THE ROLE OF TOTAL PRODUCTIVITY ON ECONOMIC GROWTH

Victor J. Elías*

ABSTRACT

This paper aims at assessing the importance of total factor productivity (TFP) on economic growth and at 'explaining' TFP growth.

The contribution share of TFP growth to GDP growth will be estimated for 96 countries in the period 1950-1987. Additionally, previous estimates covering a longer period, though for fewer countries, will be presented as well. These estimates will be presented along with other sources of economic growth, i.e., traditional labor and capital inputs.

A brief discussion will be offered of recent literature attempting to improve on economic growth theory provided by the neoclassical growth models, though emphasizing the determinants of TFP growth.

SÍNTESIS

Este trabajo plantea una evaluación de la importancia de la productividad total de los factores (PTF) sobre el crecimiento económico e intenta explicar el crecimiento de PTF.

Se estimará el aporte de la contribución del crecimiento de PTF al crecimiento del PIB para 96 países durante el período 1950-1987. Asimismo, se ofrecerán tambien estimaciones previas para un período más largo, pero, abarcando un menor número de países. Estas estimaciones serán analizadas conjuntamente con otras fuentes de crecimiento económico, a saber, los insumos tradicionales de trabajo y capital.

Se analizará en forma breve la literatura reciente que se procupa de mejorar la teoría del crecimiento económico derivada de los modelos neoclásicos de crecimiento, pero poniendo especial énfasis en los determinantes del crecimiento del PTF.

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1. INTRODUCTION

This paper aims at assessing the importance of total factor productivity (TFP) on economic growth and at 'explaining' TFP growth.

The contribution share of TFP growth to GDP growth will be estimated for 96 countries in the period 1950-1987. Additionally, previous estimates covering a longer period, though for fewer countries will be presented as well. These estimates will be presented along with other sources of economic growth, i.e., traditional labor and capital inputs.

A brief discussion will be offered of recent literature attempting to improve on economic growth theory provided by the neoclassical growth models, though emphasizing the determinants of TFP growth. Over the last decade, the literature in the field has actively endeavored to offer an explanation of GDP growth variability across countries and over time. Recent literature has emphasized (i) the source of increasing return to scale, (ii) production and effects of human capital, (iii) catch-up effects (convergence) with respect to the leading country in terms of productivity, and (iv) structural adjustment.

Evidence will be sought for in order to verify different theories put forth to account for TFP and GDP growth. These evidences should eventually be very useful for economic policy designs.

2. TFP'S ROLE ON ECONOMIC GROWTH IN 96 COUNTRIES IN THE PERIOD 1950-1987

TFP growth rate is computed according to the growth accounting methodology under the assumption of an underlying constant return Cobb-Douglas production function. TFP growth rate is estimated then as the residual by resorting to the following expression:

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TFP growth = GDP growth - labor share times labor growth - capital share times capital growth (1)

TFP growth, according to expression (1), is the difference between the GDP growth and the sum of the contributions of labor and capital to growth.

In this section, consideration will be given only to the gross concept of TFP growth. The growth accounting approach develops indicators of the quality changes of labor and capital to be added then to the growth of each input in expression (1). If the quality growth of each input is taken into account then the residual could be considered to be the net TFP growth. Growth accounting produces input quality changes indicators based on the changes in the composition of them (weighted by the relative returns of each component).

Expression (1) will be estimated as an annual average for the whole period 1950-1987. To obtain labor and capital growth estimates is the major problem due to data availability limitations. The labor input growth will be based on different sources providing information on employment. The capital input growth calls for estimates of the capital stock, only available for a few countries; therefore, a proxy for the growth of capital based on the growth of gross investment[1] will be used.

Table 1 presents the estimates of the sources of GDP growth in terms of annual average rates for the period 1950-1987. The first two columns show the GDP per capita in 1987 US dollars as well as the total population in 1987. The fourth and fifth columns evidence the rate of growth of labor and capital inputs. The sixth and seventh columns show the labor and capital contribution to GDP growth. The eighth column gives an estimate of the TFP growth which is the same as its contribution to GDP growth. Finally, the ninth and last column indicates the share of the TFP growth to total GDP growth. The Table gives estimates for 96 countries, ranked in terms of their 1987 GDP per capita level (following the same classification of the WDR 1989 that classifies the countries into lower-income, lower middle-income, upper-middle income, and high-income).

[1] The average rate of growth of the stock of capital is approximated by the average rate of growth of gross investment. The goodness of this approximation depends on the depreciation scheme and the length of the period for which the approximation is made. In the case that the sudden death method of depreciation is the appropriate one to use, this approximation is almost exact. The length of the period to be considered depends on the behavior of gross investment. If it is very variable, a long period should be appropriate to have a good approximation. When the gross investment growth behaves smoothly the approximation will work well even for a short period. I contrasted this approximation with previous estimates of stock of capital for many countries. In most of the cases the difference between the two estimates were less than 20 %. Just in one case the approximation was very different to the other estimate.

TABLE 1

Sources of economic growth. Average annual rates for the period 1950-87. GDP, labor, and capital rates of the growth, labor and capital contribution to GDP growth, TFP growth rate and contribution share to GDP growth.

Countries	(GDP/ Pop.) (US dollars 1987)	Pop. 1987 (millions persons)	GDP	Labor	Capi-tal	Labor Cont.	Cap. Cont.	TFP	TFP Share
Ethiopia	130	44.8	3.0	1.9'	7.4	1.15	2.96	-1.11	0.0
Zaire	150	5.3	2.2	1.8'	4.8	1.07	1.94	-0.76	0.0
Bangladesh	160	106.1	3.2'	2.2'	3.3'	1.34'	1.31'	0.52'	16.3
Malawi	160	7.9	4.4	2.3'	3.4	1.38	1.38	1.64	37.4
Tanzania	180	23.9	4.1	2.5'	2.1	1.50	0.85	1.78	43.2
Madagascar	210	10.9	1.4	2.1'	0.1'	1.25	0.04	0.07	5.0
Mali	210	7.8	3.5	1.8'	4.2	1.10	1.68	0.73	20.7
Burundi	250	5.0	1.9	1.4'	6.1'	0.84	2.45	-0.98	0.0
Zambia	250	7.2	3.0	2.8'	-1.8	1.69	0.73	2.01	67.7
Niger	260	6.8	0.9'	1.9'	1.7'	1.15	0.69	-0.98	0.0
Uganda	260	15.7	2.1	2.9'	1.6	1.75	0.63	-0.33	0.0
China	290	1068.5	7.7'	2.4'	13.1'	1.45	5.26	0.96	12.5
Somalia	290	5.7	5.0	2.6'	6.9'	1.56	2.76	0.72	14.3
Togo	290	3.2	3.2	2.3'	8.1'	1.40	3.24	-1.49	0.0
India	300	797.5	4.1	1.7'	7.6	1.04	3.02	-0.02	0.0
Rwanda	300	6.4	2.3	2.8'	8.5'	1.66	3.40	-2.74	0.0
Sierra Leone	300	3.8	2.7	1.0'	1.2'	0.59	0.47	1.67	61.2
Benin	310	4.3	2.9	1.9'	1.7'	1.13	0.68	1.08	37.4
Central Afr.Rep.	330	2.7	2.2	1.2'	1.3'	0.73	0.51	0.92	42.6
Kenya	330	22.1	5.0	3.8'	2.5	2.26	0.98	2.51	50.2
Sudan	330	23.1	3.2	2.1'	5.1	1.27	2.05	0.08	2.5
Pakistan	350	102.5	5.9'	2.9'	6.5'	1.72	2.62	1.53	26.1
Haiti	360	6.1	1.7'	1.4'	6.6'	0.84	2.65	-1.77	0.0
Nigeria	370	106.6	4.3	2.7'	7.0	1.64	2.80	-0.20	0.0
Ghana	390	13.6	2.4	2.3'	3.1	1.37	1.23	-0.22	0.0
Sri Lanka	400	16.4	4.1	1.7'	5.2	1.02	2.09	1.00	24.3
Mauritania	440	1.9	1.9	2.0'	6.3'	1.21	2.50	-1.85	0.0
Indonesia	450	171.4	5.1	2.0'	6.9	1.22	2.74	1.17	22.8
Liberia	450	2.3	2.2'	2.5'	-2.7'	1.50	-1.08	1.81	81.2
Senegal	520	7.0	3.5	2.8'	3.9'	1.68	1.56	0.26	7.5
Bolivia	580	6.7	2.2	2.1	1.7	1.27	0.69	0.25	11.1
Zimbabwe	580	9.0	3.8'	2.2	0.2'	1.34	0.06	2.36	62.7
Philippines	590	58.4	4.7	2.5'	4.0	1.50	1.59	1.59	33.9
Morocco	610	23.3	3.9	3.0'	2.3	1.80	0.92	1.17	30.7
Egypt Arab.Rep.	680	50.1	5.8	2.3'	7.2'	1.38	2.86	1.52	26.3

