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SOURCES OF GROWTH IN THE GREEK ECONOMY 1951-1961

by

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SOURCES OF GROWTH IN THE GREEK ECONOMY, 1951-1961

1. Introduction

The Greek economy has experienced rapid growth over the past decade and a half. Gross domestic product (constant prices) grew at 6 per cent per annum over the period 1951-1961, a rate higher than all but a few of the countries for which we have data, and one which is particularly striking when expressed in per capita terms due to the low rate of population increase.

The purpose of this paper is to identify the major sources of this rapid growth, and in particular to investigate the growth effects of changes in the size composition of the employed labor force. Section 2 is a discussion of the underlying conceptual scheme. An outline of recent Greek growth is presented in Section 3. The basic data on factor shares and marginal productivities are presented in Section 4. Section 5 contains estimates of the contribution to growth of capital, embodied technological change, labor, economies of scale, and changes in the education and sex composition of the labor force. In Section 6 I will offer a number of possible interpretations of the observed pattern of growth.

One embarks on a study of this type with a few firmly (if recently) established preconceptions. The first, based on the work of Denison [4], Solow [8], Abramovitz [1], Kendrick [6], and others for the United States, Harberger for Chile [5] and the UN Economic Commission for Europe for various European economies [9] is that we expect a small contribution of capital to growth.[1/] The second, based on the work of Denison, Schultz and Harberger [5] as well as estimates of rates of return on educational expenditures in poor countries is that the contribution of the improved educational level of the labor force

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1/ By "small" I mean less than a third of the measured growth. However see Michael Bruno's study [3], which suggests a considerably larger capital contribution.

should be quite considerable; Denison estimates this phenomenon to account for 23 per cent of the United States growth rate over the period 1929-57 while Harberger has produced a figure of 15 per cent for the period 1941-62 in Chile.[2/] Finally, we expect to find that a large portion (often more than half) of the growth observed is unexplained by the inputs of capital and labor as conventionally measured.

The provisional results for Greece do not fall into this general pattern. The growth contribution of changes in the educational composition of the employed labor force is virtually zero. The contribution of the increase in the capital stock even on conservative assumptions is considerably higher than that found in similar studies of other countries. The unexplained sources of growth amount to less than 20 per cent of the measured change in output.

It should be stressed at the beginning that given the conceptual tools and the data used in this study the quantitative results should be treated with the greatest skepticism. Nonetheless, it is hoped that with the aid of the sensitivity analysis in Appendix 3 some plausible ranges of estimates can be developed to provide the rough outline of an explanation of Greek growth over the 1950's.

2. The Basic Model

We begin by describing the aggregate production process by the following function:

2.1 $Y = f(K, L, \ldots)$

where Y = gross domestic product,

K = a measure of the input of capital including land,

L = number of persons employed.

2/ However, a paper presented at the S.S.R.C. conference on Postwar Growth at Saltsjöbaden, Sweden (July 1965) by K. Ohkawa and H. Rosovsky, using a similar conceptual scheme, suggests surprisingly, a small contribution of education to Japanese growth in the post World War II period.

As we are concerned with the change in GDP over time we can write:

2.2 $dY = dK\,(MP_k) + dL(MP_L) + r$

or

2.3 $\frac{dY}{Y} = \frac{dK}{Y} MP_k + \frac{dL}{L} \left(\frac{LMP_L}{Y}\right) + \frac{r}{Y}$

where r is the combined growth contribution of inputs not explicitly taken account of in the measures of capital and labor used, and MP_k and MP_L represent the social marginal products of capital and labor, respectively.[3/] The term $\frac{LMP_L}{Y}$ is an estimate of the elasticity of output with respect to the labor input, or the percentage change in Y associated with a given percentage change in L.

In order to use expression 2.3 for the analysis of growth involving large values of dL or dK we must make some special assumptions about the shape of the aggregate production function, namely, that the elasticity of output with respect to both capital and labor remains constant over the range of variations being considered.[4/]

We can now define the following sources of growth. Let $\frac{LMP_L}{Y} \equiv W$:

a) The contribution of capital, $G^K = \frac{dK}{Y} \circ MP_k$

b) The contribution of labor, $G^L = \frac{dL}{L} W$

c) The unexplained residual, $R = \frac{r}{y}$

Equation 2.3 and the definitions above represent the basic model used here.

We turn now to the contribution of education to growth. There is apparently no agreed upon method for the estimation of the growth contribution of education. The methods used by Schultz, Denison, Harberger and others differ, in some cases

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3/ We adopt the somewhat unfamiliar form of the growth equation presented in 2.3, as it does not directly require a measure of the aggregate capital stock.

4/ The implied estimate of the growth elasticity of capital is $\frac{MP_k K}{Y}$. The first term in the right hand side of 2.3 can be written $\frac{KMP_k}{Y} \circ \frac{dK}{K}$.

in major ways.[5/] Schultz and Harberger use the estimate of the internal rate of return on educational expenditures as the basis of their estimates, while Denison develops an index of the quality of the labor force as affected by education. The method used below is most similar to that adopted by Denison.[6/]

In this model education contributes to growth only by being embodied in workers; it is thus different from the Schultz approach in which education can be thought of as a factor of production in its own right and the education contribution and the labor force contribution are formally separate. It also directs attention away from the possibly important areas in which education contributes directly to growth without embodiment in the worker, for example, in the production of economically useful knowledge as a by-product of an educational process.

The method used here can be outlined as follows. We introduce a new measure of the labor input which will reflect the change in quality as well as the quantity of the persons employed. Let

$$2.4 \quad L^e = \sum_{j=o}^{n} L_j \frac{MP_{Lj}}{MP_{Lo}}$$

where L_j = the number of persons employed with educational qualifications j, and

MP_{Lj} = the social marginal productivity of labor with qualifications j.

MP_{Lo} = the social marginal productivity of labor in some arbitrarily chosen educational group, o.

n = the number of educational categories used.

L^e is thus an index of labor input which takes into account the educational composition of employment.

5/ For a discussion of the methods of Schultz and Denison, see Mary Jean Bowman [2].

6/ However, I have sought to distinguish between the contribution of increases in the educational level of the labor force and the total contribution of education. Moreover, as I point out below, the opportunity costs of education are included in my estimate of the total education contribution. There are a number of alternative approaches which were not used here (nor by the above authors) but which I find difficulty in excluding on any persuasive theoretical grounds.

Using this new definition of the labor input in equation 2.3 we get:

$$2.5 \quad \frac{dY}{Y} = \frac{dK}{Y} \cdot MP_K + \frac{dL^e}{L^e} \cdot W + \frac{r}{Y}$$

We will call the second term on the right G^{LQ}, or the contribution to growth of increases in the input of labor, having taken into account the changes in both the quantity and the quality of the labor force. The difference between this estimate and that derived from equation 2.3 is G^e, the contribution of the changes in the level of education in the labor force, namely,

$$2.6 \quad G^e = \frac{dL^e}{L^e} W - \frac{dL}{L} \cdot W = G^{LQ} - G^L$$

The estimate of the contribution of capital is unchanged, while $\frac{r}{y}$, the unexplained residual, will fall in the likely case of a positive contribution of changes in the education of the labor force.

G^e may differ considerably from the total contribution of education to growth, as a major portion of educational expenditures are ordinarily required to equip new workers with a level of education equal to the average, and thus to maintain a constant educational composition of the labor force. In order to estimate the total contribution of education, we must therefore construct an estimate of the change in the labor input index, L^e, which would have occurred had no education been undertaken during the period in question. Let this estimated hypothetical change in the labor input assuming no education be $dL^{e'}$

We now have the following estimates for the total contribution of education, $G^{e'}$.

$$2.7 \quad G^{e'} = \frac{dL^e - dL^{e'}}{L^e} W$$

$G^{e'}$ is that part of the change in the labor input index which is attributable to education, multiplied by the elasticity of output with respect to the labor input.

It can be defined as the gross contribution of education to growth.

The pure contribution of the increase in the numbers employed, $G^{L'}$, is

$$2.8 \quad G^{L'} = G^{LQ} - G^{e'} = \left[\frac{dL^e}{L^e} - \frac{dL^e - dL^{e'}}{L^e}\right] W$$

or

$$2.8 \quad G^{L'} = \frac{dL^{e'}}{L^{e'}} W$$

$G^{L'}$ is thus the rate of change of the education weighted labor input index under the assumption of no education during the period in question, multiplied by a term representing the elasticity of output with respect to the input of labor.

