40,957	63,766	50,80	13,3	0.05	0,06	1,1054	1,1466	1,0495	255,217	53,843	86,663	114,711	5,377	29,189	14,729
1988	3,258	7,978	39,059	64,622	61,07	16,0	0.05	0,06	1,2036	1,2356	1,1474	289,993	62,115	86,895	140,982	6,231	26,671	17,671
1989	3,506	8,501	43,912	60,843	73,26	19,5	0.05	0,06	1,3388	1,4609	1,2018	372,790	66,000	133,276	173,514	6,666	38,014	20,411
1990	3,491	8,653	39,938	64,195	87,28	24,3	0.05	0,06	1,5043	1,6738	1,3247	395,129	68,790	123,362	202,977	7,055	35,337	23,457
1991	3,631	8,993	42,440	62,656	104,85	23,5	0.05	0,06	1,7639	1,9735	1,5663	481,177	82,267	142,541	256,369	7,995	39,257	28,508
1992	3,823	9,146	43,202	62,376	106,30	19,4	0.05	0,06	1,8697	2,0838	1,6615	526,009	92,601	147,331	286,078	8,633	38,538	31,279
1993	3,804	9,439	42,312	63,261	119,85	14,6	0.05	0,06	2,1256	2,1095	2,1472	560,230	93,634	159,706	306,890	8,406	41,984	32,513
1994	3,949	9,797	41,811	63,954	121,46	15,0	0.05	0,06	2,2532	2,2675	2,2645	632,284	107,958	172,858	351,468	9,566	43,773	35,875
1995	4,140	10,389	42,009	63,887	124,58	14,6	0.05	0,06	2,2866	2,3369	2,2387	713,175	115,916	190,339	406,920	10,399	45,976	39,168
1996	4,431	11,110	42,256	63,246	138,27	14,8	0.05	0,06	2,4786	2,5299	2,3883	824,731	129,215	214,993	480,523	11,096	48,520	43,251
1997	4,631	11,770	43,655	62,154	153,63	16,2	0.05	0,06	2,5579	2,5904	2,5422	946,426	115,009	246,107	585,311	10,165	53,143	49,729
1998	4,583	12,394	44,340	60,985	169,22	18,4	0.05	0,06	2,7547	2,7455	2,7587	1,075,352	123,867	254,326	697,159	11,330	55,493	56,250
1999	4,515	12,453	43,520	61,543	179,13	11,8	0.05	0,06	2,8941	2,7991	2,8801	1,176,796	171,026	205,379	700,391	15,874	67,637	56,243
2000	4,454	12,817	43,199	60,951	191,66	10,9	0.05	0,06	2,9877	2,9548	3,0009	1,319,192	191,721	342,331	785,140	18,832	76,859	61,258

/1/ computed in itial K-stock in 1966, and inventory method for the rest of the years.

*Calculation in k-stock.xls.

Price of Labor

Two categories of labor are needed to conduct analysis on the effects on TFP of: 1) industry shift (which requires sectoral employment and their respective wage rates); and 2) quality of labor (skilled and unskilled and their respective wages). However, there are no official records on wage rates in the Philippines, except for information on legislated wage rates. Legislated wage rates are available for the National Capital Region (NCR) and regions outside the NCR, as well as for agricultural plantation and nonplantation workers. Thus proxy indicators were devised. These are:

1) For wages by major sector, breakdowns of total compensation in the NIA into major sectors are available from 1980 to 1998. Thus, together with the sectoral breakdown of employment, sectoral wages were derived as the ratio of sectoral compensation and employment in agriculture, industry, and services. The remaining problem is how to extend sectoral compensation series beyond 1980. Information on sectoral compensation from the 1974, 1969, and 1961 input-output tables was utilized to interpolate the missing years. In particular, sectoral shares of compensation were interpolated using a geometric growth formula. These computed shares were then applied to the total compensation to derive the sectoral compensation for the missing years.

As of this writing, breakdown of sectoral compensation in 1999 and 2000 were not yet available. Data for these years were derived using the past two-year average share of sectoral compensation and then applied to the available total compensation.

2) For wages by skill, the assumption used in computing wages by skill category is that the available legislated wages apply only to unskilled workers (those who have not completed high school). The legislated daily wage was converted into a yearly rate using 240 working days (that is, 5 days a week × 4 weeks a month × 12 months). The problem arose when this computed yearly wage was multiplied by the number of employed unskilled workers because the product exceeded the overall compensation. In an ad hoc way, the resulting product was adjusted by multiplying by a factor of 0.5 to capture the fact that not all unskilled workers are working the entire 240 days in one year.

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INTRODUCTION

In the new century, the importance of productivity growth will be an important component of long-term growth in the East and Southeast Asian countries as they structurally adjust toward higher value-added production. Productivity is considered an important contributing factor for economies in reducing unemployment and increasing the efficient utilization of key resources.

The importance of productivity growth for long-term growth prospects is even more important for Singapore, as it structurally adjusts toward the higher value-added economy. As the city-state faces greater competition from the rapidly developing Southeast Asian countries of Malaysia and Thailand, and East Asian countries of the Republic of China and Republic of Korea, productivity growth is an important component for maintaining competitiveness in the global marketplace.

While most studies found near-zero total factor productivity (TFP) growth rates in Singapore, the study by Rao and Lee (1995) found positive productivity growth in the second half of the 1980s. Based on the standard growth accounting framework, they showed that productivity growth in 1987–94 was 2.6%, which is much higher than the 0.6% productivity growth in 1976–84. In a more recent empirical study by Owyong and Rao (1998), which took into account the structural changes in the economy, higher productivity growth was found after the structural break in the mid-1980s.

The current study improves on previous investigations of the aggregate TFP growth of the Singapore economy. The labor input is adjusted for quality changes in terms of skill levels and the factors for improvement in TFP growth are determined. The results suggest that labor quality in terms of skilled workers improves TFP growth in the overall economy. In addition, the results support those of Rao and Lee (1995), Owyong and Rao (1998), and Thangavelu and Rao (1999) showing that TFP growth improved and was positive after the 1985 recession.

METHODOLOGY AND DATA

This paper uses the standard growth accounting framework to derive the TFP growth for the economy. The labor input is adjusted qualitatively for different types of skill level in the domestic economy. In addition, the TFP growth measure is also adjusted for capacity utilization to derive the appropriate measures of technical efficiency. The standard growth accounting framework derives TFP growth as a residual of output growth after accounting for the weighted growth rates of factor inputs. This framework allows for adjustment in the quality of inputs, and the methodology used to adjust for the quality of the labor input is given in Oguchi (2002, see first chapter). The data used in the study are discussed in detail below. The data on GDP, gross fixed capital formation, number of workers, labor remuneration, GDP deflator, exports, and price index for capital stock were obtained from the *Yearbook of Statistics Singapore,* various issues (Department of Statistics).

Capital Stock

The aggregate capital stock for our study is given in Rao and Lee (1995). The capital stock data from 1996 are derived using the perpetual inventory method with aggregate gross capital formation from the *Yearbook of Statistics,* and the average depreciation rates given in Rao and Lee (1995). The aggregate capital stock in Rao and Lee (1995) is derived from subcategories of capital stock (residential construction, nonresidential construction, transport equipment, machinery, etc.) and using different depreciation rates for the subcategories. In Rao and Lee (1995), the initial capital stock in 1960 was derived from the investment capital-output ratio for each category of capital. Then each category of capital stock is derived using the depreciation rates given in Hulten and Wykoff (1980). Aggregate capital for the Singapore economy was also derived by Owyong (2001) using the aggregate gross fixed capital formation and inventory stock with an average depreciation rate of 3%. The initial capital is assumed to be given by the accumulated investment over the preceding 15 years. Both methods use the perpetual inventory method to derive the capital stock. As compared with the results of Rao and Lee (1995), the level of capital stock of Owyong (2001) tends to overstate the actual capital stock accumulated since the depreciation rate of 3% is much lower than the average depreciation rate used in Rao and Lee. However, the comparison of both capital stocks reveals a similar trend of a high rate of capital accumulation before the 1985 recession, followed by a lower rate of capital accumulation. Thus we could expect a higher absolute rate of capital stock in Owyong (2001), but similar growth patterns in both studies.

The capital stock is also adjusted for quality using the user cost (interest rate + depreciation rate) to derive the relative income shares for the respective categories of capital stock given above. Based on the request of the coordinator of the project, the following estimation was conducted using (interest rate + depreciation rate) as the user cost of capital. However, it should be noted that the proper formulation for user cost or price of capital is: price of capital = capital stock deflator* (interest rate + depreciation rate + tax rate of capital assets). The formulation is based on the assumption that the capital stock deflator across the different categories of capital stock is constant. This is used as a first approximation to allow for quality adjustment in capital stock.

We used the prime interest rate reported in *Yearbook of Statistics* (Department of Statistics, Government of Singapore, various years). The following depreciation rates reported in Rao and Lee (1995) were used to derive the user cost: 1.3% for residential construction, 2.9% for nonresidential construction, 18.2% for transport equipment, and 13.8% for machinery. The growth rate of quality-adjusted capital stock tends to be higher than the unadjusted capital stock. The capacity utilization index for the Singapore economy is provided in Owyong (2001), who used the production function method to derive the capacity utilization rate. A Cobb-Douglas production function is fitted to derive the theoretical value of the output. The ratio of the theoretical and actual output is taken as the capacity utilization rate. All variables in the study were debased to 1990 prices. The study covers the period from 1970 to 1998.

Labor

The data for labor in terms of education and occupational characteristics were obtained from the *Yearbook of Statistics, Labour Force Surveys* (Ministry of Labour), *and Profile of the Labour Force of Singapore,* various issues (Ministry of Labour). The broad occupational classifications of workers are given as: 1) legislators, administrators, and managers; 2) professionals; 3) technicians and associate professionals; 4) clerical workers; 5) service and sales workers; 6) agricultural and fishery workers; 7) production craftsmen, plant and machine operators, cleaners, and laborers; and 8) workers not classifiable by occupation. The wages for labor were obtained from the *Wage Survey,* Singapore National Employers Federation, Research Division, various years. However, the wages are only given by specific occupation and not available in the above broad occupational classifications. Therefore we had to reclassify the labor characteristics in the following manner to match the classification given by the wage data. We classified workers under the following categories: skilled workers are classified as legislators, senior officials, administrators and managers, professionals, technicians and associate professionals; semiskilled workers as clerical workers, service and sales workers; and unskilled workers as agricultural and fishery workers, production craftsmen, plant and machine operators, cleaners and laborers, and workers not classifiable by occupation to match the wage data. The wage for each category is derived by averaging the various occupational wages given in the *Wage Survey* based on the above occupational classifications given in each skilled category.

To be consistent with the growth accounting framework given in Oguchi (2002), the aggregate remuneration is derived by summing up the remuneration of workers for each skill category. The total remuneration reported in Owyong (2001) is the overall total payment to all workers and this is available in the *Statistical Yearbook*. However, in this case, we wanted income by individual skill category or occupational category to adjust for labor quality. In Singapore's case, no income data are available for skill or occupational category. Therefore we used the *Wage Survey* data to derive the average wage for each skill category as defined in the study. To be consistent with the methodology used in the study, the total remuneration is derived as the summation of individual remuneration for each skilled category. Thus we should expect some discrepancies in the wage shares between the current study and that of Owyong (2001). However, the wage share in our study is very close to other major studies on productivity growth in Singapore, including the important study by Rao and Lee (1995).

In the present study, labor quality is only adjusted by the occupational classifications of skilled, semiskilled, and unskilled workers. As workers who are well educated and skilled are likely to be in the category of professionals and technicians, it is likely that this classification captures both the educational and skill characteristics of workers. The employment shifts by sector could also be derived using the above methodology. However, due to the lack of wage data by sector, further decomposition of the TFP growth measure was not possible.

Table 1. Labor and wage share by type of labor in Singapore, 1970−98 (%).

	1970−75	1976−80	1981−85	1986−90	1991−95	1996−98
Labor share						
Skilled	0.100	0.123	0.170	0.231	0.286	0.374
Semiskilled	0.424	0.422	0.357	0.294	0.280	0.271
Unskilled	0.475	0.454	0.472	0.474	0.433	0.355
Wage share						
Skilled	0.273	0.318	0.400	0.457	0.542	0.625
Semiskilled	0.393	0.359	0.273	0.216	0.189	0.172
Unskilled	0.334	0.323	0.327	0.327	0.269	0.203

The value shares for factor inputs are derived by the standard assumptions of constant returns to scale and competitive markets. Dividing the total remuneration for the economy by the GDP derives the wage share. With constant returns to scale and competitive markets, the capital share is taken to be 1 minus the wage share. The wage share and labor input shares by types of skill are given in Table 1. The share of skilled workers rose over time and it was nearly 37% of the total labor force in 1996−98 as compared with only 10% in 1970−75. However, the data also reveal that the increase in the share of skilled workers was offset by the fall in the share of semiskilled workers, but not of unskilled workers. The share of unskilled workers was still significant in the domestic economy with a share of around 36% of the total labor force in 1996−98.

Comparing the wage share across the three classifications, the wage share for skilled workers also rose over the years. In the early 1970s, Singapore was still involved in labor- and capital-intensive production. This is indicated by the larger share of semiskilled and unskilled wage shares. However, as the stages of growth moved to higher value-added production, the demand for skilled and semiskilled workers increased and this had to be matched by higher wage shares for these two categories. In particular, the larger wage share of skilled workers in the late 1990s indicates the rising demand for skilled workers as the economy transformed to knowledge-based production and a widening income gap between the skilled and the unskilled.

The rising demand for skilled workers also reflects the rising employment and wage shares for these types of workers as the economy transited toward the knowledge-based economy. Currently, to reduce the rising share of wages for skilled workers, manpower policies are implemented to increase the supply of skilled workers through educational policies by increasing the opportunities for higher-level education and liberal immigration policies.

RESULTS: NEOCLASSICAL GROWTH ACCOUNTING

Growth Accounting without Adjusting for Labor Quality

The results for TFP growth without adjusting for labor quality are given in Table 2. To capture the various phases of growth, the sources of output growth are divided into five-year averages starting from 1970. The GDP growth rate declined from double-digit growth of nearly 10% in 1970‒75 to around 5% in the late 1990s. This suggests that the economy is reaching a long-term sustainable growth rate of around 5% or less.

Table 2. Quality-adjusted labor, capital stock, and TFP in Singapore, 1970‒98 (%).

	1970‒75	1976‒80	1981‒85	1986‒90	1991‒95	1996‒98
GDP	9.54	7.99	5.69	8.11	7.75	5.45
Capital	15.17	9.23	11.53	6.21	7.52	11.57
Labor	4.94	5.13	2.73	4.38	2.04	3.13
Labor** (adjusted)	5.71	5.91	3.32	5.60	4.70	4.66
Capital** (adjusted)	17.38	9.45	10.64	5.72	8.27	11.58
TFP	‒2.46	0.18	‒1.88	2.72	2.74	‒1.58
TFP* (capacity utilization adjusted)	‒1.69	‒0.22	‒1.62	2.96	1.82	‒2.91
TFP** (labor adjusted)	‒2.89	0.21	‒2.98	2.48	1.48	‒2.24
TFP*** (capacity & labor adjusted)	‒2.12	‒0.19	‒2.72	2.73	0.55	‒3.57
TFP@@ (labor & capital adjusted)	‒4.44	0.04	‒2.51	2.74	1.07	‒2.25
TFP@@@ (labor,capital & capacity adjusted)	‒3.65	‒0.36	‒2.25	2.99	0.14	‒3.58
Factor shares						
Labor	0.3272	0.3521	0.4462	0.4347	0.4599	0.4936
Capital	0.6728	0.6479	0.5538	0.5653	0.5401	0.5064
Factor shares of Owyong (2001)						
Labor	0.556	0.570	0.545	0.612	0.523	0.535
Capital	0.444	0.430	0.455	0.388	0.477	0.465
TFP## (labor and capital adjusted)	1.54	3.62	0.62	5.35	3.59	‒0.05
TFP### (labor,capital & capacity adjusted)	2.31	3.22	0.88	5.60	2.67	‒1.39

TFP## and TFP### represents the TFP growth measurement using the wage share of Owyong (2001).

The main driving factor for GDP growth was capital input with the double-digit growth in the early 1970s, early 1980s, and late 1990s. Since Singapore is a small, open economy, the economy structurally adjusted through different stages of growth, starting from labor-intensive production in the 1970s to skill- and capital-intensive production in the 1980s and then to knowledge-intensive production in the late 1990s. Almost all of the structural adjustments in the economy were induced by both high capital accumulation and the location characteristics of multinational corporations. The phases of structural adjustments are reflected by high capital growth and low TFP growth (Appendix Table 1). Investments in new capital and infrastructure are often used to phase out old industries and induce investment in new industries, machines, and infrastructure. Given the gestation period before machines and infrastructure are fully utilized for industrial production, output growth induced by capital accumulation is always reflected by low TFP growth.

The five-year averaged TFP growth given in Table 2 provides interesting results. TFP growth was negative in 1970–75 and 1981–85, which supports the studies by Tsao (1982, 1985). However, it tended to improve after the structural adjustment period of 1976–80 and after the 1985 recession. This supports the results by Rao and Lee (1995), Owyoung and Rao (1998), and Thangavelu and Rao (1999) showing that TFP tends to improve after structural adjustment periods. Currently, the economy is adjusting from skill- and capital-intensive production to more knowledge-intensive production and this clearly indicated by the high capital input growth of nearly 11% in 1996–98. In line with the high capital investment induced by the government, the TFP growth was again negative. The growth of the labor input was nearly 5% in the 1970s but it declined to only 2% in the early 1990s. This suggests the tightening of the labor market in Singapore and the importance of human capital for continuing output growth in the city-state.

Growth Accounting Adjusting for Labor Quality

The sources of growth of labor input in terms of the three categories of skill are given in Table 3.

Table 3. Sources of quality-adjusted labor growth in Singapore, 1970–98 (%).

Category	1970–75	1976–80	1981–85	1986–90	1991–95	1996–98
Skilled	10.3	5.41	12.3	6.27	9.91	6.50
Semiskilled	4.87	2.94	–2.22	2.37	0.74	6.02
Unskilled	3.63	6.29	2.74	4.65	–2.55	–2.58

The key category is skilled labor, which forms the major growth component of the labor force. However, this component tended to decrease, from nearly 10% in the early 1970s to around 6% in 1986–90. On the other hand, the growth rate of the unskilled category of workers tended to increase, from around 4% in 1970–75 to nearly 5% in 1986–90. These changing trends in terms of the falling growth rate of skilled workers and rising growth rate of unskilled workers poses serious problems in the economy as it structurally adjusts toward the knowledge-based economy. In line with these changing trends, the government allowed a greater flow of skilled immigrants into the domestic economy in the 1990s and tended to be successful in maintaining the growth rate of skilled and semiskilled workers at nearly 6% in the 1990s. Again the changing trends are indicative of the importance of skilled and educated workers to undertake more value-added activities in the domestic economy for long-term sustainable growth.

The labor quality-adjusted TFP growth is given as TFP** in Table 2. Since the unadjusted TFP growth (TFP) did not take the quality effects of skills and education of workers into account, it overstates the productivity growth in the economy. The labor quality-adjusted TFP growth is lower than the unadjusted TFP growth, which suggests that the difference is reflected by the positive contribution of skills and education to productivity growth in the economy. Labor quality-adjusted TFP growth tends to follow a similar tend to the unadjusted TFP growth, with positive growth rates after structural adjustment periods.

Another interesting trend in TFP growth rates given in Table 2 is that after adjusting for capacity utilization and labor quality, the TFP growth was very negligible and insignificant in 1970–85. This clearly suggests that before the recession period in 1985, there was not much productivity growth in the economy. However, in the post-1985 recession period of 1986–90, there was a marked improvement in TFP growth even after adjusting for capacity and labor quality. The labor quality- and capacity-adjusted TFP growth was around 2.5% in 1986–90. However, this positive trend in TFP growth was reversed in the 1990s where the adjusted TFP growth (TFP***) was again very insignificant in 1990–95 and 1995–98. The trends are also very visible when the TFP growth is derived with quality-adjusted capital stock.