Cont. Tabla 1

Countries	(GDP/ Pop.) (US dollars 1987)	Pop. 1987 (millions persons)	GDP	Labor	Capi-tal	Labor Cont.	Cap. Cont.	TFP	TFP Share
Papua New Guinea	700	3.7	4.6	2.0'	1.9'	1.18	0.78	2.60	57.1
Dominican Rep.	730	6.7	5.5	3.0'	9.9	1.78	3.94	-0.27	0.0
Ivory Coast	740	11.1	5.3	2.7'	2.1'	1.62	0.83	2.87	53.9
Honduras	810	4.7	3.9	2.8	5.0	1.69	1.99	0.19	4.8
Thailand	850	53.6	6.5	2.7'	8.6	1.63	3.44	1.43	22.0
El Salvador	860	4.9	3.7	2.8	6.4	1.70	2.55	-0.54	0.0
Congo P.Rep.	870	2.0	4.3	2.0'	-2.1'	1.17	0.84	3.94	92.3
Jamaica	940	2.4	3.4	2.2'	0.9	1.33	0.36	1.65	49.4
Guatemala	950	8.4	4.0	2.4	4.3	1.43	1.71	0.86	21.6
Cameroon	970	10.9	4.7	1.7'	4.7	1.03	1.87	1.81	38.3
Paraguay	990	3.9	4.3	2.6	7.4	1.57	2.97	-0.20	0.0
Ecuador	1040	9.9	5.7	2.7	6.8	1.60	2.74	1.40	24.4
Botswana	1050	1.1	9.8	2.7'	15.3'	1.60	6.12	2.02	20.8
Tunisia	1180	7.6	5.1	2.9'	3.9	1.72	1.56	1.80	35.4
Turkey	1210	52.6	6.0	1.9'	7.5	1.11	2.98	1.88	31.4
Colombia	1240	29.5	4.7	2.5	3.5	1.48	1.40	1.81	38.6
Chile	1310	12.5	2.6	2.0	1.1	1.22	0.43	0.94	36.3
Peru	1470	20.2	3.9	2.9'	1.4	1.74	0.56	1.64	41.5
Mauritius	1490	1.0	4.1	2.8'	7.1	1.66	2.83	-0.42	0.0
Costa Rica	1610	2.6	5.3	3.4	8.1	2.01	3.26	0.01	0.1
Syrian Arab Rep.	1640	11.2	6.0	3.4'	6.8	2.01	2.70	1.27	21.2
Malaysia	1810	16.5	5.7	3.3'	7.1'	1.96	2.84	0.92	16.1
Mexico	1830	81.1	5.2	3.4	4.4	2.01	1.75	1.46	27.9
South Africa	1890	33.1	3.8	2.1'	3.2	1.23	1.26	1.34	3.5
Brazil	2020	141.4	6.5	2.9	6.7	1.76	2.68	2.04	31.5
Uruguay	2190	3.0	0.8	0.6	-1.2	0.38	-0.46	0.89	110.8
Hungary	2240	10.6	4.5	0.1'	5.8	0.04	2.32	2.10	47.1
Panama	2240	2.3	5.1	2.7	4.3	1.59	1.73	2.29	45.0
Argentina	2390	31.1	2.7	1.2	2.1	0.72	0.86	1.07	40.5
Yugoslavia	2480	23.4	5.1	0.9'	6.4	0.55	2.54	2.02	39.5
Algeria	2680	23.1	5.9	2.6'	4.5	1.53	1.81	2.53	43.1
Korea, Rep.	2690	42.1	7.8	3.0	8.0	1.79	3.19	2.85	36.4
Gabon	2700	1.1	6.8'	1.9'	5.9'	1.11	2.36	3.30	48.8
Portugal	2830	10.2	4.4	1.2'	4.5	0.69	1.81	1.94	43.7
Venezuela	3230	18.3	4.5	3.7	5.3	2.23	2.13	0.14	3.0
Greece	4020	10.0	5.1	0.5'	5.7	0.31	2.28	2.54	49.6
Trin. and Tob.	4210	1.2	3.8	2.1'	4.2	1.23	1.67	0.87	23.0
Iran		47.0	4.0	3.2'	7.1	1.93	2.82	-0.72	0.0
Spain	6010	38.8	5.1	0.8'	4.9	0.54	1.48	3.05	60.2
Ireland	6120	3.6	3.3	1.0'	3.9	0.70	1.18	1.41	42.8
Israel	6800	4.4	7.2	2.8'	5.0	1.96	1.51	3.72	51.7

Cont. Tabla 1

Countries	(GDP/ Pop.) (US dollars 1987)	Pop. 1987 (millions persons)	GDP	Labor	Capi-tal	Labor Cont.	Cap. Cont.	TFP	TFP Share
New Zealand	7750	3.3	3.1	1.9'	3.9	1.31	1.17	0.57	18.7
Singapore	7940	2.6	8.1'	3.6'	12.4'	2.53	3.73	1.81	22.5
Hong Kong	8070	5.6	8.7	3.6'	10.0	2.49	2.99	3.18	36.8
Italy	10350	57.4	4.3	0.6	3.4	0.43	1.02	2.82	66.0
United Kingdom	10420	56.9	2.7	0.5	3.1	0.35	0.92	1.40	52.5
Australia	11100	16.2	4.0	2.1	3.2	1.49	0.96	1.56	38.9
Belgium	11480	9.9	3.3	0.7	3.1	0.46	0.92	0.19	58.4
Netherlands	11860	14.7	3.8	1.4	3.8	0.95	1.13	1.77	46.1
Austria	11980	7.6	4.2	0.2	4.7	0.17	1.40	2.59	62.3
France	12790	55.6	4.0	0.6	3.8	0.42	1.13	2.47	61.4
Germany Fed.Rep.	14400	61.2	4.4	0.9	4.8	0.63	1.44	2.36	53.3
Finland	14470	4.9	4.2	0.8	4.5	0.53	1.35	2.27	54.6
Kuwait	14610	1.9	3.5	6.7'	7.5'	4.70	2.25	-3.55	0.0
Denmark	14930	5.1	3.2	1.0	4.0	0.69	1.20	1.31	41.1
Canada	15160	25.9	4.4	2.4	3.3	1.71	0.99	1.71	38.8
Sweden	15550	8.4	3.0	0.8	3.4	0.58	1.01	1.43	47.5
Japan	15760	122.1	7.0	1.4	8.0	0.95	2.39	3.64	52.1
Norway	17190	4.2	4.1	1.0	3.9	0.67	1.16	2.30	55.7
United States	18530	243.8	3.2	1.6	3.2	1.15	0.96	1.12	34.6
Switzerland	21330	6.5	3.0	1.3	4.3	0.88	1.28	0.84	28.1

Sources : World Bank (1989b), World Bank (1988), World Bank (1989a). IMF, A. Madisson (1987), A. Maddison (1979).