One remaining adjustment is required before we arrive at an estimate of the net effect of education on growth. This is the inclusion of an estimate of the opportunity cost of the resources used in education. It should be pointed out that in estimating the hypothetical 'no education' labor force for the terminal year, we have taken account of the opportunity cost of using students' time in the educational process. There are two counteracting effects which might cause the rate of growth of the education weighted labor index L^e to diverge from the otherwise similar index, assuming no education $L^{e'}$. The negative effect of a fall in the average educational qualifications of the labor force would serve to depress $L^{e'}$ below L^e while the positive effect of a rise in the quantity of labor available due to the release of students from schools to the labor force would yield the opposite effect.[7/]

7/ The quantity of the labor force could conceivably fall if the educational system was not growing, so that the injection into the labor force of students who could otherwise be continuing their education was equally large in both the base and the terminal year. Also if participation rates for the better educated are higher than for the less well educated, the 'no education' assumption could yield a lower rate of increase in the quantity of employment.

However, we have not yet considered the opportunity cost of devoting resources to education, some part of which would have otherwise been invested.[8/] Thus to arrive at the net contribution of education we must subtract from the gross contribution the marginal productivity of these funds in their most likely alternative use.[9/]

We may now extend the analysis to consider the growth effects of changes in the sex composition of the labor force. The effect of changes in the sex composition of the employed labor force, G^s, is

$$2.9 \quad G^s = W \left(\frac{dL^s}{L^s} - \frac{dL}{L} \right)$$

where $L^s = L_{male} + L_{female} \frac{MP_{Lfemale}}{MP_{Lmale}}$.

Were adequate data available, we could use the same method to estimate the effects of changes in the age composition of the labor force.

8/ In the no education exercise I have not adjusted the national income accounts to conform to the assumption that no education was produced. Thus I am considering here not the level of GDP directly related to the change, but only that indirectly related through productive investment.

9/ One might suggest that we consider the productivity in the next best use, but this procedure would attribute an opportunity cost to education far in excess of foregone opportunities which had any chance of being realized in the given situation.

3. Some Characteristics of Greek Growth, 1951-1961

The good comparative performance of the Greek economy in terms of GNP growth is indicated by the data in Table 3.1, containing rates of growth for Greece along with the European and North American economies of the OECD. The internal structure of Greek growth as illustrated by the sectoral rates of growth in Table 3.2 suggests the following pattern: by international standards a comparatively high rate of growth in agriculture and a somewhat low rate of growth in manufacturing. The levels of gross and net domestic capital formation in Table 3.3 appear very high, gross domestic capital formation reaching about a third of GDP at the end of the period. The composition of gross investment as shown in Table 3.4 is characterized by a high proportion of investment in housing and a relatively low porportion in manufacturing. Table 3.5 presents some estimates of incremental capital output ratios, which when considered in conjunction with the slow rate of growth of the labor force suggest a fairly high productivity of capital, at least in some sectors.

Estimates of the changes in the structure of the employment classified by sex and education appear in Table 3.6. The underlying estimates of the employed labor force by sex and level of education appear in Appendix 1.[10/]

10/ The estimates of employment in 1951 are based on the 1961 census definitions, and for this reason differ from those contained in the 1951 census. The main differences between the estimates in Appendix 1 and the 1951 census results are that those in military service are excluded from the employed category here and a larger number of female workers, particularly in agriculture, have been counted as employed.

TABLE 3.1

GROWTH RATES OF GDP FOR SELECTED COUNTRIES,[a] 1951-1961

	Growth Rate*
Austria	5.5
Denmark	3.5
Germany	7.5
GREECE	6.1
Iceland	4.9
Italy	6.1
Netherlands	4.6
Norway	3.8
Portugal	4.7
United Kingdom	2.4
United States	3.2

[a] Similar data for the remaining OECD countries were not available.

* Calculated at constant (1954) prices

Source: OECD, Statistics of National Accounts, 1951-61.

TABLE 3.2

RATES OF GROWTH OF GDP BY SECTOR IN THE GREEK ECONOMY, 1951-61

	Rate of Growth*
Agriculture, Forestry, Fishing	4.8
Mining	11.3
Manufacturing	7.3
Construction	13.5
Electricity, Gas, and Water	12.1
Transportation and Communication	5.4
Wholesale and Retail Trade	5.6
Banking, Insurance, Real Estate	6.6
Ownership of Dwellings	9.6
Public Administration, Defense	1.1
Health and Education	4.1
Miscellaneous	5.2

* Calculated at constant (1954) prices

Source: OECD, Statistics of National Accounts, 1951-61, p. 107, Table 2B.

TABLE 3.3

Gross Domestic Product and Gross and Net Domestic Capital Formation, 1951-61

At constant 1954 prices in million Drs.

	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1) Gross Domestic Product	44028	43691	49902	51611	55453	58470	63452	65473	68328	70543	79042
2) Gross Domestic Capital Formation	10161	7739	8751	8396	10083	12107	13450	16843	18160	24111	24169
3) Depreciation	2514	2596	2646	2788	2808	2948	4124	3451	3685	3966	4653
4) Net Investment	7647	5143	6105	5608	7275	9159	10326	13392	14475	20145	21516

Total Net Investment 1951-1961 = 120791 Million Drs. Total Gross Investment: 1951-61 = 155970 Million Drs.

Source: Row 1: Ministry of Coordination. National Accounts of Greece, Vol. 9, p. 72 and Vol. 14, p. 45

Row 2: " " " " " " " Vol. 9, p. 77 and Vol. 14, p. 45

Row 3: " " " " " " " Vol. 9, p. 72 and Vol. 14, p. 45

Row 4 minus Row 3

TABLE 3.4

COMPOSITION OF GROSS DOMESTIC CAPITAL FORMATION IN GREECE, 1951-1961

	Percentages of Annual Totals*					
	1951	1953	1955	1957	1959	1961
Agriculture, Forestry, Fishing	13.0	7.8	6.8	11.6	11.5	12.4
Mining	4.5	1.6	0.8	1.8	0.5	0.4
Manufacturing, Construction	18.8	13.0	10.2	13.6	8.4	6.6
Electricity, Gas, Water	13.4	12.0	9.8	6.5	6.9	4.8
Transportation & Communication	16.1	12.2	16.4	22.9	40.4	45.2
Dwellings	24.0	36.8	42.1	32.6	22.7	20.6
Public Administration	0.8	5.0	2.2	1.8	1.4	1.2
Other Service Industries	9.4	11.6	11.7	9.2	8.2	8.8
	100.0	100.0	100.0	100.0	100.0	100.0

* Calculated at constant (1954) prices

Source: OECD, Statistics of National Accounts, 1951-61, p. 107, Table 3B.

TABLE 3.5

ESTIMATES OF INCREMENTAL CAPITAL OUTPUT RATIOS FOR SELECTED COUNTRIES, 1959-1959

	Ratio
GREECE	3.0
Germany	3.3
Italy	3.7
Austria	3.9
Portugal	4.0
Yugoslavia	4.2
France	4.6
Netherlands	5.2
Denmark	5.5
United States	5.5
Belgium	5.6
Iceland	5.7
Canada	6.0
Luxembourg	6.2
Sweden	6.3
United Kingdom	6.7
Finland	7.2
Norway	9.5
Ireland	13.7

Source: Economic Commission for Europe, Some Factors in Economic Growth in Europe During the 1950's, II, p. 31, Table 16

TABLE 3.6

RELATIVE EMPLOYMENT,[a] 1951-61,
DISAGGREGATED BY AGE, SEX, EDUCATION

Age	Males	Females
10-14	.382	.504
15-19	.984	.868
20-24	.995	1.037
25-29	1.339	1.555
30-44	1.239	1.743
45-64	1.630	3.364
65 up	1.982	6.662

Education	Males	Females
0-5	.906	1.299
6-11	1.561	1.754
12-15	1.564	1.766
16 up	1.483	1.713

Sex	Males	Females
	1.240	1.461

Total: 1.30

[a] Entries in the table are the 1961 employment in the relevant category divided by the 1951 employment.

4. Marginal Productivity and Factor Remuneration

In order to implement the model presented in Section 2 we need a series of gross domestic product, a capital formation series, and a series on the magnitude and educational and sex composition of the employed labor force. This material has been presented above. Annual data on the labor force is not available, so we must confine our analysis to total changes in inputs and outputs taken over the ten year period 1951-61. In addition to this aggregate information we need an estimate of the social marginal productivity of capital, relative productivity weights for labor of various categories of education and sex, and an estimate of the elasticity of output with respect to labor.

The estimate of the marginal productivity of capital is based on cross-section estimates of production functions in Greek manufacturing. The method of calculation of the marginal productivity is discussed in Appendix 2. The best available data yields a rate of ten per cent.[11/]

11/ There are a number of grounds for believing that the estimate of .10 for the marginal product of capital may be on the low side. First, the estimate is a measure of the private marginal product to the firm, not the social marginal product. The non-market external effects (including learning by doing) are probably positive. Secondly, there may be a positive relation between the size of the establishment's capital stock and the average age of the capital stock, in which case the presence of embodied technological change introduces a downward bias in the cross section estimate of the marginal productivity of capital. Third, while the interest rate on savings deposits showed a secular decline, it stood at about 9 per cent at midperiod. Assuming a depreciation rate of only 2 per cent, and knowing that savings accounts were probably one of the least lucrative alternatives to investment, one finds difficulty in explaining the rapid rate of private investment unless the private marginal product of capital was considerably greater than 11 per cent.

