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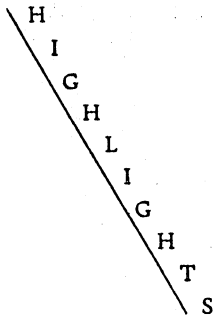
ECONOMIC GROWTH AND DEVELOPMENT

How is economic growth of the West related to the growth of the nation? What explains national economic growth? These are the basic questions examined in this section. Tolley presents some alternative growth models for an advanced economy such as ours. Kelso focuses his attention on the western interior, and asks some penetrating questions. Is all economic development good? Good for whom? Blanch takes issue with some of Kelso's points, and the comments from the floor take off from there.

Problems of Economic Growth

George Tolley
University of Chicago



Contenders for importance in explaining U.S. growth of recent decades are: 1) capital accumulation, 2) technological advance and 3) changes in the supply of the human agent in production, the latter including a) investments in human agents, b) changes in population characteristics and c) changes in effort. Changes in the supply of the human agent may be across-the-board, or they may be specific to particular groups. A reasonable estimate is that from 1870 to the present, changes in effort specific to particular groups made an 11 per cent contribution to the observed increase in real per capita income; investments in human agents specific to particular groups also made an 11 per cent contribution; capital accumulation made a 41 per cent contribution, and changes in technology made a 128 per cent contribution, the observed 300 per cent increase resulting from multiplicative reinforcement of these contributions. Growth attributable to investment processes as envisaged in capital accumulation models has been more important than one might suppose from the relatively small contribution made by growth in the physical stock of capital. Thus, since research and education are investment processes advancing technology and increasing the quality of the human agent in production, capital accumulation interpreted more broadly may have accounted for the vast majority of growth.

The problems of economic growth I have chosen to concentrate on are those having to do with the analysis and understanding of growth. The first of the two major purposes of the paper is to evaluate different explanations of growth that may be offered for an advanced national economy such as our own. The second purpose is to examine, in light of these explanations, the relationship between regional and national growth.

The major emphasis of the paper is on the first of the two purposes. We begin by considering the classical growth explanation, capital accumulation. We then list some other growth sources, having to do with technological change and changes in labor input. We then attempt to measure the contribution of the various growth sources for the past several decades. Finally, the capital accumulation model is re-examined in light of these measurements. The discussion of regional growth consists of only a few common sense remarks sketching out the view of regional growth that seems to be implied by the discussion of national growth.

Growth of the U.S. Economy

Capital Accumulation

In one class of growth models the prime mover in raising income through time is capital accumulation. We immediately recognize a long and distinguished history of thinking by professional economists directed at models within this class. Particularly germaine to the present paper are those associated with names such as Alfred Marshall and others representing what now appears to us as an older line of thought.[1/] This older line of thought, it seems to me, is, consciously or unconsciously, central in practically all economists' conceptions of growth. Let us first consider one model that attempts to epitomize such a conception, following with a discussion of some of its limitations.

The model is a simple one. Real income depends on the availability of human and non-human inputs. Savings, let us say in per capita terms, depends on per capita income and also perhaps on other variables including interest rates. That fraction of income which is saved is devoted to the production of additional non-human inputs, or capital, these continuing additions to capital being called investment. There are market mechanisms involved in achieving equality of savings and investment at the level of real income determined, as noted, by the availability of inputs. These mechanisms, however, are not central to the growth process envisaged. Given that savings and investment will somehow be equated, per capita income rises through time as a result of the per capita growth in capital.

1/ The names of Domar, Harrod, and Hicks come to mind as more recent contributors to this class of models. However, the models associated with these names deal primarily with the relation between growth and cyclical fluctuations, a subject that will not be pursued here.

This scheme is so familiar that the model itself surely needs no further elaboration here. What can be said by way of evaluation?[1] The fact that the model does not explain population changes does not seem a serious shortcoming to me. Nor does the lack of any explanation of the role of land and other natural resources seem serious. Many discussions of growth, particularly those concerned with the thinking of economists historically, begin by considering Malthus and Ricardo, who as we all know were concerned with these subjects. I have purposely not followed such a procedure in the present discussion. Models implicit in the writings of Ricardo and Malthus are clearly irrelevant in analyzing an advanced national economy, and they are more relevant to the static, backward state of underdeveloped countries than to the process of development itself in such countries. The model that has been presented, of course, gives no explanation at all of population growth. An explanation could easily be grafted on, but particularly in analyzing an advanced national economy the explanation would obviously be of a more recent kind than any propounded by Ricardo or Malthus. An explanation of the role of land and other natural resources could also be included, but perhaps one of the chief merits of the model is that these resources do not play any role in limiting growth. In my view, this aptly describes the United States historically and for as much of the future as is within our present time horizon. The decline of the value of natural resources relative to non-natural resources is one kind of evidence suggestive of this view. If natural resources were limitational we might expect their value relative to other assets to rise through time, perhaps precipitously. According to Goldsmith's figures the category including natural resources in 1900 had a value of 64.7 billion dollars out of a total national wealth of 180.1 billion dollars, that is, 55 per cent of the total. By 1948 the category including natural resources had risen to only 78.6 billion dollars while the total had risen to 461.6 billion dollars so that the percentage had fallen to about 20 per cent.[2] Another kind of evidence in support of the view that natural resources are not strongly limitational is more rigorous, and in addition it looks to the future. This is provided in such studies as the Paley Report, whose findings seem to me to indicate that serious "shortages" due to natural resources are not imminent.[3]