Notes: (') It only covers the period 1960-1987 . The shares of labor and capital inputs to compute its growth contribution were 0.6 and 0.4, respectively for countries from 1 to 73, and 0.7 and 0.3, respectively, for countries from 74 to 96.

In order to derive some lessons from the results presented in Table 1 different descriptive approaches can be followed before arriving at meaningful conclusions. Tables 2 and 3 provide alternative classifications that will be useful for the objectives of this paper.

Table 2 describes a qualitative version of TFP growth performance classified by GDP per capita level. It is possible to observe that most of the negative values of TFP growth are concentrated in the group of countries with lower GDP per capita, and next (though not in many cases) in the group of countries with low-middle income. The last two rows of this Table clearly show that the mean for TFP growth (either taking only positive values or all the observations) increases with GDP per capita. By considering the overall mean for TFP growth

TABLE 2

QUALITATIVE CLASSIFICATION OF THE TFP GROWTH PER CAPITA LEVEL

TFP growth	Sign of the GDP per capita level (number of countries)			
	Lower	Low-middle	Upper-middle	High
+	17	26	13	22
-	12	4	1	1
Total Cases	29	30	14	23
Share of positive signs (percentages)	59.0	87.0	93.0	96.0
TFP growth mean for positive cases	1.2	1.5	1.9	2.1
Total TFP growth mean	0.3	1.3	1.7	1.8

Sources: Table 1

TABLE 3

TFP GROWTH PERFORMANCE CLASSIFIED BY LOW, MIDDLE, AND HIGH GDP GROWTH

Performance	GDP growth (percentages)		
	Low 0.00 to 2.00	Middle 2.01 to 4.00	High 4.01 and more
TFP growth mean	-0.77	0.62	1.82
TFP growth standard dev.	0.89	1.28	1.04
Average GDP growth	1.4	3.3	5.4
Coefficient of variation of TFP growth	(1.27)	2.06	0.57
TFP growth share on GDP growth	-0.55	0.19	0.34
Number of countries	6	39	51

Sources: Table 1

it is also clearly perceived that there exists a big disparity between the lower and low-middle income group of countries (much higher for the latter) and a close similarity between the upper-middle income and the high ones. At a later stage an attempt will be made to explore what underlies these findings. A graphical representation of what has been described is presented in Figure 1.

Figure 1. Average TFP growth in the period 1950-1987 and GDP per capita in 1950 at US dollar of 1987.

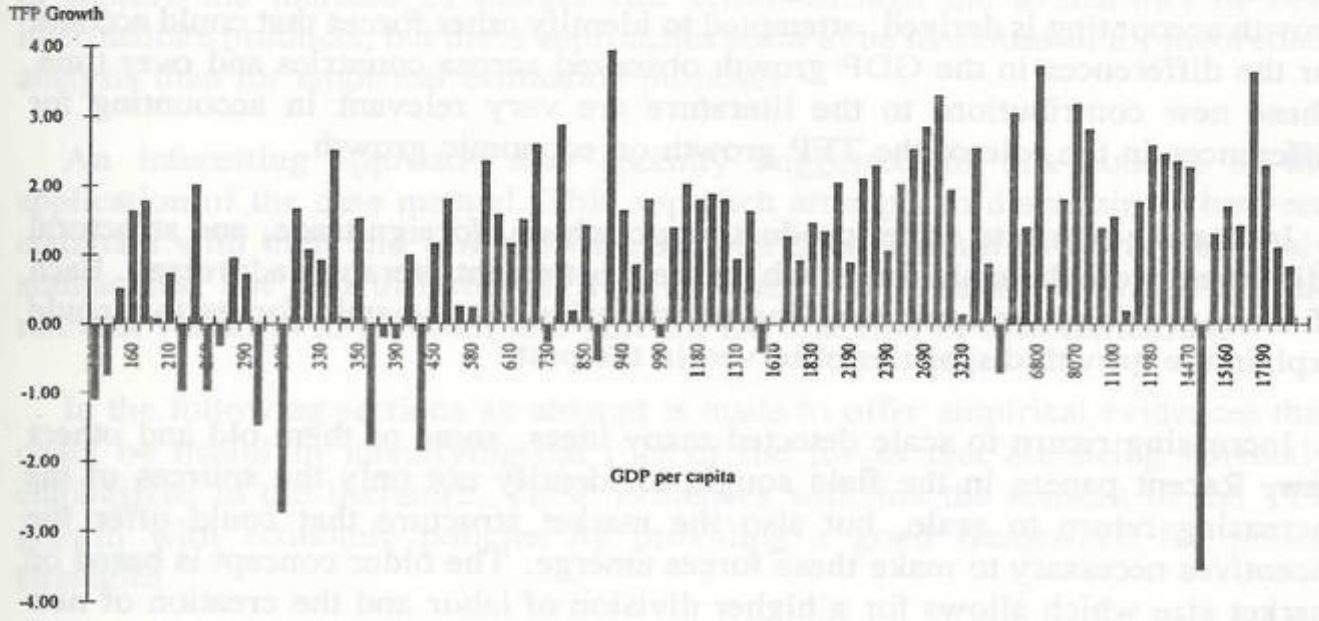


Table 3 classifies TFP growth performance according to GDP growth performance. Three categories are considered: low growth (from 0.0 to 2.0 percent), middle growth (from 2.01 to 4.00 percent), and high growth (greater than 4.01 percent). These categories clearly show that the mean for TFP growth increases with the growth level pattern. The contribution share of TFP to GDP growth (shown in the fifth row of Table 1) suggests also that TFP is more important for high growth countries than for middle-growth ones, and for middle-growth ones than for low-growth countries. Table 3 also presents a measure of variability of TFP growth behavior for different growth level categories. The high-growth countries present a much lower coefficient of variation in TFP growth with respect to middle-growth ones.

Another interesting categorization of the results presented in Table 1 could be investigated also. In the World Economic Outlook (IMF, 1989) the net debtor developing countries were classified into countries with recent debt-service difficulties and countries without recent debt-service difficulties. In the period 1974-1988 both groups present a big difference in both GDP and TFP growth. The countries with debt-service difficulties experienced a big slowdown in the GDP and TFP growth, not observed in the other group.

3. THE FORCES UNDERLYING TFP GROWTH AND CHANGES IN THE GROWTH LEVEL

Previous studies on country comparative sources of economic growth made a very important empirical effort to identify sources of growth. For many countries the TFP growth can be identified specifically as quality changes of labor and capital. For others, the net TFP growth remains very high and efforts were made to identify its other determinants.

Recent contributions extending the neoclassical growth model, from which growth accounting is derived, attempted to identify other forces that could account for the differences in the GDP growth observed across countries and over time. These new contributions to the literature are very relevant in accounting for differences in the role of the TFP growth on economic growth.

Increasing return to scale, productivity catch-up, foreign trade, and structural adjustment were the main forces which the most recent literature addressed. Each of them provides the basis enabling us to derive the dynamic forces that could explain the growth disparities observed in the past.

Increasing return to scale detected many ideas, some of them old and others new. Recent papers in the field sought to identify not only the sources of the increasing return to scale, but also the market structure that could offer the incentives necessary to make these forces emerge. The older concept is based on market size which allows for a higher division of labor and the creation of new intermediate products. The new views attempt to clearly pinpoint increasing returns through the role of human capital in the production process and in the production of human capital itself.

The forces that make foreign trade possible could in part be interpreted as the same those provided by market size. Others are derived from either efficiency incentives or the low final cost of intermediate products. Foreign trade also affects the rate of capital accumulation by changing the relative prices between investment and consumption goods.

The catch-up effects allow the countries that are lagging behind the high productivity countries to diminish the gap between them. The velocity of this convergency depends on many factors, some of which are institutional-related problems.

The structural adjustment refers in part to changes in the composition of labor and capital inputs. This composition is related especially to regional and economic sector classifications. Some of this effect was clearly observed in the traditional growth accounting through input quality changes.

