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U.S. ECONOMIC GROWTH FROM 1976 TO 1986: PROSPECTS, PROBLEMS, AND PATTERNS

Volume 11—Human Capital

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MAY 24, 1977

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LETTERS OF TRANSMITTAL

MAY 24, 1977.

To the Members of the Joint Economic Committee:

Transmitted herewith is the eleventh volume of the Joint Economic Committee study series entitled "U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns." This series of over 40 studies forms an important part of the Joint Economic Committee's 30th anniversary study series, which was undertaken to provide insight to the Members of Congress and to the public at large on the important subject of full employment and economic growth. The Employment Act of 1946, which established the Joint Economic Committee, requires that the committee make reports and recommendations to the Congress on the subject of maximizing employment, production and purchasing power.

Volume 11 comprises five studies which examine various ways in which human resources contribute to economic growth. Those areas specifically examined are population growth, labor force growth and composition, and education, The authors are Profs. S. Fred Singer and Bradley W. Perry, Dr. Marvin J. Cetron and Ms. Sharon E. Sugarek, Dr. Charles T. Bowman, Dr. James O'Toole and Dr. Stephen P. Dresch. The committee is indebted to these authors for their fine contributions which we hope will serve to stimulate interest and discussion among economists, policymakers and the general public, and thereby to improvement in public policy formulation.

The views expressed are those of the authors and do not necessarily represent the views of the committee members or committee staff.

Sincerely,

RICHARD BOLLING,
Chairman, Joint Economic Committee.

MAY 19, 1977.

HON. RICHARD BOLLING,
Chairman, Joint Economic Committee,
U.S. Congress, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith are five studies entitled "The Economic Effects of Demographic Changes" by Profs. S. Fred Singer and Bradley W. Perry, "Zero Population Growth and Economic Growth" by Dr. Marvin J. Cetron and Ms. Sharon E. Sugarek, "The Labor Force, Employment, and Economic Growth" by Dr. Charles T. Bowman, "Different Assumptions, New Tools: A Futurist's Perspective on Employment and Economic Growth" by Dr. James O'Toole, and "Human Capital and Economic Growth: Retrospect and Prospect" by Dr. Stephen P. Dresch. These five studies comprise volume 11 of the Joint Economic Committee study series "U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns." This series forms a substantial part of the Joint Economic Committee's 30th anniversary study series.

These studies, which examine various facets of the interaction between human resources and economic growth, demonstrate that many important changes are taking place in the degree and manner of their contribution to economic growth. They are taking place in such critical areas as population growth, labor force growth, the utilization of our human resources, and the contribution of further education to economic growth.

In examining the economic effects of demographic changes, Profs. Singer and Perry concluded that the United States will be better off with lower fertility rates, both in the short run of 10 years and the long run of 50 years. They found no economic difficulties inherent in zero population growth. This conclusion is supported by the fact that per capita income is greater under zero population growth.

Dr. Cetron and Ms. Sugarek also conclude that GNP per capita will be greater under zero population growth than it is in a growing population. They argue that even at the highest assessed economic growth rate of 3 percent population growth will be such that few families will be able to improve their standard of living by 1990. This leads to their second conclusion that it is essential to maintain economic growth regardless of the stabilization of population size. They find that standards of living for all would fall at zero economic growth and that economic growth of greater than 2 percent would be the minimum to ensure rising per capita wealth.

The Bureau of Economic Analysis has developed an informative body of data concerning the future of the labor force and how this will relate to economic growth. Their main conclusions, in the paper by Dr. Bowman, are the following: (1) The labor force growth rate will begin to slow down in the next few years and will be growing by the 1985–90 period at only about 40 percent of the rate of the last 5 years; (2) the proportion of teenagers and young adults in the labor force will fall sharply and the labor force will become considerably older over the decade of the 1980's; (3) the shifting age distribution of the labor force should make attainment of a low overall unemployment rate successively easier from now to 1990, assuming other factors are unchanged; (4) a recovery in productivity and lower unemployment rates may keep the rate of growth in the GNP from reflecting the labor force slow down until 1985, but a significant slow down in GNP growth is likely by at least the late 1980's; (5) sectoral shifts in employment are likely to have a smaller impact on GNP growth in the future then over the last 20 years.

A primary theme in the paper by Dr. O'Toole is that one of the major manpower problems facing America in the next three decades will be underemployment. He states that about 80 percent of all recent college graduates are underemployed and about 35 percent of all workers report that their potential is not being realized on their jobs. He stresses the seriousness of this by showing that since people spend over half their waking lives on the job, the quality of working life is thus the most important manifestation of the overall quality of life. His investigation showed that the quality of working life will probably deteriorate through the early 1980's but should start to improve to current levels by 1985.

In examining the contribution of education to economic growth, Dr. Dresch concludes that it must ultimately be considered tenuous. Investment in human capital, he argues, would primarily bring about temporary increases in the growth rate, not an increase in the fundamental, underlying rate of technological advance. He also argues that the highly educated labor market is saturated as reflected in a decline in earnings differentials associated with higher education. This deterioration in incentives for college attendance and completion will induce, in the 1980's, a significant decline in the rate of college attendance on the part of many young people. His analysis leads to the conclusion that over the next 25 years, opportunities facing young people will deteriorate, resulting in downward shifts in the relative status of successive generations, even to the point that children born to persons entering adulthood in the 1950's and 1960's will, on average, experience relatively lower economic status than their parents.

The committee is deeply grateful to these authors for these very challenging papers. Profs. Singer and Perry are with the Department of Environmental Sciences of the University of Virginia, Dr. Cetron and Ms. Sugarek are at Forecasting International, Dr. Bowman is with the Bureau of Labor Statistics, Dr. O'Toole is with the Center for Futures Research at the University of Southern California, and Dr. Dresch is director of the Institute for Demographic and Economic Studies.

Dr. Robert D. Hamrin of the committee staff is responsible for the planning and compilation of this study series with suggestions from other members of the staff. The administrative assistance of Christal Blakely of the committee staff is also appreciated.

The views expressed are those of the authors and do not necessarily represent the views of the members of the committee or the committee staff.

Sincerely,

JOHN R. STARK,
Executive Director, Joint Economic Committee.

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HUMAN CAPITAL AND ECONOMIC GROWTH: RETROSPECT AND PROSPECT

By Stephen P. Dresch

THE ECONOMIC EFFECTS OF DEMOGRAPHIC CHANGES*

By S. FRED SINGER *and* BRADLEY W. PERRY **

SUMMARY

This paper addresses the fundamental question: "In what ways do demographic variables affect economic growth"; as well as the short-run question: "What will be the net economic effect from changes in demographic variables over the next decade." Fundamental to the analysis is the fact that the magnitude of the full-employment GNP is related to the size of the labor force.

Using three fertility scenarios adapted from the most recent Census Bureau projections, we find that aggregate GNP is greatest in the long run for the high fertility scenario—the traditional result. But also, natural resource depletion and pollution abatement costs are highest. As a result, per capita economic welfare as measured by our specially constructed Q-index is lowest for this scenario. In the short run (up to 20 to 25 years), however, GNP is lowest for this scenario because child-rearing responsibilities reduce the size of the labor force.

The lowest fertility scenario, which will lead to a declining population after the year 2020, produces the greatest per-capita economic welfare, as measured by a discounted stream of Q-indices.

The initial effect of decreasing fertility is a slight increase in the labor force because of increased female labor participation, thereby increasing aggregate GNP. Eventually, the reduced labor force would lead to a lower GNP, but to greater per capita welfare because of reduced requirements for investment, resources, and environmental costs. Under this lowest fertility scenario there are the fewest dependents as a fraction of the population, at all times. Expenditures for education and child care are reduced, while medical expenditures do not increase as a fraction of consumption. The resulting trend to smaller families and increased per capita income produces a shift to relatively greater housing and house-furnishing expenditures. In general, there is a shift also to travel and recreation activities.

These results were obtained through the use of a mathematical simulation model of population, resources, and environment, which is described in the text and appendices. Numerical results are presented in tables and figures. The results are still tentative since we have not fully explored their sensitivity to all possible demographic, economic, and resource assumptions.

*Support has been furnished by the Center for Population Research of the National Institutes of Health, HEW. Initial seed moneys came from the Population Council and from the Center for Advanced Studies of the University of Virginia. The University of Virginia has also contributed generously by furnishing the academic salaries of the researchers. We wish to acknowledge the significant contributions which Henry R. Burt and James Morris made to this project as graduate research assistants.

**Department of Environmental Sciences, University of Virginia, Charlottesville, Va.

In summary, a near-zero population growth rate (ZPG) and economic growth, in the sense of per-capita welfare, are fully compatible. In fact, ZPG, or even a slightly negative population growth rate, leads to the greatest growth in per capita economic welfare. Our model calculations also show capital investment and industry expansion somewhat reduced, and the shift in consumption from manufactured goods to services accelerated. But also, the rates of natural resource depletion and of environmental degradation would be reduced.

I. How Is Economic Growth Affected by Demographic Variables?

Will reduced population growth lead to reduced economic growth, and would this be a bad thing? This is not a new question, but general opinion as to the answer has shifted drastically in the last decade, first because of environmental awareness, then because of the energy crunch, and finally because fertility rates dropped below replacement level. This last fact, by bringing about the possibility that zero population growth (ZPG) may occur much sooner than anyone expected,[1] has caused some to have second thoughts. Will ZPG, much praised in the late sixties and early seventies, necessarily be good?

The population growth project at the University of Virginia has been investigating this question for the past 5 years. The answer is a qualified "Yes," with suggestions that a very gradually declining population might be best.

Our method used in arriving at these conclusions, a mathematical simulation model of population, resources and environment, is documented in the appendixes, particularly in appendix III and appendix IV. Here we will briefly describe the model as a context for discussing the relationship between population, economic growth and economic welfare.

Our model starts with a demographic submodel (see appendix IVA) which projects the future population level and age distributions on the basis of assumed fertility patterns. In section II we report results for three fertility patterns: completed fertility at about the 1971 rate, 30 percent above, and 20 percent below this rate.[2]

The demographic submodel also arrrives at a labor force, based on recent trends in labor participation rates. We assume that female labor participation rates increase as fertility rates drop. This means

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[1] In actual fact, our population will continue to increase in number in spite of the drop in fertility, since the number of females capable of having children will be increasing over the next few years as a result of a past baby boom. Further, legal immigration, presently about 400,000 immigrants amounts to about one-quarter of native births. It can be shown that under the age distribution which exists now in the United States a true zero growth of population would not be reached until approximately 50 to 60 years from now. See footnote 2 and the discussion in "Population and the American Future" (The Report of the Commission on Population Growth and the American Future). The New American Library, Inc., New York, 1972.

[2] In these three scenarios we follow the census series I, II, and III proiections. These series assume an annual net immigration of 400,000 and completed fertility rates, i.e., the average number of lifetime births per woman of: I—2.7; II—2.1; III—1.7. For a detailed discussion of these series see: Bureau of the Census, U.S. Department of Commerce, "Proiections of the Population of the United States," Current Population Reports, Series P-25, No. 601 (October 1975). For the differences between our scenarios and the census series, see footnote 6.

The level of immigration, both in the census series and in our scenarios, assumes only legal immigration; Illegal immigration, for which there are no official statistics, probably exceeds that which is legal.

It should be noted explicitly, that none of the scenarios, nor any of the regular census series, leads to exact zero population growth (ZPG). In order to do this one would have to have a fertility rate which varies inversely with cohort size, approaching a completed fertility rate slightly less than two. This is encompassed by our scenarios II and III. The latter uses the fertility rate of 1.7, reaches a population of 251 million in 2019, and then declines gradually.

that the short-run effect of lower fertility rates is an increased labor force. Lower fertility rates do not affect the size of the working age population right away. A person born today will probably not enter the labor force for 20 years.

We combine the labor force with a growing capital stock to give an overall estimate of the productive capacity of the Nation and therefore of the potential GNP (see appendix IIB and IVB). From GNP we first set aside a certain fraction for investment, currently of the order of 15 percent, to replace and expand the capital stock to keep pace with the expanding labor force. The remainder is consumed by private individuals and by the various levels of government. Because less investment means more consumption out of the same total GNP, in the long run ZPG would provide a greater per-capita consumption, including government consumption, just because less investment would be needed.

From GNP (less investment) and from survey data on consumer expenditures, we deduce how the population spends its income (see appendix IVC). This consumption pattern of the population depends on age, income, geographic location, size of household, et cetera. Such data are available, and can be reasonably extrapolated. In any case then, so much for food, so much for housing, so much for clothing, so much for medical care, et cetera, which together with government consumption expenditures, must add up to the total consumption of that year.

To obtain the resulting levels of industry activity (see appendix IVD), we construct a final demand vector, whose sum is GNP, by adding investment and net exports to consumption. Included are of course expenditures for capital equipment, to replace what has worn out, and for additional machinery. This final demand vector then drives the industrial economy, that is, we assume that industry produces what consumers and government demand. Industrial production is simulated by means of an interindustry input-output table which keeps track of what various industries buy from each other, that is, the intermediate products and goods that are necessary in order to fill the final demand of government and the consumers. This 185-sector input-output table, although complicated and detailed, gives us a self-consistent accounting of the economy. It also produces estimates of the natural resources that are required in order to fulfill the consumption demand, and it allows us to calculate the environmental impact and required pollution costs (see appendix IID and IVF).

In a separate resources submodel (see appendix IIC and IVE), we simulate how resource costs should increase as the most readily available resources become depleted and as the cost of obtaining additional resources rises. These incremental resource costs are further increased as a consequence of the increased demand produced by economic growth and population growth. In a price submodel (see appendix IVH), both incremental resource costs and the environmental costs are added on and thereby change the relative prices of various goods. In the final feedback of the model, the consumer reacts to these changing prices by modifying his demand schedule. He buys less of goods which have risen in price, and thereby discriminates against those goods that either consume too much in the way of resources or create too much pollution in their manufacture or in their operation. Our mathematical model therefore tries to simulate as closely as possible the way in which the economic system actually works. And it tries to do this in a self-consistent way by employing input-output analysis.

At the end of the computer run, a welfare-index submodel (see appendix IV I) combines all of the results for each year into a single index, the Q-index, which measures real per capita consumption. (A full discussion of the index may be found in appendix II.) This procedure does not modify any of the previous results, and is easy to change so that different judgments as to what constitutes welfare may be used to compare scenarios. The judgments we use are presented in table 2, appendix IIA.

To summarize, then, the size of the potential GNP is related to the size of the labor force, the stock of capital, and the projected productivity.[3] The initial effect of decreasing fertility rates should be a slight increase in the labor force, increasing potential GNP. Eventually, ZPG leads to a reduced labor force, therefore to reduced requirements for investment and to greater per capita consumption.

What about the longer run? Eventually a somewhat different age structure will result. But the age structure resulting from ZPG will have fewer dependents relative to the total population.[4] True, a greater proportion of the dependents will be elderly people with higher medical expenses. But more children would have required a higher level of education expenditures.

A second long-run effect occurs in economies of scale. The lower fertility scenario will eventually result in an economy which is smaller than that of a higher fertility scenario. In the private sector, economies of scale—namely, advantages of plant size and number of plants—have been largely accomplished. In the public sector, however, there can be some further economies of scale. For example, the amount of public goods required does not rise as rapidly as population in such areas as defense and scientific research and development.

The results of our computer model, described in the next section, quantify this analysis. The preliminary answer from complete model studies is that ZPG and economic growth are not only compatible, but ZPG may lead to greater growth in per capita consumption; that is, in real per capita income and in per capita economic welfare.

II. Results of Three Fertility Scenarios

There are many kinds of results and these can best be visualized by glancing at typical results from a computer run.

The assumptions are shown in table 1a, and major results for the year 2020 are shown in figure 1b. Here we will comment on some of the prominent results. The main one certainly is that per capita welfare will continue to increase for the next 50 years.[5] In the meantime, however, much can happen in the way of technological change,

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[3] It is assumed implicitly that productivity does not depend on population, whereas the size of the labor force, and thence of the capital stock, do depend on the size of the population.

[4] A fixed level of fertility will lead eventually to a fixed age structure, all other things being equal, even in a declining population. This can be seen by recognizing that the number of children below age 1 each year are in constant ratio to the number of women of childbearing age. See for example, N. Keyfitz and W. Flieger, "Population, Facts, and Methods in Demography," W. H. Freeman & Co., 1971, pp. 24–27.

[5] This assumes a surprise free future and is the result of a series of runs of the computer model using extreme but realistic scenarios.

and this fact makes projections beyond 30 to 50 years quite uncertain. Of particular interest, of course, are differential results, obtained by running the model with one of the main assumptions slightly changed. Since we are primarily interested in the effects of population growth, we present the results from three runs having different fertility assumptions (see footnote 2). We label the three runs series I, II, and III following the census series.[6] The population over time for the three runs is shown in figure 1. Run III is seen to lead to a maximum in approximately 50 years, declining thereafter. This is not a constant level and thus is not technically ZPG.

TABLE 1a.—*Assumptions and Parameters Used in Computer Runs*

Fertility: The age-specific fertility of 1974, trended with a 5-year half-time to a completed fertility per woman of,
Run I: 2.7 children.
Run II: 2.1 children.[1]
Run III: 1.7 children.
Mortality: 1974 values held constant.
Immigration: assumed constant at 400,000.
Labor Participation Rates: 1974 rates and following recent trends. Adjustments are made in the different runs for women of childbearing age.
Unemployment: 8 percent for 1975, trended to 4 percent with a half-time of three years.
Work Hours: 40 per week in 1975, decreasing by 10 percent with a half-time of 25.5 years.
Labor Productivity: Annual rate of increase begins at 2.4 percent per year in 1975 and decreases to 2.0 percent per year with a half-time of 15 years.
Geographic Distribution of Population: Present trends are extrapolated.

[1] Without immigration and with a smooth age distribution this completed fertility rate would lead to ZPG. However, with the assumed immigration rate a value somewhat less than 2.0 must be used (The Census Series II-R accomplishes this with a rate of 1.976). Further, to compensate for the past variations in fertility, which led for example to the "baby boom" of the 1950's, fertility must be varied inversely with the size of the child-bearing population.

TABLE 1b.—RESULTS OF THE MODEL FOR THE YEAR 2020

Fertility	2.7	2.1	1.7
Population (millions)	380	297	251
Labor force (millions)	184	158	141
Capital stock (trillion 1958 dollars)	9.0	8.3	7.8
GNP (trillion 1958 dollars)	4.4	3.8	3.4
GNP per capita (thousand 1958 dollars)	11.5	12.7	13.5
Q-index (100 in 1975)	227	253	269

[6] Our population scenarios are based on the same assumptions as the census series but are not identical to them. Completed fertility, 2.7 for series I, 2.1 for series II, and 1.7 for series III, and legal immigration of 400,000 per year are the same. But our demographic model trends age-specific fertility whereas the census projections trend completed fertility for a given cohort. We use our own demographic submodel in these runs. We begin with the estimated population and actual fertility rates for 1974 to arrive at an estimate of the 1975 population, and trend total completed fertility to the census values with a half-time of 2½ years, beginning in 1975. Thus, half the change is accomplished by mid-1977, 75 percent by 1980, et cetera. Fertility rates were obtained from Public Health Service, USDHEW, Monthly Vital Statistics Report, vol. 24 No. 11, Suppl. 2 (February 1976). Mortality rates were obtained from this same publication, vol. 24, No. 13 (June 1976).