To be consistent with the previous APO projects, the wage share of Owyong (2001) was also used to estimate TFP growth and compared with our results (Table 2). However, it should be emphasized that the wage share of Owyong (2001) is much larger than in most studies on productivity growth in Singapore. Rao and Lee (1995) reported a capital share of 0.55 to 0.62, Toh and Low (1996) reported a capital share of 0.5 to 0.60, and Owyong and Rao (1998) reported an average capital share of 0.55 for the Singapore economy. As compared with the results of Owyong, the wage share in the current study is much closer to those in previous studies on TFP growth on Singapore and is consistent with the capital-driven growth experience of the Singapore economy. Therefore in Owyong (2001) there is an overestimation of the contribution of labor to productivity growth. This is reflected by the higher and positive TFP growth for all subperiods in Owyong's publication as compared with the current study.

SOURCES OF TFP GROWTH

Regression Analysis

The sources of TFP growth were determined by estimating a linear model with the following variables: the share of foreign direct investment (FDI) to GDP ratio (ShFDI); share of government expenditure on education (shEdu); share of foreign equity ownership (Shown); and share of exports to GDP (Shexp). The importance of FDI in productivity growth is clearly highlighted in the literature in terms of technology transfer. To capture the "learning-by-doing" effects on productivity growth, the lag of the share of FDI in was used in the regression analysis. It is possible that there might be some gestation period before workers learn the new technologies and thus the lag in the share of FDI is expected to capture this effect. We utilized the following baseline model to study the above:

$$\triangle Log\,(TFP) = a + b\,(ShFDI) + c\,(\ ShFDI\,(-1)\ ) + d\,(Shedu) + e\,(Capacity) + \varepsilon \qquad \text{(Eq. 1)}$$

Both unadjusted (TFP) and labor quality-adjusted (TFP**) TFP are used as dependent variables together with the capacity utilization index (capacity).

The FDI data were obtained from various issues of *Foreign Equity Investments in Singapore* (Department of Statistics) and the various components of the government expenditure were from the *Yearbook of Statistics*.

The results of the baseline regressions are given in Table 4. The results indicate that there is a strong "learning-by-doing" effect in the domestic economy. The coefficient of the lag in the share of FDI is robust and statistically significant for all the regressions. The negative effect of the share of FDI and positive effect of its lag suggest that workers take some time before they unbundle new technology embodied in the form of FDI. This suggests that a sufficient gestation period should be allowed for workers to learn new technology.

Table 4. Sources of TFP growth in Singapore, 1971−98.

	TFP	TFP	TFP**	TFP**
Constant	−0.032 (−1.358)	−0.030 (−1.357)	−0.027 (−1.144)	−0.026 (−1.119)
ShFDI	−0.259 (−1.254)	−0.236 (−1.171)	−0.218 (−1.029)	−0.201 (−0.949)
ShFDI(−1)	0.509** (2.569)	0.456** (2.333)	0.507** (2.505)	0.470** (2.289)
Shedu	−0.134 (−0.997)	−0.103 (−0.776)	−0.259* (−1.890)	−0.237 (−1.712)
Capacity		0.003 (1.544)		0.002 (1.021)
R^2	0.327	0.394	0.341	0.371
DW	1.873	1.555	1.865	1.703
Obs.	27	27	27	27

*10% level of significance.
**5% level of significance.
t Values are given in parentheses.

However, the negative effect of current FDI must be interpreted with caution as the estimated coefficient is not statistically significant. As compared with current FDI, the lagged FDI is statistically significant and robust to different specifications as given in Tables 4 and 5. Given the importance of FDI for augmenting domestic capital formation and also as a means to capture foreign technology, the positive effect from the lagged FDI is not very surprising. Therefore this indicates an important source of capital and embodied technology flow into the domestic economy. The share of government expenditure on education is not statistically significant and hence it does not have any effect on productivity growth.

Table 5. Sources of TFP growth in Singapore, 1971−98.

	TFP	TFP	TFP**	TFP**
Constant	−0.138 (−0.858)	−0.039* (−1.906)	−0.036 (−1.639)	−0.034 (−1.580)
ShFDI				
ShFDI(−1)	0.291** (2.985)	0.257** (2.643)	0.325** (3.290)	0.300** (2.973)
Shedu	−0.138 (−1.017)	−0.105 (−0.786)	−0.263* (−1.914)	−0.239 (−1.728)
Capacity		0.003 (1.624)		0.002 (1.098)
R^2	0.282	0.355	0.3111	0.345
DW	1.710	1.413	1.826	1.577
Obs.	27	27	27	27

*10% level of significance.
**5% level of significance.
t Values are given in parentheses.

The baseline model is modified to estimate the effects of exports and foreign ownership on TFP growth. Since the export growth in the economy is driven by multinational corporations, there might be a high correlation between the share of exports and share of foreign ownership. The results of the regressions with share of exports (shexp) are given in Table 6. The results show that only the lagged share of FDI is relatively robust to the inclusion of the share of exports as one of the variables (although the lagged share of FDI is not significant in the first regression with unadjusted TFP and this might be due to the high correlation between exports and FDI). The share of government expenditure is negative and statistically significant if adjusted TFP growth is used as one of the dependent variables. However, the negative result is not very robust to the alternative specification with unadjusted TFP growth.

Table 6. Sources of TFP growth in Singapore, 1971−98.

	TFP	TFP	TFP**	TFP**
Constant	−0.094 (−1.570)	−0.089 (−1.594)	−0.020 (−0.551)	−0.020 (−0.567)
ShFDI	0.096 (0.442)		−0.006 (−0.025)	
ShFDI(−1)	0.225 (1.068)	0.298** (2.191)	0.431* (1.963)	0.427** (3.323)
Shedu	−0.098 (−0.536)	−0.101 (−0.574)	−0.384** (−2.386)	−0.384** (−2.450)

Continued...

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Capacity	0.409* (1.955)	0.389* (1.894)	0.055 (0.261)	0.055 (0.270)
Shexp	0.0001 (0.730)	0.0001 (0.796)	−0.0001 (−0.482)	−0.0001 (−0.512)
R^2	0.514	0.509	0.456	0.457
DW	1.866	1.826	1.720	1.719
Obs.	26	26	26	26

*10% level of significance.
**5% level of significance.
t Values are given in parentheses.

In Table 7, the results with the share of foreign ownership are shown. The results are similar to the regression with the share of exports. The lagged share of FDI is relatively robust, except for the first regression with unadjusted TFP. However, dropping the share of FDI tends to improve the results, suggesting multicolinearity between FDI and ownership.

Table 7. Sources of TFP growth in Singapore, 1971−98.

	TFP	TFP	TFP**	TFP**
Constant	−0.044 (−0.409)	−0.153 (−1.109)	0.005 (0.051)	0.006 (0.059)
ShFDI	−0.033 (−0.144)		−0.005 (−0.024)	
ShFDI(−1)	0.339 (1.539)	0.334** (2.406)	0.402* (1.820)	0.397** (3.665)
Shedu	−0.184 (−1.184)	−0.106 (−0.610)	−0.372** (−2.384)	−0.371** (−2.478)
Capacity	0.210 (0.978)	0.395** (2.063)	0.050 (0.228)	0.049 (0.235)
Shown	0.0156 (0.071)	0.197 (0.760)	−0.082 (−0.376)	−0.083 (−0.408)
R^2	0.413	0.504	0.454	0.454
DW	1.690	1.720	1.800	1.800
Obs.	26	26	26	26

*10% level of significance.
**5% level of significance.
t Values are given in parentheses.

Various combinations of independent variables were used to test for sources of TFP growth. The rate of growth of the share of government expenditure on education (change in the share of government expenditure on education) was used as one of the regressors and it was not significant. The share of exports and imports were also used to test as potential sources of TFP growth and neither variable was significant. Given the small sample used in this study, it highly possible that the regression analysis might not provide valid results. Also, it is highly likely that there might be bi-directional causality from trade variables to productivity, thereby invalidating the simple linear regression used. However, one needs to highlight that these simple regressions provide some indications of potential sources of growth in TFP, which could provide directions for future research.

CONCLUSIONS

The key component of the long-term growth in the Singaporean economy is the quality of education of the labor force. The quality of labor in terms of skill and education forms an important component of the labor force in the economy. Further, to maintain the long-term growth prospects in the higher value-added economy, the quality of the labor force should be enhanced and improved to maintain competitiveness. The government is increasing the share of expenditure on education and training and retraining of workers to meet the challenges of the knowledge-based economy. Further, the government is also increasing the share of expenditure on R&D. The share of R&D expenditure to GDP was only 4% in 1990, but increased to nearly 8.4% of GDP in 1998. This is to encourage the development of indigenous technology and improve the quality of labor and capital in the domestic economy. The R&D data for Singapore were obtained from the *National Survey on R&D in Singapore,* National Science and Technology Board, Singapore, various years. The complete series of data for Singapore are only available from 1990.

The changing trends in TFP growth clearly provide important policy implications. The negative relationship between capital accumulation and TFP growth suggests that there must be sufficient "gestation" or "learning-by-doing" effects in the economy before there are signs of positive TFP growth. The economy needs this lag period to learn new technologies and acquire technology-specific skills as the economy structurally adjusts through large capital investments. Given vast improvements in the quality of labor through education and skills, significant improvements in productivity growth occur as human capital complements new technological changes through capital investment. The "learning-by-doing" effect in the economy was also confirmed by the regression analysis.

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APPENDIX . DATA USED FOR CALCULATIONS AND ANALYSES.

Appendix Table 1. Growth rates of real GDP, real capital stock, employment, capital share and labor share in Singapore, 1971−98 (%).

Year	GDP	Capital	Capacity utilization rate	Labor share	Capital share
1971	12.08	16.17	−0.37	0.267	0.733
1972	12.88	16.93	1.9	0.313	0.687
1973	10.84	15.96	−4.4	0.326	0.674
1974	7.77	13.88	−0.41	0.316	0.684
1975	3.81	12.87	−0.61	0.334	0.666
1976	6.62	10.12	0.85	0.346	0.654
1977	7.17	9.52	1.27	0.344	0.656
1978	8.04	8.43	−0.88	0.342	0.658
1979	8.60	8.80	−0.04	0.342	0.658
1980	9.53	9.21	0.82	0.356	0.644
1981	9.00	10.53	−1.31	0.376	0.624
1982	6.38	10.99	−1.88	0.399	0.601
1983	7.27	12.28	2.92	0.434	0.566
1984	7.37	12.03	0.87	0.460	0.540
1985	−1.31	11.83	−1.91	0.471	0.529
1986	4.06	8.33	−2.47	0.466	0.534
1987	9.12	5.84	4.81	0.450	0.550
1988	10.46	5.30	1.76	0.431	0.569
1989	7.82	5.29	−1.32	0.421	0.579
1990	8.83	6.27	−4.02	0.428	0.572
1991	7.58	6.56	5.02	0.442	0.558
1992	4.50	7.27	−3.37	0.471	0.529
1993	9.43	7.68	5.00	0.472	0.528
1994	8.38	8.15	−0.76	0.455	0.545
1995	8.87	7.95	−1.25	0.457	0.543
1996	7.40	14.45	−1.34	0.462	0.538
1997	9.40	13.23	2.68	0.479	0.521
1998	1.11	7.03	2.65	0.509	0.491

Appendix Table 2. Growth rates of labor, quality-adjusted labor, TFP, TFP*(capacity utilization adjusted), TFP (labor quality adjusted), and TFP***(capacity and labor quality adjusted) for Singapore, 1971–98 (%).**

Year	Labor	Quality-adjusted labor	TFP	TFP*	TFP**	TFP***
1971	9.19	6.09	−2.23	−1.86	−1.40	−10.3
1972	9.92	9.60	−1.86	−3.76	−1.76	−3.66
1973	1.41	3.14	−0.39	3.98	−0.94	3.44
1974	3.03	9.84	−2.68	−2.28	−4.84	−4.43
1975	1.10	2.30	−5.12	−4.51	−5.53	−4.92
1976	4.33	3.64	−1.53	−2.38	−1.30	−2.14
1977	3.77	2.37	−0.38	−1.64	0.11	−1.16
1978	5.90	3.77	0.47	1.34	1.20	2.08
1979	6.27	6.38	0.66	0.70	0.63	0.67
1980	5.34	8.95	1.69	0.87	0.41	−0.41
1981	6.87	8.09	−0.16	1.15	−0.61	0.69
1982	5.67	5.96	−2.49	−0.62	−2.61	−0.73
1983	2.43	11.92	−0.73	−3.65	−4.85	−7.77
1984	1.42	2.77	0.22	−0.65	−0.39	−1.27
1985	−2.75	−2.41	−6.27	−4.35	−6.43	−4.52
1986	−1.65	−1.66	0.38	2.85	0.39	2.86
1987	4.22	4.89	4.01	−0.80	3.71	−1.10
1988	4.99	6.77	5.29	3.53	4.53	2.77
1989	4.57	5.85	2.83	4.15	2.29	3.61
1990	9.75	8.73	1.06	5.08	1.49	5.52
1991	−0.80	1.74	4.28	−0.74	3.15	−1.87
1992	3.34	7.39	−0.92	2.45	−2.83	0.54
1993	0.99	2.37	4.91	−0.09	4.25	−0.74
1994	3.53	5.60	2.33	3.09	1.39	2.15
1995	3.15	6.87	3.11	4.37	1.41	2.66
1996	2.67	4.21	−1.60	−0.26	−2.31	−0.97
1997	4.61	6.42	0.30	−2.38	−0.57	−3.25
1998	2.12	2.90	−3.43	−6.08	−3.82	−6.47

Appendix Table 3. Growth rates of quality-adjusted capital, TFP@@ (capital and labor quality adjusted), and TFP@@@ (capacity, capital, and labor quality adjusted) for Singapore, 1971–98 (%).

Year	Quality-adjusted capital	TFP@@	TFP@@@
1971	18.60	−3.18	−2.81
1972	19.90	−3.80	−5.70

Continued...

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1973	17.71	−2.12	2.25
1974	15.86	−6.18	−5.77
1975	14.83	−6.83	−6.22
1976	10.26	−1.34	−2.19
1977	9.50	0.11	−1.15
1978	8.38	1.23	2.11
1979	9.42	0.22	0.26
1980	9.87	−0.01	−0.84
1981	11.21	−1.04	0.27
1982	11.07	−2.65	−0.77
1983	11.49	−4.44	−7.33
1984	9.79	0.81	−0.06
1985	9.64	−5.28	−3.37
1986	6.43	1.40	3.87
1987	4.50	4.44	−0.37
1988	4.81	4.80	3.04
1989	5.44	2.20	3.52
1990	7.39	0.86	4.88
1991	7.79	2.46	−2.55
1992	8.37	−3.41	−0.04
1993	8.28	3.93	−1.06
1994	8.90	0.97	1.73
1995	8.00	1.39	2.64
1996	16.67	−3.51	−2.17
1997	10.45	0.09	−1.80
1998	7.62	−4.12	−6.76

The capital shares for the respective categories are not reported here but are available from the author.

Appendix Table 4. The use of Owyong's (2001) wage share and the respective TFP growth rates for Singapore (%): TFP## (capital and labor quality adjusted) and TFP### (capacity, capital, and labor quality adjusted).

Year	Wage share	TFP##	TFP###
1971	0.587	4.00	4.37
1972	0.584	3.92	2.02
1973	0.564	3.04	7.42
1974	0.506	−0.28	0.12
1975	0.539	−2.96	−2.35
1976	0.585	2.27	1.43

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1977	0.597	3.26	1.99
1978	0.578	4.28	5.16
1979	0.589	4.34	4.38
1980	0.502	3.94	3.11
1981	0.501	2.82	4.13
1982	0.505	0.68	2.56
1983	0.543	1.82	−1.13
1984	0.541	2.84	1.96
1985	0.636	−5.05	−3.14
1986	0.706	2.13	4.60
1987	0.665	7.28	2.48
1988	0.609	7.95	6.20
1989	0.570	5.08	6.40
1990	0.510	4.30	8.32
1991	0.435	3.10	−1.92
1992	0.591	0.96	4.33
1993	0.600	5.97	0.97
1994	0.474	3.33	4.09
1995	0.517	4.58	5.83
1996	0.483	−1.29	0.44
1997	0.500	3.85	1.17
1998	0.492	−2.73	−5.38

Appendix Table 5. Growth rates of labor: skilled, semiskilled, and unskilled for Singapore, 1971−98.

	Growth rate of labor			Wage share		
Year	Skilled	Semiskilled	Unskilled	Skilled	Semiskilled	Unskilled
1971	−8.36	10.42	11.92	0.248	0.425	0.327
1972	8.36	9.41	10.65	0.235	0.415	0.350
1973	11.04	0.68	0.37	0.248	0.396	0.356
1974	35.70	−1.37	−0.76	0.297	0.370	0.333
1975	4.55	5.58	−4.05	0.340	0.356	0.304
1976	1.93	2.99	6.33	0.341	0.356	0.303
1977	−1.84	3.25	5.85	0.332	0.354	0.314
1978	−3.89	6.87	7.55	0.310	0.364	0.326
1979	6.79	6.17	6.24	0.293	0.372	0.335
1980	24.06	−4.58	8.85	0.313	0.347	0.340
1981	11.53	10.02	2.89	0.335	0.323	0.342

Continued...

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1982	6.39	8.85	2.66	0.342	0.327	0.331
1983	39.56	−28.02	11.37	0.403	0.275	0.322
1984	5.53	1.95	−0.70	0.464	0.219	0.312
1985	−1.56	−4.02	−2.51	0.457	0.220	0.323
1986	−1.66	−1.73	−1.61	0.445	0.224	0.331
1987	6.46	4.46	3.03	0.446	0.225	0.329
1988	11.17	2.43	3.55	0.455	0.219	0.326
1989	8.89	2.60	3.54	0.470	0.209	0.321
1990	6.48	4.10	14.75	0.468	0.201	0.331
1991	7.17	6.29	−9.39	0.484	0.198	0.318
1992	15.11	−0.34	−1.77	0.527	0.193	0.280
1993	4.76	2.09	−2.44	0.551	0.187	0.262
1994	9.15	3.37	−0.75	0.563	0.189	0.248
1995	13.37	−7.70	1.61	0.587	0.176	0.237
1996	6.27	13.78	−9.04	0.612	0.170	0.204
1997	9.18	2.70	1.05	0.626	0.175	0.199
1998	4.04	1.60	0.26	0.637	0.172	0.191

THAILAND

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INTRODUCTION

The source of factors generating economic growth in Thailand has been investigated since 1972 in numerous studies. The main factor determining economic growth is capital accumulation, including human capital, which helps generate increasing returns on capital and technological growth. Young (1995) and Krugman (1994) argued that the source of economic growth in Southeast Asia was the expansion of the factors of production which would experience diminishing returns to scale. Economic growth would thus not be sustainable in the future. This hypothesis has been tested for all Southeast Asian countries including Thailand from 1980–96. After Thailand faced the Asian financial crisis in 1997, the economic structure has changed completely from a boom period into a recession. This hypothesis needs to be tested again and factors explaining the declining growth need to be analyzed.

The objective of this study is to calculate the total factor productivity (TFP) growth in Thailand during 1977–99, using the growth accounting method developed by Oguchi (2001). The study covers the period from the energy crisis (1977–81), beginning of the expansion period (1982–86), boom period (1987–91), declining period (1992–96), and recession period after the financial crisis (1997–99). Sectoral analysis of TFP growth is also performed for eight economic sectors. TFP growth is decomposed to separate the effects of business fluctuation, labor quality improvement, and industrial shift on crude TFP growth. The factors determining TFP growth, such as foreign direct investment (FDI), R&D spending, degree of openness, the average education level, and dummy variables reflecting structural change after the financial crisis will be used to analyze the source of growth in Thailand during 1977–99. The results of the analysis are compared with the results of previous studies. Finally, some policy implications are derived from the analysis.

REVIEW OF THE LITERATURE

There have been many studies using both the econometric approach and the growth accounting approach to calculate TFP growth and investigate the source of economic growth in Thailand during 1950–96. Wannitikul (1972), using the econometric approach based on the Cobb-Douglas production function with the assumption of constant return to scale and the assumption of Hick's neutral technical change, studied TFP growth during 1950–69. There were some limitations in that study, however, due to the availability of the data at that time.