Recent publications offer many useful insights which make it possible to extend the traditional approach to growth accounting. The quantitative tools for the identification of the role of these growth forces have not been developed as yet. The empirical evaluation is still in its initial stages.

Some authors have provided an approach to the measurement of the effects of the increase of market size and foreign trade. These results will be presented in the next sections. Most of these estimates are very tentative and do not have a clear theoretical basis. Other approaches provide interesting interpretations of how to capture the increase of market size effect through the availability of new intermediate products, but these approaches seem to be more useful for theoretical analysis than for empirical estimation purposes.

An interesting approach also recently suggested in this context is the application of the case method. This approach attempts to discriminate between countries with high and low growth characteristics. Countries feature not only similarities, but also differences. The key factor is to establish which are the relevant variables to be taken into account for this kind of discrimination.

In the following sections an attempt is made to offer empirical evidences that could be useful in identifying the role of the forces that are being currently emphasized in the literature. These evidences will link the sources of the TFP growth with economic policies by providing a good framework for policy strategies.

4. A GRAPHICAL COMPARATIVE ANALYSIS OF TFP GROWTH

Figures 2a), b) and c) show the simple relationship across countries between the TFP growth with the GDP growth, the initial GDP per capita, and the capital input growth (See pages 30 and 31). The clearest positive association is observed with the GDP growth. It can be noticed that the TFP growth is not related to capital accumulation (according to Arrow's theory of endogenous technology TFP growth should be related to the rate of growth of the sum of past gross investment which is more or less similar to the rate of growth of gross investment).

5. THE ROLE OF HUMAN CAPITAL

A. Krueger, in her well-known 1968 paper, assessed the role of human capital as one of the main determinants of income per capita differences across countries. She computed the percentages of income per capita for 22 countries (developed and developing ones) with respect to the U.S.A income per capita in 1960. These percentages varied from 3.0 (India) to 72.6 (Canada). Then she equalized the physical capital per capita across countries to the level of the U.S.A., and once

again computed the new income per capita for each of the 22 countries as percentages of the U.S.A income per capita. For most of the 22 countries these percentages remained below 50, so a big difference in the income per capita of these countries with respect to U.S.A prevailed despite the equalization of resources. Then differences in human capital per capita appeared to be the main force accounting for this big surplus.

Figure 2a. Dispersion diagram of TFP growth with GDP growth. Period 1950-1987. Sources: Table 1.

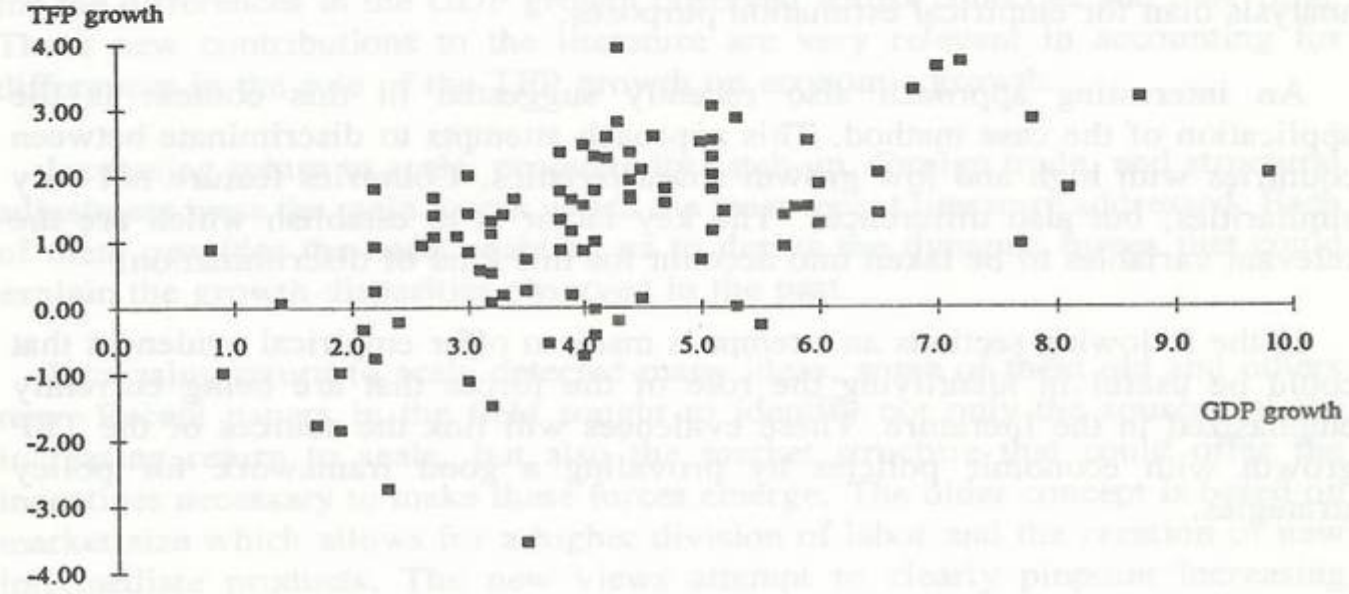


Figure 2b. Dispersion diagram of TFP growth (1950-1987) with GDP per capita (1950). Sources: Table 1.

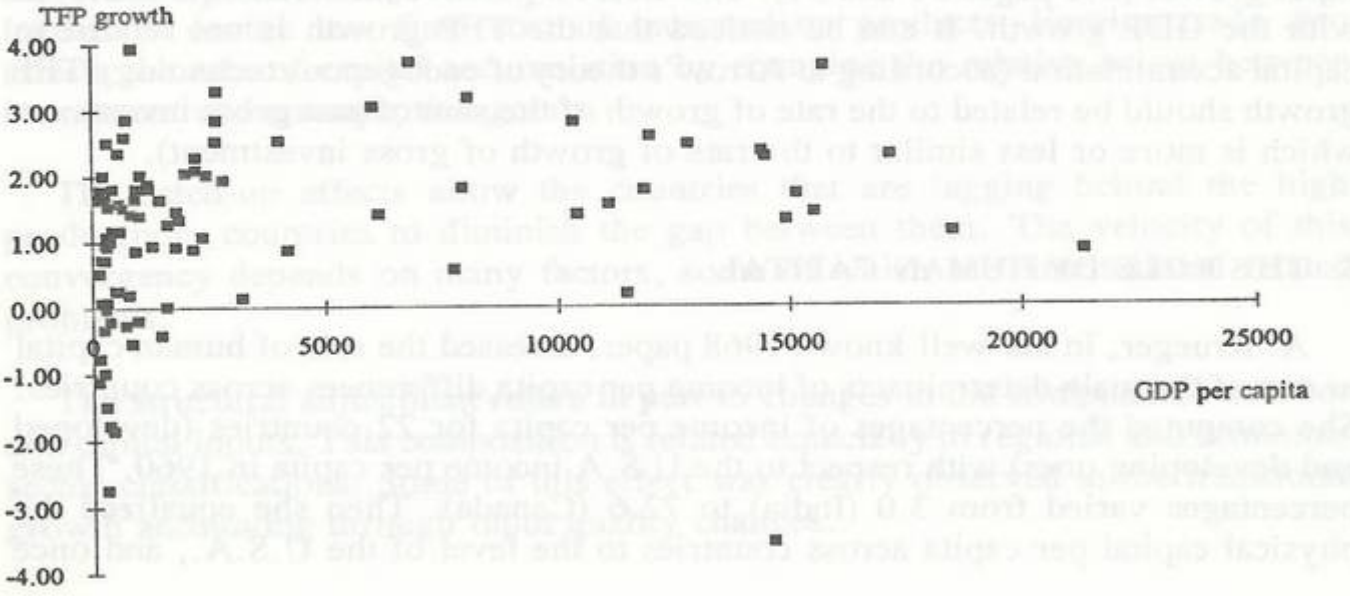
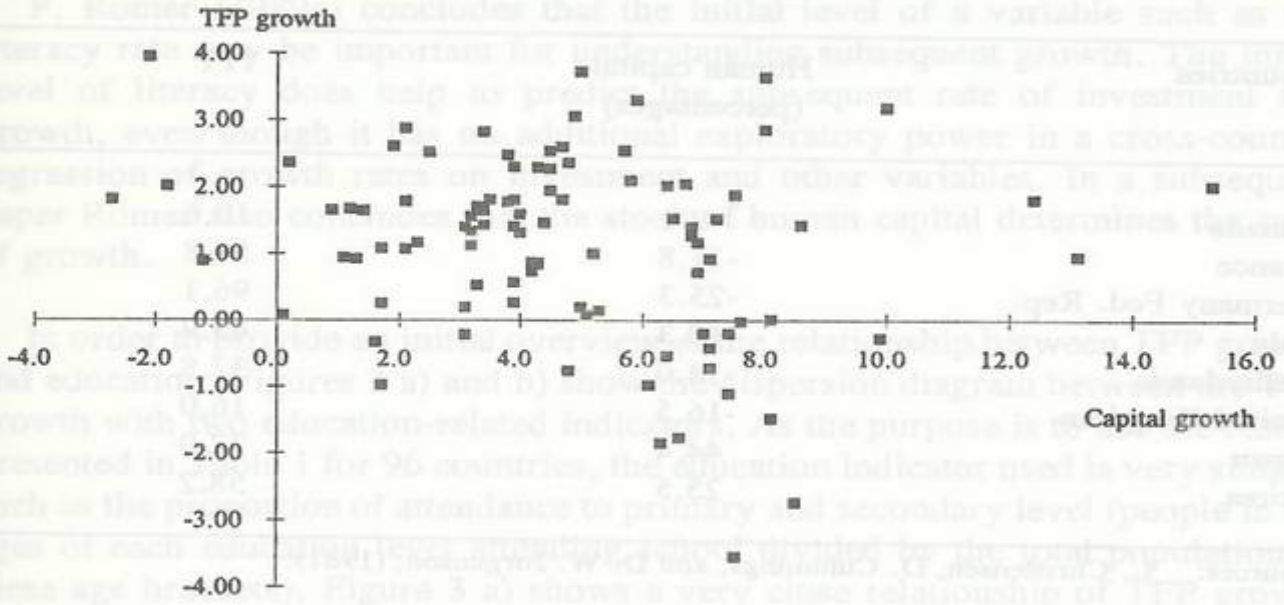