1/ In evaluating the model, we pass over a characteristic that would be of much more interest if the present discussion were directly oriented to policy matters. This characteristic is the close and straightforward relationship of the model to static, or stationary, models that indicate conditions relevant to the maximization of real national income at any point in time. I refer to criteria for efficient resource use as implicit in the writings of the classical and neo-classical economists and as made more explicit in writings in the more recent field of welfare economics. This characteristic is an important merit from the point of view of forming rational policies. A complication raised by growth is the introduction of an additional welfare condition, namely the optimal rate of savings. We will not explore this complication here; however, the footnote on page 15 is obviously relevant to it.

2/ These figures are reproduced in The National Industrial Conference Board, The Economic Almanac 1953-54 (New York: Thomas Crowell, 1953), p. 480. The values quoted are in 1929 prices.

3/ The President's Materials Policy Commission, Resources for Freedom, Vols. I-V (Washington: Government Printing Office, 1952).

To proceed to another characteristic of the model, the implicit assumption of full employment of resources does not seem a serious shortcoming. Rather, such an assumption seems superior to giving any important weight to unemployment considerations in analyzing most long-run growth problems.

Can we then find nothing seriously wrong? Evidence cited by Solomon Fabricant in his essay, "Economic Progress and Economic Change," seems to directly contradict an important implication of this model and thus to provide a damning criticism.1/ Reporting on studies at the National Bureau of Economic Research on historical trends in the U.S. economy, Fabricant says: "With a given 'dose' of labor and tangible capital we have learned to produce a larger and larger volume of goods for consumption and investment: output per unit of input has risen somewhat under fourfold, or about 1.7 per cent a year on the average."2/ Thus, "national income per capita has been multiplied over fourfold," while "total input per capita has risen by less than a fifth," with the inference clear that "the major source of our economic advance has been a vastly improved efficiency."3/ Put bluntly, this evidence would seem to indicate that income growth has been due primarily to technological advance or other changes in given conditions rather than to capital accumulation.

Apparent Increases in Efficiency

Let us take our cue from this evidence and look now towards explanations of growth that are consistent with continuing observed increases in output per unit of input. As a first step, I would like to delineate four categories of change that may contribute to growth aside from capital accumulation.

A first and most obvious category of change might be referred to as pure technological change. This is simply an increase in the quantity of any output for the same inputs of capital and of labor of comparable types, achieved through more efficient organization of the productive process. This kind of change is familiar to us as a shift in production function. The rising price of labor relative to the price of capital makes for difficulty in interpreting the extent of pure technological change. The problem is the familiar one of distinguishing shifts in production isoquants from movements along a given isoquant associated with changing relative prices. As we shall discuss, there may have been as much as a fourfold rise in the price of labor relative to that of capital. This rise may be due simply to the diminishing marginal productivity of capital associated with capital accumulation, to pure technological changes themselves that have raised the marginal productivity of labor, or to an illusion created by neglect of possible increases in quality of labor. Regardless of cause, however, the rising relative price has surely induced many dramatic

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1/ Solomon Fabricant, "Economic Progress and Economic Change," 34th Annual Report, National Bureau of Economic Research (New York: National Bureau of Economic Research, Inc., 1954).

2/ Op. cit., p.8.

3/ Ibid.

shifts towards capital intensive techniques. In casual observation, we may wrongly label these as technological advance and make the false inference that these shifts rule out an important role in growth for the remaining categories to be considered.

All of the remaining categories, instead of shifting production functions, alter the conditions of supply of the human agent in production. Thus, a second category includes changes in skill and quality attained through education and other deliberate "investment in human agents." These may be of a very general nature, such as the basic skills acquired in public education of children; or they may be highly specific, such as skills acquired in specialized technical and professional training.

A third category includes changes in the skill of the labor force associated with changing population characteristics rather than with the deliberate investment referred to in the previous paragraph. Demographic considerations are obviously relevant to this kind of change, as for instance in altering the proportion of the population of working age and of differing working age groups.

The fourth and final category might be called, for want of better terminology, changes in effort. These are changes wherein a person contributes a different kind or intensity of input per unit of time, the difference not being associated with any deliberate investment in human agent. The use of the word deliberate emphasizes that these changes are obviously affected by human experience, but it would be mere tautology to characterize all supply-changing experiences as investment in human agent. Changes in effort may be very general or widespread, as when mass changes in attitude induce people to work harder; or such changes may be connected specifically with particular groups, industries, or areas within an economy. An example of the latter is the amelioration of "depressed" groups, industries, or areas, such that labor of given skill changes from lower to higher productivity employment. Movement of the Southern Negro into industrial employment provides a concrete illustration.