Tinakorn and Sussangkarn (1994, 1998), using the growth accounting method based on the framework of the Solow-Denison approach, studied TFP growth during 1970–96. The analysis included both the aggregate level and the sectoral level divided into the agriculture, manufacturing, and service sectors. The important step in this study was the decomposition of TFP growth with the change in the quality of factors of production. The labor input data were classified according to age, sex, and level of education, and then the index of adjustment was constructed from the classified data. Private-sector, state-owned enterprise, and public-sector employees were separated from own-account and unpaid family workers, and the adjustment was based on the 1995 data from the Social Accounting Matrix (SAM). The decomposition of the business fluctuation effect from crude TFP growth was analyzed using the capacity utilization rate, which constructed from the capital-output ratio method. The conclusion from that study was that the average growth of the whole economy during 1980–95 was approximately 8.12%. The contribution of labor and of improving the quality of labor, capital, and land were 0.96 (11.87%), 1.80 (22.21%), 5.01 (61.76%), and 0.03 (0.41%), respectively. The contribution of the adjusted TFP growth was about 1.27 (15.62%) and the crude TFP growth was 2.11 (25.97%).

Tinakorn and Sussangkarn (1994) also compared the results of the analysis with those in other Asian countries. Multiple regression analysis was used to determine factors determining TFP growth. The growth of the degree of openness of the economy, that of the share of employment in the nonagricultural sector, and that of gross capital stock at constant priced were the main sources of the growth of TFP.

Limskul (1988) compared TFP growth in Thailand and the newly industrializing economies, i.e., Japan, the Republic of China, and the Republic of Korea before and after the Second World War. The economy was divided into four sectors: the primary sector; the manufacturing sector comprising mining, construction, and transportation; the finance sector; and the service sector. The study used the CES and VES production function and applied the Kinoshita estimation method in calculating capital stock during 1960–86. The highest TFP growth was found in the electricity and water supply sector and most of the studied sectors had negative TFP growth.

The conclusion indicated that TFP growth in the primary sector in Thailand was lower than that in Japan and that TFP growth in the service sector was low compared to that in the Republic of China and Republic of Korea. The growth of capital contributed more to the growth of GDP, which was quite similar to that in Japan, but the efficiency of labor contributed more in the case of the Republic of China and Republic of Korea.

Kaipornsak (1995) studied the TFP growth of eight economic sectors, 13 industrial sectors, and five major crops. The analysis used the econometric approach based on the Cobb-Douglas production function with the assumption of constant return to scale. The results were compared with the trans-log production function using four factors of production, i.e., capital, labor, land, and fertilizers in the agricultural sector. The results were consistent with those of Limskul (1988) and showed that the highest TFP growth was in the electricity and water supply sector and a declining trend in TFP growth was found in the manufacturing sector.

In the analysis of 13 industries, Kaipornsak (1995) found that the chemical industry had the highest TFP growth (60.9%), the labor factor contributed most in the transportation industries (49.9%), and the capital factor contributed most in the petroleum industry (109.6%). In analyzing the five major crops, the study found a declining trend in the use of factors of production, the highest TFP growth was found in the production of rice and soybeans, and the lowest TFP growth was found in the production of maize and sugar.

According to Kaipornsak (1995), the factors determining the source of TFP growth were R&D spending, FDI, and the competitiveness of the country reflecting the market structure and the strength of organizations. The dummy variables of the competitiveness of the manufacturing and the mining and quarrying sector were highly significant in the industrial sector, reflecting the high industrial concentration and the state protection of industry.

Wiboonchutikula (1982), Brimble (1987), and Sakonpan (1997) studied TFP growth in the industrial sector in Thailand and the intermediate factors of production were included in the analysis. Wiboonchutikul (1982) analyzed the TFP growth of 25 industries during 1963–76 and concluded that the growth of the industrial sector was quite high compared with the developing countries, but the TFP growth was quite low compared with that in the developed countries. The low rate of TFP growth occurred during the import-substitution policy period (1960s), and the rate became higher during the export-promotion policy period (1970s). The high cost of intermediate products and energy resulted in declining TFP growth. The survey analysis of farm machinery firms showed that the economies of scale factor was insignificant in the contribution to TFP growth, but the efficiency of expanding the company increased it.

Brimble (1987) studied the TFP growth of 139 companies in seven industries during 1975–83 using the econometric approach with the trans-log production function based on the assumption of constant return to scale, monotonically and in concavity form. The main source of economic growth during that period was growth in factors of production (60.2%), specifically 0.7% from the labor factor, 10.8% from the capital factor, 48.7% from the intermediate factor, and 39.9% from TFP growth. The highest TFP growth was found in the automobile (7.62%) and electrical industries (6.93%), and the lowest in the rubber industry. TFP growth was decomposed into three parts. The first stemmed from technological progress, which was approximately 76.7%, and the second was from technical efficiency, which was approximately –1.3%. The residual was the difference between frontier elasticity and the observed factor shares, which was 24.6%.

Sakonpan (1997) studied the TFP growth of 25 industries during 1979–91, using the same methodology as Wiboonchutikul. The study concluded that the TFP growth of Thai industry was rather low (3.29%) during that period. The TFP growth of the export industries was higher than that in import industries or import-substitution industries. Thailand should have a policy of increasing TFP growth to compete in the world market.

In conclusion, most studies of TFP growth in Thailand during 1960–90 used both the growth accounting approach and the econometric approach with different forms of the production function, assumptions, and study periods. The conclusion depended on the objective of the study, analysis of the data, and estimation method used to analyze TFP in Thailand. The present study is an extension of the study of TFP growth. The period covered is 1977 to 1999, during which Thailand faced the downturn of its economy due to the Asian financial crisis.

DATA AND METHODOLOGY

Data

Output Growth

The GDP data were obtained from the National Economic and Social Development Board for the period 1977–99 and GDP at 1988 prices was used to calculate the output growth series.

Labor Input

The total employment data from 1977–99 were obtained from the third round of the Labor Force Survey conducted by the National Statistical Office of Thailand. The total employment was divided into employers, private employees, government employees, own-account workers, and unpaid family workers. The wage rates for employers, own-account workers, and unpaid family workers were not available, and therefore we used private wages as a proxy and combined the payment for private employees and government employees to calculate the total labor payment. The labor share was calculated from the ratio of the total payment to GDP at factor cost. This calculated labor share was higher than that in Tinakorn and Sussangkarn's study of TFP growth (1998). The imputed wage from that study was adjusted for the difference between the average private wage and government wage and the five mentioned categories of wages from the SAM in 1995. This adjustment was used to construct the imputed wage based on the 1995 SAM data and multiplied by total labor to obtain the total payment, which was lower than in this study.

For the adjustment of the quality of labor, the labor force data were classified according to age, sex, and level of education. The age variable was divided into five groups (19 or younger, 20–29, 30–39, 40–49, and 50 years or older). The sex variable was classified for male and female. The level of education was divided into primary, secondary, vocational, and teacher's college and university levels.

Capital Input

The composite index of capital stock, which was the weighted average of gross capital stock at 1988 prices (75%) and net capital stock at 1988 prices (25%) was used to represent the capital stock series in this analysis. Gross capital stock at 1988 prices was the only variable used in Tinakorn and Sussangkarn's study (1998). The capital share was calculated as 1 minus the labor share. Then we used the two-year moving average of the income share of labor and capital to calculate the contribution of labor and capital.

The decomposition of the capital data was not available for the adjustment of the effect of the quality change in capital.

Methodology

The methodology used in this study is the growth accounting method developed by Oguchi. The decomposition of TFP growth to separate the business fluctuation effect, the improved quality of labor, and the industrial shift effect are included in the analysis. The study also attempted to investigate the source of TFP growth with the structural change due to the Asian financial crisis.

Model of the Estimation of TFP Growth

Equations 1 and 2 were used as models for the estimation of TFP growth.

$$Qt = At\ F\,(Kt, Lt) \qquad \text{(Eq. 1)}$$

$$Qtg = TFPG + Sk\ Ktg + Sl\ Ltg \qquad \text{(Eq. 2)}$$

where $TFPG$ is TFP growth, Sk is the income share of capital, Sl the income share of labor, and Qtg the growth rate of output.

By assuming the trans-log production function, we have:

$$\ln Q_t = \ln a_0 + a_t T + a_k \ln Kt + a_l \ln Lt + 1/2\, b_{kk} (\ln Kt)^2 + b_{lk} \ln Kt . \ln Lt$$

$$+ 1/2\, b_{ll} (\ln Lt)^2 + b_{kT}\, T. \ln Kt + b_{lt}\, T. \ln Lt + 1/2\, b_{TT}\, T^2 \qquad \text{(Eq. 3)}$$

Differentiation of Eq. 3 with respect to time gives:

$$Qt^* = a_t + a_k\, Kt^* + a_l\, Lt^* + b_{kk} (\ln Kt).\ Kt^* + b_{lk} (Kt^* . \ln Lt + Lt^* . \ln Kt) + b_{ll} (\ln Lt).\ Lt^*$$

$$+ b_{KT} (T.Kt^* + \ln Kt) + b_{lT} (T.\,Lt^* + \ln Lt) + b_{TT}\, T \qquad \text{(Eq. 4)}$$

where variables with (*) indicate the instantaneous growth rate of the variable. It can be shown that

$$Qt^* = TFPt^* + Sk.\,Kt^* + Sl.\,Lt^* \qquad \text{(Eq. 5)}$$

Since the rate of change in TFP given in Eq. 5 is our instantaneous rate of change, for the discrete time we take the average of two consecutive periods.

$$TFPGt = \ln\,(TFPt - TFPt-1) = (\ln Qt - \ln Qt-1)$$

$$-1/2\,(Skt + Skt-1)\,(\ln Kt - \ln Kt-1) - 1/2\,(Sl_t + Sl_t -1)\,(\ln L_t - \ln L_t -1) \qquad \text{(Eq. 6)}$$

Equation 6 is the equation used to estimate TFP growth. Therefore the interpretation of TFP growth is the part of economic growth which cannot be explained by the contribution of the factors of production. This is the crude estimation of TFP growth. Many factors affect TFP growth such as improvement in the quality of labor, effect of business fluctuations, and industrial shift. Therefore they must be separated from TFP growth.

Model of the Estimation of TFP Growth Adjusted for Improved Quality of Labor

Equation 7 was used to estimate TFP growth adjusted for improvements in the quality of labor:

$$Qt^{*} = TFPt^{**} + Sk\,Kt^{**} + Sl\,Lt^{**} \qquad \text{(Eq. 7)}$$

where $Lt^{**} = \frac{1}{2}(Sl_1t + Sl_1t\text{-}1)(\ln L_1t - \ln L_1t{-}1) + \frac{1}{2}(Sl_2t + Sl_2t{-}1)(\ln L_2\text{t} - \ln L_2t{-}1)$, Sl_1t = income share of the first type of labor L_1t, and Sl_2t = income share of the second type of labor L_2t.

$$SlLt^{**} = \frac{wlL1 + w2L2}{Q}\left(\left(\frac{wlL1}{wlL1 + W2L2}\right)\left(\frac{dL1}{L1}\right) + \left(\frac{w2L2}{wlL1 + w2L2}\right)\left(\frac{dL2}{L2}\right)\right)$$

$$= \frac{\frac{wlL1 + w2L2}{L1 + L2}(L1 + L2)}{Q}\left(\frac{wldL1}{\frac{wlL1 + w2L2}{L1 + L2}(L1 + L2)} + \frac{w2dL2}{\frac{wlL1 + w2L2}{L1 + L2}(L1 + L2)}\right)$$

$$= \frac{w\,(L1 + L2)}{Q}\left(\frac{w1}{w}\left(\frac{dL1}{L1 + L2} + \frac{\frac{w2}{w1}dL2}{L1 + L2}\right)\right)$$

$$= \frac{w\,(L1 + L2)}{Q}\left(\frac{w1}{w}\left(\frac{dL1 + \frac{w2}{w1}dL2}{L1 + L2}\right)\right)$$

$$= \frac{w\,(L1 + L2)}{Q}\left(\frac{\frac{w1}{w}dL1 + \frac{w2}{w}dL2}{L1 + L2}\right) \qquad \text{(Eq. 8)}$$

where w = average wage rate, Lt^{**} = growth rate of a quality-adjusted aggregate labor input, and Q = labor in efficiency units.

We can use Eqs. 7 and 8 to calculate $TFPt^{**}$ and the difference between $TFPt^{*}$ and $TFPt^{**}$ is the part due to the quality change in labor input. The estimation method is the same when we want to separate the effect of industrial shift from crude *TFPGt*.

RESULTS OF ANALYSIS

TFP Growth, 1977–99

The 1977–99 period being considered can be divided into five subperiods to cover the whole range of the business cycle. A summary of the results of GDP growth is shown in Table 1 with the contribution of capital, labor, and the TFP growth. The average growth of GDP during 1977–99 was 6.20%, of which approximately 3.53% (56.96%) stemmed from the contribution of capital and 1.40% (22.56%) from labor. The contribution of TFP growth was a low 1.27% (20.48%).

Table 1. Sources of economic growth, 1977−99.

Year	Growth (%)	Contribution			Contribution (%)		
		Labor	Capital	TFPG	Labor	Capital	TFPG
1977	9.40	6.37	1.67	1.36	67.72	17.81	14.48
1978	9.42	4.23	1.80	3.39	44.89	19.16	35.94
1979	5.11	−1.40	2.12	4.39	−27.35	41.44	85.91
1980	4.50	3.61	2.39	−1.49	80.09	53.04	−33.13
1981	5.74	5.00	2.30	−1.56	87.19	40.01	−27.21
1982	5.21	1.17	2.16	1.88	22.45	41.50	36.05
1983	5.43	0.84	2.65	1.94	15.43	48.82	35.75
1984	5.59	1.95	2.57	1.08	34.88	45.87	19.25
1985	4.54	−0.33	2.31	2.56	−7.31	50.96	56.35
1986	5.39	1.73	2.35	1.30	32.19	43.60	24.21
1987	9.09	1.82	2.99	4.28	20.00	32.89	47.11
1988	12.48	3.22	3.88	5.37	25.84	31.12	43.04
1989	11.50	1.86	4.85	4.80	16.14	42.15	41.71
1990	10.59	0.34	6.32	3.92	3.23	59.74	37.03
1991	8.21	0.43	6.49	1.28	5.28	79.07	15.64
1992	7.77	1.84	6.04	−0.10	23.62	77.65	−1.26
1993	8.05	−0.35	5.66	2.74	−4.37	70.36	34.02
1994	8.57	−0.09	5.80	2.86	−1.01	67.62	33.39
1995	8.90	0.69	5.89	2.31	7.81	66.20	25.99
1996	5.72	−0.49	5.53	0.68	−8.53	96.71	11.82
1997	−1.46	1.36	3.47	−6.28	−93.50	−238.12	431.62
1998	−11.40	−1.58	1.07	−10.89	13.87	−9.39	95.52
1999	4.13	−0.08	0.85	3.36	−1.94	20.56	81.38
Period mean							
1977−1981	6.83	3.56	2.06	1.22	52.12	30.08	17.79
1982−1986	5.23	1.07	2.41	1.75	20.49	46.03	33.48
1987−1991	10.37	1.53	4.91	3.93	14.80	47.31	37.89
1992−1996	7.80	0.32	5.78	1.70	4.11	74.12	21.77
1997−1999	−2.91	−0.10	1.80	−4.60	3.44	−61.79	158.35
1977−1999	6.20	1.40	3.53	1.27	22.56	56.96	20.48

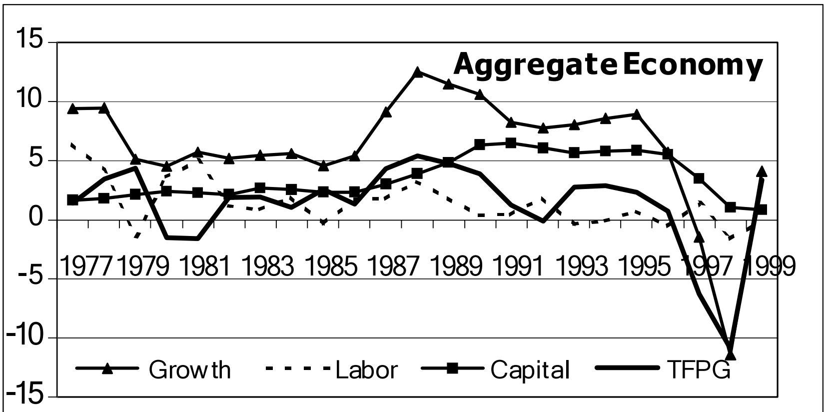
TFPG, TFP growth.

The movement of TFP growth during 1977−99 is shown in Figure 1. The first subperiod of 1977−81 was the energy crisis period with the rising costs of energy, and the average growth rate was only 6.83%; the contributions of labor, capital, and TFP growth were 3.56%, 2.06%, and 1.22%, respectively. The second subperiod of 1982−86 was the beginning of the expansion period under the export-promotion policy to stimulate FDI.

The growth rate was 5.23%, and the contributions of labor, capital, and TFP growth were 1.07%, 2.41%, and 1.75%, respectively. The third subperiod of 1987−91 was the boom period, with an average growth rate of 10.37% due to the influx of capital flows in the form of FDI in capital-intensive industries. The contribution of TFP growth was a high 3.93%. The fourth subperiod of 1992−96 was the beginning of the recession period, with a growth rate of 7.80% to which the contribution of capital was very high, averaging 5.78%. However, capital flows were in the form of portfolio investments and short-term loans which did not help generate TFP growth. Therefore TFP growth was only 1.70% during this period. The last subperiod of 1997−99 was the recession period with −2.91% declining growth caused by the Asian financial crisis with heavy capital outflows contributing only 1.80% to growth. Therefore TFP growth was the lowest in our analysis at −4.6%.

In conclusion, the growth of the Thai economy increased continually after 1977 except during the Asian financial crisis. In the first half of the period analyzed (1977−86), the Thai economy was faced with an energy crisis, and the export-promotion policy emphasized labor-intensive industries. The contribution of labor was quite high, but it moved in the opposite direction to TFP growth. TFP growth was only 1.22% and 1.75% during that period. In the second half of the period analyzed (1987−96), the Thai economy faced a financial shock with high growth of capital in the form of FDI, with capital-intensive industries generating high TFP growth. When portfolio investments and short-term loans increased to more than FDI during the last subperiod, the growth of capital started to decline, causing declining growth in output and lower TFP growth. It reached the nadir during the financial crisis.

Figure 1. Contributions to economic growth, 1977−99.



Sectoral Analysis of TFP Growth

When the period of analysis was divided into five subperiods, the first from 1977 to 1981 was hit by the energy crisis, and TFP growth for all sectors was 1.22%. The contributions of capital and labor were high in almost all sectors. The second subperiod, from 1982 to 1986, was the beginning of the expansion period, and TFP growth was about 1.75%. The export-promotion policy stimulating FDI played an important role in this period. Only TFP growth in the mining and quarrying, and transportation and communications sectors started to rise with growth rates of 7.37% and 3.53%, respectively.

In the third subperiod from 1987 to 1991, TFP growth of 3.93% was the highest during this period due to the economic boom from the influx of foreign capital, and the contribution of capital to output growth was high for all sectors. Sectoral TFP growth was very high in the agriculture (2.41%), electricity and water supply (4.65%), mining and quarrying (3.63%), and commerce (2.89%) sectors due to the expansion of exports.

During the fourth subperiod (1992–96), TFP growth started to decline with the beginning of the recession. Capital flows were entering the economy in the form of portfolio investments instead of FDI, but the growth rate of capital was still high in the construction, manufacturing, and electricity and water supply sectors. The TFP growth contributions in these sectors were negative at –8.19%, –1.37%, and –0.42%, respectively.

In the final subperiod analyzed, from 1997 to 1999, TFP growth was -4.60%, and Thailand was feeling the effects of the Asian financial crisis. There was a declining trend in TFP growth in almost all sectors, especially manufacturing (–7.98%), construction (–13.20%), electricity and water supply (–5.00%), transportation and communications (–5.35%), commerce (–10.45%), and service (–1.43%).

Summary of Sectoral Analysis

Agricultural Sector

The growth rate in the agriculture sector fluctuated greatly with an average growth rate of 2.97%, of which 58.25% was generated by TFP growth. TFP growth was the main source of output growth in this sector. The percentage contribution of capital was low, except during 1992–96. TFP growth continued to increase despite the low contributions of capital and labor during the Asian financial crisis.