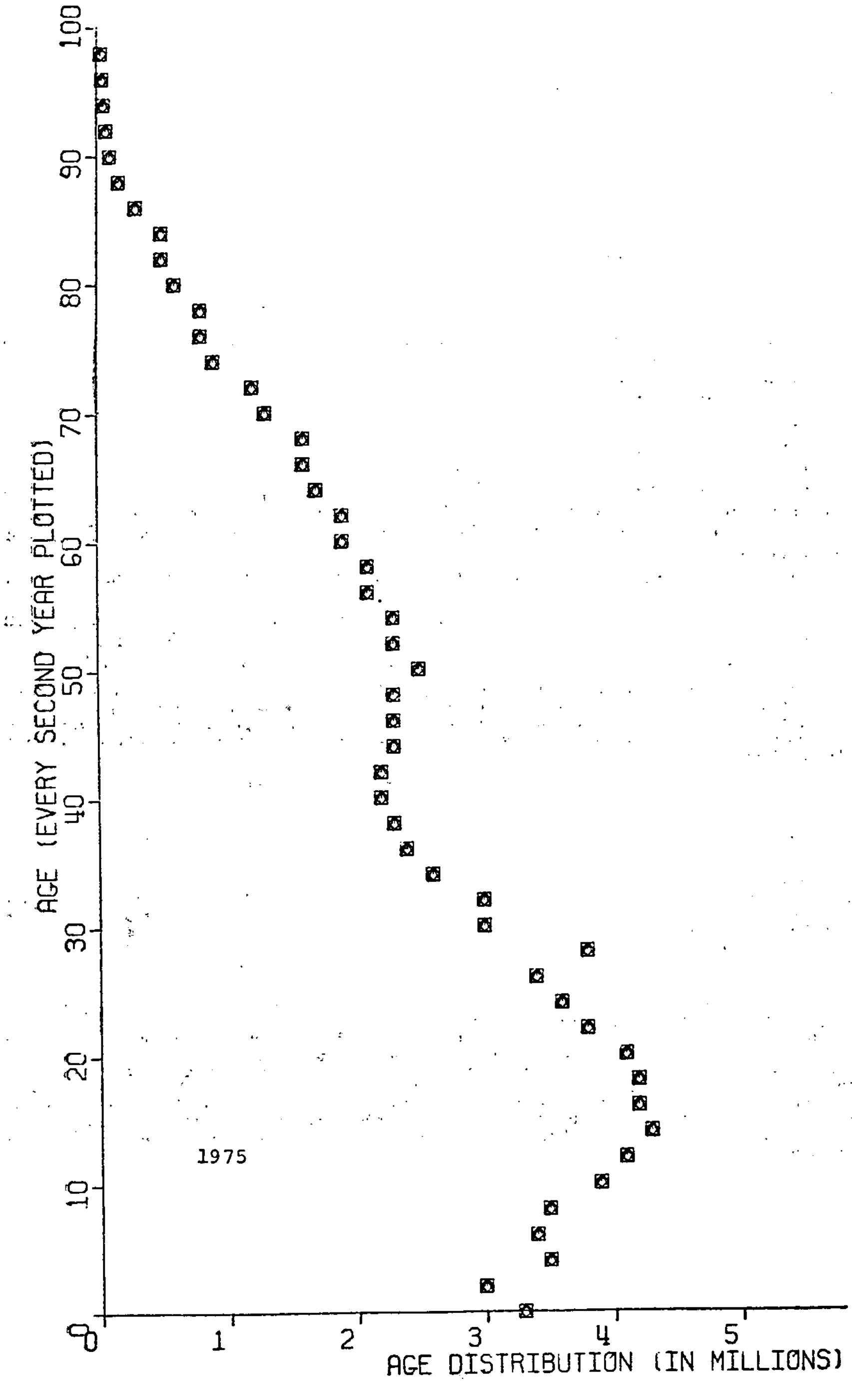
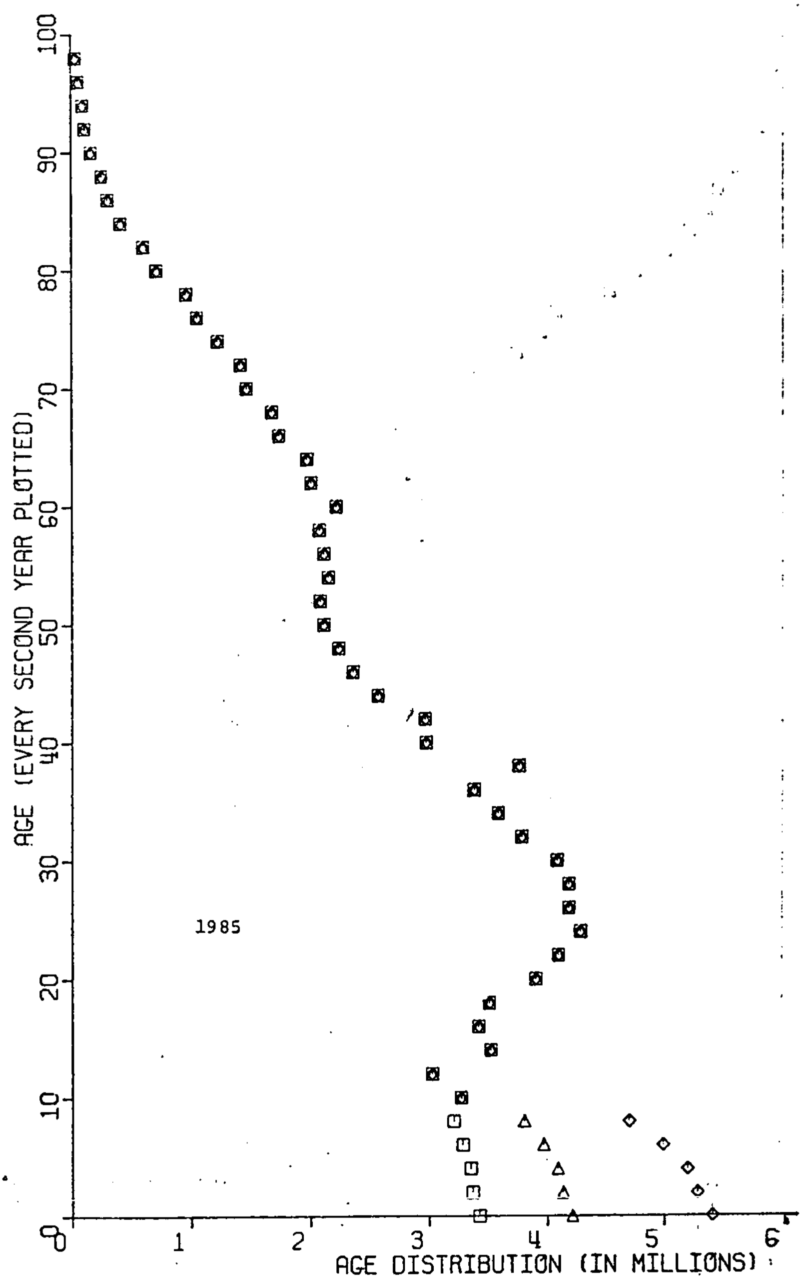


Figure 1.—Age distribution of the U.S. population in 1975. Points are plotted for every second year and include both male and female components. We have updated the census estimates for 1974 to obtain these values. (See footnotes 2 and 6.)



(□); 2.1 children (△); 2.7 children (◇). (See footnoes 2 and 6).

FIGURE 2.—Age distribution of the U.S. population in 1985. Points are plotted for every second year and include both male and female components. To obtain these results we use our demographic model and three fertility assumptions: Completed fertility per adult woman of 1.7 children.

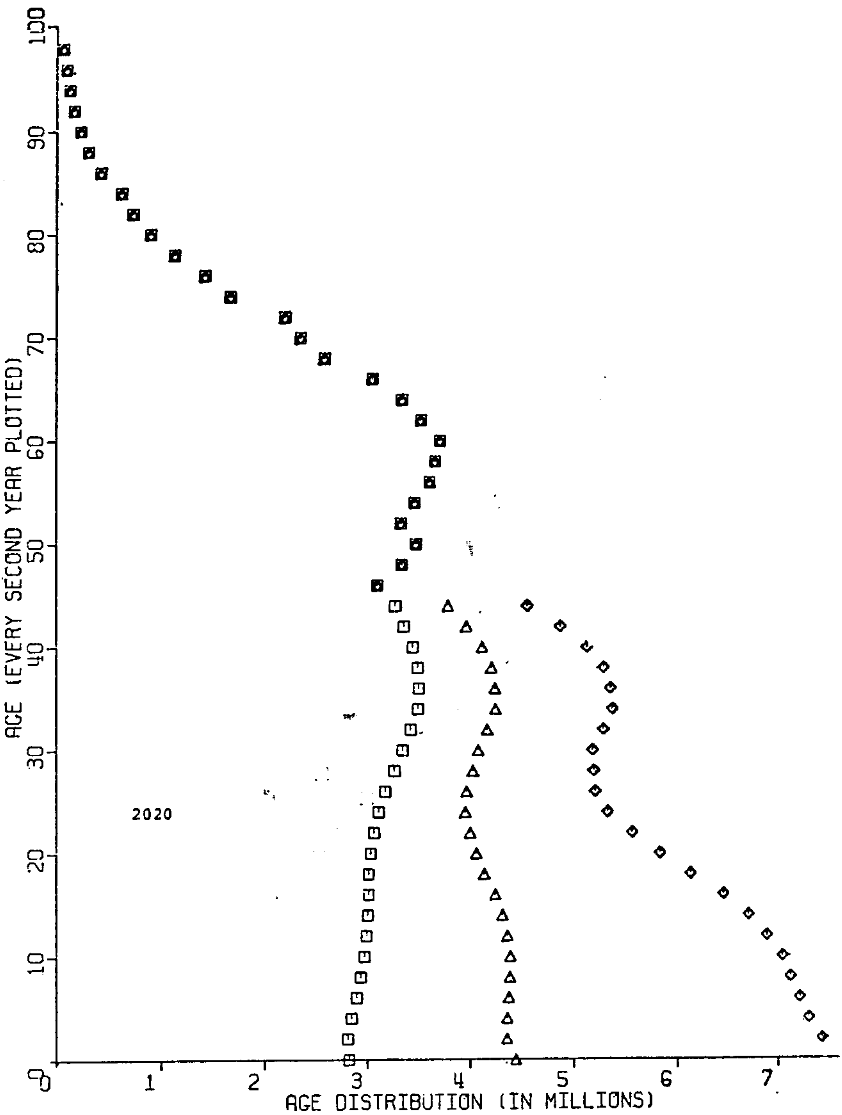


FIGURE 3.—Age distribution of the U.S. population in 2020. Points are plotted for every second year and include both male and female components. To obtain these results we use our demographic model and three fertility assumptions: Completed fertility per adult woman of 1.7 children (□); 2.1 children (△); 2.7 children (◇). (See footnotes 2 and 6.)

The most important changes occur in the demography of the Nation. As seen in figure 4, the U.S. population in the year 2020 would be 251 million under the lowest fertility scenario, compared with a population of 380 million using series I fertility. The age distributions under these two assumptions would be radically different. Comparison of the age distributions for the three scenarios in 1985 (Fig. 2) and in 2020 (Fig. 3) with that of 1975 (Fig. 1) shows these differences dramatically.

First we note that the distributions projected for 1985 are identical except for the number of children below age 10. The only differences among the three scenarios for 1985, then, are a result of the presence or absence of these children. These differences will result primarily in different consumption of education, medical care, and housing.

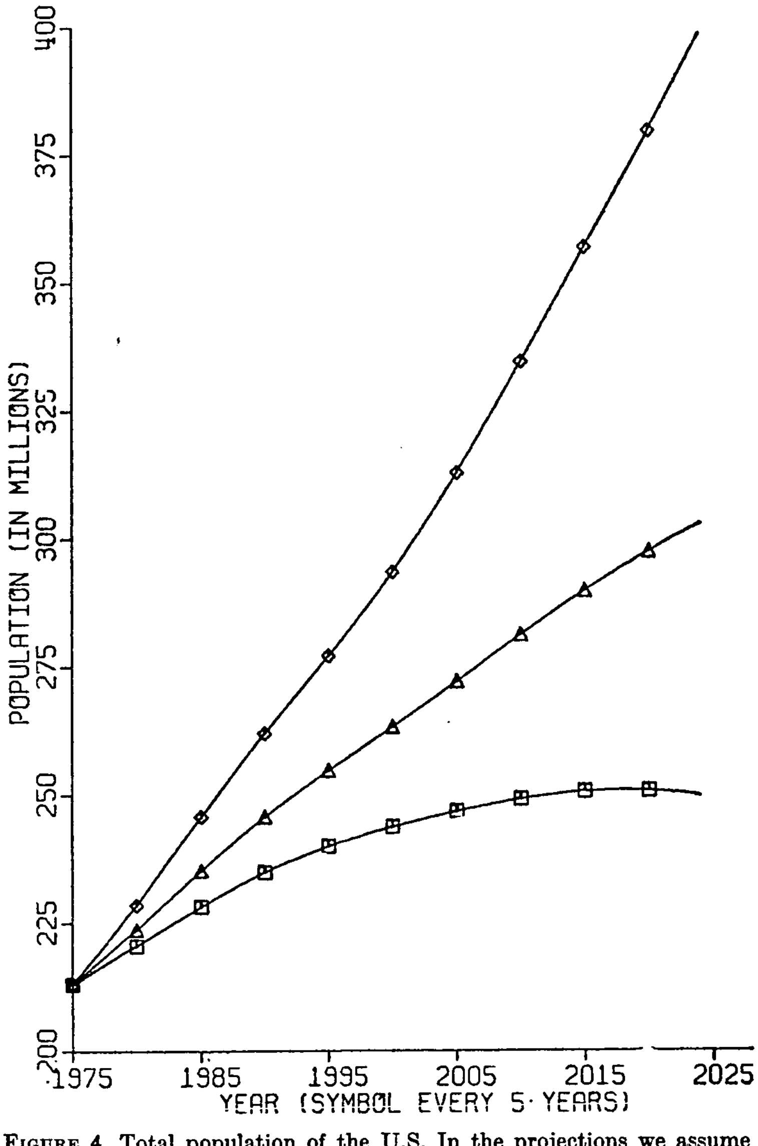


FIGURE 4. Total population of the U.S. In the projections we assume constant net immigration of 400,000 per year and completed fertility per adult woman of 1.7 children (□); 2.1 children (△); 2.7 children (◇). (See text and footnotes 2 and 6.)

The second thing to note is the presence of the (ca.) 1960 "baby boom" and its "echoes". This group is presently entering the labor force and beginning family formation. In 1985 we see the first echo, amplified in the higher fertility scenarios. By the year 2020 the baby boom cohort is reaching retirement, its first echo is in the productive years, ages 34–44, and a second, quite damped, echo is in its teens.

These oscillations in the age structure are averaged out in the curve of total population (Fig. 1) but show up markedly in the dependency ratio (Fig. 5), the ratio of population of nonworking age to that of working age (assumed to be ages 18–65). The peak in the dependency ratio at about 1993 is a result of the first echo. The rise in 2020 results from the retirement of the baby boom cohort. These oscillations affect the gross national product (GNP) only slightly (Fig. 6), per capita GNP and welfare somewhat more (Fig. 10), but more so educational expenditures (Fig. 7) and medical expenditures (Fig. 8). The effects on taxation and government transfer payments implicit in these results are not shown, but are substantial and may cause political difficulties. These effects will be more closely examined in the later analysis of the economy and of per capita welfare.

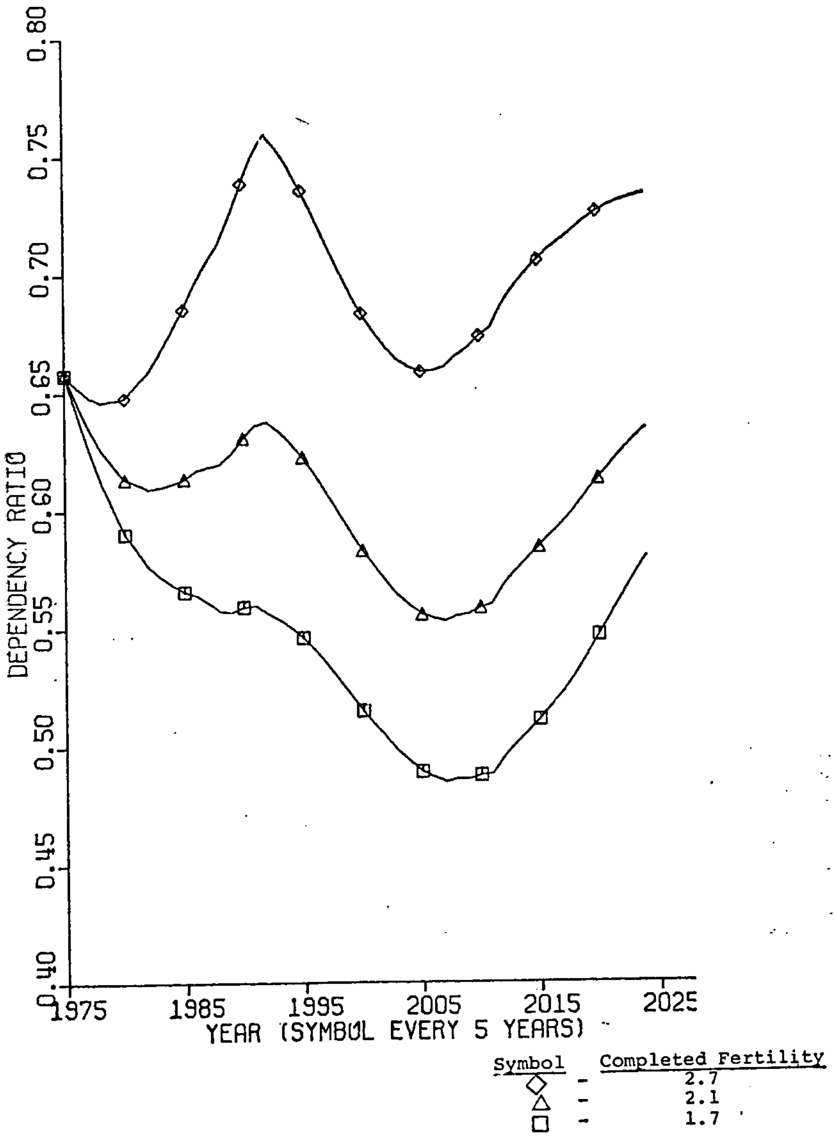


FIGURE 5.—Dependency ratio (nonworking age population to that of working age, 18–65 years).

The results for GNP of the econometric model are shown in figure 6 and summarized for the year 2020 in table 2. For the highest fertility scenario, population is 51 percent higher than for the lowest fertility scenario, labor force 30 percent higher, capital stock 15 percent higher, but per capita GNP is 15 percent lower, and the Q-index is 16 percent lower.

At first glance, the results of table 2 would seem to provide arguments against no growth. The United States would appear to be comparatively worse off, both domestically and internationally, under a low-growth situation. American business would seem to suffer since far less would be demanded and sold, and therefore profits would be less. Expectations for the future growth of the economy would be lessened, thus decreasing incentives for investment, entrepreneurial risktaking, technological advancement, product innovation, business ventures, and so forth. The U.S. position internationally might be hurt since total GNP would be lessened under no growth, and thus the American clout abroad would be less relative to other countries whose GNP's would be at normal levels. American trade would be hurt, since fewer goods and services would be produced for export, while other countries would be normally increasing their production of exports as their GNP's and populations rose.

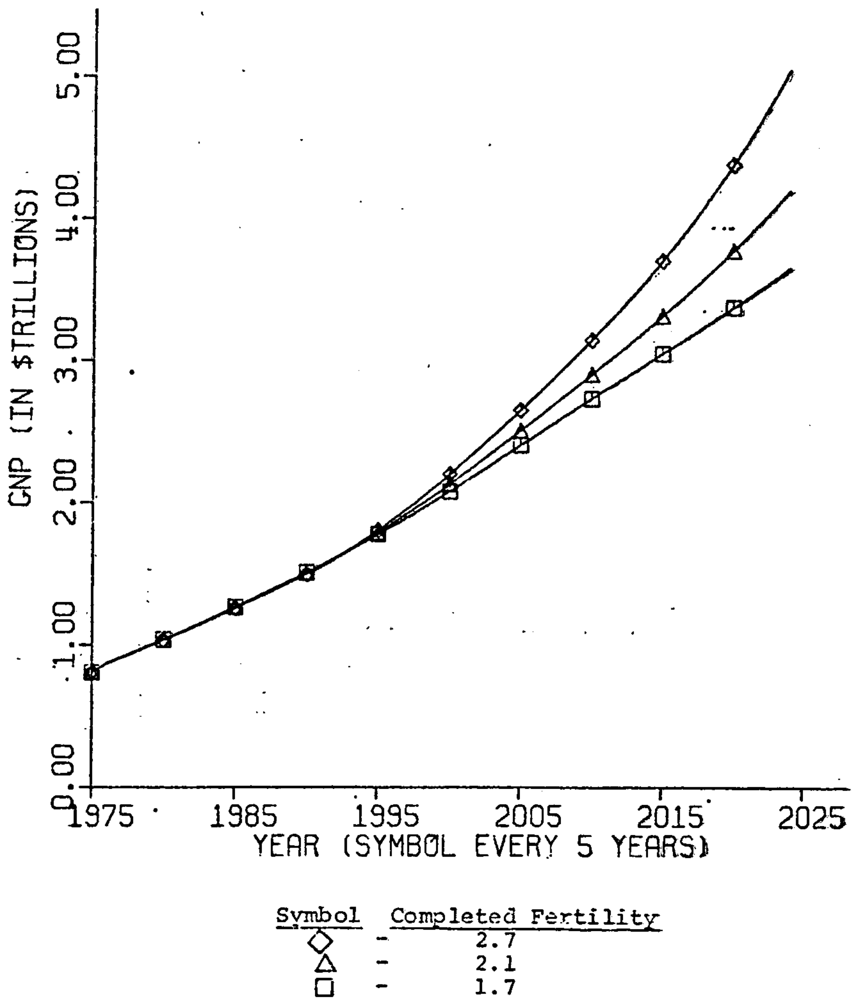


FIGURE 6.—Gross national product (GNP) in 1958 dollars.

However, the arguments presented above are misleading, and the conclusions drawn from them are incorrect. In fact, U.S. businessmen, individually, will be better off under low growth. While there may be fewer aggregate sales and profits over the entire economy, sales and profits per company or per store or per individual would be greater. This conclusion is supported by the fact that per capita income is greater under ZPG. For similar reasons, the inducement for entrepreneurial risktaking is not necessarily lessened. In fact, inducements for continued investments, product innovations, business formations, and similar business growth elements might still increase under ZPG for the following reasons:

1. The increased amount of personal discretionary income under ZPG would enable individuals to maintain a level of consumption at least equal to that under present trends, at the same time saving more.
2. The higher personal discretionary income would call forth additional goods and services which would not be demanded under a continued population growth situation. New products, new luxury goods, new services would be sought and paid for.

Production of these new goods and services would require new investments, new business formations, new technological advances, et cetera. This shifting of demand away from (or beyond) today's bundle of goods and services would not necessarily hurt present business concerns, since the shifting, if very gradual, would provide ample time for businesses to adjust their current production and output—and indeed, take advantage of the new demands themselves. Thus General Motors may produce fewer cars, but would produce more leisure and luxury goods.