Research is needed whose purpose is to reveal the relative contribution of each of the above categories to U.S. growth. An important part of this research would take the form of attempting to identify the contribution in raising real wages through time of the second, third, and fourth categories of change. Highly exact estimates might not be possible, of course. Nevertheless, through use of data on research and education, expenditures, labor force participation, these related where needed and possible to earnings of specific groups, we ought to be able to get a much better idea of the quantitative importance of different kinds of change. This would be useful in studies of immediate practicality concerned, say, with manpower and defense; and it would increase our understanding of growth. For instance, we would clearly seek much different explanations depending on whether the major source of growth were in the fourth category rather than the second or third.

Measuring Labor Input

Pending more exhaustive investigation of the kinds just referred to, let us attempt to interpret, in a tentative way, evidence readily available that is helpful in distinguishing between the different sources of growth.

To consider the categories in reverse order, changes in effort of the general or widespread variety may well be ruled out as a major source of recent U.S. growth simply by casual reflection. The implication would be that there has been a progressive tendency for the labor force as a whole to increase effective input per hour. Such a tendency might be dominant in determining growth in some underdeveloped areas of modern times and may have been dominant in European countries and the U.S. in the more distant past. However, we usually expect such phenomena to be associated with unmistakable mass changes in attitude of the sort that have not been witnessed in the U.S. in the past several decades, which are of concern in this paper. Perhaps increases in general health and well-being have made for somewhat more effective labor inputs; but offsetting this might be a tendency for people to work less intensively with rising income. Neither of these factors seems very major.

What of changes in effort associated with particular groups, industries, or areas? An implication, if these changes were the major source of growth, would be that growth has occurred primarily with transfers of labor from less to more productive employment, rather than with across-the-board or general rises in return to labor throughout the economy. That is, we would expect the return to labor of a given type in a particular activity would not rise much but instead growth would occur with changes from less to more remunerative types of employment. This picture is surely not appropriate for the U.S. There have been continuing rises in returns to labor in all types of employment. However, the precise extent of rises in labor return in various types of employment is of course difficult to ascertain, and for this reason it may not be safe to rule out some role for this kind of change. At one extreme would be a situation where the fourfold rise in the return to labor per man hour at the national level was associated with a fourfold rise in return in every kind of employment within the nation; that is, the total increase would be across-the-board. At the other extreme would be a situation where the fourfold national increase was associated with no changes in return in particular employments but rather with changes in composition of employment. This is the extreme that surely can be ruled out. Fourfold differentials in wage rates are rare enough; obviously much more fantastic changes in the composition of the labor force than actually occurred would have been necessary to fulfill this extreme. Suppose, however, that there has been a three- or three-and-a-half-fold across-the-board increase in labor return, with the remainder of the national increase accounted for by, say, declines in depressed groups, industries, or areas. It would not seem warranted to assert that this situation is inconsistent with the readily available evidence. Evidence on trends in earnings in particular occupations as given in Historical Statistics indicates only a fairly wide bracket of possible increases, depending in part on which price deflator one uses. The bracket covers the fourfold national increase for the eighty-year period during which this increase occurred according to Fabricant's figures. A complication in interpreting such evidence, of course, is the diverging movement in earnings between some occupation groups.

Some observations on the changing nature of the economy support the contention that changes in effort associated with particular groups, industries, or areas may have made a non-negligible contribution to growth. Growing urbanization has meant that more labor may be hired in markets that are efficient in bidding labor to its most remunerative

employment. The rising use of the automobile has undoubtedly made labor more mobile. The spread of mass communication and marketing undoubtedly tends to engulf and eliminate "backward" segments of the population. Agriculture, which has contained much unremunerative and backward labor, has been declining. The migration of the Southern Negro was mentioned earlier.

Similar inferences may be drawn regarding changes in population characteristics and investments in human agents. Across-the-board changes associated with population characteristics may surely be ruled out altogether. Age was mentioned as an example wherein the composition of labor input could be changed by changing the proportions of labor of different productivity. Declining participation by old and young suggests perhaps some modest increase in effective labor input associated with age. Increasing labor force participation by women suggests a slight decline in effective labor input associated with sex, supposing that wage differentials for women indicate differences in productivity. Differing natural reproduction rates of groups of differing productivity would also change effective labor input. None of these factors is very impressive; changing population characteristics would seem to contribute at most second order effects rather than first order effects in explaining growth for the period in question.

Significant across-the-board changes in skill through investments in human agents can probably be ruled out. Although dramatic increases in literacy, such as occurred in earlier times and such as are possible in underdeveloped areas, could lead to these changes, the coverage or quality of public education as between 1870 and the present time in the country surely does not account for really substantially greater general productivity. Light is thrown on more specific changes that may be associated with investments in human agents by reference to skill categories of the labor force. The evidence to be cited covers only about half the period, but it is indicative of trend. In 1910, about 13 million persons in the labor force were classified as unskilled out of a total of about 37 million. By 1940 the total labor force had risen to about 52 million whereas there were still only about 13 million unskilled.[1/] The supposition from earnings data does not seem unreasonable that labor in the skilled categories might be about twice as productive as unskilled labor; on this basis, the change in composition would account for about a five per cent increase in average productivity of the labor force from 1910 to 1940 and, extrapolating, something like 15 per cent from 1870 to date.