Fourth, we have a substantial amount of circumstantial evidence (the high rate of growth and the low incremental capital output ratios, for example) which would lead us, or at least me, to expect a higher social marginal product of capital. Fifth, the fact that manufacturing received a small and declining share of private investment during this period suggests that the marginal products derived from manufacturing production functions may underestimate the private marginal products elsewhere in the economy.

We desire an estimate of the marginal product of capital which will measure the effect of a change in the capital stock on GDP as conventionally measured. We thus must not only include the effect of investment on output directly, but its additional effect on the size of the depreciation term in the national income accounts. Throughout the period depreciation was around 5.5 per cent of GDP or, (assuming an aggregate capital output ratio of 2.5), 2.2 per cent of the capital stock. We must thus add approximately 2 per cent to the marginal product of capital, yielding an estimate of .12. This figure amounts to little more than a deviously arrived-at guess. Alternative rates of .10 and .15 are used in parts of the analysis below. Advocates of using a higher figure should note that using the wage share of .79 as an estimate of elasticity of output with respect to labor and assuming that the aggregate production function is characterized by constant returns to scale, a social marginal productivity of capital of .15 implies that the aggregate capital output ratio is 1.4, which seems somewhat low.[12/]

Using the assumption that the wage represents the marginal productivity of the worker we have used the wage share of GDP, wL/Y, as an estimate of the elasticity of output with respect to labor.

The data underlying the estimate of the wage share is in Table 4.1. Contributions by employers to social insurance are included in the estimate of wages and salaries on the grounds that they are considered by employers to be part of the wage. In this case the relevant price of labor parameter for the employer is the wage plus the required contribution to social insurance.

[12/] If $.15K = (1 - .79)Y$, then $K/Y = 1.4$. The implied K/Y ratio for a SMP_k of .10 is 2.1. Alternatively if the aggregate production function is of the form:

$$Y = AK^aL^b \text{ and } a + b \neq 1$$

then if $SMP_k = .15\,b = .79$ and $K/Y = 2$, $a + b = 1.09$.

TABLE 4.1

THE WAGE SHARE, 1961

		Figures in Current Million drs.
1)	G.D.P.[a]	93,411
2)	Wages and Salaries of Workers Outside of Agriculture[a]	34,908
3)	Wages and Salaries imputed to	
	a) Agricultural Labor[b]	17,669
	b) Self-Employed[c]	21,615
4)	Total Actual and Imputed Wages (2+3a+3b)	74,192
5)	The Wage Share $\frac{(4)}{(1)}$	.79

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[a] Ministry of Co-ordination, National Accounts of Greece, Vol. 14, p. 45

[b] The labor remuneration in agriculture is based on data for labor earnings in agriculture in 1960 and the assumption that the labor share agriculture in 1961 was the same as in 1960, namely .62. I am grateful to Dr. Anna Kokkova for supplying data on labor earnings in agriculture in 1960.

[c] The estimate of the remuneration of the self-employed is based on the number of self-employed in 1961 and 1958 data on relative earnings of the self-employed vis a vis wage and salary earners. Cf. S. Geronimakis, [14], Table 5, p. 12.

There is some evidence that the resulting wage share at .79 represents an underestimate of the elasticity of output with respect to labor. Anna Kokkova has found that wages are below the estimate of the marginal productivity of labor in all of 25 manufacturing sectors for which she estimated production functions.[13/] Two complementary explanations for this apparent divergence between the marginal productivity of labor and the wage can be offered. First, given a considerable extent of imperfect competition in both product and factor markets in Greece, we would expect the wage to ~~exceed~~ fall short of the value of the marginal product as long as employers seek to maximize profits. Second, average labor productivity has risen very rapidly over the period. Given the considerable amount of unemployment in some labor categories throughout the period we would expect that despite upward pressure, wages would not rise as rapidly as marginal productivities.[14/]

The relative productivity weights for labor by sex and educational level appear in Table 4.2. These weights are based on an earnings survey for the year 1960 of over 1,000 workers in private establishments in the Athens area.[15/] The general pattern conveyed by Table 4.2 is as expected. Male earnings are higher

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13/ A. Kokkova, [15], pp. 217 and 222.
Contributions to social insurance and some of the imputed wages were not included in her definition of the wage. However, for the industries under consideration, the magnitude of these omissions is far too small to account for the divergence mentioned above.

14/ The depressing effect of surplus labor on the wage may have been instrumental in insuring a high rate of profit and rapid capital accumulation over the period.
There is a third possible explanation of the divergence between the wage and the marginal productivity of labor, namely, that the quality of the labor force in terms of years of education, or skill level, is positively correlated with the size of establishment as measured by number of workers employed. In this case cross section estimates of the marginal product of labor will be upward biased.
Although there thus seems little ground for suspecting that the wage share overestimates the elasticity of output with respect to labor, I have used alternative estimates both above and below .79 in Appendix 3.

15/ This survey was directed by Harvey Leibenstein and was carried out by Mrs. Aik. Kalergi and the statistical staff of the Center of Planning and Economic Research in Athens. I am indebted to Professor Leibenstein for allowing me to use this data.

TABLE 4.2

RELATIVE EARNINGS WEIGHTS

Years of Education	Males A	Males B	Females A	Females B
0-5	.9127	.9674	1.1789	1.1079
6-11	1.0000	1.0000	1.0000	1.0000
12-15	1.2979	1.2028	1.4014	1.2408
16 up	2.1572	1.7410	3.0995	2.2597
Total Weights	1.0		.5648	
Male-Female				

than female, and earnings are positively correlated with years of education.[16/]

In view of the fact that attributes positively correlated with higher earnings (e.g., intelligence, energy, social class background) are also positively correlated with the likelihood of one's getting an education, we may suspect that the observed earnings differentials among labor classified by level of education are only partly attributable to educational differences. As an alternative to using the full earnings differentials we adopt the arbitrary assumption that 60 per cent of the differences in earnings are to be explained by differences in educational attainment and arrive at the two sets of weights in Table 4.2.[17/] We will refer to the weights based on the full earnings differentials as the A weights and the alternative weights based on the 60 per cent assumption as the B weights.

Even using the B weights we may still attribute too much to formal education if there is a positive relation between the years an individual has been in school and the amount of on-the-job training received.[18/] The higher earnings associated with additional years of education may be partly explained by the fact that a larger amount of resources is devoted to the on-the-job training of individuals with relatively more education.

16/ I have no plausible explanation for the lower female earnings in the group with 6-11 years of education compared to those with 0-5 years. Harvey Leibenstein is preparing a detailed study of returns to education in Greece on the basis of these and other data, and I have therefore not offered any comprehensive discussion of the relative earnings of labor with different educational qualifications. The absolute level of earnings in the Athens area is undoubtedly higher than the national average. However, we have no reason to suspect that the relative earnings are distorted. The observed earnings may represent an understatement of actual earnings of the group with the highest level of education because of various non-wage payments to this group and the greater ease with which they can understate their earnings. Any plausible correction to take account of this possibility will not significantly alter the results.

17/ The implications of using alternative assumptions are discussed in Appendix 3. Denison used the 60 per cent assumption in his study of U.S. growth. Recent work in the U.S. has suggested that his estimate was in the right general area. However, currently available studies for the U.S. on this question are far from conclusive. We have no comparable studies for Greece.

18/ On the basis of the U.S. data as reported in Mincer [10] we would expect this to be the case.

5. Sources of Growth in the Greek Economy

5.1 Capital and Labor

Table 5.1 presents estimates of the contribution of capital and labor as conventionally measured to Greek growth over the period 1951-61. In these calculations I have used a wage share of .79 and an estimated social marginal product of capital of .12. However, enough has been said about the basic data and the methods of estimation to suggest that the alternative estimates using .90 and .70 for the wage share and .10 and .15 for the productivity of capital are certainly worth consideration. The alternative estimates appear in Appendix 3.[19/]

The choice of a capital measure raises a number of problems. We seek a measure of the flow services of capital; yet we have at our disposal series of the gross additions to the capital stock and book depreciation. While the gross additions to capital stock are probably an overestimate of the change in capital services through the failure to account for physical depreciation, the net additions (gross investment minus book depreciation) surely must be an underestimate. The depreciation estimate takes account of the fall in the value of the capital stock due to aging, namely, the effect of the shorter life remaining, the presence of newer, more productive capital goods and the physical deterioration of the asset. For the purposes of this study we are interested only in the reduction in the flow of services of capital due to aging;[20/] use of the net capital formation series is thus inappropriate. In view of the rapid rate of gross (continued on next page)

19/ Calculations based on the joint use of a wage share of .90 and a marginal productivity of capital of .15 appear in the Appendix, but should be regarded with the utmost skepticism, as the implied aggregate capital output ratio assuming constant returns to scale is .67. The same warning applies to the joint use of .90 and .12 or .10 although with less force.