Internationally, the absolute size of any country's GNP makes very little difference with regard to its performance in the world market. Rather it is the comparative position of a Nation's terms of trade—a relationship involving labor costs, capital costs and production functions—which largely determines the competitive advantages and disadvantages a country may face. It is virtually impossible to foretell the terms of trade for any country five decades hence. One must consider, however, two aspects of the U.S. position: First the relative insignificance of the international sector in the GNP and America's very low dependence upon it—although this may be becoming less true in the future. And second, the distinct probability that higher per capita incomes and therefore larger investments in research, science, and technology can lead to technological advances which will compensate for our higher labor costs.

Other economic effects of moving toward ZPG involve the composition of spending within the economy—especially in the public sector. The largest change from present trends would come in educational spending (see fig. 7). This change is caused by the shifting age distribution of the population. The effect of a relatively greater number of elderly persons is to increase Government transfer payments, which are in large part social security payments. This transfer does not affect the total welfare, but the increasing burden on wage and salary deductions may have political repercussions if present funding schemes are maintained. A factor through which an older age distribution can affect the average welfare is medical expenditures, but our scenarios do not show this happening (see fig. 8.).

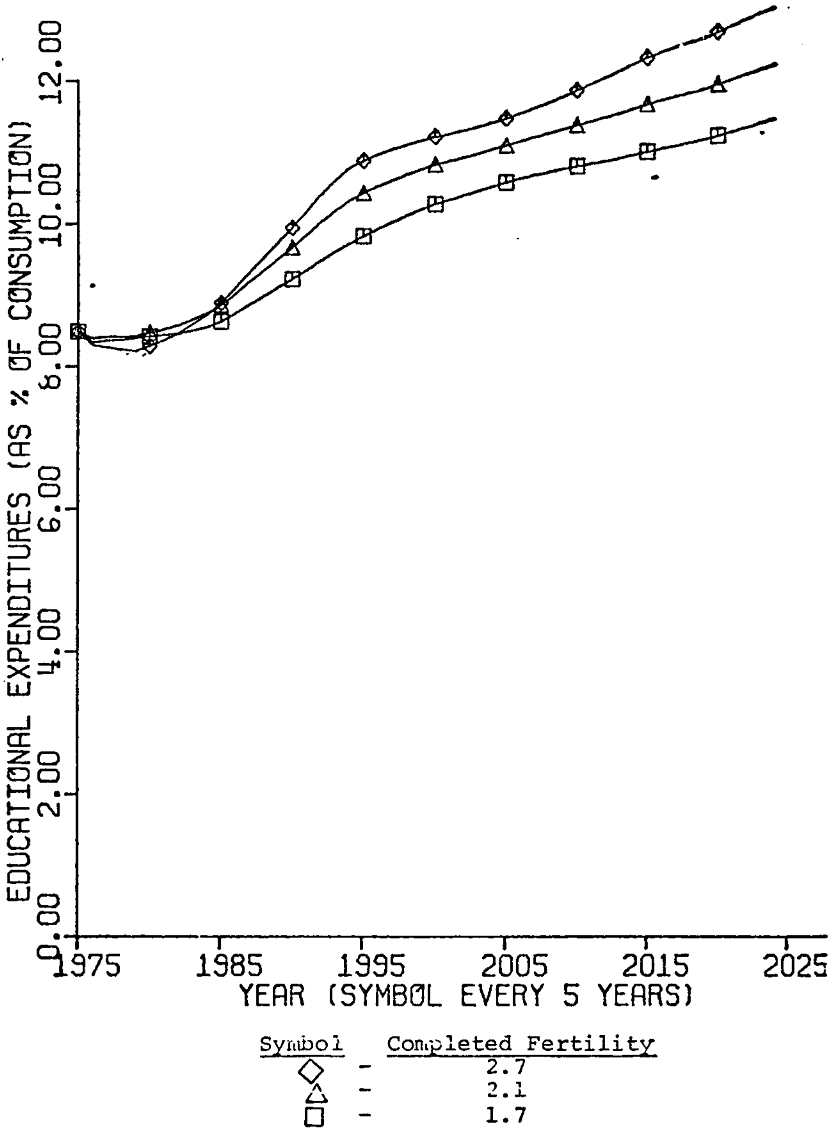


FIGURE 7.—Education expenditures as a fraction of total consumption.

The most significant expenditure differences arise in the private sector due to differing degrees of demand for natural resources. The more GNP rises, the greater the demand for resources, the greater the amount of marginal resources used, and the higher the costs to get those marginal resources. This result will be offset to some extent by substitution, both in production and consumption, but not completely. We do not subscribe to the assertion that growth in resource use and growth in GNP can be completely decoupled. This increased level of production would further result in a greater use of the environment as a dumping ground and consequently, a greater amount of money would be required to clean it up (see fig. 9) without a corresponding improvement in environmental quality.

We may use our interindustry model (see appendix IIID) to examine the differences in industry activity between runs I, II, and III. The major effects are in education and medical care, as we have noted. As run III produces the highest per capita income (fig. 10), the general trend toward services is augmented in this scenario, and there is a marked increase in housing and household furniture, et cetera, and recreational equipment.

What does all this mean? Can we say anything about average welfare and about its distribution? In our investigations we have proceeded by defining an index of welfare, labeled the Q-index, which measures per capita consumption, less instrumental expenditures.

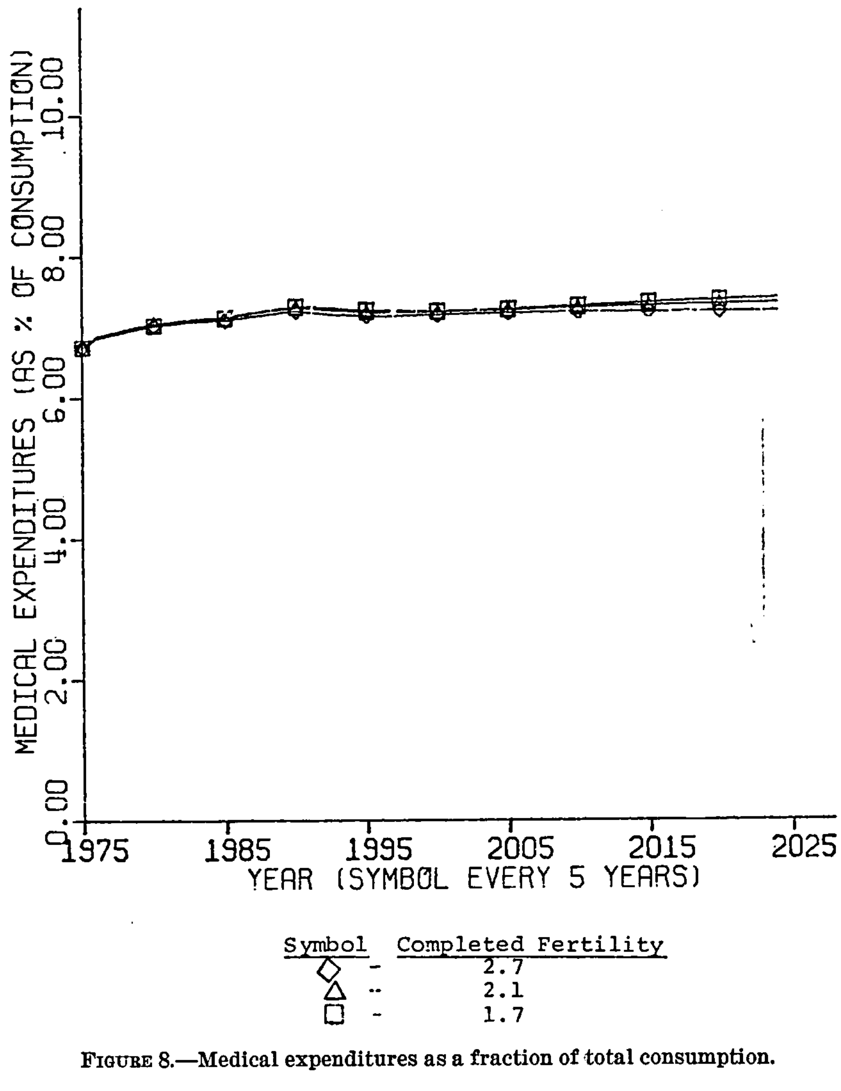


FIGURE 8.—Medical expenditures as a fraction of total consumption.

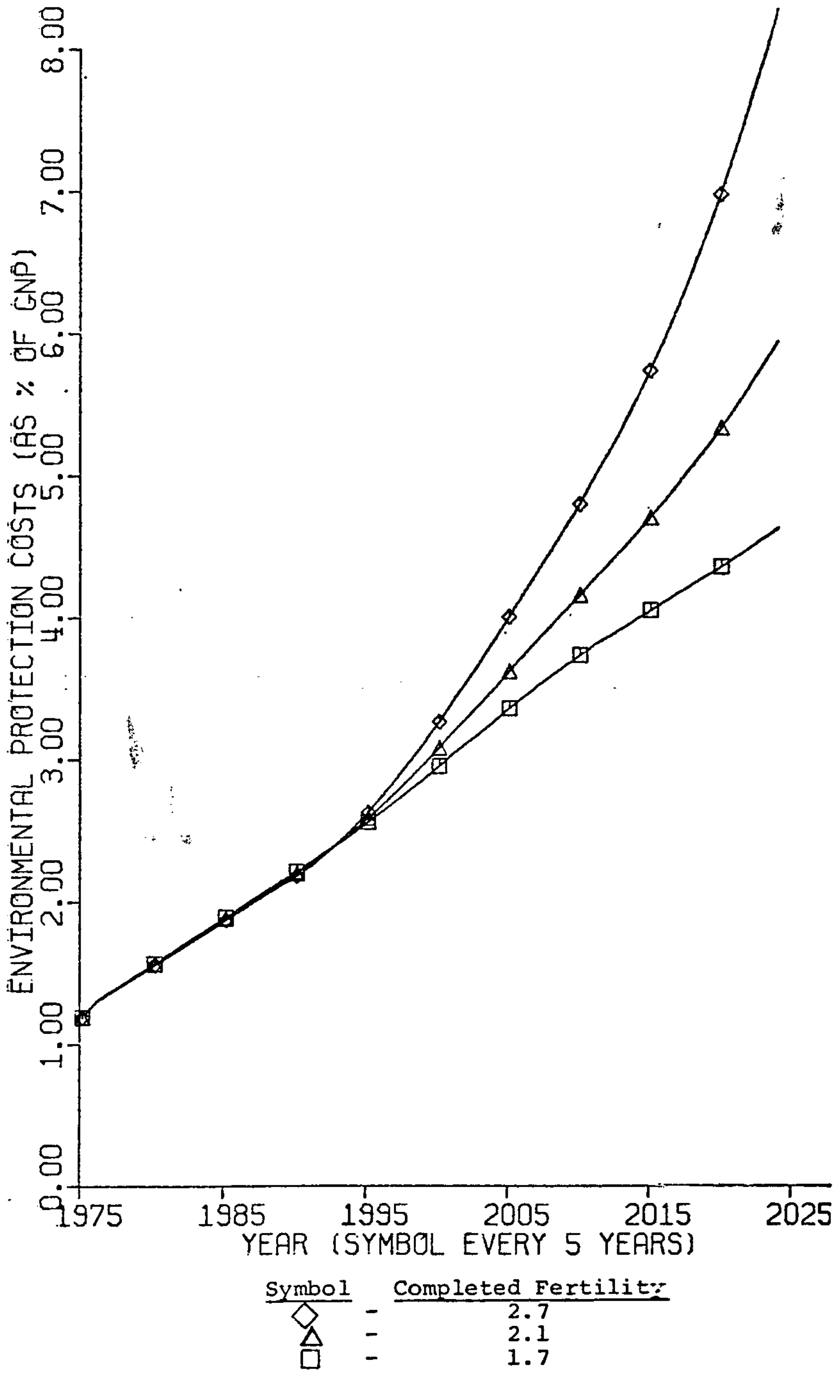


FIGURE 9.—Environmental costs as a percent of gross national product.

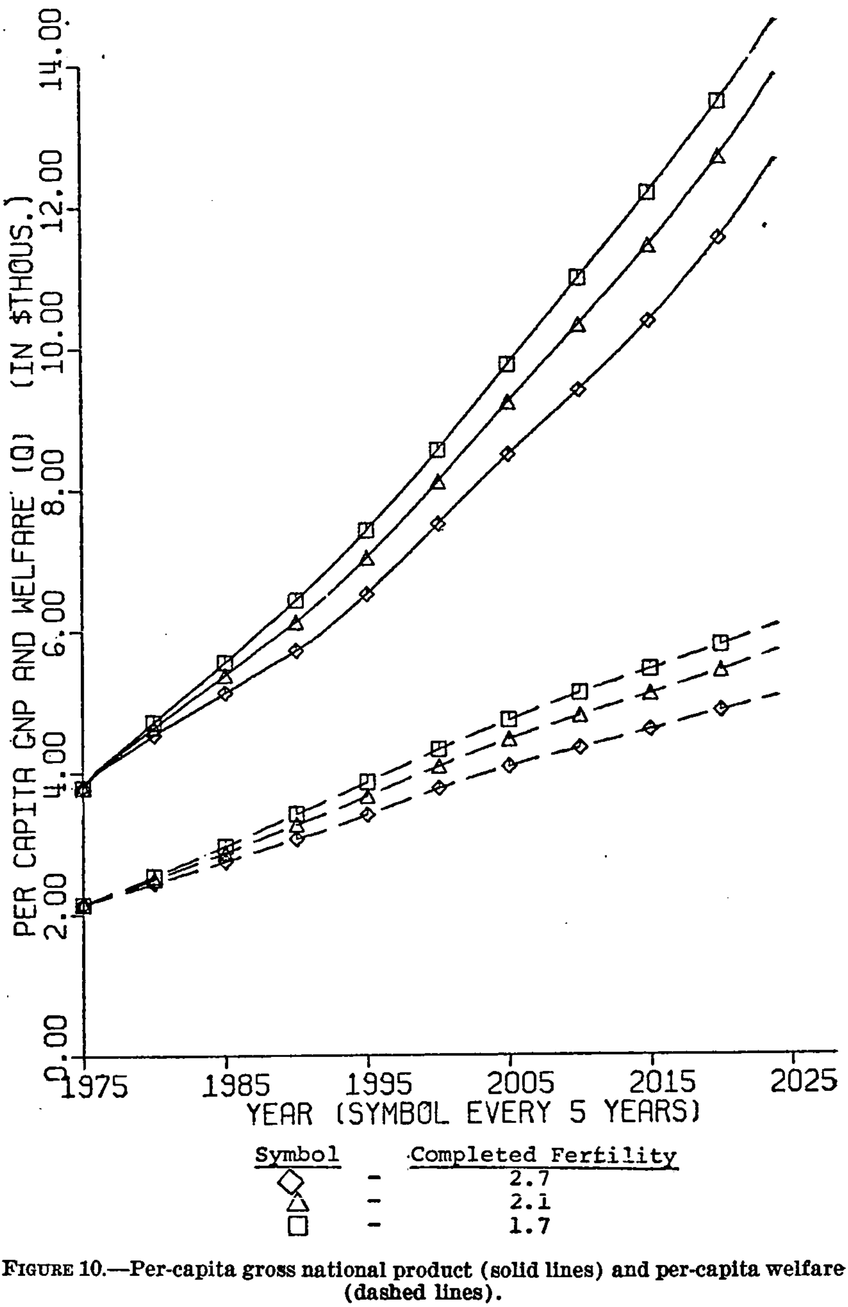


FIGURE 10.—Per-capita gross national product (solid lines) and per-capita welfare (dashed lines).

The index is calculated by a diagnostic program which adds together all of the goods and services which contribute directly to economic and societal welfare, such as food, clothing, shelter, recreation, and personal services. The Q-index does not count investment expenditures, nor expenditures for pollution control or resource development. Instrumental expenditures are "regrettable necessities," such as expenditures for defense, police, commuting to work, pollution control, which should not be counted as items of welfare consumption. Instrumental expenditures such as these are recognized to be a direct consequence of economic growth and population growth and simply maintain the status quo but should not be counted as contributing to welfare. A fuller discussion of the Q-index may be found in appendix II.

Projected per capita GNP and per capita welfare (as measured by the Q-index) are displayed in figure 10 for the three population scenarios. Per capita GNP is greater, the lower the fertility rate, as is per capita welfare.

III. Conclusions

The use of a mathematical model confirms our expectations that the United States will be better off with lower fertility rates, both in the short run of 10 years and the long run of 50 years. There appear to be no economic difficulties inherent in ZPG. There may be social and political difficulties arising from lower rates of economic growth and a changed age structure, but these are beyond the scope of this work.[7] From the economic point of view, the population should be better off in a lower population growth situation. Reduced growth means that resources are freed from investment needs and can be allocated to social programs, recreation development, etc. Further, the rates of natural resource depletion and of environmental degradation are reduced.

Appendix I. The Population Growth Project at the University of Virginia

We describe here the development of the project from its conception to the present (October 1976).

A. Early Interest in Optimum Population Specifications

The precursor of the project was a 1969 symposium on the subject of optimum population organized for the American Association for the Advancement of Science by the Principal Investigator, Professor S. Fred Singer, then Deputy Assistant Secretary of the Interior for Scientific Programs. The Department of Interior at that time had responsibilities not only for natural resources, excluding agriculture and forestry, but also for important aspects of environmental quality, principally water pollution control. One of the topics uppermost in people's minds was whether the population of the United States had grown too fast, or was growing too fast, in view of the available resources and available absorptive capacity of the environment.

The 1969 symposium, later expanded into a book published by McGraw-Hill,[8] examined the effects of population size, growth rate, and geographic distribution from many different points of view, not only from the standpoint of natural resources, energy, and environment, but also from the biological, sociological and psychological points of view. There was considerable divergence of opinion

[7] Many of the social and cultural implications of no-growth or even negative-growth societies have been discussed very capably, e.g. in the essay by Lincoln and Alice Day in, "Is There an Optimum Level of Population?" (S. F. Singer, Editor), McGraw-Hill, New York, 1971. See also the essay by Mancur Olson on "The No-Growth Society," as well as other essays in a special issue of Daedalus (1973). More recently Fred Hirsch—"Social Limits to Growth," Harvard University Press, 1976—has asserted that increased competition for the most attractive real estate, social status and other "positional" goods decreases satisfaction and leads to frustration. This situation in turn leads to a breakdown in the foundations of society and thus at least threatens further growth. Such analysis is intriguing but far beyond the scope of this paper.

[8] Singer, S. F., (ed.), Is There an Optimum Level of Population?, McGraw-Hill, New York (1971).

on what is a desirable level of population, and divergence also on whether the concept of an optimum level is valid. It became evident that one of the things lacking was a means of measuring the general state of welfare of the nation. In other words, there was no way to tell whether one state of population, economy, etc. was better than another. There was no means of comparing two scenarios at the same time, or two scenarios at different times. Many of the participants, however, did express themselves on the fact that the gross national product was simply not an adequate indicator of the general welfare, and some recommended an amended GNP.

This view was not universally accepted. Some people favored the so-called "social indicators" which measure a whole variety of conditions related to quality of life, such as crime rates, pollution status, health status, education status. etc. Others felt that there were certain aspects of life which were "priceless." Strictly speaking, this means that any other consideration would be of no interest, since by definition there can be only one priceless quantity in the world. If, for example, a quiet countryside or a wilderness preserve is priceless, then every other consideration must be worth less, and a good deal less. However, since universal agreement cannot be reached, for example, on wilderness preservation versus recreational use of public lands, then from the point of view of welfare economics the criterion of Pareto optimality is of little help, meaning that there is no way of making some people better off without at the same time making at least someone worse off.

It became clear that without a way of specifying and measuring what amounts to quality of life, there was really no way of specifying and expressing anything about an optimum level of population. For example, from the point of view of those who prefer wildernesses the optimum level of population would be extremely low, less than 50 million people for the United States.

It was in the process of writing and editing the book that some of these conclusions became clearer. It became evident, for example, especially in writing the chapter on environmental quality, that continued growth may well increase per-capita GNP, but that a larger and larger fraction would have to be devoted to pollution abatement, leading to a leveling off and eventual decrease of the "net" per-capita GNP.

B. Conceptualization of the Q-Index

The idea of a single index, called IQL or Q-index, to measure something akin to quality of life jelled quite early in the discussion following the AAAS symposium and is embodied in Appendix F [9] of the book, *Is There an Optimum Level of Population?* In this formulation we reject first of all the idea that the quality of life cannot be quantified. The use of an index of this type is implicit, if not explicit, in every government decision affecting national welfare. We also reject the use of social indicators for the purpose of the optimum population problem, although social indicators have their uses for the purposes for which they are designed.

The problem of measuring quality of life, or welfare, has a considerable history in modern economics, culminating in the "new welfare economics" of the 1940's.[10] The conclusion of this effort is two-fold: only the marginal contribution of various inputs to individual welfare—consumption goods, time, other persons, etc.—can be measured numerically with any degree of confidence; and there is no generally acceptable manner of combining measures of individual welfare to obtain that of the population.

Our effort has been much more modest than this. We measure the quantity of one of the inputs to welfare: consumption. To measure consumption we fixed on the idea of a single index made up of an amended GNP, expressed on a per capita basis, incorporating all of the "goods" and eliminating all of the "bads." As we saw it then, it meant subtracting from the GNP all of the instrumental expenses which are themselves caused by population and economic growth, such as environmental protection costs and the incremental costs for resources which come about because of continuing depletion. We also subtract excess urban costs which relate to population level and density. Of course, investment is subtracted.