Relative Importance of Labor, Capital, and Technology

In Figure 1, the earlier period, say about 1870, is used as a base, and it is assumed that, in per capita terms, income (Y) increased fourfold; capital input (C) increased fourfold; and labor input (L) increased by a third. Thus, while Fabricant reports that per capita man-hours on net remained about constant, the figure assumes that the effectiveness of the average man-hour rose by a third. This is in line with the conclusion above that elimination of depressed areas and investments in human

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1/ Historical Statistics, op. cit., p. 65.

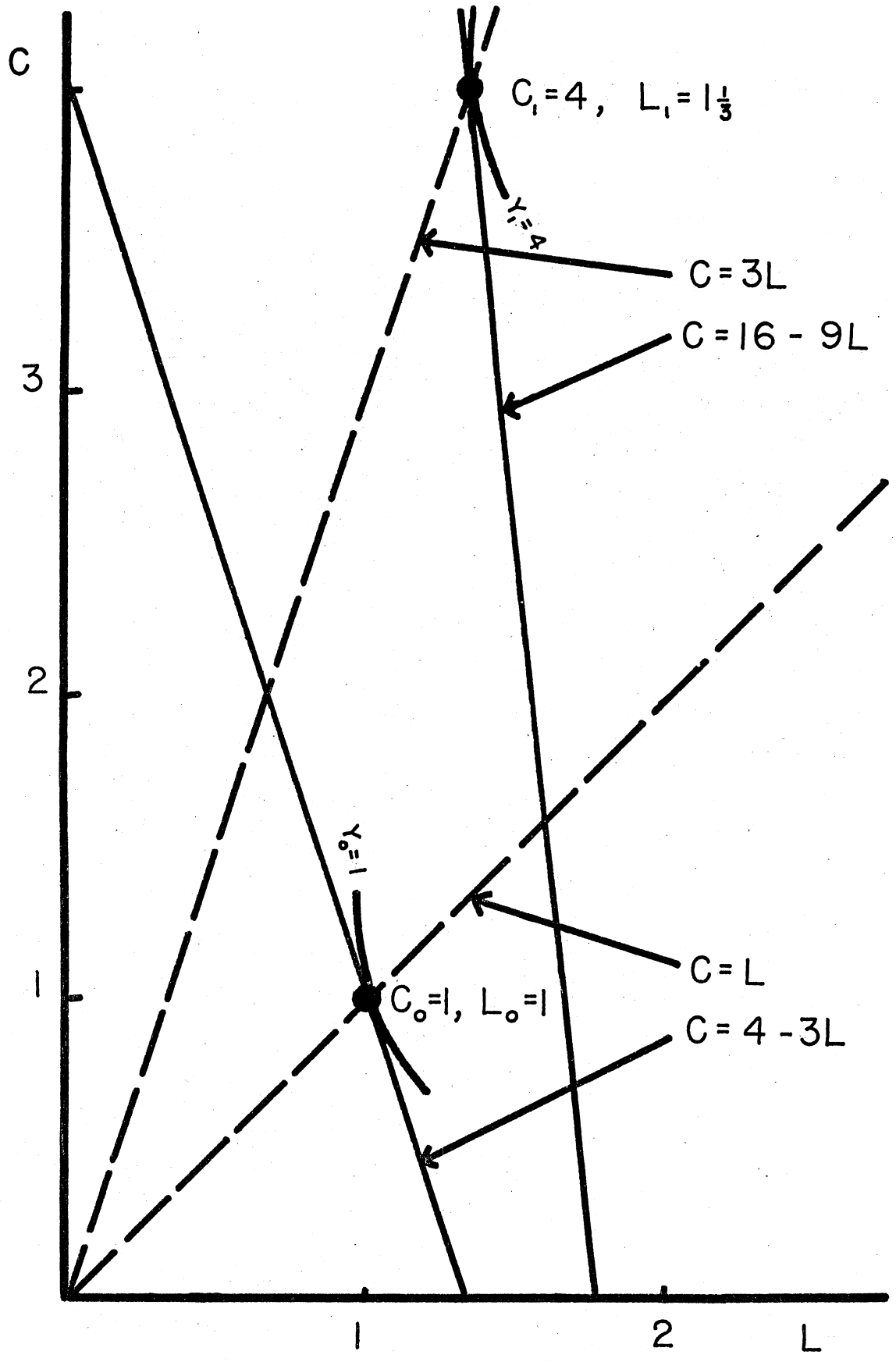

FIGURE 1

agents may have contributed significantly to growth. Since the data are most deficient in regard to the change in labor input, two additional estimates of this change will be considered later.

The slopes of the income contours in the figure result from supposing that the prices of labor and capital measure their marginal product, prices being derived from the assumed quantity of each factor and share in income. Thus, assuming three-fourths of income paid to labor in both periods, the one-third increase in labor and four-fold increase in capital implies that the price of labor has more than doubled while the price of capital has remained constant. 1/

Supposing this conception of the data is accurate, how shall we interpret the rise to a contour corresponding to a quadrupled per capita income? One reasonable interpretation is that the technological changes which occurred would have raised per capita income to 2.28 times its former level, that the capital accumulation would have raised it to 1.41 times the former level, that the increase in effective labor input would have raised it to 1.24, and that the increases taken together multiplicatively account for the fourfold rise.