Figure 2c. Dispersion diagram of TFP growth with capital input growth. Period 1950-1987. Sources: Table 1.



Christensen, Cummings, and Jorgenson (1981) used the relative productivity approach in order to measure the sources of the decrease in the difference in income per capita between eight industrialized countries with respect to the U.S.A in the period 1950-1973. They estimated the role of physical capital, human capital[2], and net TFP. For each of these sources they computed the relative value between each one of the eight countries with respect to U.S.A. The Table which follows presents the rate of change, throughout the whole period 1950-1973 (though the period is shorter for some countries), of the relative level of human capital and TFP.

From Table 4 it becomes clear that only for fast growers, such as Japan and Korea, both human capital and technology played important roles in the reduction of the differences in the income per capita with respect to the U.S.A. For the other countries the human capital difference widened. For all eight countries technology played an important role in the reduction of the income per capita differences, which in part may be due to the productivity catch-up hypothesis.

[2] The growth of human capital is estimated using the growth accounting methodology, which provides the expression: weighted sum of the changes in composition by education level of the labor force, the weights given by the relative wages for education level i and the weighted average of wages for all kinds of labor. The TFP comes from the usual net residual.

TABLE 4

RATE OF CHANGE OF THE RELATIVE LEVEL OF HUMAN CAPITAL AND TFP BETWEEN EACH ONE OF THE EIGHT COUNTRIES AND THE U.S.A. FOR THE PERIOD 1950-1973

Countries	Human capital (percentages)	TFP
Canada	-9.1	10.6
France	-11.8	51.8
Germany Fed. Rep.	-25.3	96.1
Italy	10.3	43.9
Netherlands	-14.0	32.8
United Kingdom	-16.5	16.0
Japan	44.4	77.9
Korea	25.5	58.2

Sources: L. Christensen, D. Cummings, and D. W. Jorgenson, (1981).

In a very recent work Jorgensen and Fraumeni (1989) develop a new account for the U.S.A in order to formally incorporate human capital into the product, consumption, and investment accounts. For the period 1950-1984 the average annual rate of growth of full income, human and non-human capital was 2.11 percent, 1.78 percent, and 2.90 percent, respectively. As the income share of human capital was around 85 percent, growth accounting leaves a value of 0.16 percent for the average annual rate of change of the net TFP growth. Applying some of the new developments to the role of human capital on economic growth, these figures implied an increasing return scale of human capital of around 9 percent (0.16/1.78)[3].

This new empirical approach to growth accounting paves the way to many interesting questions. Some of them had been already posed by R. Nelson, and others were pointed out recently by P. Romer (1989 a), b) and c)).

R. Nelson[4] pointed out an interaction effect between education and technological change. The rates of return on education will be greater, the faster the pace of technological change (as education influences the rate of diffusion of technology). He also pointed out that education could diminish the expansion cost

[3] This estimate is based on Lucas' model (1988), and applying the calibration technique it is possible to get an implied estimate for the coefficient of human capital input.

[4] See his comments on the article of Z. Griliches (1970).

appearing in a rapid growth country. This argument implies that an expansion in foreign trade will have a greater effect on growth for countries with a higher level of education.

P. Romer (1989c) concludes that the initial level of a variable such as the literacy rate may be important for understanding subsequent growth. The initial level of literacy does help to predict the subsequent rate of investment and growth, even though it has no additional exploratory power in a cross-country regression of growth rates on investment and other variables. In a subsequent paper Romer also concludes that the stock of human capital determines the rates of growth.

In order to provide an initial overview of the relationship between TFP growth and education, Figures 3 a) and b) show the dispersion diagram between the TFP growth with two education-related indicators. As the purpose is to use the results presented in Table 1 for 96 countries, the education indicator used is very simple, such as the proportion of attendance to primary and secondary level (people in the ages of each education level attending school divided by the total population in these age brackets). Figure 3 a) shows a very close relationship of TFP growth with the primary level but a very diffuse one (Figure 3b)) with respect to the secondary level. These figures support the hypothesis posed by Romer and already mentioned in the preceding paragraph.

Figure 3a. Dispersion diagram between TFP growth (1950-1987) and primary educational indicators (1965).