Influenced by the work of Juster of the National Bureau of Economic Research [11] and of Nordhaus and Tobin of Yale University,[12] we added to the GNP

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[9] Singer, S. F., "Is There an Optimum Level of Population?" Pages 398–405.
[10] Graaf, J. deV., "Theoretical Welfare Economics," Cambridge University Press, (1957).
[11] Juster, F. Thomas, "A Framework for the Measurement of Economic and Social Performance," in "The Measurement of Economic and Social Performance" (MESP), "Studies in Income and Wealth, No. 38," ed. Milton Moss, National Bureau of Economic Research, New York (1973).
[12] Nordhaus, William O. and James Tobin, "Is Growth Obsolete," MESP.

the non-market components such as household production, as well as the imputed value of leisure time. But because of the large uncertainty in the value of house hold production and leisure time, we decided to keep these imputations to a minimum by using them only as corrections. The index and its components are discussed in detail in section II of this paper.

C. The Mathematical Model

It became clear at the outset that in order to quantify the Q-index, one would have to express the various amendments to the GNP numerically, in dollars per-capita, so that they could be added or subtracted, as the case may be. Without a mathematical simulation model all judgments concerning the effects of population level, or its growth or geographic distribution, would be simply qualitative. We considered briefly using assumed relationships between the important quantities, such as birth rate, economic production, environmental protection costs, etc. (somewhat in the fashion in which the Club of Rome *Limits to Growth* [13] project is constructed), but immediately rejected this possibility as being little more than an unrealistic exercise. It seemed to us to be necessary to use real data, plus theory, for making a simulation model that projects important quantities into the future.

It turns out, somewhat surprisingly, that a model of the United States is the simplest one that can be constructed, much simpler than a model of the world, and much simpler even than a model of a subsection of the United States, i.e., a regional model. This has to do with the fact that the United States is a reasonably homogeneous region, has a relatively closed economy, and also that statistics are available which apply to the country as a whole. But the most important reason for our choice of a US model is that any policies that would be examined would be national policies and therefore applicable to the whole country.

Another important specification of the model was the fact that it had to be linked to demography. Since demographic changes occur slowly, typically with a time scale on the order of decades, this argued for a long-term model, and fixed some of the parameters of the economic part of the model as well. It argued against the use of monthly or quarterly economic models, and in favor of the use of a neoclassical style of economic growth model. Right from the beginning, therefore, we eliminated any consideration of business cycles, recessions, etc., assuming that the government would use fiscal and monetary policies, as appropriate, to keep the economy on an even keel, providing a steady growth, with a small and constant level of unemployment. Needless to say, that does not happen, and one of the important problems to settle is how to simulate the differences between the actual development of the economy and the idealized development envisaged in the model. Since fluctuations always lead to economic inefficiency, one can make the general statement that fluctuations always depress the real level of welfare and therefore the Q-index.

On a longer time scale, we have fluctuations of fertility leading to "boom and bust" situations in the progression of cohorts. This feature, however, can be simulated in our model, and it can be shown that this fluctuation leads to a growth path which is less than optimum compared to one in which the fertility is constant or varies quite smoothly.

The development of the model has proceeded more or less along the lines sketched out by us in 1971. The progression in complication has been steady and orderly through Mark I, Mark II, and now Mark III. Right from the beginning we knew that we would have to have a model of the complexity of Mark III, which incorporates an interindustry input-output table. However, it seemed advisable to start with a simpler model with components that could be carried over directly into the more complicated one.

Accordingly, Mark I, which was completed during the first full year of the Project (1972), had a full-scale demographic sub-model to which was added a rather simple neoclassical economic growth model, followed by a very crude method of computing the Q-index.[14]

Mark II used the demographic sub-model of Mark I without significant changes, but elaborated on the economic sub-model by introducing various options of building up the capital stock of the economy. However, the main addition was in

[13] Meadows, D. H., D. L. Meadows, J. Randers and W. W. Behrens, "Limits to Growth," Universe Books, New York (1972).

[14] Singer, S. Fred, "A Study of Optimum Population Levels—A Progress Report," Proc. Nat. Acad. Sci. USA 69, 3339 (1972).

the calculation of the Q-index. Mark II used judgmental projections of the various consumption categories, such as food, clothing, housing, furniture and appliances, education, health care, etc. It therefore furnished a more realistic estimate of the Q-index. It incorporated a reasonably good accounting of non-market production and leisure time, but only crude models for urban disamenities, for environmental protection costs, and for resource costs.[15]

Our major effort for the last two years has been on what we call Mark III. This model is unique in several ways.

(1) It has a fully articulated demographic section, giving the age, geographic, and income structure of the population.

(2) Pollution abatement and resource depletion costs are determined within a 185-sector interindustry model of production [16] and are fed back: (a) through the interindustry production model thereby affecting industry activity; and (b) through a price model thereby affecting the composition of consumption. This price model, developed completely at Virginia, is a long-run, average-cost interindustry model. The calculation of price indices of consumption goods includes the effect of changes in labor productivity, capital stocks and rates of depreciation, pollution abatement costs, and resource costs.

(3) Most original, however, is the determination of a per capita index of "real" income, a corrected per capita GNP called the "Q-index." This single index is used as a diagnostic to compare one scenario of population growth with another, under given economic assumptions. The index is constructed by weighting the different components of consumption according to our judgment of their contribution to individual welfare. However, these weights can be easily changed to reflect the values of other users of the model.

In addition to the large-scale model, we have modified the much smaller Mark II version so that it may be calibrated against Mark III. This more compact model incorporates many of Mark III's unique characteristics, thereby enabling it to be used in initial research investigations at a fraction of the full model's time and cost.

Appendix II. Specification of the Q-Index

The need for a single index in this research has already been discussed. This index serves as an objective function by which different "states" and even time paths can be compared. The optimum path of development would be one which achieves the maximum values of the Q-index over time, expressed as a maximum of the "present value," i.e., discounted to the present by means of an assumed social rate of time preference (discount rate). As discussed in section IB, the index does not measure quality of life, happiness, etc. and is only an approximation to economic welfare.

The determination of the index is carried out at the end of a forecast, so that different judgments may be applied to the weighting of various components of market and non-market activities, to the distribution of income, and to the discount rate. Thus a variety of optima are possible, depending on these judgments. The optima are constrained to a feasible set by beginning with the present and using a consistent, validated projection model.

A primary requirement of economic indices is that they be easy to understand and to manipulate. For this reason, the Q-index is a linear sum, with all goods and services measured at present prices. This distinguishes it from consumer surplus measures. These latter recognize that individuals are willing to pay more than the market price for most of the goods they purchase. Price only measures the value of the last good purchased. For this reason, the Q-index will understate the benefits derived from consumption. However, we are primarily interested in effects at the margin, and measures of consumer surplus are extremely difficult to construct.

Another question related to consumer surplus is that of diminishing returns and satiation. An increase in consumption does not necessarily lead to a proportional increase in well-being, as our index assumes. The Q-index does take this into account by allowing the application of a utility vector to the distribution of income at each point in time.

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[15] Singer, S. Fred, "Economic and Welfare Implications of ZPG," in Working Papers in Alternate Futures and Environmental Quality, EPA, Washington (1973).

[16] Almon, Jr., Clopper, Margaret B. Buckler, Lawrence M. Horwitz, and Thomas C. Reinbold "1985: Interindustry Forecasts of American Economy," D. C. Heath and Company, Lexington, Mass. (1974), referred to hereafter as "1985."

This utility vector applies a weight to each income group, which is 1.0 for the lowest income and diminishes toward the highest. Thus, for some choices of the utility vector, an increase in average income could be offset by an increasing disparity of the distribution.

This can be stated mathematically as follows. Let consumption be divided into 17 categories: z_i, $i=1 \ldots 17$. Then the total consumption, Q, which contributes to welfare is given by the following relation:

$$Q=\sum_{i=1}^{17} w_i z_i$$

where the weights

$$0.0 \leq w_i \leq 1.0$$

form a "value vector" which reflects our judgment as to the contribution of the i[th] consumption sector to an individual's well-being.

The distribution of income is taken into account by forming the product

$$\tilde{Q}=Q \cdot U$$

where $\tilde{Q}$ is consumption corrected for the distribution of income. The distributional correction, U, is given by the relation:

$$U=\sum_{i=1}^{11} U_i f(I_i)$$

where $f(I_i)$ is a discrete distribution over 11 income classes and the U_i form the utility vector. Thus U is less than 1.0. Tentatively we have related the U_i to the marginal federal income tax rate.

The discounted present value of the index, Q_o, is formed using the relation

$$\tilde{Q}_o=\sum_{t=o}^{T} (1+r)^{-t} \tilde{Q}_t$$

where r is the social rate of time preference, usually called the social discount rate. There are thus three places where judgments are introduced explicitly into the Q-index: in the value vector, the utility vector, and the social discount rate.

A. Relative Importance of the Components

To better understand the Q-index, consider it as a modification of the Gross National Product (GNP). The GNP not only measures the productive output of the nation, but is identically equal to the national income. From this identity follows the use of the GNP as a measure of national welfare.

The GNP consists of four components: personal consumption, private investment, government expenditures, and net exports. Investment and net exports do not contribute to current well-being and are thus excluded from the Q-index. For the same reason we exclude government construction and purchases of consumer durables. But imputations for "services" derived from these latter two items must be made.[17]

These modifications lead to a measure of total consumption, both government and private, which is divided among 17 categories. The weighting factors used by us in combining the 17 consumption levels to form the Q-index are shown in Table 2a along with historical 1975 and forecast 2020 per capita values. The forecast values are presented as an example only and should not be taken as final results.

The weights are just our judgment as to how much these items contribute to welfare. (For example, all of primary and secondary education is regarded as investment;[18] half of all other education is considered consumption.) When the

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[17] This is just the procedure presently being followed for residential construction by Commerce in compiling the national accounts: residential construction is counted as investment, and imputations are made in personal consumption for services derived from housing.

[18] In human capital; presumably it leads to increased labor force productivity, and therefore, increased GNP, in the future.

weights are taken into account, consumption is reduced by about one-third. Thus one-third of annual consumption expenditures may be counted as regrettable necessities. And we are not including in these regrettable necessities costs associated with urbanization or pollution abatement.

In Table 2b we show examples of the corrections which we make to per capita consumption in determining the Q-index: costs associated with urbanization and pollution abatement; incremental costs of natural resource depletion; and important non-market corrections (such as household production and leisure time).

TABLE 2a.—FORMATION OF THE Q-INDEX FOR THE YEARS 1975 AND 2020 [VALUES ARE PER CAPITA IN 1959 DOLLARS AND PERCENT OF CONSUMPTION]. COMPONENTS OF CONSUMPTION

Component	Assumed weight	1975 total		2020 total		1975 weighted		2020 weighted	
		Value	Percent	Value	Percent	Value	Percent	Value	Percent
Food	1.0	571.7	17.0	758.0	14.4	571.7	22.1	758.0	18.7
Clothing	1.0	303.7	9.0	464.3	8.8	303.7	11.8	464.3	11.4
Housing [1]	1.0	708.4	21.1	1,119.8	21.2	708.4	27.4	1,119.8	27.6
Transportation [2]	1.0	338.0	10.0	600.0	11.4	338.0	13.1	600.0	14.8
Medical care	1.0	230.3	6.8	355.5	6.7	230.3	8.9	355.5	8.7
Other [3]	1.0	363.6	10.8	608.5	11.5	363.6	14.1	608.5	15.0
Education (primary and secondary) [4]	0	163.3	4.9	269.9	5.1				
Education (higher) [4]	.5	74.7	2.2	175.9	3.3	37.4	1.4	87.9	2.2
Education (other) [4]	.5	27.6	.8	97.2	1.8	13.8	.5	48.6	1.2
Defense [4 5]	.05	296.6	8.8	408.8	7.7	14.8	.6	20 4	.5
General Government [4]	0	238.3	7.1	323.9	6.1				
Sanitation and safety [4 6]	0	47.1	1.4	100.4	1.9				
Consumption		3,363.3	100.0	5,282.2	100.0	2,581.6	100.0	4,063.4	100.0

[1] Purchases of consumer durables are excluded; services of consumer durables and of publically owned housing are imputed.
[2] Services of highways are estimated and included in personal transportation in proportion to use. Community costs are subtracted in the urban disamenity correction so must be included here.
[3] Includes personal business, recreation, religious and charitable activities, and foreign travel.
[4] Services of Government structures are estimated and included in appropriate sector.
[5] Includes defense, space, international affairs, and finance.
[6] Pollution abatement activities are held constant at 1971 values.

TABLE 2b.—CORRECTIONS TO CONSUMPTION

[Values are per capita in 1959 dollars and percent of consumption. The values shown are examples only and should not be taken as final results]

	1975 value	Percent	2020 value	Percent
Consumption (weighted)	2,581.6	76.8	4,063.4	76.9
Pollution abatement [1]	−60.4	1.8	−126.2	2.4
Urban disamenities	−393.1	11.7	−448.3	8.5
Resource costs [2]	−23.2	.6	−974.3	18.4
Market contribution to index	2,104.9	62.6	2,514.6	47.6
Household production [3]	93.2	2.8	0	
Leisure time [4]	41.6	1.2	585.5	11.1
Nonmarket corrections	134.8	4.0	585.5	11.1
Total	2,239.7	66.6	3,100.1	58.7
Q-index	100.0		138.4	

[1] Incremental costs of abating to 1971 ambient levels.
[2] Incremental costs associated with natural resource depletion from 1971.
[3] This corrects for increased female labor participation rates: A 50-percent increase for women between ages 25 to 34 and ages 55 to 64 and a 75-percent increase for women between ages 35 to 45; female average wage rates (75 percent of average) are used.
[4] This corrects for decreased average work hours per week; 10 percent between 1971 and 2020.

The major part of the Q-index is seen to arise from household consumption (mainly private, but also partly governmental expenditures on various services). That consumption increases, on a per capita basis, results from our assumption that the total productivity of the economy increases with time. Because this assumption is the major factor in the variation of the Q-index, we will discuss it in the next section.

B. Productivity

In neoclassical growth theory, the production of goods and services is usually modeled as a functional relationship between output, labor and capital. A particularly simple form is the Cobb-Douglas production function:

where

$$Y = CL^{\alpha}K^{1-\alpha}$$
$$C = C_o \exp(\gamma t)$$
$$K = \Sigma_i K_i \exp(\kappa_i t)$$
$$L = \Sigma_i L_j \exp(\gamma_j t)$$

and

C_o = a constant.
K_i = stock of capital of type i.
L_j = labor of type j.
γ = time rate of neutral change in productivity.
κ_i = time rate of change of capital productivity in category i.
λ_j = time rate of change of labor productivity in category j.

We may use this function to analyze factors which affect productivity. The Cobb-Douglas form suggests three categories: those which affect the productivity of capital, those which affect the productivity of labor, and those which affect the productivity of both. Edward Denison has associated four major factors with increasing productivity:[19] education of the labor force; technological progress; economies of scale; and shifts in the production among the different sectors of the economy. We will discuss these factors and others in what follows.

1. *Productivity of Capital*

The capital/labor ratio affects overall productivity directly through the production function. That is, for a given supply of labor, more capital implies more production. In optimal control theory terms, the capital-labor ratio is a state variable; it depends on past investments in capital stock and on past fertility rates. In neoclassical economic theory it is usually presumed that population grows at a constant rate, say 1 percent per year. The capital growth rate is adjusted by a controlled variable, namely the savings ratio, i.e., the fraction of GNP which is not consumed but reinvested.

The newness of capital affects productivity, since newer capital tends to be more productive than older capital stock. Each year a new vintage of capital is added, based on the amount invested during the current year. At the same time, the existing capital stock depreciates. A good example is the international steel industry, where both Japan and Germany had their capital stock destroyed and were able to introduce new capital stock after World War II, thereby achieving a higher productivity than the U.S. steel industry. The policy variable in this case is one which encourages the creation of capital stock; for example, an investment tax credit or a more rapid depreciation of existing capital stock. In general, lower interest rates encourage industry to borrow money and increase their capital investments.

Proper use of capital is obviously important. If prices are distorted, then resources will be allocated in a non-optimum way and this will generally result in a lower GNP growth. Market failures of various sorts exist, some produce by legislation, some are produced by monopoly.

2. *Productivity of Labor*

Human capital must be treated somewhat differently than physical capital. By human capital we understand the investments that have been made in the labor force, generally in terms of education. The work of Edward Denison tells us that at least over the past decades investment in education has contributed importantly to the improvement in human capital and therefore to the productivity of workers. Whether or not this trend will prevail in the future is hard to say. It would seem reasonable that there arises a saturation phenomenon after an overwhelming fraction of the population has achieved a certain level of education.

Labor quality overall is affected by a number of factors. If immigration remains an important component of population growth, as is now the case, then the quality of immigrants can have an effect on labor quality.

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[19] Denison, Edward F., "Accounting for United States Economic Growth: 1929–69," Brookings (1974).

Labor participation rates, i.e., the ratio of labor force to the total number of people in the employable age groups, has an impact on overall productivity. If all of the potential labor force were to be employed, then, provided an appropriate capital stock is available, a greatly increased GNP would result which would increase the average per capita GNP.

Income distribution may affect productivity, but we don't know which way. A more egalitarian distribution may reduce losses due to strikes and labor unrest, but it may also decrease incentives.

Poor use of human capital results when the labor force is not adequately trained nor adequately employed. This is one of the strongest economic arguments for equal employment opportunities for minorities and women.

Sickness and mortality, as well as accidents, affect the labor force productivity. Reducing the losses from sickness and accidents can be one of the strongest economic arguments for OSHA and for improvement of environmental quality, assuming that much sickness is due to environmental causes. Similarly, medical research, preventive medicine, and improved therapy can be economically justified.

The age structure of the labor force, which is determined by fertility, may have an effect on labor productivity. Both skill and dependability increase with age, whereas perception and speed decrease. At this time there is insufficient data to determine the net effect of this factor.

3. *Other Factors*

Of Denison's four primary factors, education, which has already been discussed, has the largest effect at present upon increasing productivity. Technological progress is the second most important, and the only factor whose effect he sees as increasing. Technological progress can be incorporated into the capital sector (by more productive capital equipment). It can also be "disembodied" and displayed separately as a "neutral" productivity increase. It is believed that the technological progress coefficients depend on investments in R&D, and ultimately on investments in basic science. It would be important to demonstrate these relationships more conclusively.

Sectoral shifts and economies of scale are of lesser and decreasing importance. Yet these two factors will significantly decrease the rate of growth in the next decades. Decreases in productivity will accompany shifts of demand from goods toward services. At the same time, most industries have reached, or passed, the size at which scale economies can be expected to continue increasing.

Economies of scale and reduced transportation and communications cost are recognized as being responsible for urban concentration. But this same concentration results in increased personal transportation and housing costs, which together with congestion and perhaps some other costs of crowding are referred to as urban disamenities. We treat these separately in our work, but it must be recognized that these factors compete with one another.

Factors such as land, mineral resources and the environment have not been successfully incorporated into production functions even though they are recognized by economists as input factors in production. As mineral resources become depleted, for example, additional costs are incurred in using lower grade resources. In the absence of new technology, natural resource costs will increase even if there is no further economic growth simply because the quality of resources becomes poorer. A major step forward would be the development of an essentially inexhaustible source of energy at relatively low cost, such as fusion, which could stabilize the cost of resources for a very long period.

As food needs increase, additional land must be put into agricultural production. If, as is often the case, it is poorer land, then the average productivity of agriculture will decrease—all other things remaining the same.

And as manufacturing and other polluting activities increase in scale, clean air and water become socially more costly resources. Pollution abatement is an important instrumental cost, which will become a greater fraction of GNP as economic growth continues. This is the cost of maintaining the air and water environment at a fixed level of quality as the amount of discharged pollutants increases.

Many of the factors in productivity discussed in this section are better analyzed at a detailed industry level. Studies have been made at a 50–100 sector level which show success in prediction (for example, those undertaken by Professor Clopper Almon and those by the Bureau of Labor Statistics). In these studies, particularly, our lack of understanding of what productivity even means has appeared in the areas of services and government.

Finally, there are numerous unpredictable factors which will decrease productivity. Losses from natural catastrophies, from hurricanes, tornadoes, floods, earthquakes and from fires, cause a large destruction of capital stock in the nation every year. The destructive capabilities may stay the same, but the economic size of the losses increases as the investment value per unit area increases, as a result of population growth and economic growth.

In the same category fall crop failures produced by poor weather, drought, plant pests, and plant diseases.

Losses to the economy also arise from manmade causes, including crime, vandalism, and riots. A separate category comes from labor strikes, which not only cause loss of production in the affected area or industry, but because of industrial interconnections, can lead to wisespread effects in the economy.

Another manmade cause is the consequence of improper government intervenvention. We have the costs which come from excess governmental regulation and from the uncertainties and delays produced by governmental actions. These have increased so much in the past few years that they may by now be an important cost category, consuming a large number of people and resources. In addition, there is a considerable loss in market discipline associated with monopolistic price setting practices and trade protection which result from government intervention or the lack of it.

C. Resources

The economic theory of natural resources is well understood, dating back at least to Ricardo's treatment of land rent. The standard treatment abstracts from the world of imperfect information, poorly operating or non-existent futures markets, and divergence of the social rate of time preference.[20] This treatment concludes that for a social optimum the net price, that is, price less unit cost, should increase at a rate equal to the market rate of interest until the resource is exhausted or a cheaper one is substituted. The result is the same whether there is a competitive market or monopoly: under certain artificial assumptions about the demand curves.