This interpretation, as well as the others to be considered in this section, assumes that increasing or decreasing returns for the economy as a whole can be ignored. 2/ More specific to the figures just given is the assumption that the historically observed stability in relative share in income paid to labor and capital can be extrapolated to additional situations. 3/

In order to relax the latter assumption, let the subscript o refer to the earlier period and the subscript 1 refer to the present; and consider three indexes, such that $Y_1 = T_1 F_1 L_1$. T_1 is equal to $\frac{f_1(C_0, L_0)}{f_0(C_0, L_0)}$, where $f(C, L)$ gives Y. T_1 is thus an index of income under the supposition that inputs did not change, but technology did. F_1 is $\frac{f_0(C_1, L_1)}{f_0(C_0, L_0)}$

1/ The unit of measurement of the factors is their amount in the earlier period, and the unit of value is income in the earlier period. The price of labor for the earlier period is 3/4 rising to 9/4 for the later period (the factor share of 3 divided by the 1-1/3 units of labor). The price of capital remains at 1/4 for both periods, the increase from 1/4 to 1 in factor share being exactly matched by the increase from 1 to 4 in quantity of capital.

2/ Increasing or decreasing returns to scale will appear as changes in technology in these interpretations.

3/ Suppose $L\frac{\partial Y}{\partial L} = \alpha$ and $C\frac{\partial Y}{\partial C} = 1-\alpha$, where α is the proportion of income and to labor. Solving $dY = \frac{\partial Y}{\partial L}\cdot dL + \frac{\partial C}{\partial L}\cdot dC$, and taking $\alpha = 3/4$ we obtain the Cobb-Douglas type function $bL^{3/4}C^{1/4}$. Technological change is reflected in b, and it can be seen that the data imply b rose from 1 to 3 3/4 (about 2.28). It is obvious that if only labor input had changed, income would have risen to $4/3^{3/4}$ (about 1.24); and if only capital had changed, the rise would have been by a factor of $(4)^{1/4}$ (about 1.41). In terms of the analysis to follow, $T_1 = 2.28$, $F_1 = 1.75$, $I_1 = 1$.

that is, an index of income under the supposition that technology did not change but factor inputs did. I_1 can be considered an index of "interaction" between technology and factor inputs.

Suppose initially that there was no interaction, i.e., $I_1=1$. A familiar line of reasoning enables us to set limits for T_1 and F_1. Utilizing the two observed slopes and assuming the contours are not convex, we find a lower limit for T of 2 and an upper limit of 2.5. Corresponding to these are upper and lower limits for F of 2 and 1.6.[1/]

If we drop the assumption of no interaction, the upper limits remain the same; but the lower limit for F_1 drops to 1.33 and the lower limit for T_1 drops to 1.[2/]

These limits depend on the usual, very general assumptions regarding production contours. These assumptions may be unreasonably general in the present analysis. If technological change has really contributed as little as nothing to growth (that is, if $T_1=1$ at the limit mentioned in the preceding paragraph), the contours are sharply cornered at both observed points. The existence of these corners could imply that only a historical accident prevented the share in income of either labor or capital from approaching zero; or, put another way, only accidentally was the price of labor relative to capital prevented from approaching zero (or infinity). The necessary accident is the occurrence of technological change shifting the contour corner in just the same ratio as the change in ratio of factor inputs.

The limits for T_1 and F_1 may be narrowed if we are willing to rule out occurrences approaching the extreme just mentioned. One possibility is to suppose that, while alternative courses of growth might have altered to some extent the historically observed stability in proportionate factor shares, we can realistically rule out situations wherein labor would have received more than nine-tenths of income or less than two-thirds of income. This would imply that F_1 lies between 1.49 and 1.89; and that T_1

1/ Pass a line through the origin and through the observation for the earlier period (equation C=L). This intersection with the price line for the later period, C=16-9L, is at the point (1.6, 1.6). It can then be seen that $f_1(4,4/3)=4 > f_1(1.6,\ 1.6)=1.6\ f_1(1,\ 1)$. Hence

$T_1=\frac{f_1(1,\ 1)}{f_0(1,\ 1)} = f_1(1,\ 1) < \frac{4}{1.6} = 2.5$. From the assumption $I_1 = 1$, $F_1 > 1.6$.

The intersection of C=3L with the price line for the earlier period, is at (2, 2/3). Since $f_0\ (4,4/3)= 2\ f_0\ (2,2/3)$ and $f_0\ (2,2/3) < f_0\ (1,\ 1)=1$, $F_1 = f_0\ (4,4/3) < 2$; and from $I_1 = 1$, $T_1 > 2$.

2/ The upper limits as derived in the preceding footnote, do not change because they do not depend on the assumption that $I_1 = 1$. To get a new lower limit for F_1, draw L=1 (passing through the first observation) and C=3L (passing through the second observation), and consider their intersection at (3, 1). It can be seen that $1 < f_0\ (3,\ 1) = 3/4 f_0\ (4,4/3)$, so that $F_1 = f_0\ (4,4/3) > 4/3$. To get a new lower limit for T_1, consider the intersection of C=4 and C=L. $4 < f_1\ (4,\ 4) = 4f_1\ (1,\ 1)$, So $T_1=f_1(1,\ 1) > 1$.

lies between 2.08 and 2.50. The 2.50 maximum for T_1 was established earlier. However, the minimum for T_1 is raised very substantially, and there is also some narrowing of the limits for F_1 in both directions. 1/

Figure 2 presents visually statements that have been made regarding T_1 and F_1. The point estimate first given (2.28, 1.75) for $\alpha = 3/4$ is shown. This lies on the curve $T_1 F_1 = 4$, which depicts admissable values of T_1 and F_1 if $I_1 = 1$. The square shaded area is a confidence region determined by the limits discussed in the preceding paragraph. The darker area in the center shows how the confidence region would be further circumscribed if one wished to rule out values of I_1 greater than 1.10 and less than .90. It may be noted that the previous analysis already implies fairly narrow limits for I_1, namely that it has a value between .847 and 1.29.