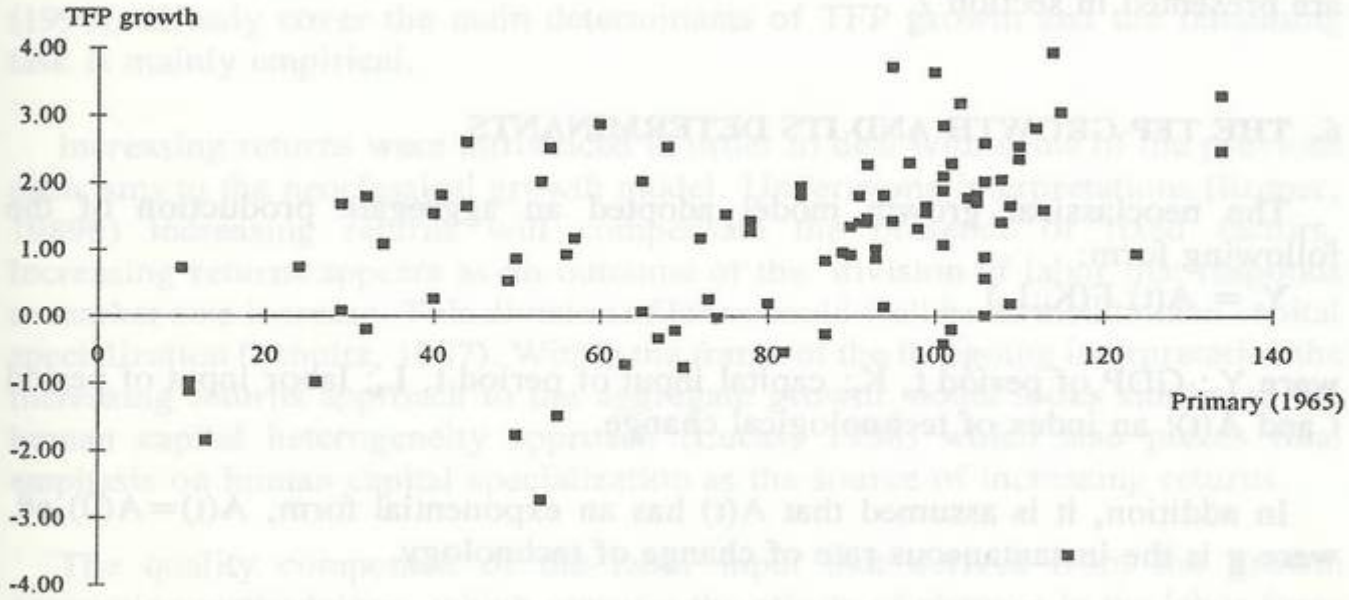
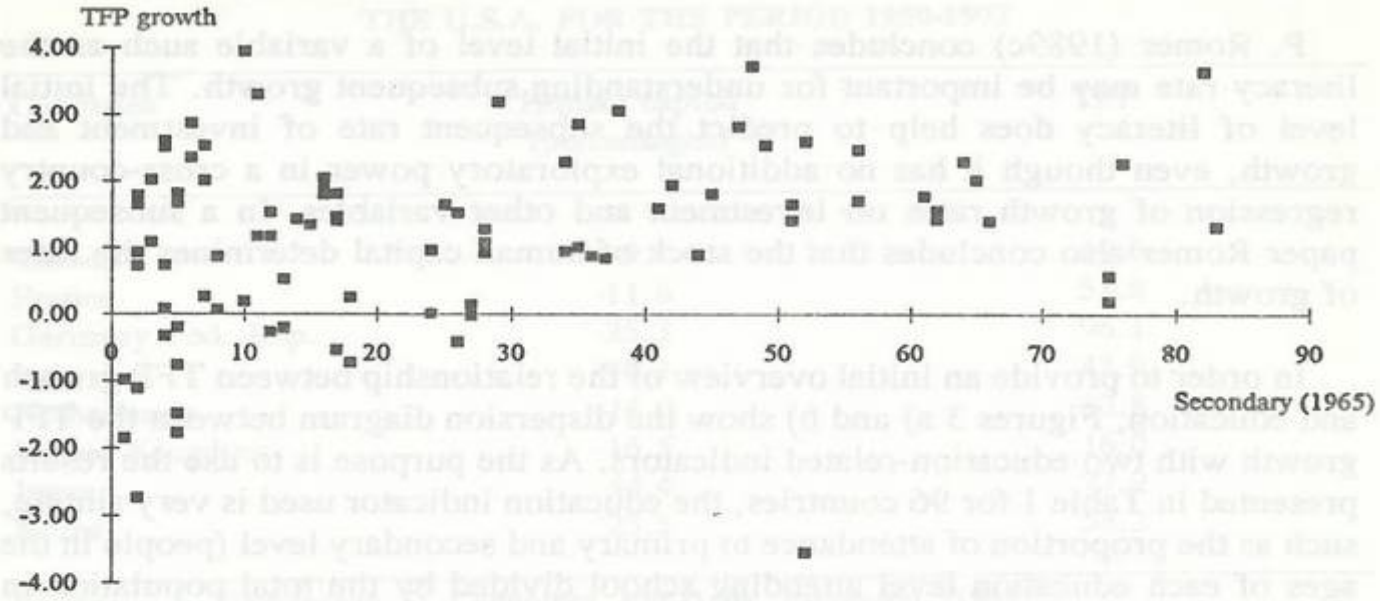


Figure 3b. Dispersion diagram between TFP growth (1950-1987) and secondary educationl indicators (1965).



The growth accounting approach provides the measure of education as a source of growth. This measure is the weighted sum of the changes in the proportion of labor of a given educational level in the total labor force. The weights are given by the ratio between the unit wage for each labor with a certain educational level and the weighted unit wages across all kinds of labor. This indicator is available for few countries only and will be used in the next sections in order to verify its relationship with other sources of growth and to search for the possibility of double accounting for the effect of education. Further discussions on this topic are presented in section 7.

6. THE TFP GROWTH AND ITS DETERMINANTS

The neoclassical growth model adopted an aggregate production of the following form:

$$Y_t = A(t).F(K_t,L_t)$$

were Y_t: GDP of period t, K_t: capital input of period t, L_t: labor input of period t and A(t): an index of technological change.

In addition, it is assumed that A(t) has an exponential form, $A(t)=A(0)\ e^{gt}$, were g is the instantaneous rate of change of technology.

Many critiques to this model can be summed up as follows:

i) it does not explain differences in the GDP growth across countries and over time; (Lucas, 1988),

ii) it implies big differences in the rates of return across countries to account for differences in income per capita (King and Rebelo, 1989 and Romer, 1989 b),

iii) only the variable in terms of rates of growth plays a role whereas the variable in terms of levels does not (Romer, 1989 c),

iv) using information across countries for a given period, no negative correlation (convergence) is observed between rate of growth of GDP per capita and the initial level of the income per capita (Barro, 1989), and

v) it implies a smooth path of technology through time and across industries. The evidence in no way seems to resemble this. (Harberger, 1990, Schultz, 1987, Jorgenson, 1990).

The critiques listed above were forwarded with no other purpose but that of attempting to improve the neoclassical growth model and, in general, they do not deny in any manner the usefulness of the framework which made growth accounting a powerful tool to begin the study of the economic growth process.

Growth accounting complements the aggregate production approach stated above by introducing the possibility of heterogeneity of the basic inputs, capital and labor, and by defining some possible determinants of A(t) in an ad-hoc manner. It also introduces the structural adjustment contribution to TFP growth stemming from sectoral redistribution. These extensions, according to Harberger (1990), already cover the main determinants of TFP growth and the remaining task is mainly empirical.

Increasing returns were introduced in order to deal with some of the previous criticisms to the neoclassical growth model. Under some interpretations (Romer, 1989b) increasing returns will compensate the presence of fixed factors. Increasing returns appears as an outcome of the division of labor that responds to market size increase. This division of labor could well be termed human capital specialization (Schultz, 1987). Within the frame of the foregoing interpretation the increasing returns approach to the aggregate growth model looks similar to the human capital heterogeneity approach (Lucas, 1988) which also places final emphasis on human capital specialization as the source of increasing returns.

The quality component of the labor input that derives from the growth accounting methodology, which captures the effects of changes in the labor force composition, does not encompass the effect of human capital specialization. Then, human capital plays two roles in economic growth. The first, through an increase

in the level of education of the labor force and, the second, through the human capital specialization effect (division of labor).

In keeping with this line of interpretation of the mechanism of the increasing returns effect on economic growth, there could be different alternatives to quantify its role in the past TFP growth. There are those who follow the measurement of the source of the market size increase, such as foreign trade, whereas others directly use the GDP increase itself as a measure of the market size increase (Maddison, 1987). A direct measurement of human capital specialization, for which more detailed information of the labor force would be needed, could still be another possibility.

Jorgenson (1990), in performing a detailed study of sources of growth for the U.S.A. (period 1948-1985), supports the idea that the reallocation of capital and labor resources is one of the major factor that explains net TFP growth (TFP growth net of capital and labor quality changes). He further reinforces this idea as an explanation of the productivity slowdown phenomena produced since 1973. The measurement of this effect is carried out by using the traditional growth accounting methodology for inputs heterogeneity. This resource reallocation effect is very variable across countries, and the U.S.A. could well be a very particular case.