Mining and Quarrying Sector

The average growth rate of the mining and quarrying sector was high continually during 1977–96, but started to decline after 1997–99. The percentage contributions of capital and TFP growth were 60.68% and 35.48%, respectively, but the contribution of labor was only 3.92%.

Manufacturing Sector

The average growth rate was rather high in manufacturing, especially during 1987-91, at about 14.38%. The contribution of capital played the most important role as a source of economic growth. The contribution of labor and TFP growth did not have much impact on the growth of the manufacturing sector.

Construction Sector

The growth pattern of the construction sector was consistent with that of the overall economy. During the boom period, the growth rate was as high as 15.80%. Capital and labor contributed more to the growth of this sector. TFP growth had significant effects only during the boom period.

Electricity and Water Supply and Transportation and Communications Sectors

The growth patterns of the electricity and water supply and transportation and communications sectors were similar to the general pattern of economic growth and were generated by the growth of capital. The average contribution of capital was as high as 90.47% and 69.05% for electricity and water supply and transportation and communications, respectively. TFP growth and the contribution of labor played a very insignificant role in generating growth in these industries except during the boom period.

Commerce Sector

Commerce includes both wholesale and retail trade and the banking, insurance, and real estate sector. The movement of TFP growth in different periods was consistent with the growth pattern of the commerce sector. During the boom period, the contribution of TFP growth was about 2.89% and it was −10.45% during the recession period. The contribution of capital to growth in this sector was about 86.76%, and only 38.43% was due to the contribution of labor.

Service Sector

This sector includes both tourism and public administration. Therefore it was difficult to separate the effects of tourism from the huge defense expenditure. This was shown by the high contribution of capital of approximately 65.14% and only 33.75% from labor. During the recession period, the contribution of labor was as high as 115.35%, which came from tourism, and the contribution of capital was only 38.30%. However, TFP growth did not have any significant effect on the growth of this sector.

Conclusion

In conclusion, the contribution of capital played a very significant role in generating growth in the mining and quarrying, manufacturing, construction, electricity and water supply, and transportation and communications sectors (Table 2 and Figure 2). Labor contributed the most only in the service sector. During the boom period, all the contributions of capital, labor, and TFP growth helped stimulate the growth of the economy. TFP growth contributed the most in the agricultural sector.

Table 2. Sectoral TFP growth, 1977−99.

Sector	Labor	1977−81	1982−86	1987−91	1992−96	1997−99	1977−99
Agriculture	Output	3.25	3.24	4.29	3.16	−0.43	2.97
	Labor	2.58	0.20	0.54	−1.85	−0.58	0.25
	Capital	0.25	0.60	1.33	3.03	−1.06	0.99
	TFPG	0.43	2.44	2.41	1.97	1.21	1.73
Mining & quarrying	Output	12.85	18.98	10.35	7.64	4.93	11.47
	Labor	1.62	0.32	0.26	−0.21	0.11	0.45
	Capital	8.85	11.29	6.45	12.20	−11.29	6.96
	TFPG	2.38	7.37	3.63	−4.34	16.11	4.07
Manufacturing	Output	7.72	5.45	14.38	9.70	0.23	8.13
	Labor	2.02	0.89	2.29	1.07	0.12	1.38
	Capital	5.51	4.75	11.19	10.00	8.09	7.89
	TFPG	0.19	−0.19	0.90	−1.37	−7.98	−1.14

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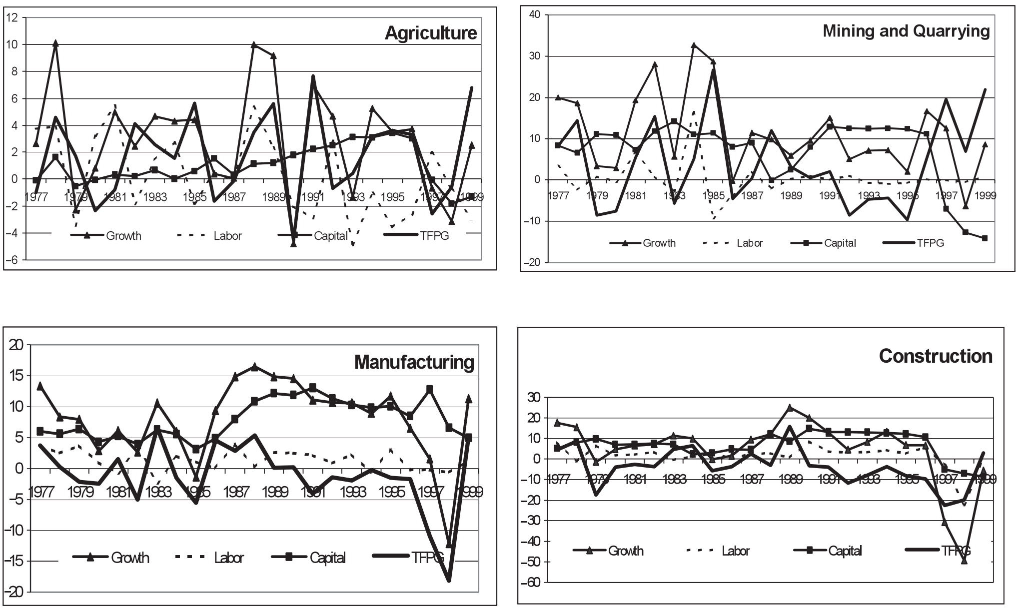
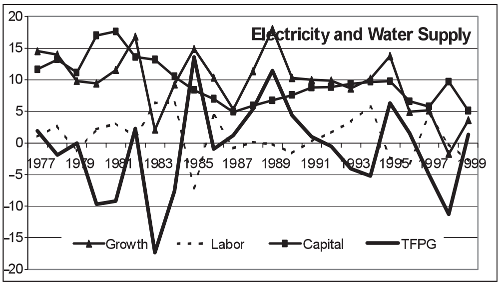
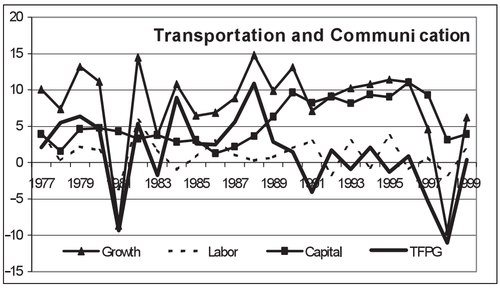
Construction	Output	8.60	5.94	15.80	7.89	−28.51	4.59
	Labor	3.45	1.39	3.57	3.80	−8.36	1.56
	Capital	7.39	4.93	10.65	12.28	−6.95	6.75
	TFPG	−2.23	−0.37	1.58	−8.19	−13.20	−3.72
Electricity & water supply	Output	11.87	10.68	10.98	9.47	2.34	9.65
	Labor	1.53	2.18	−0.45	1.05	0.48	1.00
	Capital	14.12	10.51	6.78	8.84	6.86	9.64
	TFPG	−3.79	−2.01	4.65	−0.42	−5.00	−0.99
Transportation & communications	Output	6.62	8.48	10.76	10.54	0.43	7.97
	Labor	0.93	2.09	1.41	0.71	0.32	1.16
	Capital	3.84	2.86	6.01	9.33	5.46	5.50
	TFPG	1.86	3.53	3.34	0.50	−5.35	1.31
Commerce	Output	6.85	3.50	11.92	8.19	−9.46	5.39
	Labor	3.64	2.00	1.62	1.52	1.22	2.07
	Capital	3.30	4.60	7.40	6.34	−0.23	4.68
	TFPG	−0.10	−3.11	2.89	0.33	−10.45	−1.36
Services	Output	9.21	6.47	5.48	5.01	2.67	6.04
	Labor	2.13	1.78	1.37	2.25	3.08	2.04
	Capital	4.48	3.28	4.30	5.41	1.02	3.93
	TFPG	2.60	1.41	−0.81	−2.66	−1.43	0.07

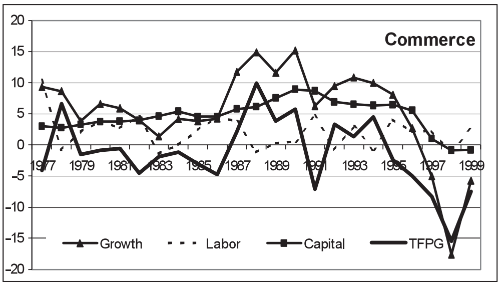
TFPG, TFP growth.

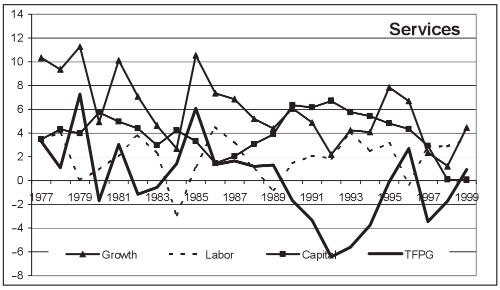
Figure 2. Sectoral TFP growth, 1977−99.











Decomposition of TFP Growth

Business Fluctuation Effect

As shown in Figure 1, there is concomitant movement between TFP growth and business fluctuations. The rate of TFP growth was high during the expansion period and low during the recession period. Therefore the effect of cyclical trends should be removed from TFP growth. Many methods can be used to adjust for the effect of business fluctuation, such as adjustment with the estimated production function, working hours of labor, and unemployment rate, and the capital-output ratio method. The capital-output ratio is used to adjust for business fluctuation in this study. The method is (Srivastava, 2001):

1) Create a capital-output (*K/Y*) series based on the capital stock and GDP data used for the analysis.
2) Arrive at a linear trend to the (*K/Y*) series.
3) Draw a line parallel to this trend passing through the lowest point on the (*K/Y*) series.
4) The potential or capacity (*K/Y*)* ratio is given by the points on the lower line.
5) Potential output is given by $Y^* = K/(K/Y)^*$.
6) Y/Y^* gives capacity utilization and this ratio is used to adjust the capital stock.

This adjustment method is adjusted from the capital stock actually used in the process of production, not all available capital stock. The results of the linear trend are:

$$K/Y = \underset{(21.22)}{2.5563} + \underset{(4.33)}{0.0380}\,T$$

(t statistic in parentheses)

$$(K/Y)^* = 2.1692 + 0.0380\,T$$

The results of constructing capacity utilization are shown in Figure 3. The points on the lower line give the potential or capacity (*K/Y*), which is consistent with the potential output, and then we can calculate *Y/Y** ratio. The ratio *Y/Y** is the ratio of the total aggregate demand over the potential output, reflecting the capacity utilization ratio of the economy. Then we can use this capacity utilization to adjust the capital stock and recalculate the TFP growth adjusted for capacity utilization (TFPGcu). The results of TFPGcu calculations using the capital-output ratio method are shown in Table 3.

Figure 3. Constructing capacity utilization, 1977−99.

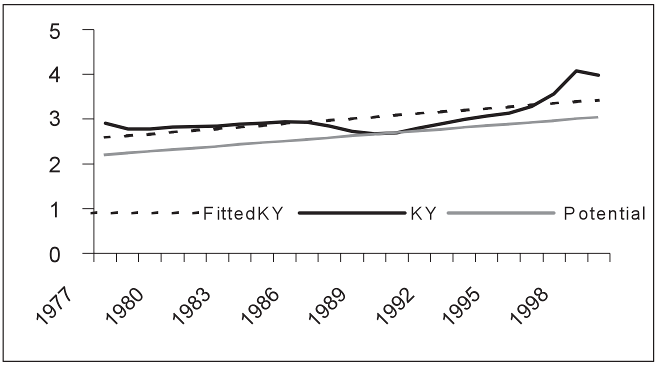


Table 3. Capacity utilization ratio (K/Y or the Wharton method).

Year	Aggregate economy	Agriculture	Mining & quarrying	Manufacturing	Construction	Electricity & water supply	Transportation & communications	Commerce	Service
1977	90.24	82.82	93.92	97.96	90.71	100.00	83.09	95.19	82.76
1978	94.68	87.53	103.02	100.00	100.00	100.00	86.03	100	85.54
1979	94.76	85.70	92.97	100.56	90.71	97.90	90.73	99.48	90.68
1980	93.38	85.65	83.08	98.54	90.05	88.21	93.43	100.62	88.22
1981	92.98	88.46	90.49	98.56	90.37	80.85	79.42	100.78	91.28
1982	92.68	89.27	101.80	96.83	90.55	83.07	86.19	98.87	92.18
1983	91.78	91.10	89.38	99.73	95.10	73.15	83.32	93.74	92.12
1984	90.97	94.08	105.17	99.15	105.44	69.96	87.42	90.57	87.90
1985	90.11	95.34	118.86	94.61	104.61	73.31	87.59	88.46	92.40
1986	90.46	90.70	105.85	98.30	102.46	75.34	90.33	86.57	96.91
1987	93.21	89.09	15.12	103.56	108.92	75.51	93.90	89.54	100.11
1988	97.78	94.89	112.22	106.89	106.58	79.46	101.57	95.29	100
1989	100.00	100.00	112.41	107.15	125.54	88.66	101.29	96.63	97.80
1990	99.00	90.13	110.21	107.77	130.11	90.74	100.00	99.90	93.30
1991	95.51	90.54	108.11	102.95	127.39	91.16	94.28	94.52	88.20

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1992	92.30	88.20	96.02	99.99	114.48	91.61	89.54	94.40	79.90
1993	89.65	78.92	87.00	98.07	106.53	90.09	86.82	95.75	74.53
1994	87.47	75.18	78.87	95.03	104.28	88.97	83.31	96.64	69.83
1995	85.70	70.59	67.90	94.26	95.62	90.84	80.50	95.77	68.79
1996	82.01	67.81	68.60	90.54	89.00	89.01	75.39	90.79	67.67
1997	75.73	66.66	80.44	78.27	73.19	88.24	67.76	85.44	65.34
1998	66.22	66.53	82.67	63.92	52.60	77.07	57.37	73.13	65.94
1999	67.93	69.28	100.00	67.50	60.94	75.57	56.19	70.54	68.79
Period mean									
1977-81	93.21	86.03	92.73	99.12	92.37	93.39	86.54	99.22	87.69
1982-86	91.20	92.10	104.21	97.72	99.63	74.96	86.97	91.64	92.30
1987-91	97.10	92.93	109.61	105.67	119.71	85.11	98.21	95.18	95.88
1992-96	87.42	76.14	79.68	95.58	101.98	90.11	83.11	94.67	72.14
1997-99	69.96	67.49	87.70	69.90	62.24	80.29	60.44	76.37	66.69
1977-99	89.33	84.28	95.40	95.66	98.05	85.16	85.02	92.72	84.36

As shown in Figure 4, TFPGcu and TFP growth had similar patterns during the first half of the study period (1977-86). The two patterns diverged during the boom period and TFPGcu was less than crude TFP growth. TFPGcu was higher than TFP growth during the recession period. TFP growth adjusted for business fluctuation was more stable.

Therefore, for the aggregate level, the capacity utilization rate was less than 90% before the boom period, full capacity (97.10%) was used during the boom period, and then excess capacity occurred during the recession and the financial crisis, when the utilization rate was only 69.96%. The capacity was fully used in the mining and quarrying, manufacturing, construction, and commerce sectors. There was excess capacity was in the agriculture, electricity and water supply, transportation and communications, and service sectors. Therefore TFPGcu was higher than crude TFP growth, as shown in Table 4, except in the mining and quarrying and agriculture sectors during the recession. TFPGcu was much higher than TFP growth during the recession due to the excess capacity of both capital and labor.

Table 4. Comparison of Output, TFP growth (TFPG), and TFPGcu, 1977-99.

Sector	Growth	1977-81	1982-86	1987-91	1992-96	1997-99	1977-99
Agriculture	Output	3.25	3.24	4.29	3.16	-0.43	2.99
	TFPG	0.43	2.44	2.41	1.97	1.21	1.73
	TFPGcu	-1.27	1.94	2.45	7.75	0.50	2.43
Mining &quarrying	Output	12.85	18.98	10.35	7.64	4.93	11.47
	TFPG	2.38	7.37	3.63	-4.34	16.11	4.07
	TFPGcu	1.35	4.24	3.21	4.75	3.55	3.41

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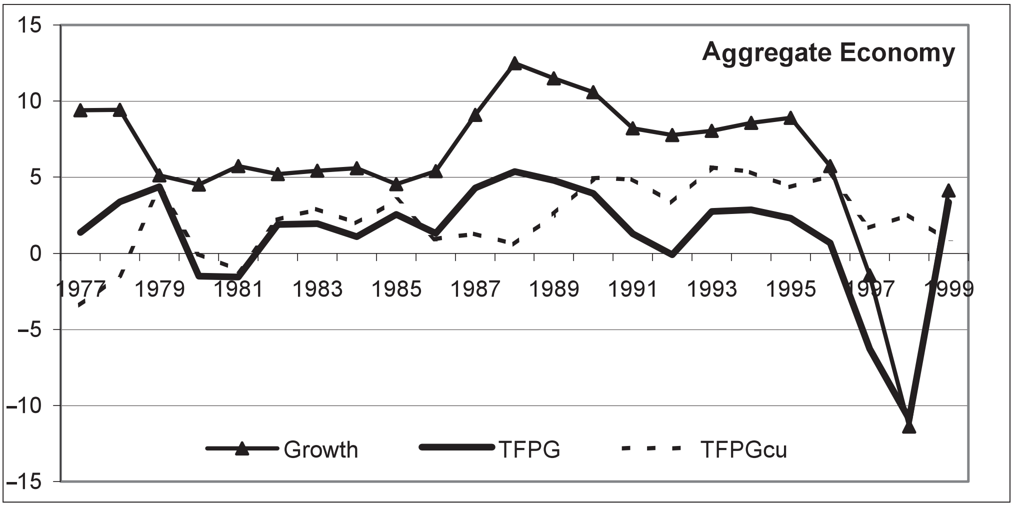
Manufacturing	Output	7.72	5.45	14.38	9.70	0.23	8.13
	TFPG	0.19	−0.19	0.90	−1.37	−7.98	−1.14
	TFPGcu	−1.22	−0.14	−0.03	1.20	1.80	0.20
Construction	Output	8.60	5.94	15.80	7.89	−28.51	4.59
	TFPG	−2.23	−0.37	1.58	−8.19	−13.20	−3.72
	TFPGcu	−5.33	−2.89	−2.77	−1.01	−0.58	−2.69
Electricity& water supply	Output	11.87	10.68	10.98	9.47	2.34	9.65
	TFPG	−3.79	−1.14	4.65	−0.42	−5.00	−0.99
	TFPGcu	−0.11	−0.60	0.84	0.06	0.46	0.10
Transportation& communication	Output	6.62	8.48	10.76	10.54	0.43	7.97
	TFPG	1.86	3.53	3.34	0.50	−5.35	1.31
	TFPGcu	2.15	0.95	2.49	4.97	4.45	2.88
Commerce	Output	6.85	3.50	11.92	8.19	−9.46	5.39
	TFPG	−0.10	−3.11	2.89	0.33	−10.45	−1.36
	TFPGcu	−2.22	−0.07	1.14	1.14	−2.03	−0.27
Service	Output	9.21	6.47	5.48	5.01	2.67	6.04
	TFPG	2.60	1.41	−0.18	−2.66	−1.43	0.07
	TFPGcu	−0.44	0.22	1.70	2.64	−1.98	0.64

Figure 4. TFP growth adjusted for business fluctuation.



Effect of Improvement in Labor Quality

Denison (1976), Grilliches (1996), and Jorgenson and Grilliches (1967) were the pioneers in studying quality-adjusted TFP growth using the growth accounting method.

Grilliches (1971) put the emphasis on the embodied technological change in the labor force and in capital. Denison (1976) emphasized the adjustment of labor, because of the heterogeneous quality of capital which made it difficult to use the duration of capital, capital efficiency, and method of calculating the depreciation rate to decompose the quality change in capital. Therefore Denison treated the embodied technological change within the residual. We also must separate the effect of improved quality of labor from crude TFP growth and therefore the quality of labor was adjusted based on differences in age, sex, and level of education.

Table 5. Distribution of share of employment classified by level of education, 1977−95.