The price of a natural resource then consists of two parts: the cost per unit and the net price. The cost per unit depends on the new discovery rate and technological progress in extraction and use. The net price is identical to the profit per unit and accrues to the owner of the resource. It is his desire to maximize this profit which gives the owner the incentive to allocate the resource most efficiently.

In the case of domestic resources, only the unit cost contributes to the social cost of resource depletion. The profits are part of the national income but, of course, may have distributional implications. The full price of imported resources must be used as the unit social cost, as the profits accrue to owners outside the U.S. Thus, it is the domestic depletion of a resource which is particularly important. For example, we shall show below that the world price of oil will probably be fairly independent of U.S. population and economic growth. However, the resource cost to the U.S. depends on the fraction imported, and thus is very sensitive to U.S. growth.

It is useful to divide the discussion of resources into three parts: (1) energy resources, including uranium and fossil fuels; (2) non-fuel mineral resources; (3) land resources. This division is based on transportation and recycling. Both fuel and non-fuel mineral resources are generally transportable, whereas land is not. For this reason world market prices pertain to them. There are some mineral resources, such as sand and gravel, which are not economically transportable. But only non-fuel mineral resources are recyclable. In fact, recycling requires the use of energy resources.

1. *Land*

Land resources can be divided into three categories: land for urban and industrial use, including mining, reservoirs and highways; recreational land; and agricultural land. There seems to be no real limit to urban and industrial land within the U.S., at least for the foreseeable future. Economic forces may raise the price of land in areas where the population concentration is very high and thereby encourage cities to spread out over a larger area. This type of spreading out of urban and industrial use competes with the other two categories, but this competition, at present, does not appear to be generating significant scarcity.

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[20] See, for example, Nordhaus, William D., "The Allocation of Energy Resources," Brookings Papers on Economic Activity 3, 529 (1973).

The question as to whether there is a limit to recreational land is a real one, particularly for wilderness areas, national parks and so on, which are rapidly becoming overcrowded or despoiled. To relieve overcrowding various limited access and user charge schemes have been developed. Increased congestion costs, user charges, and increased transportation expenditures are evidence of market response to a change in demand. The principal cause of these increased costs is the change in per capita demand rather than population growth.

In the case of agricultural land, it is generally believed that for the near future, say the next 50 years, there will be no real limit set by population growth within the U.S.

In the short run, however, expanding agricultural crop land may lead to a reduction in the cost inasmuch as there is an overinvestment in agricultural equipment.

For all land only the increased cost of utilization counts into the resource cost. Increased prices which result from increased demand and competition between uses, but not from increased cost, may have distributional consequences but do not contribute to increased social cost.

2. *Energy Resources*

We have modeled the price of energy resources as follows: we assume that at least until the year 2020 oil constitutes the marginal energy resource and therefore that its price will in some way set the price of all other energy resources. This means that we cannot assume synthetic oil at a price lower than the world price of oil, nor that natural gas can fully take the place of oil.

We further assume that there will be some kind of effective cartel in operation which will control the price by restricting the production of oil and thereby will prevent a competitive market from existing. Under these circumstances the price can be calculated by a simple model which divides the suppliers of oil into two categories, the price takers and the cartel core. Price takers produce all-out, at the current price. Their supply function is essentially set by the current price which, however, they do not control. The cartel core restricts its output in such a way as to maximize the present value of net revenue over time. such calculations have been carried out, for example, by Robert Pindyck at MITS, and an analytic model has been developed by V. Farrell of the U.S. Treasury Department. Combining their results with some judgmental considerations concerning cartel erosion, we have shown that an initial relative price drop to about $10 per barrel should be followed by a gradual increase in the price of oil by 1.5 percent per year. The price curve depends on the assumed rate of interest, but it is even more sensitive to the assumed demand function.

The price of domestic oil is assumed to be the same as that of world oil on a BTU basis. The price of coal is assumed to be moving towards the price of world oil and then stabilizing at a fixed percentage. The same is true for uranium whose price is discounted to produce electricity at a price level which is competitive with electricity produced by either coal or oil.

Note that the prices of energy resources depend on the world demand function and economic growth, and only indirectly on population growth. Specifically, we may assume that U.S. demand, currently one-third of world demand, will not exceed this percentage and may even drop considerably as other and less developed countries industrialize. Therefore, we can assume that energy prices are fairly insensitive to population and economic growth in the United States.

As we noted at the beginning of this section, this does not mean that the social cost of increased energy prices are independent of U.S. growth. Increasing imports will increase the social cost to the United States. Thus it is through the depletion of domestic resources that the resource cost comes about.

3. *Mineral Resources*

The prices of mineral resources fluctuate greatly but have not changed appreciably in the last several decades. To model these prices we assume that competitive markets will be maintained. Thus we assume that the present competitive net price will grow at the market rate of interest. Unit costs are determined from Bureau of Mines data on recoverable world resources by country. The point of supply and demand equilibrium is obtained by assuming that world demand is a slowly changing multiple of U.S. demand.

The critical parameters in this analysis are the long-run United States and world supply elasticities determined from the Bureau of Mines data. These are apt to be conservative because they assume current technology and extrapolate, usually in a conservative fashion, from known reserves to undiscovered resources. Thus forecast prices rises may be dampened as new resources come into play, such as the mineral resources of the deep ocean bed.

4. *Recycling, Substitution and Conservation*

These three factors will tend to decrease resource costs and increase the Q-index. Recycling, as has been noted, is directly applicable only to mineral resources, although there are indirect savings of energy involved. [21] Substitution is the primary technique for reducing resource costs. Goeller and Weinberg have recently stated and supported a principle of " 'infinite' substitutability": [22]

> With three notable exceptions—phosphorus, a few trace elements for agriculture, and energy producing fossil fuels—society can subsist on inexhaustible or near-inexhaustible minerals with relatively less loss of living standard. . . whether it would be anything like our present society depends on how much of the ultimate raw material—energy—we can produce . . . .

What they are saying is that for every mineral resource except energy, and the others noted, there is a known "backstop technology" that can provide a substitute in essentially unlimited quantity.

D. Pollution Abatement

As with resource costs, there will be increased costs of pollution abatement associated with economic and population growth. The source of these added costs is the need to maintain the quality of a given environment in the face of increasing discharges of polluting wastes.

There are three approaches to modeling these costs: the optimum abatement approach; the standards approach; and the fixed ambient quality approach. The first approach involves the determination of the optimum point: that point at which a dollar of abatement expenditure just results in a dollar of benefits. This approach is not generally practicable because of poor knowledge of benefit functions. We have carried out this type of analysis for automobile emission abatement. [23]

By the standards approach, we refer to the estimation of the costs of meeting legislated emission standards. The legislation generally includes a timetable which determines by which year certain standards have to be met. This has been the approach of the modeling effort at EPA. [24] We do not use this approach in our project, as the standards are independent of the population and economic variables in which we are interested.

Our approach is based on the assumption of a fixed level of environmental quality. By means of this simple device we avoid having to calculate the dollar benefits of a clean environment, assuming instead that they do not change from year to year. What varies is the abatement of the emissions of various pollutants which depend on population level, geographic distribution, affluence, and on technological parameters. The accompanying Table 3 gives these dependencies in detail. By requiring that the ambient quality remain fixed as population grows, we are therefore imposing stricter emission limits, and therefore more stringent abatement procedures which are also much more expensive.

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[21] Secondary use of waste heat is generally regarded as a technique of energy conservation in the sense of less use rather than as recycling.

[22] Goeller, H. E. and Alvin M. Weinberg, "The Age of Substitutability," Science 191, 683 (1976).

[23] Singer, S. Fred, "A Re-examination of Cost and Benefits of Automobiles Emission Control Strategies," report to Economics and Science Planning of work performed under NSF grant no. STP75-21384 (March 1976).

[24] Environmental Protection Agency, "Strategic Environmental Assessment System," draft (December 1975).

TABLE 3.—FACTORS UPON WHICH POLLUTION CONTROL COSTS ARE DEPENDENT[1]

Pollution problem	Factors on which costs are dependent	Extent to which technology can decrease costs
Sewage	Population levels and geographic distribution, but little on GNP.	Moderately.
Garbage	Population levels and geographic distribution; also on per capita GNP (goods portion).	Substantiall
Agricultural and construction	General population level, and moderately on GNP	Do.
Resource extraction (mining)	Goods portion of GNP, and therefore indirectly on population level (but not on geographic distribution).	Do.
Electric powerplants and industry	GNP (and especially goods portion of GNP); to some extent on geographic distribution of population; indirectly on general population level.	Do.
Automobile operations	Population levels and geographic distribution; less so on per capita GNP.	Substantially or even radically.
Toxic substances (including radioactivity).	Mostly induced by technology; indirectly by GNP and therefore by population level.	Radically.

[1] Singer, S. Fred, "Future Environmental Needs and Costs," EOS (Transactions of the American Geophysical Union), 55, 948 (1974).

E. Urban Disamenities

The belief that urban living involves greater net costs to the individual as city size increases is certainly quite old, but attempts to measure this cost are quite recent and represent a conjunction of welfare and urban economics. The term "urban disamenity" appears to have been coined by Tobin and Nordhaus,[25] who along with Hoch [26] feel that much, if not most, of this disamenity is associated with psychic effects of crowding.

The rapid development of urban economics during the last decade brings a different perspective to this question. City growth is explained as resulting from economies of scale, both public and private, which increase production with size until costs arising from spatial extension constrain further growth.[27] These costs of increased distances to travel and then of increased housing costs arising from substitution for travel are borne privately for the most part and constitute a large part of the urban disamenity. From empirical data we have determined that these costs indeed explain the disamentiy, with direct transportation costs accounting for about half.

To estimate the magnitude of the urban disamenity, we assume that wages for the same occupation between two cities should just measure the difference in net living costs. The data available for estimating such a measure consist of wage surveys taken periodically for about 40 Standard Metropolitan Statistical Areas (SMSA) by the Bureau of Labor Statistics.[28] Hoch has used this data to measure wage differentials as a function of city size, as well as of region, climate and other factors. He finds that on average a 9.4 percent increase in wages is associated with an order of magnitude increase in SMSA population.

We explain the observed wage differences as compensation for increased living costs, partly due to increased prices, partly due to increased expenditures. Price differences among SMSA's explain about half (i.e., .0468) of the observed wage differential (i.e. .094), and are primarily associated with increased housing costs. The remainder of the price differential results from wage and property cost multiplier effects.[29]

The rest of the wage differential is explained by the necessary increase in transportation expenditures, primarily for commuting, also associated with an increase in city size.

[25] Tobin, James and William Nordhaus, Economic Growth, National Bureau of Economic Research, New York (1972).

[26] Hoch, Irving, "City Size Effects, Trends, and Policies," Science 193, 856 (1976).

[27] See, for example, Mills, Edwin S., "Studies in the Structure of the Urban Economy," published for Resources for the Future by the Johns Hopkins Press (1972).

[28] Handbook of Labor Statistics 1973, Bureau of Labor Statistics, U.S. Department of Labor, USGPO Washington (1973).

[29] Tolley, George S., "The Welfare Economics of City Bigness," J. of Urban Economics 1, 324 (1974).

Although the price of transportation (e.g., the price of gasoline) does not differ significantly among SMSA's, both theory [30] and expenditure data [31] suggest that transportation expenditures increase with income and city size, the component depending on city size being 5–6 percent with each order of magnitude in population.

The total national urban disamenity may be estimated from Hoch's result. Using the current distribution of population among SMSA's and assuming a population of 25,000 gives a zero-level of urban disamenity, we find that urban disamenities account for about 9 percent of national income. This may increase or decrease depending on what we assume to be the future metropolitan distribution of population.

F. Non-Market Corrections

As noted in Table 2, we make corrections to the Q-index for changes in work hours and labor participation. We anticipate increased participation of women in the work force. If these women were not part of the work force, it is generally assumed that they would produce goods and services within the home, thus the term "household production." On the average, we assume that, in the earlier period when they were not part of the labor force, their household services should be valued at the wage rate for household employees, assumed to be the federal minimum wage, on average. Thus we make an imputation at this wage rate in the earlier period for the production of that fraction of the female population, by age cohort, which joins the labor force in the later period.

The imputation for the value of leisure time gained from a decrease in working hours has caused us much difficulty. From one point of view, this imputation seems straightforward. If the worker chooses to work one hour less, the value of the leisure time obtained must be at least as great as the income foregone. In other words, the opportunity cost of leisure is the wage rate. Only the marginal hour is valued at the wage rate; the remaining hours of non-work time are worth more. But this is the same type of valuation as consumer surplus. Since we have decided to value all consumption at the marginal rate, we should value all leisure at the margin, to be consistent. Thus we use the wage rate to value increased leisure time in computing the Q-index.

There has been a long controversy concerning leisure valuation, which has most recently been of interest in recreation economics.[32] The approach generally used was initially developed by Becker.[33] A simplified form will be presented here.[34]

We assume that there are two activities, work and leisure, and the only inputs are time, t_W and t_L, respectively. The individual's utility is thus a function of these variables alone. There are two constraints, a time constraint and an income constraint. To formulate the income constraint we assume that income is spent at a constant rate, a, during leisure time. The function to be maximized is then

$$L(t_W, t_L) = U(t_W, t_L) + \lambda(Wt_W - at_L) + \delta(T - t_W - t_L)$$

where T is the total time available, W is the wage rate, and λ and δ are multipliers which may be interpreted as the marginal value of income and time, respectively. The first order conditions give

$$U_1 + W\lambda - \delta = 0$$

and

$$U_2 - a\lambda - \delta = 0$$

where U_1 and U_2 are the first derivatives of the utility function with respect to work time and leisure time, respectively. Only the first condition need concern us here. If we set the units of value by letting λ equal 1, then we have the result

$$\delta = U_1 + W$$

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[30] Perry, Bradley W., "Estimation of the Urban Disamenity," in process.

[31] The 1960–61 Survey of Consumer Expenditures, Bureau of Labor Statistics, U.S. Department of Labor, USGPO, Washington (1963).

[32] See, for example, Evans, A. W., "On the Theory of the Valuation and Allocation of Time," Scottish Journal of Political Economy 19(1) (1972).

[33] Becker, G. S., "A Theory of the Allocation of Time," Economic Journal 75, 299 (1965).

[34] We owe a great deal to discussions with Elizabeth Gardiner, who has also given us an early draft of a forthcoming paper.

In words, the marginal value of leisure time is equal to the sum of the net marginal utility of work and the wage rate. At the margin, the net utility of work should be large and negative; this is the most unpleasant hour. A value often quoted is $\delta = W/3$, derived by Beesley [35] from data on commuting in London. This implies $U_l = -2W/3$ which is consistent with our expectation.

However, in our valuation of leisure time, we must use the full wage rate. The reason is that we do not count the utility of work time in the Q-index. We remarked in section IB that we are not attempting to measure total welfare, but only the quantity of consumption which is an input to welfare. A consequence of not including the utility of work is that we do not capture the benefits of improved working conditions.

Appendix III. Description of the Mathematical Simulation Model

The mathematical simulation model consists of three basic parts: a demographic sub-model, an economic section, and a welfare index sub-model (see Fig. 11). The first two simulate population and economic activity, year by year, for a predetermined period into the future, usually 10–50 years. The third, the welfare index sub-model, uses the results of these to compute the Q-index and a set of discounted present values of the index using three different social discount rates. The logical flow of the model is given in Fig. 11. There are no feedbacks to the demographic sub-model. The economic section consists of six sub-models, shown in more detail in Fig. 12, which indicates both the detailed feedbacks and the places in the model where contributions to the computation of the Q-index are made.

There are three major feedback paths. The first is the allocation of annual output to pollution abatement and to resource exploration, development and importation, which decrease the amount of GNP available for consumption. The second major feedback is through prices, the shift in consumption to less polluting and less resource-intense items in response to increases in relative prices. Substitution and conservation within industry also take place. The third major feedback is the effect of scale economies and shifts in industrial activity on labor productivity. As described below, present trends show a significant slowing down in the rate of increase of labor productivity and thus in the rate of economic growth as measured by GNP per capita. A minor feedback, which we have investigated but not introduced into the model, is the effect of changing income and changing leisure activity costs on work hours.

In the general description of our model we pay particular attention to the variables controlling the results of the model, which are put into the calculation from the outside: the so-called exogenous variables. The principal exogenous variables are fertility and technological progress; these two determine the primary trend of per capita consumption and thus of the Q-index. The major variables are indicated in regular type in Fig. 12, and those which are exogenous are starred: fertility, death rates, government expenditures, interest rates, technological changes, world demand for natural resources, and the explicitly normative factors in the determination of the Q-index.

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[35] Beesley, M. E., "The Value of Time Spent in Travelling: Some New Evidence," Economica, p. 1974 (May 1965).

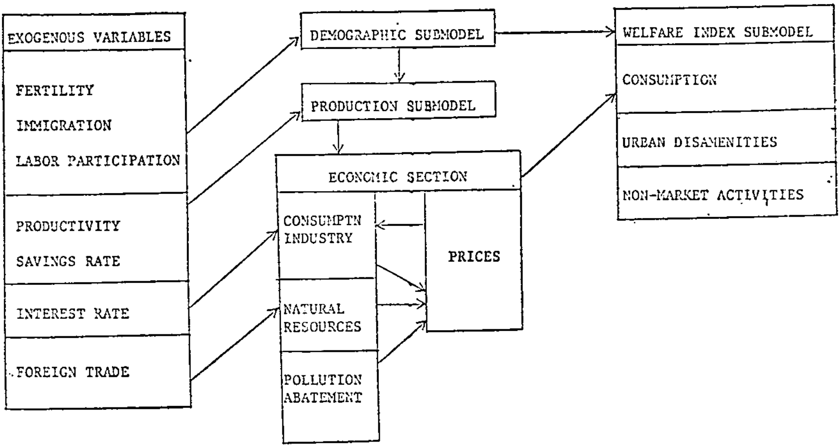

Figure 11.—Logical flow of the mathematical simulation model for studying optimum population levels. For clarity, the production submodel is separated from the remainder of the economic section. Only the most important exogenous variables are listed; others are listed in the text.

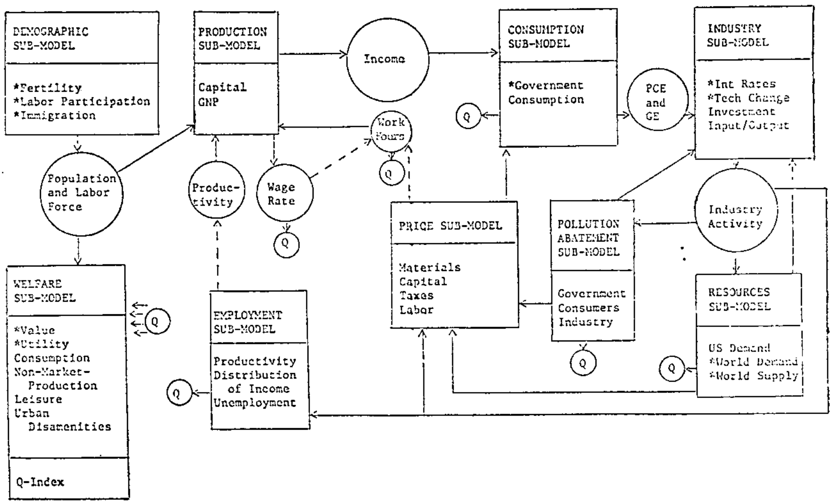

Figure 12.—Detailed schematic diagram of the mathematical simulation model. Solid lines indicate flow of information. Broken lines indicate information flow which is carried out manually. Circles labeled "Q" show where portions of the Q-index are determined. Asterisks indicate exogenous specification of variables.

The major assumptions which go into the model and the quality of the data base all have an influence on the quality of the simulation. The ideal, of course, is a simulation model which captures all of the important relationships, yet is simple enough so that it can be run economically on high-speed computers. The assumptions should be clearly displayed, and if possible be under the control of the investigator, so that the change in results follows clearly from any change in the assumptions. The accepted approach is to let the exogenous variables assume different values in order to "parameterize" their effect. We can study, for example, the long-range effects of differing fertilities.

A. Assumptions

The purpose of our mathematical model is to simulate the effects of future population growth or of other demographic changes. Although the model treats the U.S. as a whole, without regional divisions, it does separate the population by size of metropolitan area. Since the model is driven by demographic development, it is of necessity a long-range model meant to simulate developments over a period of some decades. For this reason, the economic part of the model does not reproduce rapid fluctuations of the economy such as are incorporated in conventional quarterly or monthly economic forecasting models. We assume, for example, that the government through fiscal and monetary controls manages to keep the economy on a steady path, avoiding recessions, increases in unemployment, and business cycles generally. Of course, like any other simulation model, ours is a surprise-free model involving no wars, major social or economic upheavals, or natural calamities. However, any such catastrophe can be programmed in by hand.

The model simulates what will happen in the future based on certain mathematical identities, on demographic and economic theory, and on a judicious extrapolation of a large data base of economic and behavioral data about the U.S. economy and the U.S. population.

Our mathematical model is not a normative model, nor is it optimizing; it simply simulates what is most likely to happen without commenting whether that is good or bad. It says: Here are the most likely consequences based on theory and on the empirical data, taking into account all of the effects which we have been able to build into the structure of our model. Only at the very end, after all the calculations are completed, is there an attempt to measure the "goodness" of the state of affairs in any particular year. This new feature of the model we call the welfare index sub-model. It is purely diagnostic; that is, it does not affect the run of the mathematical simulation model; it merely looks at the results and weighs them in some appropriate fashion to determine the per-capita welfare of the U.S. population in any particular year. In order to relate it to the measure of welfare of a standard year, we express it in the form of an index. This has the virtue of allowing one to judge at a glance whether things are better or worse off. It has the disadvantage of forcing one to weight the state of affairs according to a particular set of value judgments. However, as will be described later, the set of value judgments can easily be varied, since the Q-index is a linear combination of certain outputs of our model. It is therefore possible to define a variety of Q-indices, corresponding to different sets of value vectors of different decision makers.