Jorgenson (1990) and Harberger (1990) emphasize the importance of studying not only long run growth, but also GDP growth behavior for short subperiods (Jorgenson studies subperiods defined from peak to peak business cycle stages), for which the aggregate production and the smooth technological functions do not seem to be very appropriate. A careful observation of different subperiods might make it possible to perceive how the technological phenomena takes place. According to the U.S.A. experience the TFP growth is very different across industries, and it also changes differently across time for the different industries. In some subperiods the TFP growth contribution to GDP growth is concentrated in a small number of industries. Jorgenson and Harberger's are very helpful when it comes to considering the disequilibrium approach to the analysis of technological change (Schultz, 1987).

Romer (1989 a) and Harberger (1990) suggest that most of the TFP growth for developing countries and for some developed ones is catch-up growth and in no case any new technology. The catch-up effect depends primarily on the productivity gap between these countries and the country with the higher productivity level, and on the mechanisms available to derive the benefit of the existing higher technology. Abramovitz (1988) suggests the importance of institutional barriers in this mechanism. As this gap is defined across countries, foreign trade should become an important mechanism to reduce it. Again here, as in the case of the increasing returns effect due to the division of labor, human capital specialization should also play an important role in what respects taking advantages of the existence of this gap.

TABLE 5

Growth contribution of education, quality of labor, foreign trade, scale economies, and catch-up effects for some developed economies in subperiods 1913-1950, 1950-1973, and 1973-1984.

Countries and subperiods	Education	Foreign Trade	Scale	Catch-up
France				
1913-1950	0.36	0.01	0.03	0.00
1950-1973	0.36	0.19	0.15	0.52
1973-1984	0.60	0.06	0.07	0.49
Germany Fed. Rep.				
1913-1950	0.25	-0.04	0.04	0.00
1950-1973	0.20	0.21	0.18	0.68
1973-1984	0.10	0.06	0.05	0.40
Japan				
1913-1950	0.60	0.02	0.07	0.00
1950-1973	0.52	0.26	0.28	1.02
1973-1984	0.44	0.05	0.11	0.44
The Netherlands				
1913-1950	0.27	0.05	0.07	0.00
1950-1973	0.43	0.65	0.14	0.38
1973-1984	0.55	0.12	0.05	0.19
United Kingdom				
1913-1950	0.33	0.00	0.04	0.00
1950-1973	0.20	0.16	0.09	0.14
1973-1984	0.32	0.06	0.03	0.29
United States				
1913-1950	0.41	0.01	0.08	0.00
1950-1973	0.41	0.05	0.11	0.00
1973-1984	0.54	0.02	0.07	0.00

Sources: Angus Maddison (1987)

In Maddison's study (1987) for six developed countries for the periods 1913-1950, 1950-1973, and 1973-1984, estimates are provided for growth contribution of education quality of labor, foreign trade, scale economies, and catch-up phenomena and are presented here in Table 5. The growth contribution of the

education quality of labor does not present big changes over time and across countries. The other three TFP growth sources are very unstable over time and across countries. Part of this phenomena could be due to Maddison's approach in measuring the growth contribution of these last three effects.

In this section, there follows an analysis of the suggested modifications to the neoclassical economic growth model and by virtue of which it is feasible to resort to the different possibilities as determinants of the TFP growth behavior. These determinants were defined also in a way such that it is easy to see their links with both economic policy and the quantification of its effects.

In order to evaluate the importance of each determinant on the behavior of the TFP growth, it is possible to estimate a multiple regression model such as the following one:

TFP growth = a_0 + a_1 Foreign trade + a_2 Initial educational level +
a_3 Catch-up + a_4 Human capital specialization +
a_5 Agricultural labor force share + Stochastic Term

where: TFP growth = the growth accounting residual (average for period 1950-1987).

Foreign trade = [(average annual rate of growth of export + average annual rate of growth of imports)/2] times the average share of exports and imports on the GDP, (period 1950-1987).

Catch-up = the ratio of GDP per capita of country i to the GDP per capita of US at 1950.

Human capital specialization = Change between 1985 and 1960 of the proportion of the people attending the tertiary level of education with respect to the total population in the tertiary school age.

Agricultural labor force share = Proportion of the labor force in the agricultural sector in 1960.

The TFP growth represents the average annual rate of change of total factor productivity in the period 1950-1987, an estimation already presented in Table 1 for 96 countries. The variables explaining it were estimated according to the definition reviewed above.

The data used to estimate the model is of the cross-section type, using the information of 96 countries for the period 1950-1987. As some of the growth effect hypothesis could depend on some other special characteristics of each country, additional qualitative variables will be used in order to explore their relevance. Apart from these problems, some additional econometric difficulties

could possibly arise due to the presence of heterokedasticity and spatial autocorrelation in the stochastic term.

According to the definition of the determinants of TFP growth, a positive sign should be expected for all parameters excepting a_3 (catch-up). The bigger the gap (the smaller the value of this variable), the bigger the TFP growth to be expected.

The model added a variable which has not been discussed thus far. This is the agricultural labor force share at the beginning of the period. This variable tries to capture the suggestion of Mellor (1987) by emphasizing the importance of agriculture in promoting economic growth. He expected a rapid response in middle income countries and a milder response in low income per capita countries. The way the variable is defined considers the possibility of displacing labor resources from agriculture to other expanding sectors and which are more labor intensive.

The regression model could be a very useful approach to organize all relevant information and to develop the connections between sources of growth and the design of economic policies. The other approach to be discussed in the next section resorts to the case method (Schultz, 1987) relying more on statistical discrimination methodology.

The OLS (ordinary least squares) estimate of the multiple regression model without using dummy variables to capture special characteristics of groups of countries (growth level, continent, others), gave the following result:

a_0 (constant)	0.939	
a_1 (foreign trade)	0.132	(t-test = 1.38)
a_2 (initial educational level	0.002	(t-test = 2.71)
a_3 (catch-up)	0.023	(t-test = -4.87)
a_4 (human capital specialization	0.009	(t-test = 0.45)
a_5 (agricultural labor force share)	- 0.011	(t-test = -1.40)
R squared	0.321	
no. of observations	96	

By introducing three dummy variables for low income per capita, lower medium income per capita, and upper medium income per capita (according to the WDR 1989 classification), and only for the constant term, the following OLS estimates of the multiple regression model are arrived at:

a_0 (constant)	2.260	(t-test = 2.66)
a_1 (foreign trade)	-0.002	(t-test = -0.03)
a_2 (initial educational level)	0.010	(t-test = 1.63)
a_3 (catch-up)	-0.025	(t-test = -5.60)
a_4 (human capital specialization)	-0.008	(t-test = -0.47)
a_5 (agricultural labor force share)	0.014	(t-test = 1.46)
a_6 (dummy for low income countries)	-3.25	(t-test = -4.63)
a_6 (dummy for lower medium income countries)	-2.04	(t-test = -4.02)
a_7 (dummy for upper medium income countries)	-1.30	(t-test = -2.78)
R squared	0.457	
no. of observations	96	

In the regression without dummy variables, foreign trade displays positive statistically significative coefficients with a value of 0.10, similar to those used by Maddison (1987) in his estimate for sources of growth for developed economies. By including dummy variables, the foreign trade effect disappears.

The initial educational level has a positive effect, as expected by some economists (Romer and Rebelo), though its statistical significance is not very high. Its effect is almost similar in the regressions either with or without dummy variables.

The catch-up variable has the expected negative sign and is statistically very significant in both regressions. Its contribution to TFP growth is far below the values used by Maddison (1987), which are almost five times greater than the one obtained here.

The variable used to capture the effect of human capital specialization is not statistically significant in both regressions. The role of agriculture in TFP growth, represented by the agricultural labor force share at 1960, seems to be weakly relevant with a positive effect in the second regression only.