Period mean	Primary		Secondary		Vocational		Teacher & university	
	Male	Female	Male	Female	Male	Female	Male	Female
1977−81	47.44	44.34	3.31	1.21	0.74	0.53	1.40	1.03
1982−86	45.68	42.43	4.33	1.69	1.18	0.81	2.22	1.67
1987−91	44.42	40.01	5.48	2.51	1.48	0.97	2.74	2.38
1992−96	42.08	37.43	7.24	3.83	1.62	1.05	3.54	3.21
1997−99	38.70	33.48	9.76	5.92	1.82	1.15	4.67	4.5
1977−99	43.76	39.63	5.95	2.96	1.38	0.91	2.89	2.53

When we first calculated TFP growth, we did not include the quality change in the factors of production. Labor was more efficient as labor quality improved and made more contributions to the growth of the economy. Therefore, to separate this effect from TFP growth, labor force data were classified according to age, sex, and level of education with a total of 40 categories. The revised equation for the recalculation of TFP growth is:

$$Q^{*}t = TFP\,t^{**} + S_K\,K\,t^{**} + S_L\,Lt^{**}$$

$$S_L\,Lt^{**} = \frac{w\left(\sum_{i=1}^{40} L_i\right)}{Q}\left(\frac{\sum_{i=1}^{40}\frac{w_i}{w}\,dL_i}{\sum_{i=1}^{40} L_i}\right) \qquad \text{(Eq. 9)}$$

where w = average wage rate; wi = wage rate in each category; and Lt^{**} = growth rate of labor in efficiency units.

The classified labor force data according to age, sex, and level of education were available from 1977 to 1999. Therefore we can adjust for labor quality improvement for the whole period (Table 6). The growth rate of employment in efficiency units increased continuously. The contribution of labor also increased, making that of TFP growth smaller. The mean TFP growth rate was reduced from 1.26% to 0.52% during 1978−95. The mean TFP growth rate during the five subperiods were 1.10%, 0.87%, 3.12%, 1.05%, and −6.04%, respectively.

Table 6. Effect of decomposition for improvement in labor quality

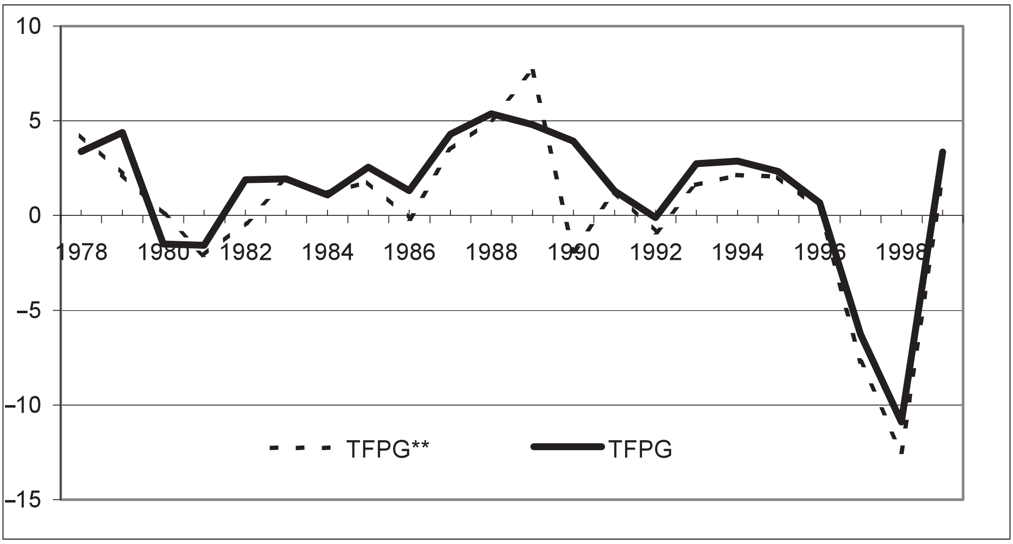
Year	Labor growth	Labor** growth	Output growth	Contribution		TFPG**	Unadjusted TFPG
				L**	K		
1978	4.82	6.81	9.42	3.37	1.80	4.25	3.39
1979	-0.46	-2.37	5.11	0.81	2.12	2.18	4.39
1980	2.82	5.92	4.50	2.03	2.39	0.08	-1.49
1981	8.40	7.86	5.74	5.55	2.30	-2.11	-1.56
1982	4.02	1.89	5.21	3.43	2.16	-0.38	1.88
1983	-2.21	1.41	5.43	0.88	2.65	1.90	1.94
1984	3.19	3.19	5.59	1.82	2.57	1.20	1.08
1985	-0.56	-0.56	4.54	0.45	2.31	1.78	2.56
1986	3.19	3.19	5.39	3.18	2.35	-0.14	1.30
1987	3.49	3.49	9.09	2.64	2.99	3.46	4.28
1988	6.39	6.39	12.48	3.49	3.88	5.11	5.37
1989	-1.07	3.83	11.50	-0.97	4.85	7.63	4.80
1990	14.93	0.74	10.59	6.13	6.32	-1.87	3.92
1991	-6.44	0.95	8.21	0.46	6.49	1.26	1.28
1992	3.03	3.92	7.77	2.59	6.04	-0.85	-0.10
1993	-1.02	-0.72	8.05	0.78	5.66	1.61	2.74
1994	-0.25	-0.18	8.57	0.64	5.80	2.14	2.86
1995	0.90	1.48	8.90	0.96	5.89	2.05	2.31
1996	-1.10	-1.06	5.72	-0.13	5.53	0.32	0.68
1997	2.84	2.84	-1.46	2.80	3.47	-7.72	-6.28
1998	-3.14	-3.14	-11.40	0.00	1.07	-12.47	-10.89
1999	-0.16	-0.16	4.13	1.21	0.85	2.08	3.36
Period mean							
1978-81	4.55	4.71	6.19	2.94	2.15	1.10	1.18
1982-86	1.82	3.32	5.23	1.95	2.41	0.87	1.75
1987-91	3.08	4.86	10.37	2.35	4.91	3.12	3.93
1992-96	0.69	2.04	7.80	0.97	5.78	1.05	1.70
1997-99	-0.15	2.75	-2.91	1.34	1.80	-6.04	-4.60
1978-99	2.08	3.56	6.05	1.91	3.61	0.52	1.26

L**, growth rate of employment in efficiency units; TFPG**, decomposition of TFP growth for improvement on labor quality; TFPG, TFP growth.

As shown in Figure 5, TFP growth adjusted for improvement in the quality of labor was smaller than crude TFP growth, except in 1989 during of the boom period when the adjusted TFP growth was greater than TFP growth due to the declining growth rate of labor (-1.07%). The contribution of the effect of quality change was less than 1% from 1977 to 1999.

From the results of analysis, we found out that there was not much improvement in the quality of labor. As shown in Table 5 more than 80% of labor had only primary-level education and worked at low wages. The labor force participation rate of males with primary education was approximately 44% and that for females 40% during 1977−99. The structure has not change much since.

Figure 5. TFP growth adjusted for improvement in the quality of labor.



Industrial Shift Effect

The marginal productivity of labor is different in each of the eight economic sectors. There is a tendency for labor in the less productive sectors to transfer to the more productive sectors of the economy. This will increase the productivity of the whole economy without changing the amount of labor. The difference in the wage rate can be used as the proxy for the difference in the marginal productivity of labor. Therefore the decomposition method for the industrial shift effect is the same as for the adjustment for the quality of labor. The labor force data are classified according to the amount of labor used in the eight economic sectors.

$$S_L Lt^{**} = \frac{w\left(\sum_{i=1}^{8} L_i\right)}{Q} \left\langle \frac{\sum_{i=1}^{8} \frac{w_i}{w} dL_i}{\sum_{i=1}^{8} L_i} \right\rangle \qquad \text{(Eq. 10)}$$

where Lt^{**} = growth rate of labor in efficiency units, S_L = share of labor, w_i = private-sector wages in sector I, and w = average wages.

If the growth rate in employment in efficiency units (considering the productivity difference by sectors) is greater than the crude growth of employment, then there will be a shift of employment from less productive to more productive sectors. In this case, the shift helped GDP growth. In our TFP estimation, the effect is included in TFP growth and must be separated.

The results of analysis of the industrial shift effect are shown in Table 7, which indicates that the contribution of the growth rate of the labor in efficiency units increased from 1.40% to 2.32% due to industrial shift during the entire study period (0.92%). The contribution of labor to TFP growth increased due to industrial shift, which made labor more efficient as it moved from less productive agriculture to more productive manufacturing, construction, commerce, and services. The impact was relatively high during the period 1982-86 and also 1992-96, which was the restructuring period when labor moved from agriculture to manufacturing and commerce. During the period of the Asian financial crisis, labor shifted among various sectors, which helped alleviate the unemployment problem. It is trivial that we have the industry shift effect which makes the growth of labor more efficient. But the effect is quite small with only a 14.89% contribution.

Table 7. Decomposition of industrial shift effect.

Year	Output growth	Contribution				Effect of industrial shift
		L#	K	TFPG	TFPG#	
1978	9.42	3.42	1.80	3.39	4.19	-0.81
1979	5.11	1.21	2.12	4.39	1.78	2.60
1980	4.50	3.79	2.39	-1.49	-1.67	0.18
1981	5.74	3.92	2.30	-1.56	-0.48	-1.08
1982	5.21	4.62	2.16	1.88	-1.57	3.45
1983	5.43	0.33	2.65	1.94	2.45	-0.51
1984	5.59	1.19	2.57	1.08	1.84	-0.76
1985	4.54	0.77	2.31	2.56	1.45	1.10
1986	5.39	3.41	2.35	1.30	-0.37	1.67
1987	9.09	3.65	2.99	4.28	2.46	1.83
1988	12.48	1.59	3.88	5.37	7.01	-1.64
1989	11.50	1.50	4.85	4.80	5.16	-0.36
1990	10.59	1.97	6.32	3.92	2.30	1.62
1991	8.21	2.90	6.49	1.28	-1.18	2.46
1992	7.77	1.31	6.04	-0.10	0.42	-0.52
1993	8.05	2.67	5.66	2.74	-0.29	3.03
1994	8.57	0.48	5.80	2.86	2.30	0.56
1995	8.90	3.09	5.89	2.31	-0.09	2.40
1996	5.72	0.40	5.53	0.68	-0.22	0.89
1997	-1.46	1.54	3.47	-6.28	-6.46	0.18

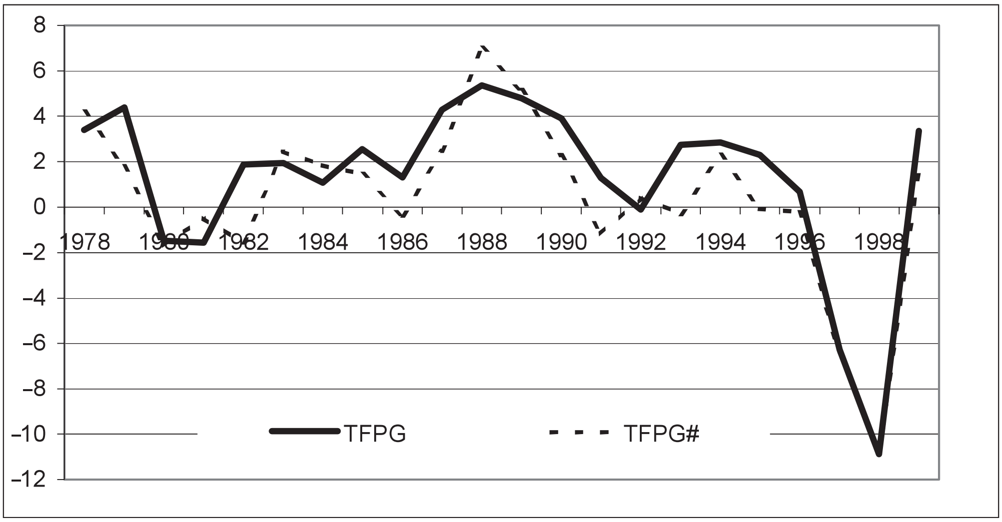
Continued...

...Continued

1998	−11.40	−1.59	1.07	−10.89	−10.88	−0.01
1999	4.13	1.68	0.85	3.36	1.60	1.76
Period mean						
1978−81	6.19	4.37	2.06	1.22	0.41	0.81
1982−86	5.23	2.06	2.41	1.75	0.76	0.99
1987−91	10.37	2.32	4.91	3.93	3.15	0.78
1992−96	7.80	1.59	5.78	1.70	0.43	1.27
1997−99	−2.91	0.54	1.80	−4.60	−5.25	0.64
1978−99	6.05	2.32	3.53	1.27	0.35	0.92

In Figure 6, it is shown that the effect of industrial shift was very strong in the second and the third periods of the boom era. Labor was transferred from agriculture to manufacturing, which made it more efficient, and the growth of the economy improved, as did TFP growth. During the last period, the industrial shift effect was less efficient, the efficiency units decreased, industrial shift thus made a lower contribution, and TFP growth declined during this period.

Figure 6. Decomposition of industrial shift effect from TFP growth.



Factors Determining TFP Growth

The growth accounting method can be used to calculate TFP growth. Multiple regression analysis can be applied to investigate the source of economic growth in Thailand during 1977−99. There are many studies on the source of economic growth in the last period.

Kaipornsak (1995) studied the source of economic growth in Thailand and found that spending on R&D, especially government expenditure, and the degree of openness with the emphasis on FDI were major factors. The dummy variables of competitiveness reflecting the structural change of the economy and the institutional factor were also included in the analysis.

Tinakorn (2001), using multiple regression analysis, found that the main sources of economic growth were the growth of the degree of openness of the economy, the growth of the share of employment in nonagricultural sectors, and the growth of gross capital stock at constant prices.

In this study, the growth rate of FDI reflecting capital flows during 1988–92, the growth rate of the spending on R&D, the growth of capital stock, and the dummy variable reflecting the financial crisis are included in the analysis. The estimated results of factors determining TFP growth are shown in Table 8. The results indicate that the growth of openness and the growth of labor in nonagriculture sectors have a positive impact on TFP growth. However, the ratio of FDI to gross fixed capital formation has a negative impact. The lagged variable of this ratio has a positive impact on TFP growth. These factors can explain about 86% of the total fluctuation in TFP growth.

Table 8. Estimated results of factors determining TFP growth.

Dependent variable: TFP growth				
Method: Least squares				
Date: 06/04/02; time: 10:54				
Sample (adjusted): 1981 to 1999				
Included observations: 19 after adjusting endpoints				
Variable	**Coefficient**	**SE**	**t Statistic**	**P value**
C	−0.120228	0.758802	−0.158445	0.8764
GOPEN	0.205985	0.043732	4.710116	0.0003
GSHR	0.078543	0.053871	1.457964	0.1669
SFDIK	−0.335158	0.067332	−4.977705	0.0002
LSFDIK	0.247097	0.071273	3.466927	0.0038
R square	0.862272	Mean dependent var.		1.133158
Adjusted R square	0.822921	SD dependent var.		3.892733
SE of regression	1.638093	Akaike info criterion		4.045876
Sum square of residual	37.56687	Schwarz criterion		4.294413
Log likelihood	−33.43582	F statistic		21.91235
Durbin−Watson statistic	2.066475	Probability (F statistic)		0.000007

GOPEN, growth of openness; GSHR, growth of labor in the nonagriculture sector; SFDIK, ratio of FDI to gross fixed capital formation; LSFDIK, lagged variable of SFDIK.

In our analysis, we used many exogenous variables, such as R&D spending, government spending, the ratio of government investment to GDP, the dummy variable for the financial crisis, and the growth of portfolio investments. These variables have a very insignificant impact on TFP growth. Our study has some limitations due to the small number of observations. The pooling technique of the time series data and the sector data was necessary due to the unavailability of the sector data for the exogenous variables.

COMPARISONS WITH THE RESULTS OF OTHER STUDIES

Our estimated results were compared with those of Tinakorn (2000) and Tinakorn and Sussangkarn (1994, 1998). Our study period was from 1977 to 1999, which was extended from the previous study and covered the recession during 1997–99. The present study found that the contribution of capital was smaller for the whole period. The contribution of labor was higher in some periods and lower in other periods compared with the results of Tinakorn and Sussangkarn. The differences in results occurred because the data series in the previous study were adjusted using the imputed wage payment based on the SAM in 1995. The adjusted wage share was smaller, which made the contribution of capital higher than in our study. Comparison of the sources of economic growth in the two studies are shown in Table 9. TFP growth was higher by only about 0.18% in the present study.

Table 9. Comparisons with the results of the previous study (Tinakorn, 2001).

Year	Current study				Previous study			
	GDP growth	Contribution			GDP growth	Contribution		
		Labor**	Capital	TFPG**		Labor**	Capital	TFPG**
1978	9.42	3.37	1.80	4.25	NA	NA	NA	NA
1979	5.11	0.81	2.12	2.18	NA	NA	NA	NA
1980	4.50	2.03	2.39	0.08	NA	NA	NA	NA
1981	5.74	5.55	2.30	−2.11	5.74	3.07	3.69	−1.02
1982	5.21	3.43	2.16	−0.38	5.21	0.75	3.3	1.16
1983	5.43	0.88	2.65	1.90	5.43	0.57	3.78	1.09
1984	5.59	1.82	2.57	1.20	5.59	1.3	3.82	0.48
1985	4.54	0.45	2.31	1.78	4.54	−0.23	3.30	1.47
1986	5.39	3.18	2.35	−0.14	5.39	1.25	3.07	1.06
1987	9.09	2.64	2.99	3.46	9.09	1.33	3.80	3.97
1988	12.48	3.49	3.88	5.11	12.48	2.36	4.82	5.29
1989	11.50	−0.97	4.85	7.63	11.50	1.47	5.89	4.13
1990	10.59	6.13	6.32	−1.87	10.59	0.29	7.41	2.89
1991	8.21	0.46	6.49	1.26	8.21	0.92	7.53	−0.24
1992	7.77	2.59	6.04	−0.85	7.77	1.14	7.01	−0.38
1993	8.05	0.78	5.66	1.61	8.05	−0.41	6.67	1.79
1994	8.57	0.64	5.80	2.14	8.56	−0.10	6.55	2.11
1995	8.90	0.96	5.89	2.05	8.46	0.39	6.27	1.81

NA, not available.

A comparison of the capacity utilization ratio is shown in Table 10. We used the same method to adjust for capacity utilization, which is based on the capital-output ratio. The capacity utilization rate was very similar in the present and previous studies and therefore the adjustment pattern is in the same direction.

Table 9 compares the labor data used in the previous analysis (Tinakorn, 2001) in efficiency units adjusted for the quality change in labor by age, sex, and level of education with the present data. The labor quality adjustment index was constructed for adjustment of TFP growth. The labor quality improvement effect is very insignificant. In our analysis, we used Oguchi's (2001) method of adjustment for the improvement in the quality of labor. Both methods of adjustment led to similar results.

Table 10. Comparison of the capacity utilization ratio in the current and previous study (Tinakorn, 2001).

Year	Capacity utilization ratio	
	Current study	Previous study
1977	90.24	NA
1978	94.68	NA
1979	94.76	NA
1980	93.38	NA
1981	92.98	90.07
1982	92.68	90.29
1983	91.78	89.92
1984	90.97	89.62
1985	90.11	89.19
1986	90.46	89.91
1987	93.21	93.08
1988	97.78	98.17
1989	100.00	100.97
1990	99.00	100.56
1991	95.51	97.52
1992	92.30	94.63
1993	89.65	92.24
1994	87.47	90.27
1995	85.70	88.32
1996	82.01	84.29
1997	75.73	NA
1998	66.22	NA
1999	67.93	NA

CONCLUSIONS AND POLICY IMPLICATIONS

The growth of the output of the Thai economy increased continuously since 1977 except during the Asian financial crisis in 1997-99. In the first half of the study period (1977-86), the main source of economic growth was the expansion of capital and labor. In the second half of the study period (1987-99), the main contribution to the economic growth came from capital. TFP growth played a very insignificant role in the contribution of output growth. When TFP growth is decomposed to separate the effects of improvement in the quality of labor, business fluctuation, and industrial shift, the contribution of TFP growth is even smaller. We found a high contribution of TFP growth in the agriculture, transportation and communications, and mining and quarrying sectors. We did not find any significant contribution of TFP growth in the manufacturing sector and only a small contribution in the service sector. These results are consistent with the negative impact of FDI on TFP growth from the analysis of factors determining TFP growth, but the lagged variable gave a positive impact.