20/ We would like a measure of depreciation which accounted for the effects of physical deterioration and the less intensive use of old machines as newer machines become available. This latter effect is not the same as the effect of obsolescence on the market value of an asset.

investment over this period, we can expect that the average age of the capital stock was relatively young. For this reason I have used the gross domestic capital formation series in the estimates appearing in Table 5.1.[21/]

Two major conclusions are inspired by the data in Table 5.1. First, the contribution of capital appears to be very large, and second, the portion of the growth in GDP which cannot be explained by changes in the inputs of labor and capital as we conventionally measure them is relatively small.

5.2 The Growth Effect of Changes in the Employment Ratio and Emigration

We may decompose the contribution of labor into that part which is attributable to the change in population and that which is attributable to changes in the overall fraction of the total population employed, or the overall employment ratio. Thus we may say:

5.1 $dL = dL^P + dL^R$

and

5.2 $dL^P = dP \cdot R_{51}$

where dL = the change in the numbers employed, 1951-61;

dL^R = the portion of dL attributable to changes in the overall fraction of the total population which is employed;

R_{51} = total employment in 1951 divided by the total population in 1951, referred to here as the "employment ratio";

dP = population of 1961 minus the population of 1951.

Table 5.2.1 presents estimates of the contribution to growth of changes in the employment ratio and changes in the size of the total population. We observe here a very significant contribution by the change in the overall employment ratio, which stood at .346 in 1951 and had moved up to .411 by 1961.[22/]

21/ The capital contribution falls to .41 of the observed rate of growth when the net domestic capital formation series is used. Cf. Appendix 3.

22/ Because we estimated the 1951 employment figures on the basis of 1961 participation rates for each subcategory of labor by age, sex and kind of education, there may have been shifts in the actual employment ratio which we have not observed here. Changes in the overall rate are of course consistent with constant individual rates by age, sex, and education as the overall rates probably change primarily through changes in the age, sex, or educational composition of the labor force.

TABLE 5.1

THE GROWTH CONTRIBUTION OF CAPITAL AND LABOR

1.	Ten Year Growth Rate, $\frac{dY}{Y}$ a/	.7952
2.	Investment Output Ratio, $\frac{dK}{Y}$ b/	3.542
3.	Social Marginal Product of Capital, SMP_k	.12
4.	Contribution of Capital to Growth G_k, [2x3]	.4250
5.	$G_k/\frac{dY}{Y}$ [4/1]	.5345
6.	Growth Rate of Labor, $\frac{dL}{L}$ c/	.3029
7.	Wage Share, $\frac{W}{Y}$ d/	.79
8.	Contribution of Labor to Growth, G_L [6x7]	.2370
9.	$G_L/\frac{dY}{Y}$ [8/1]	.2980
10.	The Residual, R, [1-4-8]	.1332
11.	$R/\frac{dY}{Y}$	.1675

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a/ Source: Table 3.3

b/ Source: Table 3.3. The gross domestic capital formation series was used.

c/ Source: Table 3.6

d/ Source: Table 4.1

TABLE 5.2.1

THE CONTRIBUTION OF POPULATION GROWTH AND CHANGES IN THE FRACTION OF POPULATION EMPLOYED

1.	Change in Employment 1951-61	799,354
2.	Fraction of Total Population Employed 1951	.349
3.	Change in Population 1951-61[a/]	842,242
4.	The Wage Share	.79
5.	Rate of Change in Employment Due to Population Growth $\frac{(3 \times 2)}{L_{51}}$	.1072
6.	Rate of Change in Employed Due to Change in the Fraction of Total Population Employed $\frac{[1-(3 \times 2)]}{L_{51}}$	.1938
7.	The Growth Contribution of Population Growth, G_p (4x5)	.0847
8.	The Total Growth Contribution of Labor (from Table 5.1)	.2370
9.	The Growth Contribution of Change in the Fraction of Total Population Employed, G_R = (8-7)	.1523
10.	$G_p / \frac{dY}{Y}$, Growth Contribution of Population Growth, as a Fraction of Total Growth Rate	.1065
11.	$G_R / \frac{dY}{Y}$, Growth Contribution of Change in the Fraction of Total Population Employed, as a Fraction of the Total Growth Rate	.1915

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a/ National Statistical Service of Greece, Statistical Yearbook of Greece, Athens, 1966, p. 30.

In interpreting these figures one should keep in mind the fact that increased growth through increased population and increased growth through increased labor input per capita have rather different welfare implications.

In conjunction with the changes in the overall employment ratio a second factor had a major influence on changes in the supply of labor over this period; this was emigration. Without pretending to explore any but a small part of the question we may indicate one component of the growth effects of emigration, namely that which operates through the reduction in the employed labor force in Greece. We can identify this effect, G^{em} as:

$$G^{em} = W\left(\frac{dL-dL^{em}}{L}\right)$$

where dL^{em} is the increase in the labor force of 1961 over 1951 assuming that there had been no net emigration. If we assume that net immigration over the period amounted to 300,000, which is consistent with the avilable data,[23/] and if we further assume that .8 of these individuals would have been employed had they remained in Greece,[24/] we arrive at the estimate in Table 5.2.2.

23/ See X. Zolotas, [12] p. 34 and S. G. Triantis [11] p. 210.

24/ The assumption that 80 per cent would be employed may be too low, as the emigrants tend to be from age groups of the population with very high labor force participation rates. However, if the majority of this group emigrated from the agricultural sector our estimate of the total employment effects of emigration is probably too high. We have also made the implicit assumption here that the educational and sex composition of the group which emigrated is roughly similar to the group which constituted the net addition to the domestically employed labor force. Given the high portion of males among the emigrants during the period and the important role of overseas emigration by skilled and semi-professional workers, this assumption may result in an underestimate of the negative growth effects of emigration.

TABLE 5.2.2

A PARTIAL ESTIMATE OF THE GROWTH EFFECTS OF EMIGRATION

1.	Employed labor force, 1951	2,639,931
2.	Employed labor force, 1961	3,439,285
3.	a) Estimated net emigration, 1951-61	300,000
	b) Of which, those assumed to be employed in 1961 in the absence of emigration	240,000
4.	Rate of growth of employment (actual)	1.3031
5.	Rate of growth of employment assuming no emigration (2+3b)/(1)	1.3938
6.	The wage share	.79
7.	The partial growth contribution of emigration	-.0717
8.	C^{em} as fraction of $\frac{dY}{Y}$	-.0902

The large negative con.ribution of emigration to Greek growth must be viewed as a very partial estimate. First it excludes all of the possible positive effects, both short run and long run (such as emigrants' remittances and the eventual return of some of the workers with skills acquired abroad). Second, the use of an elasticity of output with respect to labor of less than one naturally implies that any reduction in the labor force is associated with an increase in output per worker. For this reason the welfare effects of emigration are particularly difficult to interpret.

While very little confidence can be placed in the precise numerical values of the results in Table 5.2.2, the magnitude of the estimate may indicate that even over the 1950's when annual emigration was less than one third of what it has been more recently, the net outflow of labor produced a significant retarding effect on Greek growth. Further work is needed both in refining the above estimates and in investigating to what extent the positive effects of emigration offset this negative effect.

5.3 The Growth Effects of Changes in the Sex and Educational Composition of Employment

The existence of an unexplained residual in Table 5.1 suggests that among other things our measure of the labor input may be inadequate. We have therefore developed the education and sex weighted labor input

weighted indices L^e and L^s described in secton 2, and attempted to measure the contribution of the increase in the educational level and changes in the sex composition of the employed labor force. The results appear in Tables 5.3.1 and 5.3.2. The contribution of the increase in the educational level is minute. The negative sex effect is explained by the more rapid growth of female workers. Having accounted for the educational level and the sexual composition of the labor force we are left with a virtually unchanged unexplained residual. We must conclude that changes in the sex and educational

TABLE 5.3.1

TEN YEAR GROWTH RATIO OF VARIOUS LABOR INDICES

	Total Ed. Wts. (A)	Partial Ed. Wts. (B)
Growth Rate of Labor Force	.3029	.3029
Growth Rate of Labor Force Weighted by Sex	.2806	.2806
Growth Rate of Labor Force Weighted by Education	.3276	.3157

Source: Appendix 1 and Table 4.2

TABLE 5.3.2

THE GROWTH CONTRIBUTION OF CHANGES IN THE COMPOSITION OF THE LABOR FORCE

	Full Ed. (A) Wts.		Partial Ed. (B) Wts.	
	Absolute Contribution	As Percentage of Growth Rate	Absolute Contribution	As Percentage of Growth Rate
(1)	(2)	(3)	(4)	(5)
Growth Contribution of Change in the Composition of the Labor Force:				
Sex	-.0176	-.0221	-.0176	-.0221
Education	.0195	.0245	.0101	.0127
Growth Contribution of Unweighted Labor	.2370	.2980	.2370	.2980
Total Contribution of Labor	.2389	.3004	.2295	.2886
Growth Contribution of Capital	.4250	.5345	.4250	.5345
Residual	.1313	.1651	.1407	.1769

Source: Tables 5.3.1, 5.1, and 4.1.

composition of the labor force made no significant contribution to Greek growth during this period. Using the capital contribution estimate from Table 5.1, the explained sources of growth now changes from 83 per cent of the growth rate either to 82 per cent or not at all, depending on which education weights are used.