In order to arrive at greater confidence in the results presented above it becomes necessary to explore other definitions for the variables proposed in the

regression model. In this respect it will become necessary to combine time series studies for few countries where the basic information could allow for a better model specification. The model and results presented in this section should be greatly useful to further explore in this direction.

7. THE CASE STUDY APPROACH

Schultz (1987) in attempting to come up with an answer to the question on whether it is "possible for small nations to attain high level of per capita income via trade and specialization, with the gains to be had from increasing returns made possible by specialized human capital"(Schultz, 1987, page 13), resorts to the case method. He compares the cases of Singapore and Jamaica for the period 1970-1982. These countries had the following in common: population, female life expectancy, and external debt. They differed, however, in area, population density, exports, imports, economic growth rate, and per capita GNP.

With this approach, Schultz opens a probably fruitful method to identify the main forces of growth. Statistics provides the discrimination analysis which is in al likelihood the most appropriate methodology in applying this approach to a larger number of cases.

In this section, the number of cases useful to identify the variables that discriminate fast and slow growers will only be extended somewhat.

Table 6 presents some characteristics of slow growing countries (less than 3 percent annual growth in the GDP) and fast growing ones (more than 6 percent annual growth in the GDP):

Table 6 discloses that two variables, TFP growth and Trade Volume per capita, discriminate reasonably well between slow and fast growing countries. By comparing the United Kingdom (slow grower) with Japan (fast grower) the Trade Volume per capita seems not to do well in terms of discriminating between them. In this case differences in the rate of growth in the Trade Volume appears to be more relevant.

In the multiple regression model presented in the previous section foreign trade lost its relevance when the dummy variables were incorporated in the regression. In Table 6 foreign trade seems to be very meaningful in explaining the great differences in growth performance shown by many countries. The definitions given to foreign trade were different in the two approaches. This comparison suggests the need to further analyze the more appropriate way of dealing with this source of economic growth in order to quantify its relevance.

TABLE 6

CHARACTERIZATION OF SLOW AND FAST GROWING COUNTRIES IN THE PERIOD 1950-1987

Countries	Population (millions persons)	Area (1000 squares km.)	Population density (persons per square km.)	Trade vol. per capita (1987 US dollars per capita)	TFP growth
			SLOW GROWERS		
Zaire	5.3	2345	2.3	301	-0.76
Madagascar	10.9	587	18.6	28	0.07
Burundi	5.0	28	178.6	17	-0.98
Niger	6.8	1267	5.4	53	-0.98
Haiti	6.1	28	271.9	43	-1.77
Mauritania	1.9	1031	1.8	225	-1.85
Bolivia	6.7	1099	6.1	84	0.25
Chile	12.5	757	16.5	407	0.94
Uruguay	3.0	176	17.0	397	0.89
Argentina	31.1	2767	11.2	205	1.07
United Kingdom	56.9	245	232.2	2305	1.40
			FAST GROWERS		
China	1068.5	9561	111.8	37	0.96
Thailand	53.6	514	104.3	218	1.43
Botswana	1.1	582	1.9		2.02
Turkey	52.6	781	67.3	194	1.88
Syria	11.2	185	60.5	121	1.27
Brazil	141.4	8512	16.6	185	2.04
Korea	42.1	98	429.6	1120	2.85
Israel	4.4	21	209.5	1926	3.72
Singapore	2.6	1	2600.0	10997	1.81
Hong Kong	5.6	1	5600.0	8656	3.18
Japan	122.1	378	323.0	1876	3.64

Sources: Table 1 and World Bank (1989b).
Notes: Col (1) to (4) refers to year 1987. Col (5) is an average for the period 1950-1987

8. SOURCE OF TFP GROWTH LINKS TO ECONOMIC POLICIES

The results presented in this paper show the importance of TFP as a source of economic growth and its role in accounting for different growth performances across countries. The relevance of TFP on economic growth, though not homogeneous across countries, is generally important.

The TFP growth involves not only world technological growth, but also improvement in efficiency and catch-up growth. The multiple regression results show that this is so. This TFP growth composition offers enough room for economic policies implementation once the link between them becomes identified.

The discussion of the determinants of TFP growth and the multiple regression model should become very useful in identifying and quantifying these links. The determinants used in this model are connected with economic policies related to: foreign trade, general education, agricultural sector, human capital specialization, and improved technological implementation. Domestic structural adjustment reflected mainly in domestic resources reallocation also plays an important role.

The results obtained in this paper are only an average quantification across countries of the importance of each link of TFP growth. A further study of the interaction effects between these variables and the level of development for each country will make a link quantification possible for groups of countries.

The variables mentioned above that are likely targets for economic policies explain almost 40 percent of the TFP growth variability across countries. Due to the high variability in TFP growth, this degree of explanation could well be deemed as very reasonable.

Technological adoption (catch-up phenomena) is seemingly the most important source of TFP growth. Though the model was helpful only to quantify its importance, it did not make it possible to identify its mechanism. The statistically non-significance of the foreign trade and human capital specialization could be mainly due to the econometric dominant effect of the productivity gap. In Madison's accounts (1987) the catch-up effect explained more than 50 percent of TFP growth in the period 1950-1984. In my regression model it was only 10 percent. Madison's results are only for six developed economies and this could explain part of the difference detected.

Technological improvement in the agricultural sector seems to have some impact on TFP growth. Its relevance appears to depend on country development level. The multiple regression results show that this effect is much less than the one brought on by the catch-up. In terms of future perspective it could conceivably be expected that the catch-up effect will decline while the role of agriculture could either persist or increase.

From other studies it is clearly perceived that domestic factor mobility plays an important role in explaining TFP and GDP growth. For the period 1950-1987 the coefficient of variation of the income per capita across states in the U.S.A. decreased from 20 to 16 percent, whereas across countries it remained at the very high level of 140 percent. For the period 1961-1984 in the O.E.C.D. countries there was a very high tendency to factor price equalization due to factor mobility (reflected through the tendency to equalization of relative factor endowments).

The coefficient of variation decreased much more for developed countries than for developing ones. This fact could reflect that the initial value of some growth determinants, such as, for instance, educational level of attainment are important.

An interesting phenomena also observed in developed economies is the positive interaction of international factor mobility with domestic factor mobility. This is another way in which trade policy affects the development of the economy.

A more complete analysis of the human capital specialization hypothesis requires a more detailed empirical research. In recent studies in the U.S.A. (Mincer, 1988, and Jorgenson and Fraumeni, 1987) there are some indications of an increase in human capital specialization. Mincer shows a decrease in the proportion of total expenditures on job training with respect to expenditures on formal education, and Jorgenson and Fraumeni show a higher increase in the cost per student at the college level with respect to high and primary levels. From their study it is also possible to derive implicit estimates of a value of 0.09 for the increasing return to scale obtained through this input.

A comparative study such as the one carried out in this paper offers problems concerning the period chosen to make the comparison across countries. An interesting alternative to the common period is to choose periods with similar growth phases. This approach would enable us to either eliminate irrelevant variables or to maintain some characteristics constant, thus allowing for a better identification of the effects of the main variables. This approach involves a problem in that it requires a longer period of information not as yet available, except for some countries and economic sectors.

This approach could be complemented with the case method, which, in part, was presented in this paper. The results obtained with this approach support the role of the TFP foreign trade through the trade volume indicator. Other studies suggest the role of the foreign debt situation, but this seems to be more a reflection of slow growth rather than a cause of it.

Many important topics were not considered here. One of them would be the role of the public sector through its expenditures and actions. It was in part investigated by Barro (1989), who observed a negative effect of aggregate public consumption expenditures on economic growth. The role of the composition of

public expenditures should be explored in greater detail in order to have a clearer picture of the role of this sector.

I hope we have gained a further understanding of the economic growth process and the links of TFP growth with economic policies. Much additional research is needed to arrive at a better identification and quantification of the effects of the determinants of TFP growth. I hope this paper has contributed to shed more light on the problem from an empirical perspective.

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