Thailand should devise a policy giving priority to the agriculture sector both to improve the quality of labor and to invest more in this sector instead of the manufacturing sector. Thailand should also have an appropriate policy on the form of capital flows. Because capital flows alone did not help much in generating TFP growth, they should be combined with the appropriate factors of production and technological transformation.

Another important factor that contributes to the low TFP growth in Thailand is the problem of measurement of capital. Thailand was in the process of developing its economy and therefore undertook many major investment projects during the past 10 years. The total impact of those investments should have been divided into a number of periods, not simply concentrated in the initial period. This would have reduced the dependency on capital and TFP growth would have increased continually.

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INTRODUCTION

In the course of the economic reforms (doi moi) after 1989, Vietnam was recognized as a rapidly growing economy. However, the impacts of the first round of economic reforms have nearly been exhausted, with significant declines in economic growth occurring from 1996, well before the Asian financial crisis. To achieve sustainable growth, the economy needs a second wave of reforms concentrating on greater improvement in efficiency rather than on more inputs.

The sharply lower growth rates of the Vietnamese economy from 1996 pose a question on the nature of growth during doi moi: was the growth process mainly intensive or extensive? In addition, the factors that contribute to efficiency enhancement or productivity growth should be identified. Thus documentation of productivity growth and its underlying determinants may be helpful to further economic policy reforms.

The answer to the above question involves one or more measure of productivity, such as labor productivity, capital productivity, and total factor productivity (TFP), etc. Among them, TFP is thought to be the most comprehensive measure. In addition, as Vietnam's economy has been undergoing considerable changes, a comprehensive measure of productivity can provide an account of efficiency developments in the reform process. Hence the current paper focuses mainly on TFP and its determinants. Other studies have provided TFP growth estimates for Vietnam (Appendix A). However, for the sake of a consistent and deeper review of TFP performance in the reform process, the author provides a new set of TFP growth estimates in this paper. In the estimation of TFP growth from 1986 to 2000, the author relies on a growth accounting framework that decomposes overall growth into increases in inputs and enhancement of productivity. Based upon the estimates of TFP growth rates, an examination of the determining factors of TFP growth follows the accounting exercise.

ESTIMATION OF TFP GROWTH

In this section, TFP growth in the period 1986-2000 is estimated. The framework to compute TFP growth is discussed first. Second, the data needed to estimate TFP growth are reviewed.

Growth Accounting Framework

The current paper relies on the growth accounting framework used by the Asian Productivity Organization (2001), which was initiated by Solow (1957). We employ the following production function:

$$Y_t = A_t f\,(K_t\,,L_t)$$

where Y_t is total output, K_t is the capital stock, L_t is total employment (labor), and A_t measures the efficiency in the combination of two primary inputs, capital and labor. The specification of the production function shows that A_t is independent of growth in the two primary inputs. Consequently, total output can change in line with A_t even if quantities of capital and labor remain the same. As A_t reflects the efficiency of the combination between labor and capital, it is termed TFP, which is distinguished from the factor productivity of productive factors like capital and labor. In this study, we are concerned with the growth rates of A_t rather than its levels.

To estimate the annual growth in TFP in Vietnam, we adopt the growth accounting framework. This framework is not subject to the constraints of stable marginal impacts of factor growth on total output. In principle, this framework allows for marginal effects of factor growth to change over the years. Hence, we use the following model to estimate annual growth in TFP. The model shows that growth in total output may come from growth in capital stock, or total employment, or TFP, or from all of them.

$$YG_t = S_{Kt}KG_t + S_{Lt}LG_t + TFPG_t$$

where the suffix G means growth. It is noted that S_{Kt} and S_{Lt} are the relative shares of capital and labor in total income, respectively. As the production function is specified as having only two primary inputs, $S_{Kt} + S_{Lt} = 1$. It should be borne in mind that S_{Kt} and S_{Lt} may change over time.

From the above-mentioned model, the growth accounting formula as a residual calculating procedure assumes the discrete version and the trans-log version.

The discrete version:

$$\%DTFP_t = \%DY_t - S_{Kt}\%DK_t - (\,1 - S_{Kt}\,)\ \%DL_t$$

where $\%DTFP_t$, $\%DY_t$, $\%DK_t$, and $\%DL_t$ are growth rates in percentages of TFP, total output, capital stock, and total employment, respectively. The prefix $\%D$ means percentage changes in variables.

The trans-log version:

$$DLTFP_t = DLY_t - S^*_{Kt}DLK_t - (\,1 - S^*_{Kt}\,)\ DLL_t$$

where DLY_t is the growth rate of total output, DLK_t is the growth rate of the capital stock, DLL_t is the growth rate of total employment, and $DLTFP_t$ is the growth rate in TFP.

Different from the discrete version, the capital income share $S^*_{Kt} = (S_{Kt} + S_{Kt\text{-}1})\ /\ 2$ is used to reflect the fact that all the growth rates are instantaneous growth rates. Those growth rates are signaled by the prefix DL (first difference of log-transformation). For example, the instantaneous growth rate of the variable X in year t is $\ln X_t - \ln X_{t-1}$. In the next section, the data needed to estimate TFP growth from the growth accounting formula are described.

Data Issues

Under the approach adopted, we need data on total output growth, capital stock growth, employment growth, and the relative income shares of capital and labor.

Data sample

The data sample reflects the overall performance of the economy. This means that data include the activities of both the public and private sectors. In this paper, the data available in various official reports by government agencies like the General Statistical Office (GSO), the Ministry of Labor, Invalids and Social Affairs (MOLISA), and the Central Institute for Economic Management (CIEM) are mainly used.

In the case of Vietnam, only TFP growth for the period 1986–2000 is estimated rather than that for the period before 1986. The rationale for only investigating this short period is that: 1) 1986 officially marks the critical move from a central planning system to a market one. 2) In 1985, the government carried out an overall reform in wages, prices, and currency. The use of the new currency from 1985 allows direct and consistent measures of the variables under study over the period 1986–2000. 3) Data on capital equipment in the private sector before 1985 are not officially reported (GSO, 2000a). In addition, for the sake of intertemporal comparison, all the necessary original variables are valued at 1994 prices before being used to calculate growth rates.

Total Output

In principle, total output in growth accounting is GDP measured at factor cost. GDP at factor cost is calculated as:

GDP at factor cost = GDP at market price – net indirect taxes

The GSO (2000a, 2001) provided the necessary information on GDP at market prices valued at both current and 1994 constant prices. For the value of net indirect taxes, the GSO report on tax revenues and the CIEM breakdown between indirect and direct taxes were relied upon. Based on this information, the data series on GDP at factor cost valued at 1994 prices is established. It should also be noted that GDP figures include the value added generated by the public sector.

Capital stock

Currently, data on the capital stock are not available. For the sake of the study, this series was established by the author. As various sources were used and many strong assumptions imposed, the established capital stock series in level may not be very reliable. However, based upon consistent data, the series is expected to reflect the time path of the capital stock in terms of growth rate. To construct the capital stock series, the following assumptions were imposed in the use of the data.

Assumptions

1) The capital stock consists of inventories and fixed capital. In statistical reports, changes

in inventories may be termed "changes in stock." Inventories comprise raw materials, tools, and semifinished and finished goods. Fixed capital is defined by the system of national accounts (GSO, 1992) to include: buildings and other constructions; land improvement, and plantation and orchard development; transport vehicles and equipment; machinery and equipment; and breeding stock, animals, dairy cattle, and the like.

2) The capital stock is homogenous. This means that all the components in the capital stock have the same marginal productivity and the same depreciation rate.
3) The capital stock depreciates after one year at the rate of k = 0.06. The author calculates this numerical value with some steps. First, with depreciation data, gross fixed capital formation data from 1995 to 1999 (GSO, 2000c), and a certain starting depreciation rate, five different fixed capital stock series from 1994 to 1998 are established. Second, an average fixed capital stock in 1994–98 is computed from the five series on fixed capital stocks established in the previous step. Third, a new series of depreciation values from 1995 to 1999 is calculated from the fixed capital stock series in step two. With this step, there are two different series on depreciation and a sum of squared errors. Fourth is an iterative process in which the depreciation rate is altered to yield the minimum sum of squared errors. The depreciation rate of 0.06 provides the smallest sum of squared errors and it is assumed to be applicable to the whole period 1986–2000.
4) The stocks of inventories from 1994 to 1998 are assumed to be one-tenth of the fixed capital stock in the same year. Currently, the ratio between the stock of inventories and the fixed capital stock is not available from the GSO. This assumption is in line with the fact that in the period 1985–2000 changes in inventories were about 8% of gross fixed capital formation on an average basis. This ratio is derived from annual data on gross fixed capital formation and changes in inventories in the period 1985–2000.

Data

Gross capital formation during 1985–2000 was calculated in 1994 prices and current prices (GSO, 2000a, 2000c, 2001). From these data, the capital deflator over 1985–2000 can be computed. In the final results, the series on capital stock is valued at 1994 prices. Consumption of fixed capital or depreciation from 1995 to 1999 at 1994 prices can be found in a GSO publication (2000c).

From the above assumptions and data, the capital stock series is established with the perpetual inventory method. The necessary steps are:

1) Compute five capital stocks from 1994 to 1998 at 1994 prices via the information on depreciation, depreciation rate, and the ratio between the stocks of fixed capital and the stocks of inventories. These five values of the capital stocks from 1994 to 1998 are used in the next step.
2) Compute five different capital stock series from 1985 to 2000 at 1994 prices with the following formulae:

* Forward calculations: $K_{t+1} = I_{t+1} + (1 - \delta) K_t$
* Backward calculations: $K_{t-1} = (K_t - I_t) / (1 - \delta)$

3) The final series on capital stock valued at 1994 prices is the average of the five different series in step two.

When the data used are consistent over time, the procedure is expected to reflect well the growth path of the capital stock.

Total employment

In Vietnam, total annual employment is defined as the total employment measured at the middle of the year, within seven days before July 1. This employment measure includes people aged 15 years and older.

Data on total employment can be found from the GSO (2000a) for 1985–89 and MOLISA (2001b) for 1996–2000. In addition, MOLISA provides a revised version of total employment for 1990–95. From 1996, MOLISA has carried out annual surveys on labor and employment in the middle of the year, often in July. Thus the final employment data series for 1985–2000 is consistent.

Income shares of capital and labor

The underlying assumption concerning the income shares of capital and labor is that factor elasticity equals factor income share in GDP at factor cost. GDP at factor cost is composed of the compensation of employees including mixed income, direct taxes, depreciation, and net operating surplus (Table 1). Mixed income is broken down into labor income and capital income under the following framework:

1) Labor income share is assumed to be the same regarding total value added at factor cost and mixed income.
2) Labor income share = (wages, salaries, social securities) / (value added at factor cost - mixed income).
3) Labor income in mixed income = labor income share + mixed income.

Table 1. Total output by income source.

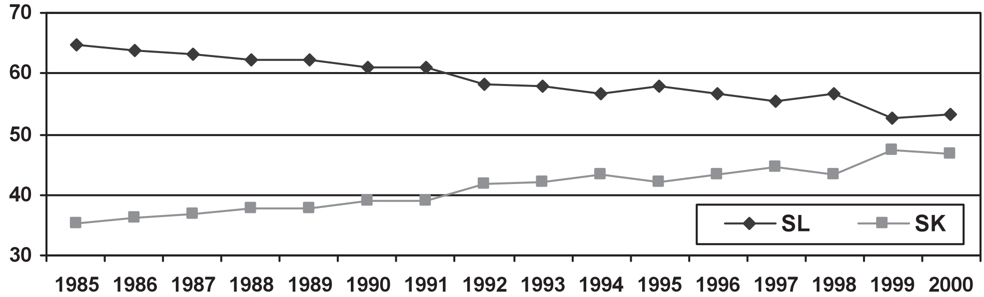
Value added at factor cost
Compensation of employees*
Wages, salaries, social security
Mixed income
Direct taxes on production
Consumption (depreciation) of fixed capital
Net operating surplus

*In Vietnam up to 2000, individual income taxes were negligible.

The annual income shares of capital and labor are computed from data provided by the GSO for the period 1989–2000. For the period 1985–88, those factor income shares are extrapolated with the information from 1989 to 2000. That is, a linear trend of the defined income shares from 1989 to 2000 is estimated. Then the linear trend helps estimate the income shares for 1985–88. Figure 1 shows the changes in these factor income shares in the period 1985–2000.

The above discussions show that there is sufficient information to estimate TFP growth in the period 1986−2000. TFP growth and TFPG* estimates are provided below after a review of the estimation framework for TFPG*.

Figure 1. Labor and capital income shares, 1985-2000 (%).



Note: S_L and S_K are labor and capital income shares, respectively
Source: Author's calculations besed upon GSO data.

Estimation of TFP Growth*

The estimation of TFP growth does not exclude business cycle effects. That means that TFP growth carries information on both economic fluctuations and technological efficiency. To account for these effects, we adjust TFP growth to arrive at TFPG*, which may serve as a better measure of technological efficiency growth. TFP growth can be broken down as:

TFP growth = TFPG* + growth in the capacity utilization rate

where the capacity utilization rate is the ratio of actual output to potential output. Thus TFPG* can be obtained with the following formula:

TFPG* = TFPG − growth in the capacity utilization rate

To estimate the capacity utilization rate, we adopt the capital/output ratio method (APO, 2001). This method involves the following steps:

1) creation of a capital/output (K/Y) series;
2) estimation of the linear trend of that series;
3) location of a baseline that is parallel to the trend line and goes through the lowest points of the K/Y series;
4) derivation of the K*/Y* series from the established baseline;
5) estimation of potential output Y* = K/capital output ratio in step 4; and
6) use of the ratio Y/Y* as the capacity utilization rate (Appendix B).

From the data sample and methods discussed above, estimates of TFP growth and TFPG* are presented in the next section.

TFP Growth and TFPG* in Vietnam, 1986−2000

From the frameworks and data discussed in the previous sections, the following results in Table 2 and Figure 2 are obtained, along with the relative contribution of capital and TFP growth to output growth. Contribution of TFP to output growth is measured by the ratio of growth rates of TFP to the growth rates of GDP. The contribution of capital to output growth is measured by the ratio of growth rates of capital timed with S_K to the growth rates of GDP. Instantaneous estimates of TFP growth are provided in Appendix C.

Figure 2. Output growth, TFP growth, and TFPG*, 1986−2000 (%).

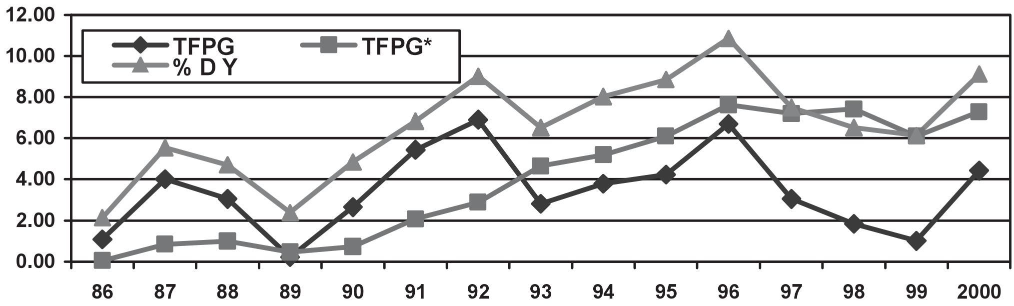


Table 2. TFP growth (TFPG): contributions of capital and TFP (%).

Year	Growth						Contribution		
	% DY	% DK	% DL	S_K	TFPG	TFPG*	K	TFPG	TFPG*
1986	2.13	−1.31	2.37	36.1	1.08	0.04	−22.16	50.93	1.99
1987	5.54	−0.15	2.53	36.8	4.00	0.85	−0.98	72.13	15.32
1988	4.69	0.05	2.61	37.6	3.04	0.99	0.42	64.86	21.12
1989	2.38	0.03	3.45	37.7	0.22	0.46	0.45	9.14	19.55
1990	4.85	0.21	3.49	39.1	2.64	0.73	1.67	54.47	14.99
1991	6.83	0.58	1.90	39.1	5.44	2.07	3.34	79.72	30.31
1992	9.02	1.93	2.24	41.8	6.90	2.88	8.92	76.59	31.97
1993	6.51	5.44	2.44	42.2	2.80	4.64	35.32	43.06	71.26
1994	8.03	6.38	2.61	43.2	3.79	5.19	34.33	47.18	64.59
1995	8.85	7.63	2.47	42.0	4.22	6.11	36.15	47.69	68.96
1996	10.87	8.46	0.92	43.2	6.69	7.62	33.62	61.55	70.14
1997	7.49	8.59	1.10	44.7	3.04	7.20	51.22	40.64	96.20
1998	6.52	9.13	1.30	43.3	1.83	7.43	60.55	28.11	113.83
1999	6.13	8.03	2.53	47.3	1.01	6.10	61.87	16.41	99.40
2000	9.12	8.39	1.47	46.6	4.42	7.29	42.89	48.49	79.85

Source: Author's calculations.

Figure 2 shows that first, TFP growth fluctuated throughout the first wave of doi moi in the period 1986-2000. The peaks of TFP growth were in 1987, 1992, and 1996, whereas the troughs were in 1989, 1993, and 1999. Immediately after the launch of economic reforms, when various changes in prices and agricultural production occurred, TFP grew rapidly. After that, TFP growth slowed down and subsequently manifested fluctuations. Second, there seems to be a close association between fluctuations in output growth and TFP growth. This comes from the fact that TFP growth does not exclude the effects of business cycles. The jump in output growth rate in 1987 was accompanied by an abrupt increase in TFP growth. In 1989, the bold reforms that included monetary tightening led to troughs in both GDP growth and TFP growth. After that year, the two variables demonstrated two consecutive cycles. From the end of 1996, TFP growth slowed. This was also a period of slowdowns in both GDP growth and consumer price index inflation. More specifically, in 1997–99, together with slowdowns initiated by the Asian financial crisis, TFP growth had slow growth rates of around 2%.

Third, TFPG* had a clearly different time path in comparison with those of output growth and TFP growth. It demonstrated a positive trend over the period 1986-2000. However, TFPG* had three development subperiods. In the first subperiod, 1986-90, TFPG* gradually increased. This suggests that the initial reforms did not bring about great improvement in technological efficiency in the early years. Subsequently, as the effects of reforms accumulated, TFPG* increased considerably in the second subperiod 1991-96. This was also the period when the effects of foreign direct investment (FDI) were manifested. Unlike TFP growth, technological efficiency gains took more time to manifest. After 1996, TFPG* was maintained at around 7% annually. This suggests that the effects of policy reforms were the most prominent in the early 1990s. In the second half of the 1990s, there were no critical changes in economic policy. This in turn suggests that a second wave of reforms could bring fresh impetus to technological efficiency gains.

In summary, the estimates suggest that TFPG* shows a more relevant picture of efficiency gains in Vietnam during the reform process than TFP growth.

TFP GROWTH AND THE NATURE OF ECONOMIC GROWTH

The contribution of TFP growth to economic growth can now be identified. This contribution is shown in Figure3. Figure 3 provides the first description of the underlying growth process in the economic reforms in Vietnam after 1986. In the period 1986-90, although the capital stock declined in 1986 and 1987, the economy grew as production and consumption behaviors were freed by gradual price reforms, by the unification of the national market, and especially by the adoption of a land-tenure contract system in agriculture. Hence, as technological efficiency growth was insignificant (Table 2), economic growth in this short period may have come mainly from the demand side. TFP growth may have contributed more than 64% of the economic growth in 1988, while TFPG* contributed 21%. It is noted that in 1989 the bold reforms depressed aggregate demand and drove down the contribution of TFP growth to total growth.