Consider now Table 1, which contains a further analysis of sources of growth. The last four columns of the table give estimates of the contribution of different kinds of increases in inputs to growth. F_C is an index of income under the supposition that capital input increased but that neither technology nor labor input changed. F_L is an analagous index for labor input. F_H and F_X subdivide labor input change into two further parts, respectively, investment in human agents and elimination of depressed groups.

1/ Consider the area north and west of (1, 1). If $\alpha < 9/10$, points where fo (C, L) = 1 must lie to the left of $C = 1/L^9$, which is the contour passing through (1, 1) from a Cobb-Douglas function where $\alpha = 9/10$. The inter-section with C=3L provides information to establish a minimum for F_1 in the manner shown earlier. If $\alpha > 2/3$, points on C = 4-3L might coincide with points where fo (C, L) = 1 between (1, 1) and (4/3, 8/9); to the left of (4/3, 8/9), points where fo (C, L)=1 must lie to the right of $C = 4\,4/3\,5L^2$, which is the contour passing through (4/3, 8/9) from a Cobb-Douglas function where $\alpha = 2/3$. This intersection with C=3L provides information to establish a maximum for F_1. The limits for T_1 are derived utilizing the same kind of reasoning in connection with the later observation rather than the earlier one.

Restricting α is only one possible way to set upper and lower limits for the rate of change of slope of the production contours. A reasonable alternative way of setting limits for this rate might be through contemplating relative price-quantity movements. Stability of relative factor shares implies that, historically, percentage increases in the ratio of capital to labor have been accompanied by equal percentage decreases in the price of capital relative to labor. Suppose we were willing to rule out situations where there was more than a threefold difference in percentage changes of the ratios. Referring again to the area north and west of (1, 1), this would imply that points where fo (C, L) = 1 lie between $3/L^2 + 1/C^2 = 4$ and $3L^{2/3} + C^{2/3} = 4$. These curves are obtained from $Sd(C/L) / (C/L) = d(dC/dL) / (dC/dL)$, with S = 3 and 1/3 respectively. As before, limits for F_1 could then be found; they are 1.51 and 1.91. Applying an analagous procedure to the later observation, limits for T_1 would be 1.71 and 2.43.

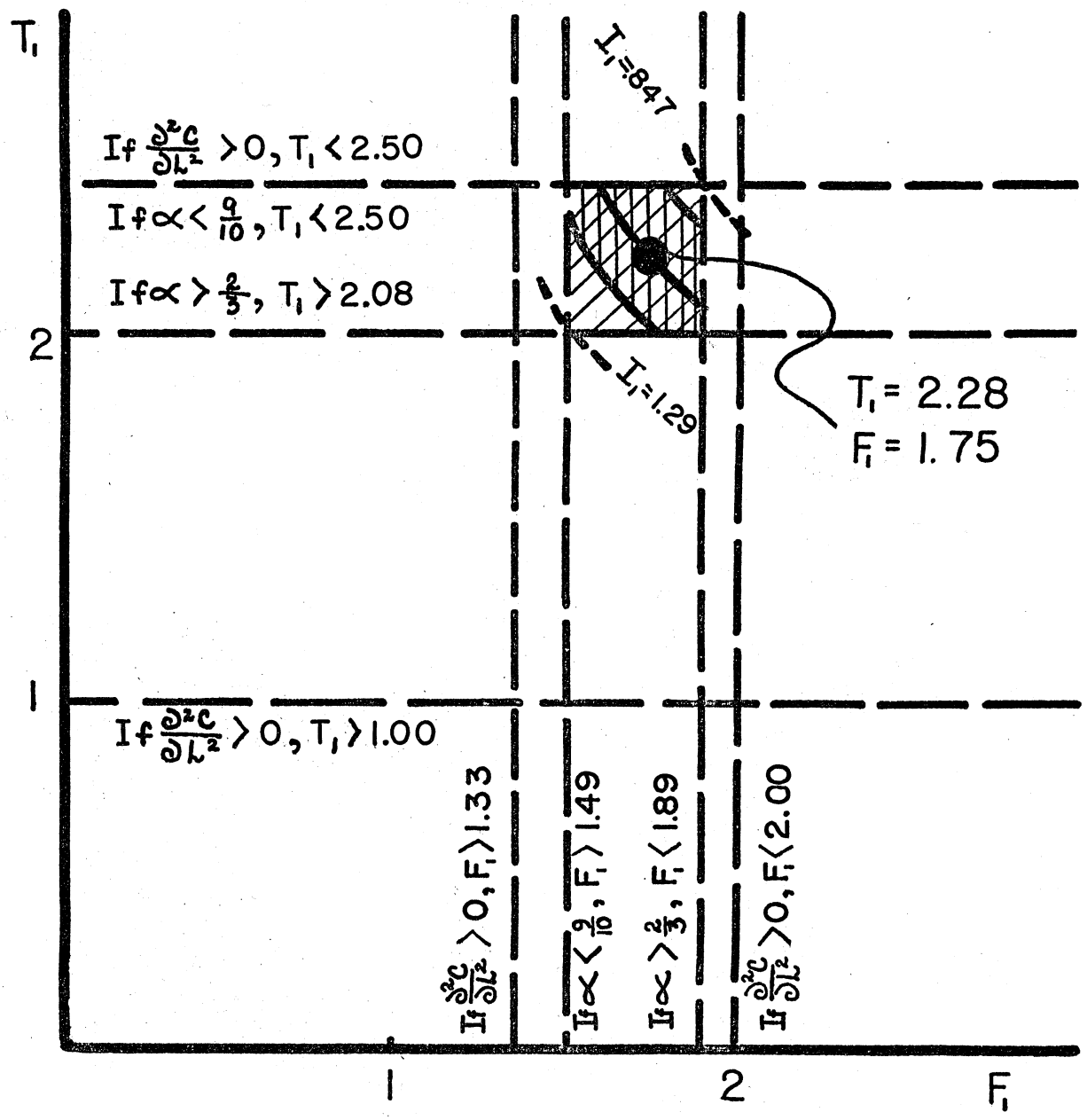
T_1
T_1=847
If $\frac{\partial^2 C}{\partial L^2} > 0$, $T_1 < 2.50$
If $\alpha < \frac{9}{10}$, $T_1 < 2.50$
If $\alpha > \frac{2}{3}$, $T_1 > 2.08$
2
T_1=1.29
T_1 = 2.28
F_1 = 1.75
1
If $\frac{\partial^2 C}{\partial L^2} > 0$, $T_1 > 1.00$
If $\frac{\partial^2 C}{\partial L^2} > 0$, $F_1 > 1.33$
If $\alpha < \frac{9}{10}$, $F_1 > 1.49$
If $\alpha > \frac{2}{3}$, $F_1 < 1.89$
If $\frac{\partial^2 C}{\partial L^2} > 0$, $F_1 < 2.00$
1
2
F_1