B. Main Components and Interrelationships

We now move to a brief description of the components or sub-models.

The demographic sub-model was constructed early on in the project. It has recently been expanded, since we can now, thanks to the more developed economic section, describe the income distribution of the population and simulate its future course. This in turn allows us to deal more certainly with the consumption demands of such a population, now and in the future. Based on such major inputs as age-specific fertility, mortality, and net immigration, our model describes the level and age structure of the population in the future, including the school-age population, retired population, and labor force; extrapolating from past trends, we obtain labor-participation rates, the internal migration, and therefore the urban versus rural population split. Using trends, we obtain such variables as household formation, which is important for guaging the demand for housing, appliances and furnishings, and may indeed have an important bearing on fertility.

The *economic section* is composed of seven parts: production, consumption, industry, natural resource, pollution abatement, employment, and price submodels. The production submodel is largely theoretical and calculates the total output of the economy based on the existing labor force and the accumulated capital stock. The calculation uses an empirical production function which has been found to match closely the U.S. experience. Under this theoretical model, however, future production depends on two factors which are not controlled by a demographic sub-model. One has to do with the future *capital stock*, and this depends on how much the economy has invested in capital stock in the preceding years. Several options are possible here, and the outcome of the calculation will depend on which option is adopted. For example, the population may decide to save a fixed fraction of the GNP and invest it in new capital stock. Or they may decide to invest in capital stock to keep the ratio of capital to labor a constant one.

The second factor not controlled by the demographic sub-model is the *productivity* of the economy, which breaks down into the productivity of labor and the productivity of capital. Economists often distinguish between the two, although in the final anlysis either one or both add to the total output. It is perhaps easiest to think of labor productivity in terms of GNP produced per manhour of work. When measured in this way, productivity is found to increase year by year according to a roughly exponential function. This increase in productivity, ascribed to technological progress, improvements in machinery, increases in the capital-labor ratio, improved education of the work force, etc.,[36] is one of the principal exogenous variables of the model.

The consumption sub-model describes how U.S. consumers spend their income, both directly and through government, and therefore how the GNP is made up of different goods and services. This sub-model tells us how the demographic parameters, primarily households, income, aged distribution and geographic distribution, dictate the mix of goods and services demanded. The mix is also affected by the relative prices forecast by the price submodel. The empirical data on the demands of consumers and households come from cross-sectional studies of he Bureau of Labor Statistics on personal consumption expenditures (PCE) and synthetic time-series data developed from Commerce Department data. The expenditures (GE) of governments, federal, state and local, are handled separately and are largely exogenous, that is, we must make special assumptions about future government expenditures.

The core of our economic section is the interindustry input-out (I–O) table contained within the industry sub-model and taken over and adapted from the INFORUM model of Almon.[37] It has 185 industrial sectors, 118 investment sectors, and is used both to compute industrial output from final demands and to divide investment among the industry sectors. It is important to realize that final demand and output are not the same. The latter includes also the outputs of a industrial sector which are purchased by other industries. (For example, the automobile industry not only supplies automobiles to the consumer but also tractors to the farmer, who supplies food to the consumer, trucks to the transportation industry, which brings goods to the consumer, and various kinds of service vehicles to other industries to enable them in turn to provide the necessary consumer goods.) The complex interdependency of all industrial sectors is captured by the I–O table, which expresses, through its matrix coefficients, the mutual purchases between industrial sectors. The I–O table can be viewed as an exercise in multiple-entry bookkeeping. Without it, one could not construct a simulation model whlch is internally self-consistent. Nevertheless, one must be aware of the limitations of the I–O table. It is linear. It is basically static, although the INFORUM tables are dynamic over a range of a few years (and we have added a price response for some coefficients). It mirrors the present technology, but exogenously we can take account explicitly of any future technological development or invention. Most important, it does not allow endogenously for substitution effects or for the effects of price changes in the various inputs. All of these features can be added by hand and are therefore under the control of the investigator. It is easy to see from inspection of the I–O table which changes are crucial and which coefficients are less important. It also allows deliberate experimentation. For example, one can simulate the effects of a gradual or a sudden rise in the price of energy, or the development of a new resource to replace one which has become too highly priced.

Through the I–O table also we can insert in the right places the use of specific natural resources and the incurrence of specific pollution control costs. In the case of natural resources we assume that on-going depletion raises the cost of production in a real sense, i.e., lower quality ores must be mined to extract the same amount of metal. In the case of fuels, such as oil and gas, we must go to deeper strata and farther away. The theory underlying our modeling of natural resources is presented in section IIC. It is clear from our preliminary investigations that fuels dominate the situation, although metals are not unimportant. But assuming that there will be no cartels for metals amd making assumptions about the probable cost of energy development, we can arrive at a very explicit cost picture which incorporates also the demography of the U.S. and to some extent the demography of the world.

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[36] Denison, Edward F., "Accounting for United States Economic Growth; 1929–69," Brookings (1974).
[37] See "1985."

We model conservation, substitution and recycling through changes in input-output coefficients. Conservation is interpreted as applying to a general class of resource, such as energy resources, and is applied uniformly across the class. Substitution is modeled by changing the relative magnitude of coefficients for, say, oil and coal. Recycling of mineral resources is modeled by reducing the coefficient for the resource recycled. Recycling out of end use is handled separately using a scrap industry.

With respect to environmental protection costs the situation is also complicated. Industrial costs have been obtained from the modeling efforts of the Environmental Protection Agency and the National Commission on Water Quality, to both of which we have also made some contribution. In addition, we have modeled the direct cost to consumers in households, primarily the costs of sewage treatment and the increased costs of purchasing and operating automobiles to take care of emission standards.

The price sub-model accepts the additional resource costs and environmental costs, and adds them to the cost of materials, the cost of capital, and cost of labor, and then adds taxes before feeding it back into the consumption sub-model. As materials and capital are in current prices, this is a simultaneous equation input-output model, just the dual of the industry model. The consumer then responds to relative price changes by varying his shopping basket or schedule of personal consumption expenditures. For this purpose we use price elasticities developed and tabulated by the Maryland group.

It is at this point also that we add up the labor needs of the industrial economy as given by labor productivity equations and industrial outputs, and compare them to the labor force available. An iteration is then performed in order to make the two quantities agree. This agreement however is conditioned by the fact that we are explicitly assuming a fixed percentage of unemployment and that we are trending a labor participation rate as well as weekly working hours. The employment sub-model further calculates the productivity of labor in each of the industry sectors; it arrives also at a distribution of income, and important demographic factor, which in turn may influence such items as formation of households, fertility, but certainly determines the consumption schedule for goods and services.

To sum up, the basic features of our economic model can be stated as follows: the production sub-model sets the total level of GNP and thereby disposable income. This in turn determines the spending pattern of the population, which in turn determines industrial activity, the need for resources, the pollution created and the abatement costs, the capital investments required, and the employment schedule. Several kinds of feedback are provided: there is an iteration on employment and there is the major feedback through the price sub-model. Finally, of course, the input-output table itself assures consistency in production and consumption.

The other entirely novel feature of our model is the addition of a welfare index sub-model. As explained earlier, it is a diagnostic sub-model, that is, it does not determine the course of the simulation of the changes in the population and the economy, which proceeds year after year. Instead, the welfare sub-model looks at the outputs that are generated and samples certain of the results that constitute what we take as real welfare (or what some might call "real income," as opposed to per capita GNP). The welfare index is constructed as described in Section II.

We note that pollution costs and resource costs are completely taken care of within the model, rather than calculated separately as in Mark II. We are now left with the following corrections: urban disamenities, household production, and leisure time valuation. And we have the task of introducing normative judgments as to what portions of market production enhance the value of life, and which do not.

C. Data Base and Its Influence on the Quality of Simulation

The major body of data used in our model is just that used by INFORUM (University of Maryland) in estimating the parameters in the consumption, industry and employment equations. They have examined the validity of their model over a short forecast period, 1967 through 1971.

TABLE 4.—*Weighted absolute error, as a percentage of industry output, for 185-sector inter-industry model for a 5-year simulation. These are averages of absolute sector errors*

	Percent
Consumption	1. 5
Investment	. 3
Output	4. 3

Of the total error in output, about a third is from consumption estimates and more than half derives from the input-output table.[1]

The major sources of "error" in our model do not occur here, however, but in the supply estimates for the resources sub-model, the pollution abatement cost functions, the urban disamenity estimates, and the leisure time and household production imputations. Our price sub-model has not yet been validated, but its precision should be such that it does not add appreciably to the total error.

Natural resource supply estimates for the long run are difficult to make, because they apply, in large part, to undiscovered deposits. In the last two years estimates of domestic petroleum resources have dropped by a factor of two. For oil and gas, the situation is even more complicated by the existence of severe distortions of the market. But we have adopted a model with a good theoretical base. This model, which we have described in section IIC, combines our judgment as to the best available resource estimates with economic analysis of natural resource depletion.

Estimates of the costs of pollution abatement are another possible source of error. Forecasts by the Council on Environmental Quality of the ten year cash costs of all abatement varied by 30 percent between 1972 and 1974. But the ratio of this difference to the GNP is only 0.8 percent.

The non-market imputations, urban disamenities, leisure, and household production, could be a much greater source of concern. These imputations are computed separately from the economic model so that the error is not compounded. They are included as corrections and are each less than 10 percent of consumption.

To summarize, the forecast of the absolute levels of industry activity in the economic model may vary significantly from reality, but this variation will be a small fraction of GNP, possibly 5 percent, in aggregate. Natural resource constraints are the largest source of uncertainty because of our poor knowledge of the mineral resource base. Pollution abatement estimates are at best only good to a factor or two. As a fraction of GNP this might be a 5 percent variation. The urban disamenity, leisure-time, and household production imputations have an unknown degree of imprecision, but their contribution to the final result is kept small by making the imputation small. However, all is well if we make differential runs in which one demographic parameter is varied; then to a first approximation all these errors will cancel in the final differential results. Of course, errors of the second order will exist, but presumably they are quite a bit smaller and can be measured, but not necessarily removed, by sensitivity analyses.

Appendix IV. Description of the Sub-Models

In this Appendix the mathematical model will be described in detail, sub-model by sub-model. In general, the equation structure of the model will not be presented.

A. The Demographic Sub-Model

This sub-model is complete and has been operational for 2½ years. The sub-model considers the native and immigrant populations and their age distributions, and allows for different fertility assumptions. It projects characteristics of households and the geographic distribution of the population.

As input parameters to the production sub-model, it projects labor productivities in different sectors, such as agriculture, manufacturing, services, and government. An effective labor force is computed after having considered labor participation rates and trends.

The following additional input variables for the economic section of the model are also forecast: school-age population, number of households, the distribution of households by the age of the head, and total real work force.

1. *Native Citizen Population*

The native citizen population, by age and sex, is forecast each year by setting the population which is age one equal to the births from the previous year and by aging by one year each of the previous year's population, decreased by an age-specific survival rate. Those immigrants who have been resident for five years are also added to the native citizen population. Births are computed as the product of an age-specific fertility rate and the female population.

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[1] Reinbold, Thomas C., "Testing a Dynamic I/O Model by Dynamic Simulation," INFORUM paper, University of Maryland, College Park, Md. (1974).

Fertility rates are introduced exogenously, using one of the following three options: (1) specification in a continuous fashion for each age from 10–49; (2) specification for the following five-year age groups: 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49; (3) specification of the total completed fertility rate and the age of peak fertility. A triangular function for fertility vs. age is assumed in this option. In these three options the age-specific fertility rates may be held constant or trended to approach exponentially a specified asymptotic value. These options also may be adjusted to achieve zero population growth in a specified year. In this case, total fertility is linearly trended from its base year value to the ZPG value.

2. *Net Immigrant Population*

Net immigration is computed each year, using one of the options listed below and given a specified age and sex distribution. Each year's immigration is then tracked separately for four additional years before being added to the native population. This allows gradual immigrant assimilation into the labor force.

Three options are currently available in our model for simulating total net immigration: (1) Net immigration may be calculated as a trended fraction of the total population. (2) Net immigration may be calculated as a function of average disposable income. (3) Net immigration may be specified exogenously.

3. *Labor Force*

The labor force is computed as the product of the total population, by age and sex, and age and sex-specific labor participation rates. The five immigrant populations (see above) are treated separately, using a relative immigrant labor assimilation factor for each population.

Two options are available for simulating labor participation rates: (1) Age and sex-specific labor participation rates may be specified exogenously for the following age groups: 16–19, 20–24, 25–34, 35–44, 45–54, 55–64, and 65–100. Male and female participation rates of the various groups may be trended independently to asymptotic levels to simulate the effects of schooling, fertility, or retirement trends. (2) The female labor participation rates of Option 1 may be superseded for ages 16–39 by calculating them within the model as a function of age-specific fertility.

4. *Other Demographic Variables*

(1) The number of students below grade 9, in grades 9–12, and in higher education, are calculated, using three sets of exogenously specified student participation rates. Those for higher education are also sex-specific. As with other parameters in model, these may be trended to reach asymptotic values.

(2) The number of households and the distribution of households by age of head are computed from the population, using exogenously specified parameters.

(3) The geographic distribution of the population into three categories—urban, rural non-farm and rural farm—is specified exogenously, using trended parameters.

B. The Production Sub-Model

This sub-model is quite simple, essentially a neoclassical model with a one-sector output, GNP. Part of the GNP is reinvested each year in capital which replaces depreciated capital and expands the capital stock. The model allows for two different production functions, Cobb-Douglas and CES, for different ways of accounting for technological progress, and for different modes of investment, including one which preserves a constant capital-labor ratio.

To provide needed values of input variables to the remainder of the economic section, the production sub-model projects disposable income and government expenditures, using forecast GNP and trend parameters.

The labor force is "fully employed" (defined as 4 percent unemployment) in the model, but work hours (the variable in the production function) per employed person follows the historical trend. The consequences of this assumption for our model are discussed below, and the possibility of a feedback suggested.

1. *The Production Function*

The three variants of the production function all assume constant returns to scale, as does the open Leontief function embedded in the industry sub-model. Research by Dale Jorgenson has shown that this is a useful and accurate assumption to make at the national level.[38]

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[38] Jorgenson, Dale W., "Investment and Production: A Review," Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, Ca. (1972).

The most developed of the three variants will be discussed last.

(1) The first variant is a constant elasticity of substitution (CES) production function with technological change embodied in the labor and capital variables. This is included in the model to test the sensitivity of the results to the Cobb-Douglas assumption: that the elasticity of substitution of capital for labor is unity.

(2) The second variant is a Cobb-Douglas production function. Technological change is again embodied in the capital and labor variables. By dividing labor into four sectors (agriculture, government, manufacturing and services) and by attaching to capital an age parameter (sometimes called "vintage"), time-trended parameters for capital-augmenting and labor-augmenting technological progress are used in computing labor and capital variables.

(3) The third variant is a Cobb-Douglas production function with disembodied technological progress. This variant allows us to take advantage of recent research. The exponent α in the function $Q=Ae^{\mu t}k^{\alpha}L^{1-\alpha}$ has been estimated by Wickens using data for the US from 1900–1960.[39] The disembodied technological progress term, μ, has been analyzed by Denison, again using historical data. He finds that it is the sum of four factors: advances in knowledge, educational level of the labor force, economies of scale, and shifts among the different sectors of the economy.[40]

These factors provide us with one of the principal positive feedbacks of the model (the other, capital accumulation, need not be commented on). Advances in knowledge may not be predictable, but we assume a positive relationship to the level of GNP. The effect of the educational level of the labor force has probably reached its peak, since most of the working age population has completed secondary school. Almon's work on labor productivity suggests the effects of scale economies has also peaked already.[41] The effect of the fourth factor is negative: the less productive service sectors are now becoming a larger fraction of the economy.

At present these feedbacks are inserted manually, both for practical reasons and to maintain control over the model.

2. *Investment*

Four options are available for the simulation of investment (which replaces depreciated capital and adds new capital stock): (1) Investment may be calculated as a trended fraction of GNP. (2) Investment may be calculated so as to maintain a constant capital-to-labor ratio. (3) Investment may be calculated as a function of the rate of growth of GNP. This is a modified accelerator model, designed to match the Almon distributed-lag model used in the *industry sub-model.* (4) Investment may be calculated as a function of GNP, taxes, dependency ratio and discretionary income, all of which influence the propensity to save.

3. *Capital Accumulation*

Two models are provided for capital accumulation: a vintage model, which keeps track of each year's investment, and a "two-bucket" model. The former is required if capital-augmenting technological progress is to be modeled. The latter better simulates the actual productivity of capital (see Chap. 6, *1985*).

4. *Labor*

The labor variable in the production function involves the total time the population spends working. For this reason, the labor force determined by the demographic sub-model must be corrected for unemployment and multiplied by the number of hours worked per employed persons. We assume a 96 percent definition of full employment, as the model is not designed to simulate business cycles but to examine the consequences of various rates of growth *at full employment.*

Hours worked per employed person have varied historically with the wage rate (negatively) and with the price of leisure goods and activities (positively). J. D. Owen has developed a mathematical relationship, based on a 50-year data base, which is particularly appropriate for use in our model.[42] At present, for reasons of simplicity, the historical trend is maintained, asymptotically approaching an exogenously specified value.

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[39] Wickens, Michael R., "Estimation of the Vintage Cobb-Douglas Production Function for the United States," The Review of Economics and Statistics, 187 (May 1970).

[40] Denison, Edward F., "Accounting for U.S. Economic Growth: 1929–69," Brookings (1974).

[41] See "1985," Chap. 9.

[42] Owen, J. D., "The Demand for Leisure," Journal of Political Economy, 79(1) (1971).

Another point must be raised at this juncture, however, and will also be taken up later in discussing the welfare sub-model. If work hours per employed person decrease as a result of rising wages, this implies an increased valuation of non-working hours, at least great enough to compensate for the income foregone. An imputation must be made, then, for leisure time valuation if we are not to underestimate the increased real income resulting from rising monetary income.

The consequences of these corrections, reduced work hours and imputation for increased leisure time valuation, are not small. But if these consequences are not affected by different rates of population growth, they merely cloud the issue. These effects will be investigated in greater detail once the model is completed and is working satisfactorily.

5. *Other Macreoconomic Variables*

The macroeconomic structure of the production sub-model is completed at this point. The remainder of this structure is embedded in the industry and employment sub-models. The macroeconomic variables required by the consumption sub-model—disposable income and government expenditures—are computed from forecast GNP using trended parameters and a government expenditure equation which has been estimated from historical data.

C. The Consumption Sub-Model

This sub-model has a two-fold purpose: first, to determine benefit streams arising from forecast consumption and government expenditures on non-durable goods and services, and from stocks of consumer durables and government construction, and, second, to produce final demand vectors of personal consumption (PCE) and government expenditures (GE). The first is used in computing the Q-index; the second drives the remainder of the economic section of the model.

We will describe first the calculations of PCE and GE, which are based on the INFORUM model, and then the determination of benefit streams arising from this activity.

1. *Personal Consumption Expenditures* (*PCE*)

The 185-sector PCE vector is calculated as a function of the size and of the age and geographic distribution of the population, the size, distribution and annual change in income, the sector price index, and time. Inflation is eliminated here as in most of the model: income is in constant dollars, defined by the consumer price index (CPI), and the yearly sector price indices are relative to the current CPI for that year.

The effects on consumption of the size and distribution of the population, average income, and income distribution were estimated using the 1960–61 Survey of Consumer Expenditures compiled by the Bureau of Labor Statistics. A replication of the survey was carried out in 1972–73, and, when the data is available, we plan to reestimate these relationships. The estimation of the remaining relationships is based on time-series data as described in "1985", Chap. 2.

2. *Government Expenditures* (*GE*)

Government expenditures are computed in three steps: setting the total GE; dividing this among 20 categories of government expenditures; and using input-output tables to transform these government "outputs" into input requirements from the 185 industry sectors (see Fig. 13).

The first step is carried out in the production submodel. Here a fraction of the forecast total GNP is assigned to government expenditures. Following Mark II, this function is modeled as a function of total GNP, total population, as well as school age population, and time.

The second step uses a set of equations and exogenous specifications to divide these total expenditures among 5 categories of federal current expenditures, 4 categories of state and local current expenditures, and 11 categories of government construction. There are feedbacks, from the pollution abatement submodel to sewer construction, for example.

The third step uses trended input-output tables to determine the goods and services which have to be supplied by industry per unit of government expenditure. These tables are taken from Department of Commerce data, as well as from more detailed data on defense expenditures.

Most of the structure used in the second step, and the tables used in the third step are taken from INFORUM and are described in Chap. 7 of *1985*.

The level of government expenditures cannot be predicted on the basis of a theory of individual decision making as can consumer and investment behavior. Therefore this is the only sector of GNP whose magnitude is essentially exogenous: it is determined by a very few trended parameters and by the level of forecast GNP.

The second step must for the same reason remain primarily exogenous. For example, the changes in space research and energy R&D expenditures since the sixties would have been difficult to predict. The future trends in the construction of highways, public housing, and mass transit are at the present time a completely open question. Our approach will be, as with other assumptions, to test the sensitivity of the model with respect to different scenarios in order to determine which assumptions are related to population growth in an important way and which are not.