5.4 The Net Contribution of Education to Growth

We will now discuss the remainder of the material directly related to education, namely, the gross and net growth contributions of education.

First we estimate the educational composition of the 1961 labor force, assuming that there was no education over the years 1951-61. For each population group by age and sex it was assumed that the percentage composition by level of education remained unchanged over the period. Thus, for example, all of those of ages 10-19 in 1961 (i.e., those who were 0-9 in 1951) were entered in our 1961 estimates as not having finished primary school. The resulting population categories were then multiplied by the appropriate employment ratios to yield the employment estimates which appear in Appendix 1. Using the method outlined in Section 2, we arrive at the results in Table 5.4. One is struck here with the somewhat unexpected estimate that the total contribution of

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25/ Changes in the measured outputs (in current prices) of a number of sectors are estimated on the basis of the changes in the inputs with the implicit assumption that output per unit of input (or output per man) remained unchanged over the period. Thus, to the extent that there were general increases throughout the economy in output per unit of input, the measured gross domestic product is downward biased through the understatement of the rate of growth of these sectors. If we seek to measure the contribution of factor inputs to measured growth we have at least two alternatives. We may exclude from the 'explained sources of growth' the effects of qualitative improvements in the factors allocated to those sectors in which the magnitude of inputs as conventionally measured is the basis for the output measure in the national income accounts. Alternatively we may adjust the output measures in these sectors to take account of the increases in output per unit of input. The effect of either procedure will be to increase the magnitude of the unexplained sources of growth. No adjustment of this type is made in this study, largely because, given the rather limited increases in output per unit of conventionally measured input, the effect on the overall results would in all likelihood be very small.

education is less than the 'partial' contribution, G^{LQ}. After subtracting the opportunity cost of the resources devoted to education[26/] (assuming that only one half would have been invested in the 'no education' case) we come to the startling conclusion that the net contribution of education was even on the best of assumptions negative! This perplexing result will be commented on in the concluding section.

5.5 Economies of Scale

So far we have attributed all of the growth effects to the changes in the factor inputs. In our preferred estimate we have used a wage share of .79 and a marginal product of capital of .12. If we assume a homogeneous production function and that all factors are paid the value of their marginal product, we may determine the degree of economies of scale once we know the aggregate capital output ratio. For example, if the capital output ratio is 2.5 the production function must be homogeneous of degree 1.09.[27/] In order to accommodate the presence of increasing returns to scale as a separate source of growth we must multiply the estimated or implied growth elasticities by (1/1.09) so as to reduce the sum of the elasticities to unity.

The difference between the original estimate of the total explained growth and the new estimate using the reduced elasticities is the contribution of increasing returns to scale. The results are in Table 5.5.[28/]

26/ This is a very rough estimate based on the national income accounts with no attempt at adjusting for implicit rents on buildings, equipment, and land, nor for any other divergence between private and social cost. It probably represents an underestimate.

27/ Euler's theorem on homogeneous function implies that if the production function is homogeneous of degree n and all factors are paid their marginal products, n times the total product will be paid out. Thus:

$$MP_k \frac{K}{Y} + MP_L \frac{L}{Y} = n$$

28/ The magnitude of the estimate of the returns to scale contribution depends, among other things, on one's guess of the aggregate capital output ratio. Estimates of the sensitivity of the estimates to changes in the assumed capital output ratio appear in Appendix 3.

TABLE 5.4

THE TOTAL AND NET CONTRIBUTION OF EDUCATION TO GROWTH

		Full Educational Weights	Partial Educational Weights
1.	Growth Rate	.7952	.7952
2.	Growth Rate of the Education Weighted Labor Force Assuming No Education, $\frac{dL^{e'}}{L^{e'}}$	.3711	.3446
3.	Growth Rate of the Educated Weighted Labor Force, $\frac{dL}{L}$	.3276	.3157
4.	Wage Share	.79	.79
5.	Total Contribution of Education (4 x [3-2])	-.0344	-.0228
6.	Pure Contribution of Labor [4x2]	.2931	.2722
7.	Opportunity Cost of Resources Directed to Education[a/] (Drs.)	1,020,312	1,020,312
8.	(7)/(1)	.0232	.0232
9.	Net Contribution of Education (5-8)	-.0576	-.0460
10.	Net Contribution of Education as a Fraction of the Growth Rate	-.0724	-.0578

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a/ Assumes that one half these resources would have been invested and MP_k = .12.

TABLE 5.5

THE GROWTH CONTRIBUTION OF SCALE ECONOMIES

	Absolute Contribution	Contribution as a Fraction of Observed Growth
1. Total Previously Explained Growth[a/]	.6639	.8349
2. Returns to Scale Contributions $(1) - \frac{(1)}{1.09}$	.0548	.0689
3. Growth Effect of Capital with Scale Economies Accounted For[c/]	.3899	.4903
4. Growth Effect of Labor Adjusted for Education and Sex[b/] with Scale Economies Accounted For[c/]	.2192	.2757

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a/ Table 5.3.2.

b/ Using the Full Education (A) weights.

c/ See text.

5.6 The Growth Contribution of Embodied Technological Change

If this year's capital goods are more productive than last year's, and if the price indices used in constructing the gross domestic capital formation series have not been corrected to take account of this quality increase, the measured change in the capital stock will be an underestimate of the change in the available services of capital. The treatment of embodied technological change thus amounts to a problem in the measurement of changes in the capital stock; in order to estimate the growth contribution we must revalue the gross domestic capital formation series.

As we have no idea of the annual rate of embodied technological change, the following must be considered a hypothetical exercise. Nonetheless, it is hoped that we can establish a broad range of estimates which will encompass what we can agree is a plausible area.

Assume that each year's capital goods are m per cent more productive than those of the previous year, and that this quality increase is not reflected in the relevant price indices.[29/] If we assume that the 1954 prices which form the basis of valuation of the gross domestic capital formation series accurately reflected the services of the capital goods installed during that year, we can now define a new gross investment series, $I_t^{g'}$

$$5.6.1 \qquad I_t^{g'} = I_t^g + I_t^{g*} \left[(1+m)^{t-54} - 1\right]$$

where I_t^g = gross investment in year t, in 1954 prices, as measured in the national income accounts.

I_t^{g*} = that portion of gross investment in year t to which the embodied technological change applies.

The new gross investment series is plotted for m = .01 and m = .02 against the old series in figure 5.6

29/ We assume that the rate of embodied technological change appropriate for dwellings and changes in inventories is zero.