FIGURE 2

Table 1. Conjectured Sources of U.S. Growth

L_1	C_1	Y_1 (=T_1 F_1 I_1)	* T_1	F_1 (=F_C F_L)	* I_1	* F_C	F_L (=F_H F_X)	* F_H	* F_X
			2.52	1.23	1.29	1.23	1.	1	1
1	4	4	2.83	1.41	1	1.41	1	1	1
			3.23	1.56	.794	1.56	1	1	1
			2.08	1.49	1.29	1.15	1.30	1.14	1.14
1.33	4	4	2.28	1.75	1	1.41	1.24	1.11	1.11
			2.50	1.89	.847	1.55	1.22	1.10	1.10
			1.59	2.14	1.18	1.14	1.87	1.37	1.37
2	4	4	1.68	2.38	1	1.41	1.68	1.30	1.30
			1.75	2.50	.914	1.56	1.60	1.27	1.27

* These columns multiplied together equal Y_1 (=4).

We may refer to the figures which are underlined to review how the growth sources have been summarized in the table. The underlined figures might be viewed as a subjective estimate of the true situation, with the additional figures giving ranges based on alternative but perhaps less likely assumptions. The indexes marked with an asterisk multiplied together yield the index of actual change in income Y . Thus, we might say (reading the table backwards) that 1) elimination of depressed groups made an 11 per cent contribution to the increase in per capita income, investment in human agents also made an 11 per cent contribution, and capital accumulation made a 41 per cent contribution; 2) measurement of these input changes would have been the same regardless of changes in technology (since $I_1 = 1$); 3) changes in technology made a 128 per cent contribution; and 4) the 300 per cent increase in income was greater than the arithmetic sum of the preceding changes (i.e., 191 per cent) because these reinforced each other multiplicatively.

In view of the ranges given in the table, the inference seems justified that the relative importance--if not the precise magnitude--of these growth contributions is correct for the assumed set of inputs.

If we assume that the ratio of capital to labor quadrupled rather than tripled (this assumes no change in effectiveness of labor input, so that observed man-hours measure labor input), the relative contribution of technology is upped, but the general picture of growth is not changed drastically. If we assume that the ratio of capital to labor only doubled (effectiveness of average man-hour doubled), it can be seen that the relative contribution of technology and input changes would be almost reversed. This analysis indicates that, at the least, the contribution of technology has been very substantial; it also indicates that the possible importance of technology is minimized by implying large increases in effectiveness of labor input. 1/

Capital Accumulation Reconsidered

Although not entirely conclusive, the measurements indicate that technological change is probably the major contributor to U.S. growth, although non-negligible roles for neither capital accumulation nor increases in effective labor input can be ruled out.