Buyer / Seller		GNP – COMPONENTS						
	185 Products Bought for Use in Production	90 Capital Equipment Buyers	28 Types of Structure Purchased	9 Government Categories	4 Other Final Demand Categories			
185 Products Produced and Sold	A Matrix Sales to Intermediate Use	B Matrix Sales to Capital Equipment Investment	C Matrix Sales to Construction Investment	G Matrix Sales to Federal and State & Local Government	Plus Exports	Less Imports	Inventory Change	Personal Consumption
	Employment (90 Industries)							

FIGURE 13.—Distribution of Product Flows in Industry Model, showing Input-Output Matrices.[1] The interindustry matrix (A matrix) gives the purchases of each industry per unit of its output; the capital equipment matrix (B matrix) gives the purchases of equipment per unit of equipment investment; the construction matrix (C matrix) gives the purchases of construction materials per unit of construction; the government expenditure matrix (G matrix) gives purchases by government sector per unit of expenditure.

[1] From "1985," p. 2.

3. *Streams of Current Benefits*

Our procedure is to value all goods and services consumed within an annual period at their present price. This applies to both PCE and GE. The theory of consumer surplus [43] assumes that consumers would be willing to pay greater than the market price for all but the last item of each good, and thus our procedure undervalues consumption, particularly of "necessities." This is true, but the measurement of consumer surplus is beset with theoretical and empirical uncertainties. Thus we follow the procedure of the national accounts and use a constant set of prices.[44]

Stocks of consumer durables and of structures represent a more difficult problem. The procedure of the national accounts again may be used. In the present accounts, a value for owner-occupied housing is imputed based on surveys of rental rates for equivalent housing. This procedure can be applied also to publicly owned housing, highways, consumer durables, etc. Where we have not found unambiguous survey results for such items, we have used the housing rental rates, corrected for the differing rates of depreciation between consumer durables and structures.

In summary, marginal value equal to market price is used to value all goods and services, as well as to value the streams of services provided by consumer durable goods and public construction.

D. The Industry Sub-model

The industry sub-model provides the essential self-consistency of our project. It determines the level and composition of investment, industry activity, and natural resource demand implied by our forecasts of PCE and GE. This sub-model is the first step in the price and productivity feedbacks and provides also the necessary information for the pollution abatement and natural resource submodels.

The industry sub-model is taken completely from INFORUM and is described in Chapters 3–6, 8 of *1985*. There are five components to the sub-model: a distributed-lag model of producer durable-equipment investment, a stock-adjustment model of construction, a foreign trade model, a model of coefficient change, and the I–O table itself. Here we will describe the components briefly and show how they function within the sub-model.

1. *Equipment Investment*

Investment is at the heart of any growth model, and it is modeled in both our production sub-model and in the investment section of our industry submodel. The latter is designed both to handle long-term growth and near-term (10 to 15 years) cyclical behavior.

A CES production function is assumed in forecasting desired capital. This function implies constant returns-to-scale and a constant elasticity-of-substitution of labor for capital. Actual investment is a weighted average (distributed lag) of the current and of the last five years' desired investment. It is this lag which defines the period of the business cycle (different for each firm).

The rental rate of capital is determined by both endogenous and exogenous variables. The endogenous variables are the relative prices of capital equipment and of materials. The exogenous variables are the corporate-profits tax rate and investment tax credit and, for each industry, the real interest rate and the tax life of equipment.

Thus the two endogenous variables in the investment equation are outputs and prices. The final step in completing the model might be to make interest rates endogenous by relating them to economic growth. Since interest rates are just the rate of return on capital necessary to make consumers forego consumption today, so that capital stocks may increase, these rates should be related to the rate of economic growth. A more slowly growing or stationary population would be expected to result in slower economic growth and lower interest rates.[45]

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[43] See, for example, Mishan, E. J., "Cost-Benefit Analysis," Praeger, New York (1971).

[44] J. deV. Graaff, in "Theoretical Welfare Economics," Cambridge U. Press (1957), convincingly argues that the goal of economics is to forecast simple, easily understood indices, such as GNP or our Q-index so as to have the fewest implicit assumptions and value judgments.

[45] See, for example, Solow, Robert M., "Capital Theory and the Rate of Return," North-Holland, Amsterdam (1963), or, for application to growth models, Hansen, Bent, "A Survey of General Equilibrium Systems," McGraw-Hill (1970).

As with other conjectured feedbacks, our approach to this one will be through sensitivity analysis: What is the consequence to the result if interest rates are made endogenous?

2. *Construction Investment*

The theory of the construction sector is basically the same as that of equipment, but this sector covers a much broader range of capital goods: residences, military structures, sewers, as well as industrial construction. Thus industrial output is replaced in the equations by consumption for housing, offices and hospitals. The comments on interest rates in the previous section also apply here. Public construction is time-trended or completely exogenous. The only exogenous private sector is oil and gas drilling, which is related to assumptions on the behavior of foreign cartels and federal regulation.

3. *Foreign Trade*

In the aggregate, we may ignore foreign trade, as payments must eventually be in balance. However, the composition of foreign trade is important to our industry structure. The present model is very simple. Imports depend on domestic demand and on the effective ratio of foreign to the domestic price. Exports depend on industry output and on the same price ratio.

Without a detailed model of the rest of the world this is as far as one can go. The INFORUM group is preparing a series of foreign models [46] to provide "the rest of the world," but we do not anticipate adding this. We do anticipate investigating the consequences of the US becoming a major net exporter in some areas, for example, food, and a major net importer of petroleum and some ores.

4. *The Input-Output Tables*

There are four I–O tables which we have taken over from INFORUM, one for each of the following: government expenditures, equipment investment, construction investment, and intermediate purchases. These tables are based on the Commerce Department tables and on historical series taken from various sources (see *1985*, Chap. 8; see also Fig. 3).

Technological change, substitution and conservation in response to price changes, and changes in product mix and definition, are represented by changes in the I–O table coefficients. Examples are: shifts in electric generation technology from the present steam turbines to combined cycle or MHD, shifts among fuels and conservation of fuel in power plants and heating, decreases in the weight and horsepower of automobiles.

The time trends in technical coefficients in INFORUM provide the coefficient changes which have been taking place historically. Thus we must handle those shifts which are not now underway, or, at least, which were not significant during the historical period. The recent increase in the price of crude oil is producing one such set of changes. We model these using a combination of physical and economic parameters.[47] For energy resources this involves computing the energy content (in BTU) of purchased fuels. Relative shifts among fuels result from changes in price per unit energy. The total energy per unit of output is modeled as responding more inelastically to the average price per unit energy of all fuel. A similar procedure has been developed for copper-aluminum substitution. Both the lack of sufficient data and the complexity of the empirical situation prevents one from going much beyond these simple cases, at least in developing empirically based models. It is certainly possible and may be necessary to model shifts away from some metals and mineral fertilizers which are forecast to increase in price significantly.[48]

New technologies and new product mixes also must be modeled exogenously. We have in hand considerable data on new technologies, particularly with respect to energy production: from the work of Just at MITRE, and from the University

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[46] Nyhus, Douglas, "Foreign Trade Equations," INFORUM Research Report No. 11, University of Maryland (July 1974).

[47] For a detailed discussion of our technique, see Perry, B. W., "The Short-Run Consequences of Increased Energy Cost," Energy Systems and Policy, 1, 75, (1974).

[48] Fischman, Leonard L. and Hans H. Landsberg, "Adequacy of Nonfuel Minerals and Forest Resources," in Population, Resources, and the Environment, R. G. Ridker, ed., U.S. Commission on Population Growth and the American Future, USGPO, Washington, D.C., (1972).

of Illinois and Brookhaven groups.[49] However, the introduction of these new technologies will not be a direct result of population growth. They will be introduced into our model only test the sensitivity of its conclusions.

E. Resources Sub-Model

The prices of non-renewable natural resources are determined using a supply and demand model, the domestic demand side of which is the consumption and industry submodels. First, we will delineate which resources we are treating. Second, we will describe the present resource supply structure. Finally, we will present the technique used to compute resource costs and their feedback consequences upon the economy.

1. *Natural Resources Treated in the Model*

Fossil-fuel energy is the only truly non-renewable resource. But the existence of high grade mineral deposits in accessible places is equivalent to the availability of the energy necessary to perform this concentration. In that sense, high grade mineral desposits are also non-renewable resources.

We have selected 14 metals and three fossil fuels for treatment in our model. Phosphate and mined nitrate fertilizers are not being treated as yet, but data for this purpose is in hand from the Fertilizer Institute. The data on metal minerals is from unpublished information from the Bureau of Mines, Department of Interior.

2. *The Supply Structure of the Model*

The supply side of the model consists of two types of approaches: competitive and monopolist. The monopolist approach is used for energy resources and the competitive for metal resources.

The following equation equates supply and demand:

$$S_w{}^t = D_w{}^t \equiv f(t)\ D_{us}{}^t$$

where

$S^t{}_w$ = world supply
$D_w{}^t$ = world demand
$D_{us}{}^t$ = US demand determined by model
$f(t)$ = slowly varying time trend of the ratio of world to US demand

all in year t.

Cumulative world depletion, Q_t is then determined:

$$Q_t = \sum_{t=0}^{t} S_w{}^t$$

Unit cost is a function of depletion:

$$c_t = c(Q_t)$$

where the cost functions have been estimated from Bureau of Mines data. Price is the sum of unit cost and unit profit, n_t.

The theory of the optimum depletion of a non-renewable resource tells us that in the competitive case the net price, or rent, should obey the following equation: $d\pi/dt = \pi r - q\partial c/\partial x$, where t=time; r=discount rate; c=production cost per unit; x=cumulative production; q=quantity supplied=rate of depletion=dx/dt. For purposes of simulation we use the difference equation:

$$\pi(t) - \pi(t-1) = r\pi(t-1) - c(t) + c(t-1)$$

and price, p, is then given by the relation,

$$\begin{aligned} p(t) &= \pi(t) + c(t) \\ &= (1+r)\pi(t-1) + c(t-1) \\ &= (1+r)\ p\ (t-1) - rc(t-1) \end{aligned}$$

For the monopolistic case, a different formulation is used which follows the work of Robert Pindyck of MIT, except that again we use the optimal control theory result. This technique is outlined in appendix IIE2.

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[49] Just, J., Borko, B. Parker, W., and Ashmore, A., "New Energy Technology Coefficients and Dynamic Energy Models," ERDA Report No. ERDA-3 (January 1975); Bullard, C. W., and Sebald, A. V., "A Model for Analyzing Energy Impact of Technological Change," presented at 1975 Summer Computer Simulation Conference, San Francisco, Ca. (July 1975); Chernicosky, E. A., "Brookhaven Energy System Optimization Model," Brookhaven National Laboratory, Report No. BNL19200 (1974).

3. *Resource Cost and Feedback*

Resource cost is given by the following relationship:

$$R_t = (c_t - c_o)\, S_{us}{}^t + (p_t - p_o)\, (D_{us}{}^t - S_{us}{}^t)$$

where the first term on the right gives the social cost of domestically supplied resources and the second term gives that of imported resources. Domestic supply is given by the equation

$$S_{us}{}^t = S(p_t)$$

again estimated from Bureau of Mines data.

Feedbacks are of two types: those from domestic cost and those associated with imports. Increasing domestic cost is fed back into exploration, drilling and mine construction and operating costs. The return of dollars spent on imports are divided between U.S. investment and export sales.

Feedbacks to domestic production costs are treated as follows. Cost multipliers, CSECT(I), computed for the Almon mining sectors, 11–17, are used to multiply all factors uniformly: materials (A-matrix), labor and capital investment. Labor and equipment investment are handled by scaling the 90-sector output with CSECT. Construction sector 12 is used for oil and gas, sector 17 for remainder.

Feedbacks to foreign cost involve an exogenously specified division of the return monetary flows between investment and exports. The investment does nothing except generate further outflows of money as earned interest. The exports either multiply the forecast export vector in INFORM, or divide up according to an exogenously specified vector.

F. Pollution Abatement Sub-Model

There are essentially three approaches used to estimate the cost of pollution abatement: using legislated standards, assuming a constant level of environmental quality, and using cost-benefit analysis to achieve an optimum level of abatement. The first is that used by the EPA, the National Commission on Water Quality, the NAS and others to estimate the cost of implementing present legislation. This is a short-run approach and not applicable within the time frame of our model. In addition, there would be benefits as well as costs to calculate, and we would have to make assumptions concerning legislation after 1985.

The second approach is the one used in our model. Since environmental quality is held constant, there are no changes in benefits to calculate. In addition, the cost calculated is a direct result of population and economic growth and not related to changing environmental preferences associated with income.

The third approach is the correct one from the point of optimization theory. Pollution abatement should only continue until the last dollar spent on abatement just results in a dollar of benefit. At the present time, there is not enough known about the shape of benefit functions to put much faith in this method. Thus, our present approach has two advantages: the costs are associated with population and economic growth in a direct fashion; no assumptions need be made about the social benefits arising from pollution abatement.

The equation structure for predicting environmental protection costs has been developed, but the parameters for only a part of this structure have been estimated, i.e., for the cost of industrial air and water pollution abatement. Both the structure and the parameters are taken from the EPA Strategic Environmental Assessment System (SEAS).

In the following, we will first review this structure for predicting cost, and then suggest how we propose to estimate the remaining parameters and validate this portion of the model. Then we shall review the present feedback structure of the effect of these costs on the composition and level of industrial activity and on the Q-index. These feedbacks are both *direct*, through the increased demand for pollution abatement goods and services, and *indirect*, through prices, which for increased pollution abatement cost result in decreased demand for products of polluting industries.

1. *Environmental Protection Cost Structure*

The environmental protection cost structure has been expanded from the earlier single equation [50] to a set of equations which compute national expenditures

[50] See Singer, S. F., "Future Environmental Needs and Costs," EOS 55, p. 954 (1974).

for pollution abatement and control, for air, water, solid waste and other pollution, by 11 abating sectors. These sectors include personal consumption of durable and non-durable goods, industry expenditures, federal, state and local government expenditures, government enterprise, regulation and monitoring, and research and development. We are following here the format and definitions of the newly created BEA series.[51]

The new equations are of the following form:

$$C = C_o \eta_1(t)\ S^{\alpha}(\eta_2(t)\ X)^{\gamma}$$

where

C = pollution abatement expenditures; C_o in the base year
$\eta(t)$ = monotonic functions, whose base year value is unity, which exponentially approach a constant value
S = ratio of population concentration to its base year value, where concentration is defined as the ratio of the urban population to the total
α, γ = constants
X = independent variable for this abatement sector.

At present all the functions use the same parameter values: the eta's approach 0.5 with a half-time of 34.5 years; $\alpha = 1.0$; $\gamma = 2.8$. The independent variables are given in Table 5.

The factors $\eta_1(t)$ and $\eta_2(t)$ give, respectively, the trends in: (1) the cost to clean one unit of waste, and (2) the amount of wastes produced per dollar of the variable X. The degree of non-linearity, i.e., the exponent γ, is modeled to match a projected total national pollution cost for the 1980's, and is assumed to remain constant thereafter.

TABLE 5.—*Independent variable, other than population, for each sector of the pollution abatement sub-model*

Sector	*Variable* (X)
Auto abatement	PCE for gasoline (dollars).
Municipal sewage treatment	Population.
Municipal solid waste	PCE for nondurable plus physical depreciation of durables (dollars).
Industry solid waste	Tons of industry solid waste.
Industry costs recovered	Industry abatement expenditures.
Government enterprise air abatement	Government enterprise output (dollars).
Federal, State, and local: Air, water, other abatement.	Federal, State, and local expenditures.
Regulation and monitoring, each medium.	Total abatement expenditures each medium.
Research and development, each medium.	Total abatement expenditures, each medium, and GNP.

The rationale behind this assumption is as follows: we hold fixed the levels of ambient environmental quality (and therefore the benefits or disbenefits), and calculate the costs of maintaining these levels. A higher degree of waste removal becomes necessary as population and output rise, and abatement costs rise rapidly and non-linearly with the degree of treatment.

The function $\eta_2(t)$ gradually decreases with time because: (i) the goods portion of the GNP is gradually diminishing, while the relatively non-polluting services portion increases. We assume this trend will continue. (ii) We model a technological improvement function, especially for industry and agriculture, which results in a gradually diminishing physical output of wastes of every unit of goods produced.[52]

The other two multiplicative terms, S and $\eta_1(t)$, in our structural equation, simulate the effect of changing population concentration and of improving abatement technology, respectively.

In 1972, $18.7 billion, or 1.6 percent of GNP, was devoted to environmental protection. The following table gives the percentage breakdown of these activities.

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[51] Cremeans, John, and Frank Segel, "National Expenditures for Pollution Abatement and Control, 1972," Survey of Current Business, February, 1975.

[52] This feature does not apply to mining as the quality of ores declines. Recycling, however, is expected to increase as its economics becomes more favorable.

TABLE 6.—*Breakdown of 1972 Expenditures for Pollution Abatement and Control (data from Cremeans and Segel, Survey of Current Business, February 1975)*

	Percent
Automobile	10
Sewers (state and local)	28
Solid waste (state and local)	9
Residential air abatement	6
Industry abatement	39
Air, 16 percent.	
Water, 17 percent.	
Solid waste, 6 percent.	
Pollution control	10

It is apparent from Table 6 that industrial air and water abatement and public water abatement are the largest components, but the remaining five components account for over one-third of costs in roughly equal proportions.

2. *Estimation and Validation of the Structure*

A. INDUSTRIAL ABATEMENT AND MUNICIPAL SEWAGE COSTS

Table 6 suggests that industrial and municipal sewage costs are the most important, but that no category is small enough to ignore. Thus far we have concentrated our effort on examining and adapting the SEAS work on industrial air and water pollution costs. Their equations are simpler in form that ours, taking into account only industry growth. But they are more detailed in application, dividing industry activity by size of plant. While this detail is probably useful for the short run, it is not practical for long-run forecasting.

We have been working closely with both the EPA and the National Commission on Water Quality and use their most recently developed cost data in estimating these equations.[53]

B. AUTOMOBILE EMISSION ABATEMENT COSTS

In September, 1974 the National Academy of Sciences (NAS) published a cost-benefit study of the emission standards mandated by the 1970 Clean Air Act. The study shows that for the statutory standards the "benefits are commensurate with the costs." But this would mean zero net benefits and implies that positive net benefits can be obtained if the standards were to be relaxed.[54] A marginal cost-benefit analysis involving also some corrections to the NAS cost and benefit outlines, suggests an optimum set of emission levels where the total national cost is only about 10 percent of the $8 billion cost estimated in the NAS study for the statutory standards.[55]

This work has given us an excellent forecast for η_1 (t) and a value for γ for the automobile abatement equation. If we assume that the US auto industry follows the lead of Japan in introducing the CVCC principle, a trend for η_2 (t) can be established. The parameter α for modeling the effect of population concentration is the most difficult, particularly as present EPA policy ignores this effect.

C. SOLID WASTE, RESIDENTIAL AIR POLLUTION CONTROL COSTS

There is readily available data on the cost of solid waste management. For the trends in η_1 (t) and η_2 (t) we assume that areas of population concentration will gradually adopt centralized solid waste management systems.

Residential air emission abatement represents the increased cost of distillate oil and of natural gas, whose combustion produces practically no polluting emissions. Our natural resources and price sub-models already take these increased costs into account.[56]

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[53] National Commission on Water Quality, Staff Draft Report, USGPO, Washington, D.C. (Nov. 1975); EPA, "1975 Report on the Cost of a Clean Environment" (to be published).

[54] Singer, S. F., "Emission Standards: Costs and Benefits," Science, 186, 689 (1974).

[55] Singer, S. Fred, "A Re-examination of Cost and Benefits of Automobiles Emission Control Strategies," report to Economics and Science Planning of work performed under NSF grant No. STP75-21384 (March 1976).

[56] It is anticipated that natural gas prices will be deregulated and will become competitive with the prices of other fuels.

Expenditures for control are broken down into regulation/monitoring and research/development. There is insufficient data available at present to estimate equation parameters. We set the first directly proportional to abatement expenditures and the latter to a homogeneous function of abatement expenditures and GNP. The inclusion of GNP as an independent variable takes into account the dependence of general R&D on the absolute size of GNP.

G. Employment Sub-Model

The employment sub-model determines two variables: labor productivity in each industry, and the distribution of family income. The first variable, aggregated over the economy, feeds back into the production sub-model to adjust the disembodied technological progress factor for economies of scale, and for shifts among the different sectors of the economy. The distribution of family income is used both in the consumption sub-model and in the welfare sub-model. Both parts of the employment sub-model are complete. The labor productivity structure is taken over completely from INFORUM and is described in Chap. 9 of *1985*. Only a brief description of the structure will be given here. The income distribution model is partially based on work carried out at the University of Maryland by Brian O'Connor and described in his thesis.[57]

1. *Labor Productivity*

The variable calculated for each industrial sector is actually labor per unit of output, just the reciprocal of labor productivity. Five different equations are used in the INFORUM model. Four of these equations use time or average installation date of capital (AID) and output level or change in output level as independent variables. A fifth equation transforms the time trend into a logistic and also uses change in output level.

At present we utilize the structure as estimated by INFORUM. However, their choice of equations, which is based on ability to simulate recent historical data that include business cycle effects, is not necessarily appropriate to our time horizon. Therefore, in further calibrations of the model we may shift more sectors over to the AID and level-of-output variables.