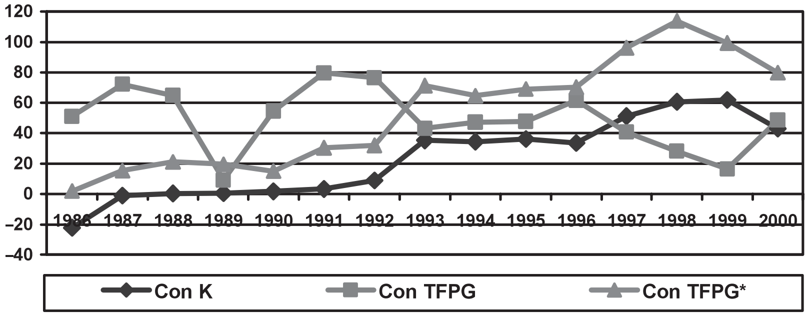
In 1991 and 1992, the contribution of TFP growth to total growth continued to outweigh that of TFPG*. This situation was reversed after 1993, especially in the period 1996–2000. However, the fact that the contribution of TFP growth declined in the late 1990s suggests that efficiency gains were offset by a slowdown in aggregate demand

(Table 2 and Figure 3). From 1996 to 2000, the contribution of TFP growth fluctuated in the reverse direction from those of both TFPG* and capital. This suggests that efficiency gains are independent of economic fluctuations in the reform process.

The overall picture shows that during the period 1986–2000, growth in capital stock played a more important role in economic growth. This suggests a sustained decline in the productivity of capital stock. An interesting point is that over the same period of time, TFPG* also increased. That means from 1986 to 2000, efficiency gains may have come largely from labor productivity growth. Figure 4 presents annual labor productivity growth from 1986 to 2000. There was also considerable improvement in labor productivity growth after 1990, in line with that of TFPG*. In addition, the average growth rate of labor productivity in the period 1991–2000 was much higher than that in the period 1986–90. This suggests a sustained growth process of the Vietnamese economy.

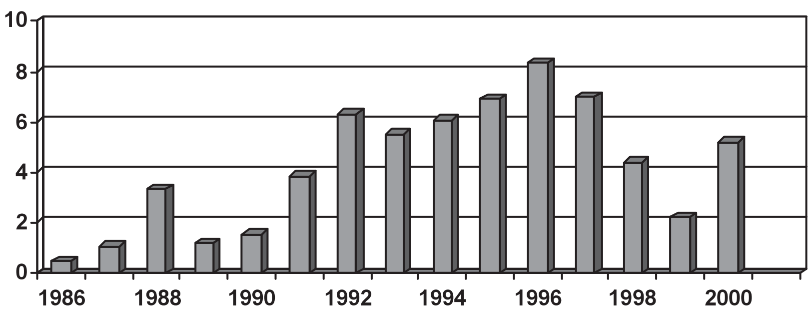
In summary, the growth process of Vietnam's economy from 1986 to 2000 was

Figure 3. Contributions (Con) of capital (K), TFP, and TFPG* to economic growth (%).



Note: The contribution of TFP to growth is measured by the ratio of growth rates of TFP to the growth rates of GDP. The contribution of capital to growth is measured by the ratio of growth rates of capital timed with SK to the growth rates of GDP.
Source: Table 2.

Figure 4. Labor productivity growth (%).



Source: Author's calculations based upon GSO (2000a, 2001) and MOLISA (2001b) data.

accompanied by efficiency gains in general and in labor productivity growth in particular. This is a positive sign for a sustained growth process. However, this only gives a general picture of what underlies efficiency gains. The next section deals with the determinants of TFP in more detail.

DETERMINING FACTORS OF TFP GROWTH IN VIETNAM

Identification of Factors Affecting TFP Growth

There are many factors that may affect TFP growth directly and indirectly. However, in this study, the only factors introduced are those frequently mentioned as being influential on productivity in the growth literature and data that can be collected. These are the factors concerning human capital and technology. The categorization of human capital and technology groups has a relative meaning because these two groups have implicit overlaps as they have many mutual, indirect relations. However, for a clear presentation, the study relies on this categorization.

Human Capital

Several types of labor are used in production. When all labor inputs are aggregated into one figure, changes in the number of workers ignore the effects of different types of labor. Since high-quality workers are more productive than others, a rise in the number of high-quality workers contributes more to output growth than a rise in others does. Therefore improvement in human capital or labor quality may lead to greater output by contributing to TFP growth, even with the same number of employed persons.

The effects of human capital can also be seen via its distribution among various sectors and industries. Labor productivity is not the same from industry to industry. Since workers tend to move from less productive to more productive industries in the labor reallocation process, overall productivity may improve even with the same total employment. This improvement contributes to TFP growth.

All these possibilities suggest that we should employ an approach that can account for different types of labor in different industries in TFP growth and TFPG* estimation. This study, due to data constraints, focuses mainly on: 1) the reallocation of labor among the agricultural sector, industrial sector, and service sector; 2) the education level of labor; and 3) technical skills of labor.

Technology

Advances in technology change methods of production. New methods of production may lead to greater output with more efficient combinations of labor and capital. Thus overall productivity may increase with advances in technology. As frequently mentioned in the literature, inventions (as reflected in the number of patents granted), FDI, and foreign trade are factors of interest in this paper. The hypothesis concerning foreign trade is that the more exposure to foreign markets and intensified competition, the more efficient businesses are. More specifically, foreign trade forces businesses to emphasize productivity improvement via new business knowledge, new technology, and training.

Framework of Analysis of the Determining Factors of TFP Growth

There are two approaches to analyze the various impacts of the determining factors of TFP growth: data decomposition; and statistical association analysis. As the number of observations is at most 15, regression analysis is not employed in this study.

Data Decomposition

Either labor or capital input is not homogenous. There are several types of labor and types of capital. If data are available, the aggregated figure of factor inputs can be decomposed to measure factor inputs more accurately. For example, the aggregated figure of labor inputs can be decomposed to determine how labor quality changes affect TFP growth. The same method can be applied for capital. However, as the necessary data on capital are not available, this paper only focuses on the decomposition of labor.

In Vietnam, although the quality of labor is not homogenous, it appears very difficult to decompose labor inputs into different categories of labor. Data on the size of employment for each level of education and the corresponding wages are not available in GSO and MOLISA reports. Hence this paper focuses on a decomposition exercise with labor among the three main sectors, which takes labor quality change into account.

The meaning of the decomposition exercise is that adjustments in the employment growth series to account for labor quality change will alter the original TFP growth and TFPG* estimates. Thus the changes in TFP growth and TFPG* estimates can provide information on the effects of labor reallocation and labor productivity growth on TFP growth. Positive labor quality changes will make the employment growth series larger. In that case, estimated TFP growth and TFPG* will decrease. Conversely, negative labor quality changes will make TFP growth and TFPG greater.

The total employment growth series is adjusted with the following formulae, one discrete and the other trans-log.

The discrete version:

$$\%DL_t = \sum_{i=1}^{3} S_{Lit}\,\%DL_{it} \;\; and \;\; \sum_{i=1}^{3} S_{Lit} = 1 \qquad \text{(Eq. 1)}$$

The trans-log version:

$$LnL_t - LnL_{t-1} = \sum_{i=1}^{3} \frac{S_{Lit} + S_{Lit-1}}{2} [LnL_{it} - LnL_{it-1}] \;\; and \;\; \sum_{i=1}^{3} S_{Lit} = 1 \qquad \text{(Eq. 2)}$$

The main point underlying the above formulae is that employment growth in each sector is weighted by that sector's labor income share in total labor income. These weights are denoted by. The three sectors are agriculture (subscript 1), industry (subscript 2), and service (subscript 3). Thus the adjusted employment growth series will carry information on labor reallocation and relative labor productivity among the sectors. This adjusted series is then embedded in the growth accounting frameworks of TFP growth and TFPG* mentioned in previous sections. The results are provided after a discussion on the statistical association analysis.

Statistical Association Analysis

The decomposition method can be applied only when data on factor prices are available for each category of input. In many cases, such data are not available but only quantitative data are found. In such cases, regression analysis is the best alternative. However, due to time constraints, statistical association analysis is employed. For example, if the number of employed persons at each education level is available but no corresponding wage rates are known, an index to present the average education level of total employed persons can be computed, and then the association between estimated TFP growth and growth in this index can be analyzed.

In this study, the effects of variables belonging to the two categories of human capital and technology on TFP growth are investigated. In addition, the effects of the combination of improvements in human capital and technology are dealt with. Once again, the division into two broad groups has a relative meaning. In this study, the emphasis is on growth rates of variables rather than their absolute values. The following sections describe the growth variables employed.

Human Capital

The dimensions of human capital of interest are: 1) growth in the literacy rate of total employed persons; 2) growth in the average education level of total employed persons; 3) growth in the proportion of total employed persons who finished secondary school; and 4) growth in the proportion of trained workers in total employment. The variables are growth rates in percentages.

The calculation of growth in the average education level of total employment requires clarification. Various education levels assume numerical values, as indicated in Table 3. The average education level of labor is then a weighted average of these values. The weights are shares in total employment (MOLISA, 2001b).

Table 3. Education level and numerical assignments.

Education level	Numerical value assigned
Illiterate	1
Incomplete primary school	2
Finished primary school	3
Incomplete secondary school	4
Finished secondary school	5

Technology

Advances in technology change our world. Invention and diffusion of new technology increase productivity. Therefore it is possible that technological progress and a new incentive system help raise the output of an economy. FDI and foreign trade are possible stimuli of technological progress. The variables are: 1) growth in the number of new patents; 2) FDI as a proportion of GDP; 3) growth in FDI as a proportion of GDP; 4) per capita FDI; 5) growth in per capita FDI; and 6) growth in openness (exports plus imports as a proportion of GDP). It is noted that FDI is annual disbursement or actual inflow.

FDI and Changes in Human Capital and TFP Growth

FDI is one of the important determinants of economic growth in Vietnam. The flows of FDI may have increased domestic investment and accelerated the formation of capital. Newly established factories based on FDI funding have created new jobs and attracted workers to more productive sectors and industries. In addition, flows of FDI have brought advanced foreign technology and management skills into Vietnam. For a certain period, new technology diffusions improve productivity. In addition, domestic human capital plays an essential role in the successful absorption of foreign capital and technology. Clearly, the combination of foreign resources and domestic human capital is highly likely to help improve productivity.

To reflect this combinative effect, the author established an index and computed its growth rate. The index is:

Index = average education level * per capita FDI

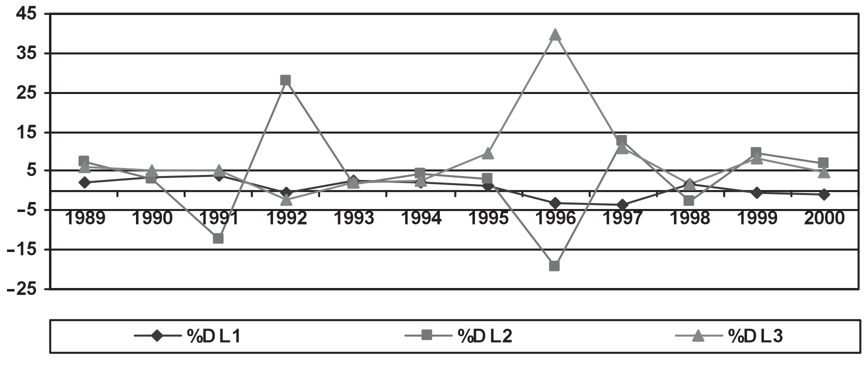
Data Decomposition

This section presents the decomposition results of labor among the three major sectors of agriculture, industry, and services. Figure 5 shows the growth rates of employment in the three main sectors. Figure 6 provides information on employment shares of these sectors from 1989 to 2000, Figure 7 offers an overview of relative productivity in terms of average wages for 1989–2000, and Table 4 also presents the results of the decomposition exercise. Appendix D provides the trans-log counterparts of the estimates presented in this section.

Figure 5 shows that growth rates of employment in the agricultural sector were the most stable. In addition, growth rates of employment in the industrial sector, even when negative, were the most unstable. Figure 6 shows another dimension of total employment, labor reallocation. The greatest labor reallocation occurred in the periods 1990–92 and 1995–97.

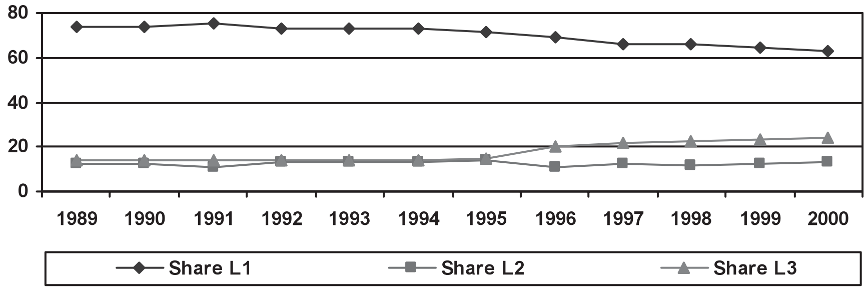
In addition, Figure 7 gives an overview of relative productivity among the three sectors. Relative productivity is measured by relative average wages in the three major

Figure 5. Growth rates of employment in the three main sectors (%).



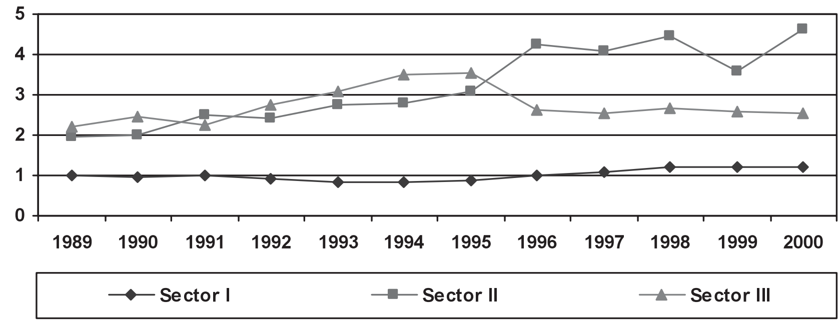
Source: Author's calculations based upon GSO (2000b) and MOLISA (2001a, 2001b) data.

Figure 6. Employment shares of the three main sectors (%).



Source: Author's calculations based upon GSO (2000b) and MOLISA (2001a, 2001b) data.

Figure 7. Relative productivity among the three main sectors (relative wages).



Source: Author's calculations.
Note: The average wage in sector I in 1989 is normalized to units. All other relative wages are the ratios of the corresponding average wages to the average wage of sector I in 1989. All average wages are measured in real terms, i.e., 1994 constant prices.

Table 4. Adjusted employment growth and changes in TFP growth and TFPG* (%).

Year	Unadjusted TFP growth			Labor reallocation and productivity changes				
	%DL	TFPG	TFPG*	%DL	TFPG	Change	TFPG*	Change
1986	2.37	1.08	0.04	—	—	—	—	—
1987	2.53	4.00	0.85	—	—	—	—	—
1988	2.61	3.04	0.99	—	—	—	—	—
1989	3.45	0.22	0.46	4.22	−0.26	−220.73	−0.01	103.21
1990	3.49	2.64	0.73	3.70	2.52	−4.80	0.60	−17.44
1991	1.90	5.44	2.07	0.84	6.09	11.89	2.72	31.26
1992	2.24	6.90	2.88	5.81	4.83	−30.06	0.81	−72.00
1993	2.44	2.80	4.64	2.30	2.88	2.79	4.72	1.68

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1994	2.61	3.79	5.19	2.94	3.60	−4.92	5.00	−3.59
1995	2.47	4.22	6.11	4.32	3.14	−25.56	5.03	−17.67
1996	0.92	6.69	7.62	5.83	3.90	−41.72	4.83	−36.60
1997	1.10	3.04	7.20	5.63	0.54	−82.32	4.70	−34.78
1998	1.30	1.83	7.43	0.57	2.25	22.64	7.84	5.59
1999	2.53	1.01	6.10	4.82	−0.21	−120.46	4.88	−19.88
2000	1.47	4.42	7.29	3.34	3.43	−22.52	6.29	−13.68

Source: Author's calculations.

sectors. While the average wage in the agricultural sector remained stable, that in the industrial sector had a clearly upward trend. The average wage in the service sector increased in the first half of the 1990s and remained unchanged after 1995. Regarding relative productivity, the agricultural sector had the lowest average wage through 1989-2000. In addition, the average wages in the industrial and service sectors revolved around each other before the industrial sector began to dominate. Therefore, in the reform process, the industrial sector experienced the largest productivity gains. Moreover, labor reallocation from the agricultural sector toward the other two sectors or from the service sector toward the industrial sector after 1995 probably raised general labor productivity.

From the estimates, we can test the hypothesis that when labor reallocates from the agricultural sector to the other two, labor productivity and hence TFP grow. To test this hypothesis, the author examined the cases of 1991, 1992, 1996, 1997, and 1998, in which there were distinctive developments in employment in the industrial and service sectors. Those years can serve as test cases for the present purpose because they convey sufficient information for intuitive comparison.

In 1992, there was a major reallocation of labor from the agricultural sector to the industrial and service sectors (Figure 6). In addition, there was a surge in industrial employment. This suggests an increase in technological efficiency. This suggestion is confirmed by the information in Table 4. In 1992, TFP growth decreased by 30 percentage points and TFPG* decreased by 72 percentage points. The decrease in TFP growth and TFPG* was due to the fact that labor quality originally embodied in TFP growth and TFPG* was transferred to the adjusted total employment growth. The efficiency gain in 1992 may thus have been largely due to labor productivity growth. The cases of 1996 and 1997 follow the same line of reasoning.

The cases of 1991 and 1998 can also serve to test the above-mentioned hypothesis. In 1991, largely due to reforms in state-owned enterprises, including liquidation and merging, the employment share of the agricultural sector increased while that of the industrial sector decreased. These developments may have had negative impacts on productivity growth. Positive changes in TFP growth and TFPG* support this expectation (Table 4). This was also the case in 1998. In 1998, due to the adverse effects of the Asian financial crisis on many FDI projects, agricultural employment share increased and so did both TFP growth and TFPG*. That means that reallocation in favor of the agricultural sector in 1998 may have reduced technological efficiency.

Labor reallocation in favor of high labor productivity industries may help improve overall technological efficiency. This has a strong implication for reforms of the labor market. That is, in addition to the legal dimension, enhancement of education, job retraining for released labor in the reform of state-owned enterprises, and infrastructure can facilitate labor reallocation, hence increasing overall productivity in the economy.

Statistical Association Analysis

In this approach, we separately consider the association between each determining factor and efficiency gains. We first deal with the group of human capital variables and then technology variables.

Human Capital and Foreign Resources

This section deals with the variables that reflect different dimensions of human capital (Table 5). In addition, we also examine the association between TFP growth and the combination of education and FDI.

Table 5. Human capital and TFP growth (%).

Year	TFPG	TFPG*	Growth in literacy rate	Growth in average education	Growth in finished high school	Growth in trained workers	Growth in education & FDI
1997	3.04	7.20	0.70	1.22	5.82	4.70	27.85
1998	1.83	7.43	1.07	2.08	11.61	3.95	−23.47
1999	1.01	6.10	−0.06	0.46	4.85	3.86	−24.47
2000	4.42	7.29	0.13	0.93	1.06	11.11	17.94

TFPG, TFP growth.
Source: Author's calculations based on MOLISA (2001b) and GSO (2001) data.

Education From 1997 to 2000, the trend of growth in the literacy rate was in line with that of TFP growth and of TFPG*. However, the loose association between growth in literacy rate and TFPG* may come from the fact that improvement in the literacy rate does not mean that labor can acquire knowledge and skills much easier. Like growth in the literacy rate, growth in average education level and proportion of total employed persons who finished high school are positively associated with TFPG*. This implies that general education may contribute to productivity gains through smoother labor reallocation.

Job Training The positive association between growth in proportion of trained workers and TFPG* is clearer. These two variables both grew rapidly in 2000. Like general education, training can also help smooth labor reallocation. In addition, job training provides laborers with specific knowledge that helps raise labor productivity.

Education and FDI Like other variables of human capital, the combination between education and FDI also demonstrates a growth path in line with that of TFPG*. A labor force with a good education can help absorb new technology and new business methods. This means education should be associated with training to facilitate FDI absorption.

The above discussions are limited in the sense that we lack long data series to arrive at reliable conclusions. However, they suggest that: 1) general education and specific job training have positive impacts on technological efficiency as they facilitate labor reallocation and labor productivity gains; 2) education should be closely combined with training; and 3) to benefit from FDI, education and training should be improved.