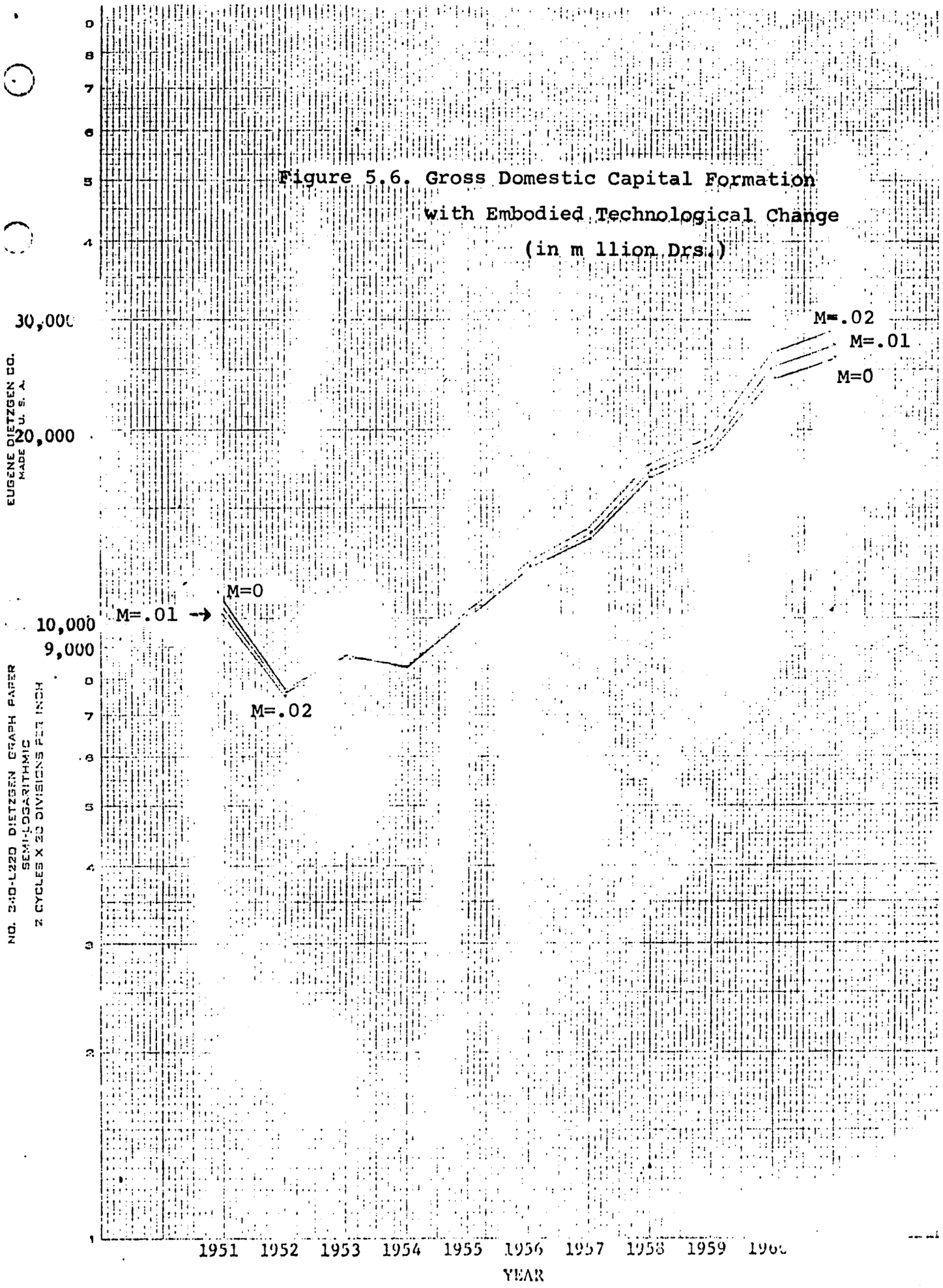

Figure 5.6. Gross Domestic Capital Formation with Embodied Technological Change (in m llion Drs.)

TABLE 5.6

THE GROWTH CONTRIBUTION OF EMBODIED TECHNOLOGICAL PROGRESS

	(1)	m = .02 (2)	m = .01 (3)	m = 0 (4)
1.	a. GDP 1951 (million 1954 drs.)	43697	43859	44028
	b. GDP 1961 (million 1954 drs.)	81593	80089	78674
	c. Rate of growth of GDP $\frac{Y_{61}-Y_{51}}{Y_{51}}$	.8762	.8261	.7952
2.	a. Change in capital stock[a/]	164107	159930	155970
	b. $(2a)/Y_{51}$	3.756	3.646	3.542
3.	Marginal product of capital	.12	.12	.12
4.	Growth contribution of capital (2bx3)	.4507	.4375	.4250
5.	Effect of the revaluation of the gross investment series on measured GDP [line 1c, col. 2 and 3 resp. minus col. (4)]	.0810	.0309	0
6.	Effect of embodied technical change on the estimated capital contribution to growth [line (4) col. 2 and 3 resp. minus col. (4)]	.0257	.0125	0
7.	Total embodied technological change contribution (5+6)	.1067	.0434	0
8.	"Total" as a per cent of $\frac{dY}{Y}$[(7)/(1c)]	.1217	.0525	0
9.	Sum of explained growth from all other sources [b/]	.6639	.6639	.6639
10.	Unexplained residual [1c-7-9]	.0906	.1188	.1313
11.	Unexplained residual as a fraction of $\frac{dY}{Y}$	.1034	.1438	.1651

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a/ Based on the gross investment series, Table 3.3.

b/ Table 5.3.2.

We must now consider the two effects of this revaluation of the capital formation series. First, because of the revaluation of the gross domestic capital formation component, the overall rate of growth of GDP has increased. Second, the contribution of capital term of equation 2.3 increases, as dK/Y has been increased.

Which of these two effects should be called the growth contribution of embodied technological change is not entirely clear. The increase in the estimate of the capital contribution appears in line 5 of Table 5.6; the effect of the revaluation of the gross capital formation series on measured GDP appears in line 6 of the same table. The increase in the contribution of capital is remarkably small even for m = .02. Notice that the unexplained residual is reduced only by the magnitude of the increase in the estimate of the capital contribution.

6. Speculations

In this concluding section I will comment briefly on the unexplained residual and suggest one possible interpretation of the small contribution of education.

There are a number of considerations which may help to explain our failure to eliminate the residual.

Some aspects of the employed labor force measures may result in there being a downward bias in the estimated rates of growth of the labor input. First, no adjustment has been made for hours worked per year. Given the shift of labor out of agriculture, we may expect average hours worked have increased. Second, we have failed to measure the growth effects of a number of influences on the productivity of the labor force. It is probable that the level of health of the labor force increased over the period, thus increasing not only the average number of work hours per labor year, but also the intensity of work per man hour. In addition, we know that during the 'fifties there was a significant reallocation of labor within the Greek economy, both from rural to urban locations and between sectors of the economy. To the extent to which these movements were in respnse to productivity differentials in the economy, a significant increase in the efficiency of the allocation of the labor force must have resulted. Failure to account for the increasing average age of the employed labor force gives the labor input index a downward bias if the observed positive age-earnings relation (at least up to age 50) reflects real productivity increases assocated with the greater experience and on-the-job learning.

We turn now to overall increases in efficiency not directly associated with any one factor. It is possible, and I think likely, that a major proportion of the unexplained residual can be classed under the heading of disembodied

technological change. To some extent one may place those phenomena usually called 'post-war reconstruction effects' in this category. During the period immediately following the civil war, the output in the economy was undoubtedly disrupted by a number of essentially organizational or infra-structure failures which were corrected during the period under consideration. This interpretation is consistent with the fact that the rate of growth over the entire period has been roughly constant, while both gross and net investment as a percentage of gross domestic product have increased sharply.[30/] In other words, rapid gains in G.D.P. made during the early part of the period (after 1953) with a relatively small level of gross and net investment have been sustained throughout the period only at the expense of a rising ratio of investment to G.D.P. One additional major source of disembodied technological change may have been the return of large numbers of successful Greek entrepreneurs from the Middle East during the mid-fifties. These businessmen have contributed significantly to the supply of entrepreneurship in the Greek economy and may have done a great deal to increase the overall efficiency of the economy.

In reviewing the many intangibles listed above, one is struck by the importance of the growth effects of rapid growth itself. Many of the increases in the overall efficiency of the economy, in particular disembodied and embodied technological change, and reallocation of labor between jobs and between the sectors and between regions of the country, are themselves closely related to the phenomenon of rapid growth, which facilitates labor mobility and reduces the resistance to technological innovation and organizational changes

The very small contribution of education to Greek economic growth may be explained by two related facts. The first is that transformation of the educational composition of the labor force has not been particularly marked; the secon

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30/ We may assume that changes in both the quantity and quality of the labor force proceeded smoothly throughout the period.

is that with the exception of university education, the increase in productivity associated with additional years of schooling appears to be comparatively small.[31/]

Explanation of this latter observation requires additional investigation. Two possible interpretations are offered here. First, the curriculum for some levels of education is heavily weighted with classical studies (for example, ancient Greek language and literature. Little attention is devoted to modern scientific subjects or modern languages. We know virtually nothing about the relationship between the content of a student's education and the associated effects on his productivity or earnings, but there is a distinct possibility that part of the answer to the low economic productivity of Greek education is to be found in its retrospective curriculum.

Second, the quality of Greek education, in terms of both the meager resources per student devoted to the schools and the often outdated methods of instruction used may militate against the educational system making a major contribution to Greek growth. The above two points are highly speculative and offered here as areas for further investigation.

It should be emphasized that the failure of an educational system to contribute to economic growth may be viewed by economists as unusual or surprising, but it cannot be regarded as a general indictment of the system or of the content of the courses offered. The apparent low economic productivity of Greek education may be the result of a perfectly rational decision to use the school primarily as a vehicle to transmit the nation's cultural heritage to the new generation and to inculcate other values thought to be socially important. The permissible role of the economist here is merely to attempt to ascertain the opportunity costs of such a decision.

31/ Leibenstein's forthcoming work indicates very low rates of return for some types of Greek education.

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APPENDIX 1

Employment by Sex and Level of Education, 1951-61

Estimates of the 1951 and 1961 employed labor force are based on population data and estimates of the fraction employed of the total in each age, sex and education cell of the population. These employment ratios are based on 1951 data. Because the 1951 employment figures have been calculated using definitions similar to those used in the 1961 census, there is some discrepancy between these data and the 1951 census results.

Although 1961 employment data are available directly, we have used a procedure analogous to that used for 1951 to determine the level and composition of the 1961 employed labor force. There is very little discrepancy between our results and the actual 1961 data.*

The employment estimates appear in Table A.1.1. The employment figures based on the 'no education' assumption as described in the text are presented in Table A.1.2.