Technological change in the classic view is exogenous, that is, erratic and unpredictable, and a given condition not explained by economic models. However, a more recent view makes growth associated with technological change less unruly. In this view, the finding of new

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1/ The estimates in Table 1 for labor inputs equal 1 and 2 are derived utilizing the same assumptions as those for labor input equal 1.33 discussed earlier. For each set of inputs, the middle estimate (where $I_1 = 1$) assume $\alpha = 3/4$. For each set of inputs, the first estimate corresponds to the lower left corner of the square confidence region as illustrated in Figure 2; the third estimate corresponds to the upper right corner.

The last four columns of the table are derived assuming $F_H = L^{X/2}$, $F_X = L^{X/2}$ and $F_C = C^{1-X}$. Since $F_H F_X F_C = L^X C^{1-X} = F_I$, $x = \log F_I - \log C_I / \log L_I - \log C_I$.
It is seen that the simple assumption throughout the table is that investments in human agents and elimination of depressed groups made equal contributions to growth.

techniques is an economic activity whose fruits depend upon the research inputs. Three examples may be noted that seem to support this view. First, the research expenditures of firms are clearly made in the anticipation of payoff. Second, dramatic strides in military technology result from research. Third, technological advance in agriculture is obviously related to the sizable government research expenditures directed toward this end. Perhaps even more convincing evidence in support of the view than the examples cited is the continuing nature of growth. We have concluded that technological change is a major contributor to growth, but growth has not been characteristically erratic and unpredictable as we might expect from technological change of the classical type.

To the extent that this view is correct, accumulation of techniques becomes similar to capital accumulation. Another possibly significant growth source considered above was investment in human agents. The similarity of this kind of investment to capital accumulation is even more obvious. It would seem meaningful for purposes of interpreting growth to define research and education expenditures as investment. This would make it clear that technological change of the persisting type and investment in human agents help resuscitate the original capital accumulation model.

Let us return to the measurements of the previous section and see how well growth appears to be explained by this re-interpretation of the capital accumulation model. Under the original interpretation, with only physical capital accumulation generating growth in the model, the fourth column of the table, F_C, would measure predicted growth--at the outside something like a 50 per cent increase in per capita income. Under the new interpretation T_1 and F_H might also be included, or all the growth contributors except F_X. The model would then account for a three- to three-and-a-half-fold rise in per capita income, that is, the vast majority of growth. This estimate is of course crude. All technological change is considered to be of the accumulation variety, even though technological change has not been entirely free from erratic spurts. The division of F_L into F_H and F_X, also important to the estimate, is rather arbitrary. Nonetheless, the figures surely indicate that the accumulation model properly interpreted accounts for a vastly greater amount of growth than would be suggested by physical capital input alone. 1/

Even granted the validity of the capital accumulation model in interpreting this period of U.S. growth, however, we have not suggested explanations of the more ultimate determinants of growth. Given the model, these include the savings rate and the productivity of investment in capital, technology, and human agents. Our major conclusion is, rather, that these instead of other magnitudes are the important growth determinants.

1/ In an earlier footnote we referred to the relation of the capital accumulation model to criteria of efficient resource use. The re-interpreted accumulation model does not bear such a close relation. There may be under-investment in technological improvements because, if they are copied, the social return is greater than the private return in making the research expenditures. Investments in human agents may not be undertaken efficiently because of the difficulty of borrowing and lending to finance these investments.

Growth of Regions Within the U.S.

An oft-repeated, but undoubtedly crucial, difference between a region and a whole economy is that in regional analysis, we cannot abstract from relations with other regions. That is, regions cannot appropriately be treated as closed economies. One model of regional growth would visualize the human resources and the non-natural capital resources as mobile between regions. If this model is valid, regions expand and contract with movements in the demand for their products; and their growth need have no particular relation to national growth.

A modification is suggested by the only reference to geographical location that occurred in discussion of national growth. We might allow for labor immobility, thus introducing the possibility of region-connected depressed areas. The South would offer a prime example. The natural resources of a region, of course, lack mobility. There may be productive region-connected investments such as those involved in regional water resource development programs, and we are all aware that the effect of such development programs on a region can be large. What is their contribution to national growth? The contribution is reflected in the higher rate of return over alternatives which the investments yield. If the rate of return is high, the investment will make some contribution toward maximizing national income at any moment, but the effect on the growth processes of the nation may be negligible.

The relation between regional growth and national growth is thus tenuous. Regional development programs in and of themselves make their greatest contribution if they have impact on backward areas. The implication is clear that unless they do this, or are productive investments in their own right, regional development as an end in itself will be at the expense of more rapid growth in other regions. If our analysis of growth in the U.S. was valid, the contribution of regional development to national growth is small for the role of depressed areas in growth in our analysis was small.

Conclusion

The main line of reasoning in this paper has been as follows: We first rejected the classical growth model because physical capital accumulation does not seem sufficient to account for observed U.S. growth; we then introduced some additional sources of growth and attempted to measure the contribution of each. A central phenomenon in these measurements is the rising real price of labor for the period in question. That is, the increase in earnings per man-hour in the economy as a whole has been the result more of wage increases for all types of labor than of transfers from low-paying to high-paying occupations. Inferences as to the relative contribution of labor, capital, and technology to growth were made assuming increases in the ratio of capital to labor of two to one, three to one, and four to one. We concluded that capital accumulation processes more broadly interpreted fare well in explaining recent U.S. growth.