Technology Many factors that may stimulate technological progress: invention, FDI as a proprotion of GDP, per capita FDI, and openness. Table 6 shows the association, direct and indirect, with lags of order 1, between TFP growth and TFPG* with other factors that may contribute to technological efficiency gains. It is noted that associations between each factor with TFP growth and TFPG* may have different signs, as in the case of the increase in the number of patents and FDI. That difference, as mentioned above, may be caused by fluctuations in aggregate demand.

The relations of interest are those between TFPG* and other variables. Regarding growth variables, the direct and indirect associations between growth variables and TFPG* are negative. These are not the expected directions of the associations. However, these results do not necessarily mean that the relations between TFPG* and its possible determinants in Vietnam are different from those in other countries. This suggestion comes from the direct and indirect positive associations among FDI as a proprotion of GDP and FDI per capita and TFPG* (Table 6).

Table 6. Research, inventions, FDI, and trade (%).

Year	TFPG	TFPG*	Growth in patents	FDI/GDP	Growth in FDI/GDP (%)	FDI/pop	Growth in FDI/pop	Growth in openness
1986	1.08	0.04	—	—	—	—	—	—
1987	4.00	0.85	—	—	—	—	—	10.8
1988	3.04	0.99	—	—	—	—	—	-13.6
1989	0.22	0.46	—	—	—	—	—	82.8
1990	2.64	0.73	—	0.022	—	44.1	—	6.5
1991	5.44	2.07	167.76	0.027	22.57	56.1	27.21	9.9
1992	6.90	2.88	72.30	0.056	106.40	123.6	120.10	4.5
1993	2.80	4.64	7.91	0.084	51.62	198.6	60.76	3.5
1994	3.79	5.19	14.02	0.092	9.80	233.1	17.37	14.3
1995	4.22	6.11	14.95	0.100	8.68	272.9	17.04	6.0
1996	6.69	7.62	-9.53	0.090	-10.13	263.8	-3.32	16.2
1997	3.04	7.20	-39.63	0.107	18.67	333.2	26.31	0.8
1998	1.83	7.43	46.19	0.077	-27.99	249.8	-25.03	2.5
1999	1.01	6.10	18.33	0.056	-27.22	187.8	-24.81	4.2
2000	4.42	7.29	—	0.062	11.02	219.5	16.86	4.4

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Coefficients of correlation							
TFPG			0.31	−0.02	0.55	−0.13	0.56	−0.36
TFPG*			−0.79	0.76	−0.67	0.91	−0.65	−0.31
Coefficients of correlation with lag 1 for determinants							
TFPG			0.49	−0.42	0.02	−0.51	0.02	0.05
TFPG*			−0.89	0.85	−0.51	0.92	−0.49	−0.30

FDI/GDP, FDI as a proportion of GDP; FDI/pop, FDI per capita; TFPG, TFP growth.
Source: Author's calculations based upon GSO (2000c, 2001) data and reports of the Agency for Industrial Ownerships and Inventions.

In addition, a small sample does not allow formal tests of the separate effects of the selected factors on TFPG*. In the reform process, FDI not only brings in extra capital but also brings in new technology, new skills, and new business knowledge and stimulates economic restructuring in general and labor reallocation in particular. The findings of positive associations between growth in FDI as a proportion of GDP and growth in FDI per capita and TFP growth support the important role of FDI in output growth as it can stimulate aggregate demand as well as domestically funded investment.

Although the statistical association analysis does not provide much information on the relations between efficiency gains and different factors, it does argue for the role of FDI and reforms in the labor market in improving overall productivity. In addition, as FDI and the labor market are complementary to each other, they should be embedded in a unified development strategy.

CONCLUSIONS

The economic reform process has brought about positive changes in the Vietnamese economy. An investigation of the nature of economic performance is meaningful for subsequent reforms. Thus it is necessary to review TFP growth, its contributions to GDP growth, and its possible determinants. In this study, TFP growth, an efficiency measure that contains business cycle effects, and TFPG*, a measure that focuses merely on technological efficiency, were estimated. In both exercises, an accounting framework based upon an aggregate production function was employed. In estimating TFPG*, the capacity utilization rate was employed to adjust the TFP growth series. As a result, TFP growth estimates using the two procedures differ. However, as each procedure has its own meaning, they are not necessarily contrary to each other. As the two procedures rely on many assumptions (Appendix E), both explicit and implicit, their results should be used and interpreted cautiously. Overall, efficiency growth has greatly contributed to GDP growth. In addition, various factors suggest the sustainable nature of economic growth in Vietnam. That is, labor productivity growth has been steady throughout the reform process.

To identify the possible determinants of technological efficiency gains, a labor decomposition exercise and statistical association analysis were performed to examine the effects of human capital and technology. The main findings were that: 1) labor reallocation in economic restructuring can greatly improve overall productivity; and 2) the combination of FDI and absorption capacity of the economy plays an important role in efficiency gains. These findings suggest that improvement in education and training quality, reforms of the labor market, and more FDI will help enhance overall productivity.

Policy Implications

The present results show that the growth process of Vietnam's economy from 1986 to 2000 was accompanied by efficiency gains in general and labor productivity growth in particular. The fact that labor productivity growth was steady during the reform process indicates the need for continuous improvement in human resources development. Identification of the possible determinants of technological efficiency gains relying on a labor decomposition exercise and statistical association analysis also suggests that improvement in education and training quality, reforms of the labor market, and attracting more FDI will help enhance overall productivity.

The decomposition results of labor also suggest that labor reallocation in favor of high labor productivity industries may help improve overall technological efficiency. This fact has strong implications for future reforms of the labor market. That is, in addition to the legal dimension, enhancement of education, of job retraining for released labor in reforms of state-owned enterprises, and of infrastructure can facilitate labor reallocation, hence increasing the overall productivity of the economy. Policies that facilitate positive attitudes of workers and employees and increase job satisfaction are expected to raise the productivity and competitiveness of firms. On the other hand, firms and enterprises, particularly state-owned ones, should be encouraged to link wages to employee productivity.

The results of statistical association analysis argue for the role of FDI and reforms of the labor market in improving overall productivity. In addition, as FDI and the labor market are complementary to each other, it is recommended that they should be embedded in a unified development strategy.

Regarding education and training, there is also a need to make both public and private education and training more responsive to market demand. The results of this study also indicate that: general education and specific job training facilitate labor reallocation and labor productivity gains; education should be closely combined with training; and education and training quality should be improved to benefit from FDI.

Facing data constraints, the effects of a small number of possible determinants of TFP were investigated. Thus other important specific determinants of TFP growth may have been ignored. Future studies may go further to deal with the underlying determinants of TFP growth and relax the assumptions employed in the current paper (Appendix E). Future studies may involve more rigorous quantitative examinations of the effects of various factors on TFP and may provide interesting policy implications for improving overall productivity.

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APPENDIX A. RESULTS OF PREVIOUS STUDIES ON TFP ESTIMATION IN VIETNAM

Estimation Methods

Previous studies, Japanese and Australian, relied on the same accounting framework.

Model

$$Y = AK^{\alpha} L^{\beta} \quad \text{(Eq. 1)}$$

where Y is total output, K capital input, L labor input, A technological constant, α technology share of capital, β technological share of labor, and $\alpha + \beta = 1$ (assumed constant returns to scale).

Transform Eq. 1 and manipulate to obtain

$$LnY = LnA + \alpha LnK + \beta \ln L \quad \text{(Eq. 2)}$$

$$LnTFP = \ln Y - \alpha \ln K - \beta \ln L \quad \text{(Eq. 3)}$$

$$dTFP/TFP = dY/Y - \alpha dK/K - \beta dL/L \quad \text{(Eq. 4)}$$

Results of Previous Studies

Equation 4 was used to estimate TFP growth in Vietnam by other groups. The Japanese and Australian groups arrived at different results (Table A.1). Using the same methodology, the differences come from variations in the data employed concerning output, employment, capital stock, and income shares.

Output

The Japanese and Australian groups used different data for output. However, the differences were minor and do not account for differences in TFP growth estimates. In addition, these two output growth data series are based upon output evaluated at constant market prices rather than at factor cost. Thus these two output growth series are different from that in the current paper, which employed GDP at factor cost and used 1994 prices.

Employment

The two employment growth series in the Japanese and Australian studies were the same. However, they were different from the employment growth series employed in the current paper as the latter is the revised version released by MOLISA.

Capital

Differences in TFP growth estimates in the Japanese, Australian, and the present studies may be due largely to the differences in the capital stock growth series.

Income shares

Of the three versions of factor income shares, the data series used in the Japanese studies seems to be abnormal as the labor income share in 1994 was 81.7%.

Appendix A,Table 1. Japanese research group's results.

	1990	1991	1992	1993	1994
General					
GDP growth rate	5.0	5.8	8.3	7.8	8.5
Labor growth rate	4.9	2.2	2.7	2.8	2.9
Capital growth rate	5.9	5.9	6.7	7.7	8.8
TFP growth rate		1.8	3.9	3.5	4.5
Share of labor		50.4	57	71	81.7
Share of capital		46.9	43	29	18.3
Services					
Total output growth rate	10.3	7.9	6.7	8.8	9.7
Labor growth rate	4.4	2.1	1.4	2.6	3.6
Capital growth rate	5.9	5.9	6.7	7.7	8.8
TFP growth rate		3.9	2.3	4	4.3
Share of labor		47.3	43.2	6.6	64.7
Share of capital		52.7	56.8	43.4	35.3
Industries and construction					
Total output growth rate	2.8	8.0	13.1	12.3	13.1
Labor growth rate	4.2	0.1	1.40	2.2	2.3
Capital growth rate	5.9	5.9	6.70	7.7	8.8
TFP growth rate		5.0	8.50	7.1	7.5
Share of labor		39	39.4	44.9	48.9
Share of capital		61	60.6	55	51.1

Appendix A,Table 2. Australian research group's results.

Year	GDP[a]	L[b]	K[c]	TFP[d]
1987	2.4	2.1	3.1	−0.1
1988	6.0	1.8	2.5	3.9
1989	8.0	1.6	5.2	5.0
1990	5.1	4.7	3.5	0.9

Continued...

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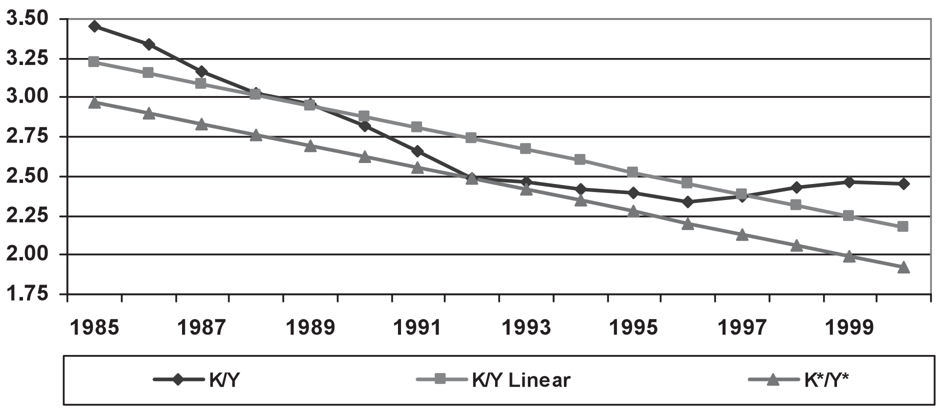
1990	5.1	4.7	3.5	0.9
1991	6.0	2.2	4.8	2.7
1992	8.7	2.7	8.0	3.8
1993	8.1	2.8	10.4	2.2
1994	8.9	2.9	16.3	0.5
1995	9.5	2.7	15.4	1.6

[a]Growth rate of real GDP extracted from GSO data.
[b]Growth rate of labor extracted from GSO data.
[c]Growth rate of capital computed using the equation $K_{t+1} = I_t + (1-d)K_t$, in which K_t and K_{t+1} are capital stocks at time t and $t+1$, respectively; d is the rate of depreciation of 0.05; I_t is actual investment; and capital stock in 1989 is derived from the input-output table published by the GSO.
[d]TFP growth =GDP growth $-(1-S_l)k - S_l\, l$, where k is the growth rate of capital stocks, l is the growth rate of labor, and S_l is assumed to be equal to 0.6 (from the GSO input-output table).

The source of Appendix A was the Center for Industrial Economics (1996).

APPENDIX B. THE CAPITAL/OUTPUT RATIO METHOD

Appendix B, Figure 1. Capital/output ratio: linear trend and baseline (K*/Y*).



Source: Author's calculations.

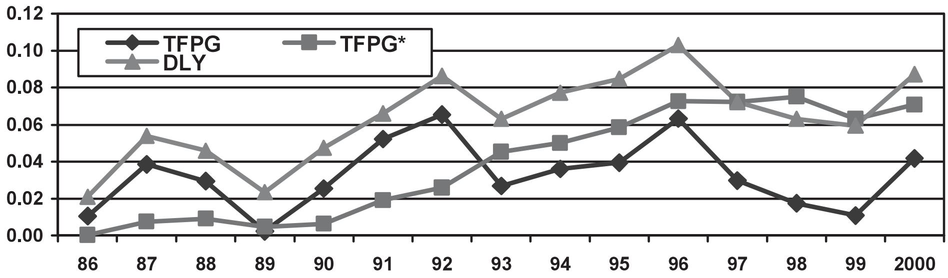
Appendix B,Table 1. Actual output/potential output ratio.

	1985	1986	1987	1988	1989	1990	1991	1992
Y/Y*	0.86	0.87	0.90	0.91	0.91	0.93	0.96	1.00
	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Y/Y*	0.98	0.97	0.95	0.94	0.90	0.85	0.81	0.78

Source: Author's calculations.

APPENDIX C. TFP GROWTH and TFPG* ESTIMATES (TRANS-LOG)

AppendixC, Figure 1. Output growth, TFP growth, and TFPG*, 1986-2000 (trans-log).



Source: Author's calculations.

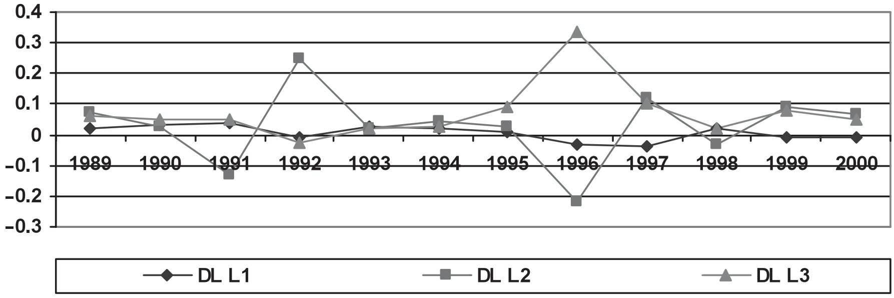
Appendix C,Table 1. TFP growth: contributions of capital and TFP (trans-log).

Year	Growth						Contribution		
	DLY	DLK	DLL	SK	TFPG	TFPG*	K	TFPG	TFPG*
1986	0.021	-0.013	0.023	0.357	0.011	0.0003	-0.22	0.51	0.02
1987	0.054	-0.001	0.025	0.364	0.039	0.008	-0.01	0.72	0.14
1988	0.046	0.001	0.026	0.372	0.029	0.009	0.00	0.64	0.20
1989	0.023	0.000	0.034	0.376	0.002	0.005	0.00	0.10	0.20
1990	0.047	0.002	0.034	0.384	0.025	0.006	0.02	0.54	0.14
1991	0.066	0.006	0.019	0.391	0.052	0.019	0.03	0.79	0.29
1992	0.086	0.019	0.022	0.404	0.065	0.026	0.09	0.76	0.30
1993	0.063	0.053	0.024	0.420	0.027	0.045	0.35	0.43	0.72
1994	0.077	0.062	0.026	0.427	0.036	0.050	0.34	0.47	0.65
1995	0.085	0.074	0.024	0.426	0.040	0.059	0.37	0.47	0.69
1996	0.103	0.081	0.009	0.426	0.063	0.073	0.34	0.61	0.70
1997	0.072	0.082	0.011	0.439	0.030	0.072	0.50	0.41	1.00
1998	0.063	0.087	0.013	0.440	0.018	0.075	0.61	0.28	1.19
1999	0.060	0.077	0.025	0.453	0.011	0.063	0.59	0.18	1.06
2000	0.087	0.081	0.015	0.469	0.042	0.071	0.43	0.48	0.81

TFPG, TFP growth.
Note: Contributions of TFP to growth are measured by the ratio of growth rates of TFP to the growth rates of GDP. Contributions of capital to growth are measured by the ratio of growth rates of capital timed with to the growth rates of GDP.
Source: Author's calculations

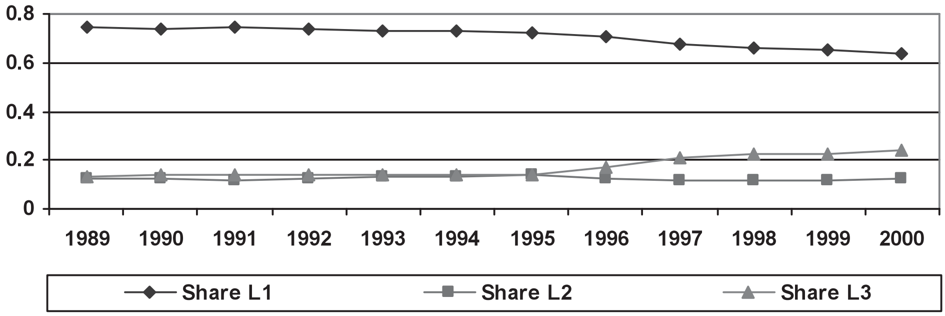
APPENDIX D. LABOR DECOMPOSITION EXERCISE

Appendix D, Figure 1. Growth rates of employment in the three main sectors (trans-log).



Source: Author's calculations.

Appendix D, Figure 2. Employment shares of the three main sectors (moving average).



Source: Author's calculations.

Appendix D,Table 1 Adjusted employment growth and changes in TFP growth (trans-log).

Year	Unadjusted TFP growth			Labor reallocation and productivity changes				
	DLL	TFPG	TFPG*	DLL	TFPG	Change	TFPG*	Change
1986	0.023	0.011	0.0003	—	—	—	—	—
1987	0.025	0.039	0.008	—	—	—	—	—
1988	0.026	0.029	0.009	—	—	—	—	—
1989	0.034	0.002	0.005	0.042	−0.003	−2.178	−0.0002	−1.033
1990	0.034	0.025	0.006	0.036	0.024	−0.042	0.005	−0.164
1991	0.019	0.052	0.019	0.007	0.060	0.141	0.027	0.386

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1992	0.022	0.065	0.026	0.045	0.052	−0.209	0.012	−0.526
1993	0.024	0.027	0.045	0.023	0.028	0.026	0.046	0.016
1994	0.026	0.036	0.050	0.029	0.034	−0.050	0.048	−0.036
1995	0.024	0.040	0.059	0.042	0.030	−0.250	0.049	−0.169
1996	0.009	0.063	0.073	0.036	0.048	0.239	0.058	−0.208
1997	0.011	0.030	0.072	0.051	0.007	−0.751	0.050	−0.310
1998	0.013	0.018	0.075	0.005	0.022	0.245	0.079	0.057
1999	0.025	0.011	0.063	0.047	−0.001	−1.090	0.051	−0.188
2000	0.015	0.042	0.071	0.031	0.033	−0.202	0.062	−0.119

TFPG, TFP growth.
Source: Author's calculations.

APPENDIX E. SUMMARY OF ASSUMPTIONS

Assumptions in the Growth Accounting Framework

1) Technological efficiency is not embedded in employment and capital stock. In other words, efficiency is independent of stocks of inputs.
2) The capital stock, consisting of fixed capital and inventories, is homogenous and has a unified implicit deflator and a unique depreciation rate. In addition, the inventory stocks from 1994 to 1998 are assumed to be one-tenth of the fixed capital stocks in the same year.
3) The depreciation rate was 6%.
4) Factor elasticity equals factor income share, i.e., the economy is in perfect competition conditions.
5) Labor income share is the same regarding total output and mixed income.
6) The capital/output ratio method leads to unbiased estimates of potential output.
7) Technological efficiency is independent of economic fluctuations.

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