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* The estimates of employment which appear here have been built up from a more detailed age, sex and education breakdown of employment.

Table A.1.1

Estimated Employment

Educational Level (Years of Schooling)	1951 Males	1951 Females	1961 Males	1961 Females
0-5	920,123	485,551	833,804	744,396
6-11	790,232	218,541	1,233,496	383,890
12-15	124,551	35,140	194,781	86,193
16 up	53,894	11,899	79,901	63,193
	1,888,800	751,131	2,341,892	1,097,033

Table A.1.2

Estimated Employment Assuming No Education

Educational Level	1951 Males	1951 Females	1961 Males	1961 Females
0-5	920,123	485,551	1,646,454	1,086,056
6-11	893,232	257,901	846,364	214,385
12-15	228,831	74,404	129,574	27,144
16 up	60,690	15,552	46,523	10,696
	2,102,876	833,408	2,686,915	1,338,281

APPENDIX 2

An Estimate of the Marginal Productivity of Capital

We seek an estimate of the social marginal productivity of capital (MPk) in the Greek economy.

Estimates based on profit statements of firms[1/] are likely to be seriously biased downward because of the attempt by firms to understate their earnings.[2/] The only economy-wide estimate of which I am aware is based on the shadow price of capital in the programming model of Nugent.[3/] However, difficulties in interpretation of his results along with the somewhat inappropriate form of his model for this purpose suggests that some alternative estimate must be sought.

I have decided to use the production function for manufacturing estimated by Dr. Kokkova from a sample of 500 large firms (employing more than 20) in 1960.[4/] Combining the estimate of the capital coefficient in her Cobb-Douglas function with the average productivity of capital in her sample we arrive at an estimate of the MPk. However, the capital measure used in estimating the function was the book value of fixed capital, which probably understates the services of capital by a significant amount due to rapid book depreciation and the exclusion of inventories. Thus the net capital stock figures used by Kokkova are associated in each firm with a much larger stock of capital

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1/ As, for example, in G. Coutsoumaris, The Morphology of Greek Industry, Athens, 1963, Chap. 9. It is possible, but perhaps not as likely, that the same applies to the data underlying the production function used below.

2/ However, see the adjustments made by H. Leibenstein in his forthcoming book on the economics of education in Greece.

3/ J. Nugent, Programming the Optimal Development of the Greek Economy, 1954-61, Athens, 1966, pp. 102, 106.

4/ A. Kokkova, Production Functions in Greek Manufacturing, Athens, 1964. I am grateful to Mrs. Kokkova for supplying some of the raw data from her study.

(including inventories), and variations in the net capital stock may reflect significantly larger variations in the real services of capital. I have therefore made the following adjustment.

Let us say that

(1) $V = f(K, \ldots)$

where V = value added.

K = book value of the net fixed capital stock used in the sample of Dr. Kokkova.

Assuming that there is a relationship between K and K', the estimate of the actual net fixed capital stock plus inventories, for the firms in Dr. Kokkova's study, as follows:

(2) $K = g\ (K')$

we can write

(3) $V = f\,[g(K'), \ldots]$

and

(4) $\frac{\partial V}{\partial K'} = \frac{\partial V}{\partial K} \cdot \frac{\partial K}{\partial K'} = MPk'$

Thus, once we obtain the estimate of the MPk from Dr. Kokkova's data we have only to ascertain the relationship (2) to determine the desired estimate of the marginal product of capital (MPk') from (4).

The MPk estimate is based on Dr. Kokkova's highly significant estimate of b_1, the capital coefficient along with the average productivity of capital:

(5) $\frac{\partial V}{\partial K} = b_1 \frac{v}{k}$

or $\frac{\partial V}{\partial K} = (.2324)\ (1{\cdot}23) = .2858$

The relationship (2) is assumed to be of the form

(2a) $K = aK'$

The parameter, a, is estimated as follows. We estimate the actual net fixed

in Dr. Kokkova's study along with the ratio, r, of gross to net capital stock for all of manufacturing in 1960 estimated by Krengel.[5/] In addition we employ an estimate of the ratio of inventories to value added (I/V = m) based on the data in Tables 5.10 and 5.2 of Coutsoumaris' study.[6/] We estimate K' as follows:

(6) $rK^* + mV = K'$

When K^* = gross fixed capital stock of the firms in the Kokkova sample.

r = ratio of gross to net fixed capital stock.

m = inventories/value added ratio.

Using the sources indicated above we have

r = .7194

K^* = 11.366 billion drs.

m = .81

V = 5.387 billion drs.

and K' = 12.539 billion drs. We know that K = 4.391 billion drs.

From (2a) we have

(7) $a = \frac{K}{K'}$

so a = .35, which is, of course, the value needed for $\frac{\partial K}{\partial K'}$

Inserting the value of a and $\partial V/\partial K$ into (4) we find that

(8) $\frac{\partial V}{\partial K'} = (.2858)\ (.35) = .1000$

Thus a marginal product of capital of 10 per cent is offered as a rough estimate.

5/ R. Krengel and D. Mertens, Fixed Capital Stock and Future Investment Requirements in Greek Manufacturing, Athens, 1966, p. 74. A depreciation rate of 3.33 to 4.0 per cent has been used in calculating net capital stock.

6/ According to Table 5.10, (Inventories) / (Gross Production) = .27 and according to Table 5.2 (Gross Production) / (Value Added) = 3.0. Thus I/V = .81. The figures apply to total manufacturing in 1957.

APPENDIX 3

The Sensitivity of the Results to Errors in the Estimates

Because of the uncertain nature of the data and the underlying assumptions used here, it is worthwhile to investigate the sensitivity of the results to changes in some of the key parameters, particularly the elasticity of output with respect to labor, the social marginal productivity of capital, the magnitude of the productivity increase associated with additional years of schooling, and the aggregate capital-output ratio.

The growth contributions of labor and the changes in the composition of the labor force are estimated using equations 2.5 to 2.8 from which it is clear that a one percentage change in the estimate of the elasticity of output with respect to labor, (wL/Y), yields a one percentage change in the estimate of the growth contribution. In similar fashion the estimate of the growth contribution of capital is changed by one per cent for every per cent change in the estimate of the SMP_k. Figure 3.1 presents the growth contribution of changes in the composition of the employed labor force as a function of the estimate of the wage share, and the sensitivity of the estimate of the growth contribution of capital is illustrated in figure 3.2.

The contribution of education to growth is not significantly increased by a rather major increase in the assumed productivity differentials among labor classified by educational level. This can be seen in Table A.3. which presents alternative estimates of the education contribution to growth using among others the assumption that the increase in marginal productivity associated with increased education is 1.5 times the observed earnings differentials.

The sensitivity of the estimate of the contribution of returns to scale to changes in the assumed aggregate capital output ratio can be estimated

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Figure A.3.2 The Growth Contribution of Capital as a Function of the Estimated Marginal Product of Capital

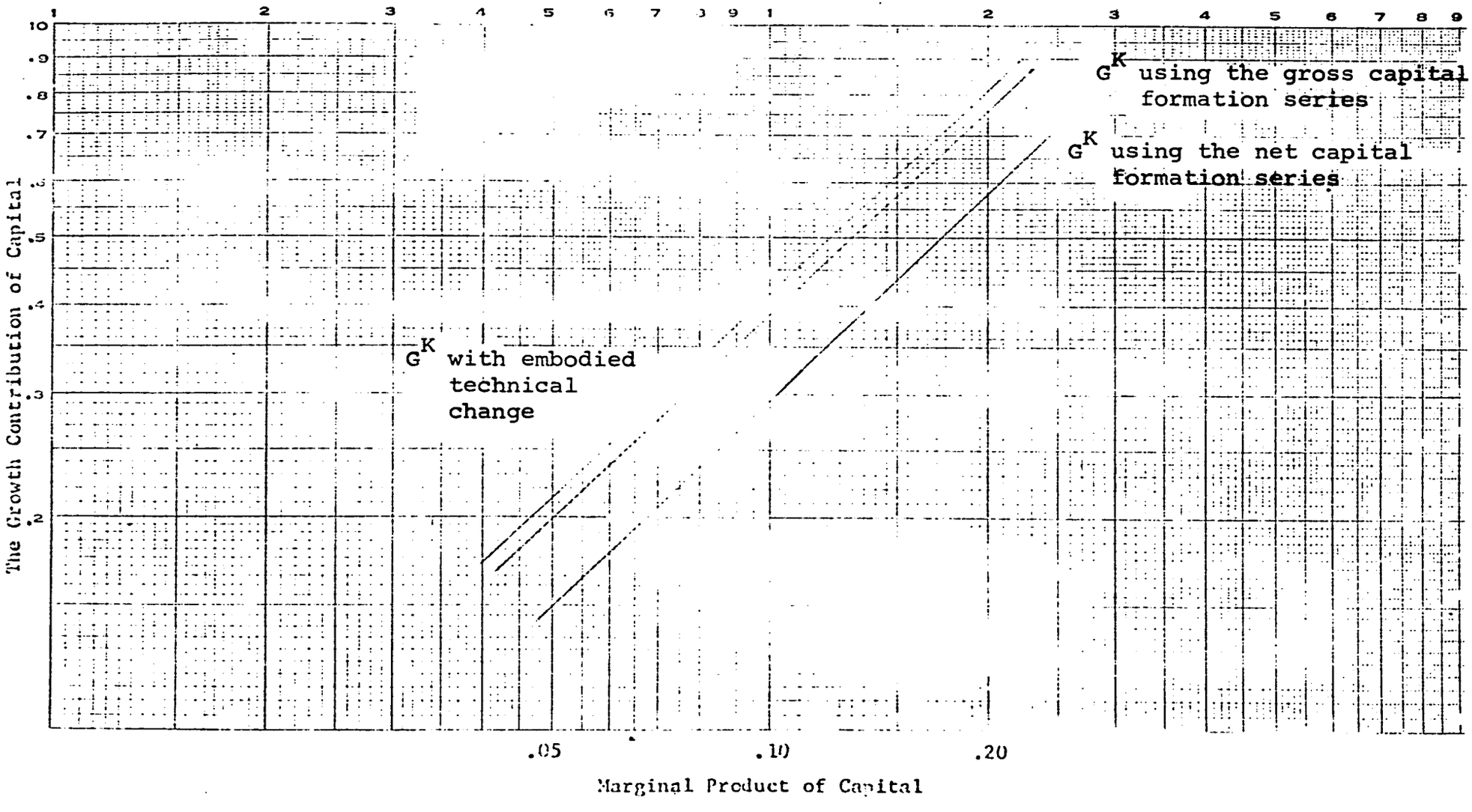
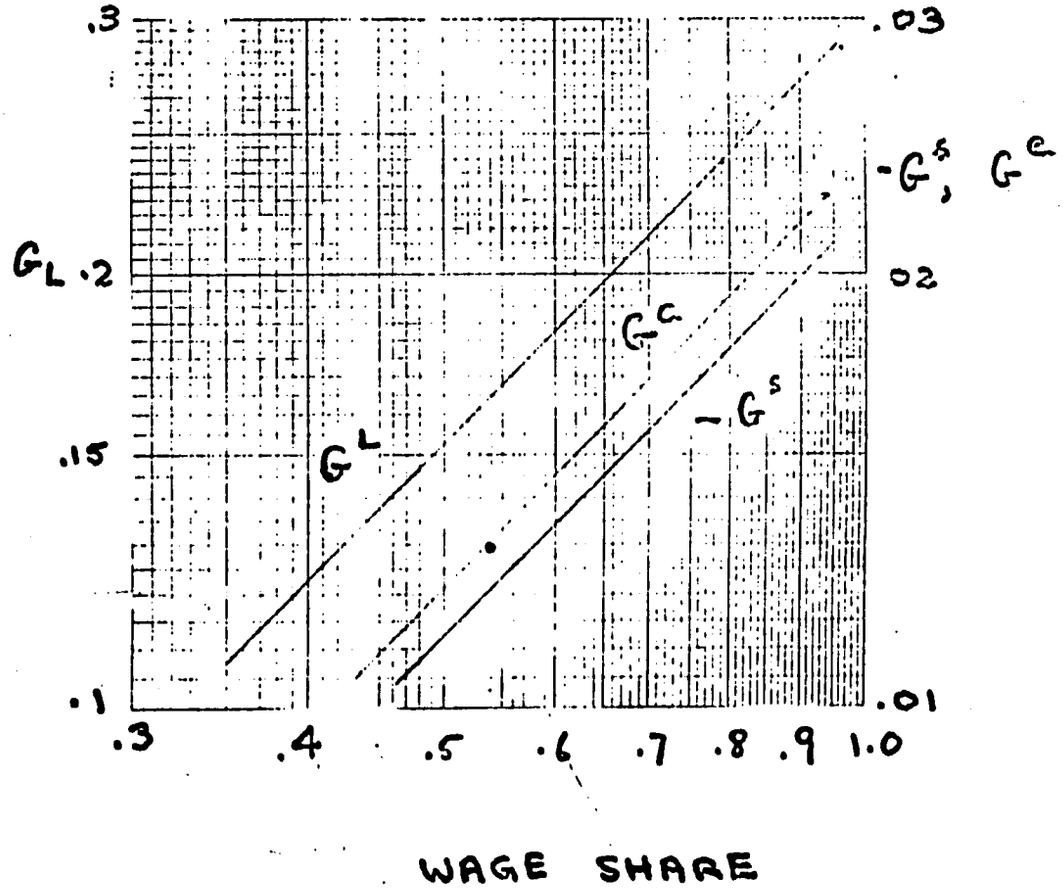


Figure A.3.1. The Growth Contribution of Labor (G^L) and of Changes in the Education and Sex Composition of the Employed Labor Force (G^e and G^s) as a Function of the Wage Share



A.3.1. $G^n = \Sigma G - \Sigma G(n)^{-1}$

where ΣG = the sum of all explained contributions to growth

n = the degree of the (assumed to be homogeneous) aggregate production function

Expression A.3.1. can be rewritten

A.3.2. $G^n = \Sigma G - \Sigma G(SMP_k \frac{K}{Y} + W)^{-1}$

where

K/Y = the aggregate capital output ratio

W = the wage share.

Differentiating A.3.2. with respect to K/Y we find that

A.3.3. $\frac{\partial G^n}{\partial K/Y} = \frac{SMP_k \Sigma G}{n^2}$

which, when expressed as an elasticity, is

A.3.4. $\frac{K/Y}{G^n} \cdot \frac{\partial G^n}{\partial K/Y} = \frac{SMP_k (K/Y)}{n^2 - n}$

Thus in the neighborhood of the preferred estimate, (i.e. with $W = .79$, $K/Y = 2.5$ and $SMP_k = .12$) a percentage change in the assumed capital output ratio yields a 3 per cent change in the estimate of the growth contribution of returns to scale, with $K/Y = 3$, the elasticity falls to 1.8. Thus it appears that the scale economics estimate is rather sensitive to the assumed capital output ratio.

TABLE A 3.1

The Growth Contribution of Capital and Labor

	$\frac{dY}{Y}$ a/ (2)	$\frac{dK}{Y}$ b/ (3)	SMP_K (4)	G_k Contribution of capital to growth (3) (4) (5)	$G_k/\frac{dY}{Y}$ (6)	$\frac{dL}{L}$ c/ (7)	$\frac{W}{Y}$ d/ (8)	G_L Contribution of labor to growth (7) (8) (9)	$G_L/\frac{dY}{Y}$ (10)	R (2-5-9) (11)	$R/\frac{dY}{Y}$ (12)
1.*	.7952	3.542	.12	.4250	.5345	303	.79	.2370	.2980	.1332	.1675
2.	.7952	3.542	.10	.3542	.4454	.303	.79	.2370	.2980	.2040	.2578
3.	.7952	3.542	.15	.5313	.6681	303	.79	.2370	.2980	.0269	.0338
4.	.7952	3.542	.12	.4250	.5345	.303	.90	.2727	.3429	.0975	.1226
5.	.7952	3.542	.12	.4250	.5345	.303	.70	.2121	.2667	.1581	.1988
6.	.7952	2.743	.10	.2743	.3449	303	.79	.2370	.2980	.2229	.2803
7.	.7952	2.743	.15	.4115	.5181	.303	.79	.2370	.2980	.0857	.1078
8.	.7952	2.743	.12	.3292	.4140	.303	.79	.2370	.2980	.1680	.2113
9.	.7952	2.743	.12	.3292	.4140	.303	.90	.2727	.3429	.1231	.1548
10.	.7952	2.743	.12	.3292	.4140	.303	.70	.2121	.2667	.1993	.2506

* Row 1 is the preferred estimate.

Rows 1 through 5 are based on the gross domestic capital formation series.

Rows 6 through 10 are based on the net domestic capital formation series.

a/ Source: Table 3.3. b/ Source: Table 3 3

c/ Source: Table 3 6. d/ Source: Table 4.1

TABLE A.3.2

GROWTH CONTRIBUTION[a] OF IMPROVEMENTS
IN THE EDUCATION OF THE LABOR FORCE

	Weights[b]		
	A	B	C
1. Growth Rate of Education Weighted Labor Force	.3276	.3157	.3392
2. Growth Contribution of Education	.0195	.0101	.0287
3. Growth Rate of Education Weighted Labor Force Assuming No Education	.3711	.3446	.3156
4. Total Contribution of Education	-.0344	-.0228	.0186

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a/ Growth contributions are expressed in absolute terms.

b/ The weights A, B, and C are based on the assumption that educational differences explain 100, 60 and 150 per cent, respectively, of the earnings differentials among labor classified by educational level.