2. *Income Distribution*

This model begins with average labor compensation in each industry. Then industry labor-compensation distributions, determined from occupation distributions by industry and labor-compensation distributions by occupation, are shifted to give the computed wage. These labor-compensation distributions are then combined to give a total distribution

$$f_t(Y)=\frac{\Sigma e_{i\ t} f_{i,t}(Y)}{\Sigma e_{i,t}}$$

where, for year t,

$f_t(Y)$ is the overall labor-compensation distribution, given in number of wage earners for each of 11 income groups;

$e_{i,t}$ is employment in industry i;

$f_{i,t}(Y)$ is the labor-compensation distribution for industry i.

At present this distribution is taken as the income distribution, neglecting government transfers. That is, we assume that all of property-type personal income goes to the highest income group, with $15,000 annual income or more, and thus does not shift the distribution. Government transfers are taken into account by adding to $f_t(Y)$ a distribution, $c_t(Y)$, whose integral is zero, whose mean is the difference between average income per wage earner and average income per family, and whose form is determined from data for a given base year. This distribution primarily represents two factors: the change in earned income to a family basis, and the result or government transfers and private old age and disability insurance programs.

Income in this model is in constant 1958 dollars. Constant dollars must be used so that we may compare different years independent of inflation. The year 1958 is selected because the most recent BLS consumption survey is for that period. When the 1972–73 BLS Survey of PCE becomes available, the base year for this section may be shifted forward.

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[57] O'Connor, Brian P., "An Income Side to an Input/Output Model of the United States," unpublished dissertation, University of Maryland (1973).

H. Price Sub-Model

This model has been developed completely within our project to fill the need for a most critical feedback: the simulation of market responses to increasing resource scarcity and pollution abatement costs. We know of no other long-run price model with the degree of detail used in our model. The basic approach was suggested by Professor Almon of the University of Maryland,[58] and his group has been helpful in providing data.

First we will give a brief overview of the sub-model, then the theory of the model and parameter determination will be discussed in more detail.[59] The sub-model uses forecast long-run average cost by industry to predict the price of that industry's product. These prices do not respond to short-run changes in supply and demand. Further, it is assumed that the long-run average cost curve is sufficiently flat so that marginal cost equals average cost. Natural resource prices are computed in the resources sub-model described above. The full resource price, including the rent component, is used in this sub-model.

The data base for parameter estimation is the value-added sections of the input-output tables published by the Department of Commerce.[60] Both the 1963 and 1967 tables have been used in this work. Unpublished data for 1967, aggregated to INFORUM sectors, was provided to us by David Belzer. The model has been used extensively on a contract with the National Commission on Water Quality (NCWQ) [61] to determine the price consequences of water pollution abatement costs. This contract has not only given added support to our work but has also exercised the model and subjected it to close scrutiny. Its results have been compared, [62] in the aggregate, to the other model used by the NCWQ, the Wharton Annual Model. Our results are a factor of two less, but proportional. It is our belief that the Wharton Model, by not including capital costs in estimating its equations, then effectively double-counts abatement costs, which include capital expenditures.

1. *Theory of the Price Sub-Model*

As stated above, prices are set equal to long-run average cost (LRAC). There are two reasons for this, one theoretical, the other practical. On the side of theory, we may expect the LRAC of an industry, as opposed to a single firm, to be fairly independent of output. It is affected far more by changes over time in technology and in consumer tastes. On the practical side, the sub-model works in harness with the industry sub-model, which assumes that unit material purchases and unit capital are independent of the output level. Only unit labor requirements, computed in the employment sub-model, are related to output, but, as described in *1985*, p. 174, this is primarily to simulate short-run changes in employment over the business cycle. For these reasons INFORUM does not provide us with data from which to estimate long-run marginal cost, and we must use LRAC.

The price equations compute the cost of materials from the input-output matrix, the cost of capital from capital stocks, property tax and capitalization rates, and labor compensation from labor productivity and wage rates. Sales and excise tax rates are used to compute the remainder of indirect business taxes. The price equations are simultaneous equations, both in the cost of materials and the replacement cost of capital stocks of plant and equipment.

Land and working capital, including inventories, are not included in capital. In order to compensate for this, the capitalization rates used in the model are significantly above market rates for some industries. It is assumed in prediction that land and working capital remain in constant proportion to plant and equipment.

For our purposes only relative prices need to be computed. The form of the equations makes it convenient to fix the average wage as the *numeraire*. Further, in the absence of a long-run wage model, it is assumed that wage rates are fixed relative to one another. For these reasons, average wage rates are held constant.

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[58] Personal communication.
[59] A complete description of the equation structure may be found in Perry, B. W., "The Virginia Price Model," unpublished draft, University of Virginia (December 1974).
[60] U.S. Department of Commerce, "Input-Output Structure of the US Economy: 1963," Survey of Current Business (Survey), USGPO, Washington, D.C. (November, 1963); "Input-Output Structure of the US Economy, Survey (February, 1974). These are referred to in the text as the "Commerce tables."
[61] National Commission on Water Quality Contract No. WQ5AC070.
[62] National Commission on Water Quality, "Macroeconomic Impacts of P.L. 92-500," prepared by CONSAD Research Corp. (1976).

Following Modigliani and Miller,[63] we assume that the capitalization rate is not affected by the debt-equity mix and is a characteristic of the industry. We must correct for inflation the nominal capitalization rate determined from the accounts. In prediction, we use the real rate, as the sub-model does not forecast inflation; wage rates are fixed, and the money supply is not treated explicitly. Any change in the price level reflects a change in the overall productivity of the economy, resulting from technological change, increased real costs of resources, and increased costs of pollution abatement.

2. *Parameter Determination*

The parameters to be determined are wage rates, property, excise and sales tax rates, depreciation and capitalization rates. Wage rates are held constant in the model. The overall wage rate is taken as the numeraire, and relative wages are assumed constant at their base year values.

Indirect taxes are generally property taxes. For those industries which have excise or sales taxes, an average of other industrial property tax rates is used. The remaining indirect tax, when property tax at this average rate is subtracted, is used to comoute either the sales or excise tax rate. Sales tax is included in value-added in the Commerce tables only for wholesale and retail trade. Sales tax does not affect LRAC; this "table" value-added therefore must be decreased by the estimated sales tax.

The capitalization rates are defined as the ratio of base year property-type income and capital stocks. Property-type income is taken from the Commerce tables. This capitalization rate is divided into three components: the effective interest rate, the physical depreciation rate, and a correction for inflation. The physical depreciation rate is taken from the industry sub-model. The correction for inflation uses an equation estimated by Feldstein and Eckstein.[64] The remainder is the effective interest rate which has a constant value for each industry.

I. The Welfare Index Sub-Model

The purpose of this sub-model is diagnostic: to aggregate the real economic welfare of the nation and convert this to a per-capita index. The computation of this index, the Q-index, has been discussed in detail in Appendix II.

First, we note that pollution costs and resource costs are completely taken care of within the model, rather than calculated separately as in Mark II. We are now left with the following corrections: urban disamenities, household production, and leisure time valuation. And we have the task of introducing normative judgments as to what portions of market production enhance the value of life, and which do not. These are carried out in the welfare sub-model just as described in Appendix II.

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[63] Modigliani, F. and Merton H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review, 48, 261 (1958). See also Kumar, P., "Market Equilibrium and Corporation Finance: Some Issues," Journal of Finance, 29(4), 1175 (1974).

[64] Feldstein, M. and O. Eckstein, "The Fundamental Determinants of the Rate of Interest," The Review of Economics and Statistics, 52, 363 (November 1970).

ZERO POPULATION GROWTH AND ECONOMIC GROWTH

By MARVIN J. CETRON *and* SHARON E. SUGAREK*

INTRODUCTION

The debate over the desirability of growth and its contribution to the quality of life in the United States has been a topic of national discourse in recent years. Until recently, it was accepted dogma that growth, both economic and population, was not only desirable but essential to the continuation and maintenance of the national standard of living. However, currently intensifying problems of environmental degradation, urban congestion, material and food shortages, and chronic unemployment have raised serious doubts as to the validity of this assumption.

Zero population growth (ZPG) has been the most publicized aspect of this debate over the desirability of growth. It has been discussed in the popular press and is now receiving serious attention from policy analysts and policymakers within the Government. While initial discussions of ZPG in the early 1960's were of a somewhat more philosophical nature, a zero growth population is increasingly likely in the United States and an examination of the effects of ZPG assumes a high degree of importance in the formulation of policy.

The fertility rate in the United States has been declining for two centuries but the precipitous drop in fertility over the last 10 years has raised serious questions as the promise, or threat, of zero population growth looms. In the long run, most demographers [1] view the cessation of population growth as inevitable. However, the manner in which a stable population will be achieved is under some dispute, as advances in biomedicine could have substantial impact upon mortality rates just as changes in immigration policy could substantially affect not only the current population, but also the future population by increasing the reproductive potential.

The major concern expressed is when ZPG will occur and how it will be achieved. It could be voluntary and result from efforts to curb fertility or it could be involuntary as the carrying capacity of our Nation is reached and some critical resource such as food, clean water or clean air limits population growth. As Robert McNamara observed:

> The population problem will be solved one way or the other. Our only option is whether it is to be solved rationally and humanely, or irrationally and inhumanely.

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* Forecasting International, Ltd., Arlington, Va.

[1] Coale, Ansley J., "Alternative Paths to a Stationary Population," and Norman B. Ryder, "A Demographic Optimum Projection for the United States," in U.S. Commission on Population Growth and the American Future, "Demographic and Social Aspects of Population Growth," Charles F. Westoff and Robert Parke, Jr., eds., vol. 1 of Commission research reports (Washington, D.C.: Government Printing Office), 1972, pp. 589-603 and 605-622, respectively.

Despite the vociferous debate, American concern over its population growth is recent. Although serious study has been made of the population growth rates of lesser developed countries, concern with the domestic rate of population growth was not manifested until the last decade. Population policy was not recognized as a legitimate area of Government policy until 1965 when President Johnson endorsed Government sponsored population control in his State of the Union address. Despite such Presidential sanctions, doubt over the legitimacy of the issue has persisted. For instance, the sale of contraceptive devices was prohibited in the State of Connecticut until the mid-sixties and there is still controversy concerning the legitimacy of Government-subsidized contraception.

The current analysis of zero population growth reflects this national suspicion of growth. We are beginning to suspect that growth may not be the panacea it was once thought, and that growth may, in fact, contribute to national problems rather than mitigate them. The recognition that there may be costs associated with population growth, even in a developed country, has led this country into an exploration of the meaning and implications of zero population growth.

The issue has been studied by a variety of diverse groups with a wide variety of interests and conclusions. A Presidential Commission, The Presidential Commission on Population Growth and the American Future, recommended that the Nation pursue ZPG as a national goal.[2] An active and vociferous lobbying organization, Zero Population Growth, Inc., which grew from a starting membership of 100 in 1969 to 34,250 in 1971,[3] contains some members who advocate an immediate reduction in fertility to mitigate a host of social and economic problems; including material shortages, inflation, environmental degradation, urban congestion, social disorganization, and population density.

Equally fervent and enthusiastic are those who argue that the result of zero population growth will be an end to economic growth and the high standard of living as we know it. This sequence of events could, in turn, lead to a decline in capital investment contributing to the continued degradation of the environment, both man made and natural; continuation of poverty and income inequality; decrease in risk taking; declining innovativeness and creativity bringing an end to American technological dominance; and a general inability to meet the pressing social problems facing the Nation.

In order to analyze and synthesis previous studies of ZGP and to develop a holistic analysis of ZPG, the National Science Foundation has commissioned Forecasting International Ltd. to conduct a detailed study of the economic, social and political impacts of ZPG.[4] An in-depth analysis of the implications of ZPG for national standards of living was a major contribution of this study and will be discussed in some detail in this paper.

ZPG is alternatively attacked as a cause of economic decline and lauded as a route to greater standards of living. In analyzing the impacts of ZPG, Forecasting International sought to assess this issue using a normative approach to investigate the level or standard of

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[2] U.S. Commission on Population Growth and The American Future, "Report of the U.S. Commission on Population Growth and the American Future," (Government Printing Office: Washington, D.C.) 1971.

[3] Barnett, Larry D., "Zero Population Growth, Inc.", Bioscience (Vol. 21, No. 759), 1971: and Larry D. Barnett, "Zero Population Growth, Inc., A Second Study," Journal of Biosociological Science (Vol. 6), 1974, pp. 1–22.

[4] Forecasting International, Ltd., "An Analysis of the Policy Implications of Zero Population Growth, May 1976.

living that would be possible within the context of ZPG, given alternative assumptions about economic growth rates.

To accomplish this analysis of the quality and quantity of goods and services that could be purchased and the proportion of the population that could enjoy a certain level of goods and services, attention was focused on the level of Personal Consumption Expenditures (PCE) associated with alternatives levels of GNP. By using statements of consumption expenditures rather than per capita GNP, it was possible to translate figures of aggregate economic growth into statements of precise standards of living. Statements of standards of living were developed based on the U.S. Department of Labor, Bureau of Labor Statistics Hypothetical Budgets.[5]

Overview of Study Approach

Aggregate levels of personal consumption expenditures were utilized to measure standards of living at the household level based on the Bureau of Labor Statistics hypothetical budgets, modified to suit family configurations within the context of zero population growth. The analysis of personal consumption expenditures was accomplished by comparing two sets of figures:

(1) The level of aggregate projected personal consumption expenditures that would be associated with each assumed economic case: aunual growth of 3 percent, 2.7 percent, 1 percent, and no growth [6] through the year 2050; and

(2) The aggregate level of personal consumption expenditures (PEC) necessary to sustain 5 PCE "scenarios"; that is quantitative statements of improved standards of living, in terms of purchases of goods and services at the family unit. The consumption levels at the family level (taking into account differential family formation patterns associated with ZPG) will be summed to determine the aggregate national PCE figure.

A comparison of projected personal consumption expenditures and the five personal consumption expenditure scenarios is made, to address the question: What does the projected rate of economic growth, under conditions of zero population growth, mean with regard to the standard of living of the U.S. population?

Essential to the formulation of this final comparison between PCE at alternative levels of economic growth and levels of PCE required to obtain a certain standard of living is a determination of—

(1) Projections of PCE at various levels of economic growth rates;

(2) Determining the family or household configuration under assumptions of ZPG; and

(3) Construction of PCE scenarios for ZPG family configurations at various standards of living based on Bureau of Labor Statistics standards.

By accomplishing these tasks we could then make assumptions about a desirable standard of living and determine the level of economic

[5] U.S. Department of Labor, Office of Information, "Autumn 1972 Urban Family Budgets and Comparative Indexes for Selected Urban Areas," U.S. Department of Labor: 73-253, June 15, 1973.

[6] Negative economic growth is not being considered as a reasonable alternative. Obviously, such economic conditions render the standard of living lower and the question we are addressing moot. Moreover, it is likely that such economic conditions would give rise to civil strife, even civil violence. Its inherent instability does not warrant consideration as a long-term trend. Economic no growth is probably a misnomer, for it implies growth of some sectors and decline of others. Economic equilibrium at zero growth in all sectors seems highly unlikely and equally as unstable as negative growth.

growth required to insure that level of PCE. By comparison of expected levels of PCE and levels of PCE required to maintain a given standard of living, we can make some statements about the effects of ZPG on standards of living.

The following discussion presents the key steps in the analytical process and an assessment of the effects of ZPG on standards of living.

Projection of Personal Consumption Expenditures at Selected Economic Growth Rates

Key to the analytical process is the formulations of projections of PCE at certain levels of economic growth. It should be noted that no attempt is made to actually forecast likely future economic conditions. However, the growth rate assumptions made here reflect a range of the most probable economic conditions.

We have chosen four economic conditions to investigate: 3 percent, 2.7 percent, and 1 percent annual real growth and the no growth case. Of course, these are viewed as annual averages and the no growth case may, for instance, reflect growth in some years, followed by economic decline in other years.

Personal consumption expenditures projections at different growth rates were developed on the basis of the perceived historical relationship between personal consumption expenditures and the gross national product (GNP). Over the past 20 years, personal consumption has remained a relatively constant proportion of GNP, with the average rate of personal consumption expenditures approximating 63.5 percent of gross national product. Historically, this ratio of personal consumption expenditures to gross national product has not been affected significantly by changes in the rate of economic growth, the rate of population growth, or the composition of the population and the labor force. On the basis of this historical inference, it is assumed that the level of personal consumption expenditures will continue to be 63.5 percent of the gross national product.

Of course, dramatic changes in the level of personal consumption expenditures could result from a Government policy decision to tax the individual and then to provide him with services which the individual would otherwise have paid for. Such an occurrence would be of no consequence to this analysis as personal consumption expenditures are used here as a surrogate measure of the population's standard of living. If Government expenditures were to supplant personal consumption expenditures, it is likely that any decrease in personal consumption expenditures would be offset by a relatively commensurate increase in Government expenditures and, as a consequence, the quality or amount of services provided to the individual would not vary significantly.

Based upon the assumption discussed above, GNP and associated PCE were calculated at each of four economic growth rates. These projections are summarized in exhibit 1 for three time frames.

EXHIBIT 1

GROSS NATIONAL PRODUCT AND ASSOCIATED PERSONAL CONSUMPTION EXPENDITURES

[In billions of 1970 dollars]

Annual rate of growth	1990 projected	2020 projected	2050 projected
Gross National Product:			
3 percent	1, 753	4, 267	10, 364
2.7 percent	1, 656	3, 692	8, 202
1 percent	1, 188	1, 398	2, 163
0 growth	974	974	974
Personal consumption expenditures:			
3 percent	1, 113	2, 709	6, 581
2.7 percent	1, 052	2, 344	5, 208
1 percent	755	1, 014	1, 373
0 growth	619	619	619

EFFECTS OF POPULATION GROWTH ON PER CAPITA WEALTH

Generally when "rising standards of living" are defined, it is in terms of per capita GNP. Exhibit 2 summarizes the GNP per capita at various rates of economic growth for a ZPG population.

EXHIBIT 2

PER CAPITA GNP: IMPACT OF ALTERNATIVE ECONOMIC GROWTH RATES AND ZPG

[In 1970 dollars]

Growth rate	1990	2020	2050
3 percent	$7, 006	$13, 872	$30, 903
2.7 percent	6, 617	12, 003	24, 457
1 percent	4, 747	4, 548	6, 450
0 growth	3, 889	3, 167	2, 905

Note: 1970 GNP per capita, $4,719.

Such an analysis indicates that under economic no growth, the per capita wealth will decline by 38 percent with achievement of a stable population. Economic growth of 3 or 2.7 percent will bring tremendous increases in per capita wealth; an annual growth rate of 1 percent barely keeps with population growth until the effects of ZPG are felt.

GNP per capita will be greater in a zero growth population than it is in a growing population. Exhibit 3 compares per capita GNP for these two types of population. It is clear that a higher rate of real economic growth must occur with the growing population (series C) than with ZPG (series E) to insure increasing standards of living.

EXHIBIT 3

A COMPARISON OF GNP PER CAPITA ZPG VERSUS NON-ZPG POPULATIONS

[In constant 1970 dollars]

Year: Economic growth rate	Series C	Series E (ZPG)
1970	[1] 4,719	
1980:		
3 percent	5,583	5,731
2.7 percent	5,458	5,603
1 percent	4,583	4,704
0	4,166	4,277
1990:		
3 percent	6,500	6,972
2.7 percent	6,141	6,586
1 percent	4,405	4,725
0	3,612	3,874
2000:		
3 percent	7,758	8,732
2.7 percent	7,088	7,976
1 percent	4,310	4,831
0	3,193	3,593
2020:		
3 percent	10,744	13,881
2.7 percent	9,296	12,010
1 percent	3,520	4,528
0	2,453	3,169

[1] Actual.

This analysis indicates that economic growth of greater than 2 percent is the minimum to insure rising per capita wealth even at ZPG, however, it says nothing about the kinds of goods and purchases that a family must and can purchase.

Therefore, an analysis of personal consumption expenditures to reveal more definitive information regarding the possible levels or standards of living that might be attainable in the future was conducted. It should be noted here that patterns of consumption are, of course, a function of the size of the household and the age of the household members. A newly married couple with a recently purchased home has very different expenditure patterns than an elderly retired couple living in a home they own. This fact has important implications since the effects of ZPG involve a change in family size and age structure. Thus the next step in the analysis of standards of living was to develop profiles of families in the future.

THE ZPG FAMILY CONFIGURATION

To construct the family configuration, the total population must, of course, first be constructed. Again, this population is not a projection of the most probable population, rather it is a possible population which provides us with a plausible way of assessing the population/economic/quality of life interaction. This population projection through the year of stabilization should not be interpreted as a statement of what will be but rather a statement of what could be.

Exhibit 4 summarizes the sex and age characteristics of a population which stabilizes in size by 2040 A.D. Based upon current mortality rates, this population projection is based upon an average fertility rate of 2.1 children per female. Such a rate compensates for those women who die before reaching or completing their childbearing years and for the fact that there have been more male children born than female in the United States. Of course, there may be short-term fluctuations. The present fertility rate in this country is 2.04–2.08 children per female, slightly below the replacement level; however, this is expected to rise above the replacement level of 2.1 for a short period of time.

This zero growth population is consistent with the assumption that low fertility will continue and is a continuation of the U.S. Bureau of Census series "E" projection which is based upon the assumption of an average of 2.1 births per female throughout their childbearing period.

EXHIBIT 4

PROJECTED TOTAL POPULATION BY AGE AND SEX

[In thousands]

Sex, age cohort	1970	1990	2020	2050
Males, all ages:				
0 to 4	8,753	10,648	11,038	11,751
5 to 15	22,768	23,642	24,930	25,850
16 to 24	16,398	16,066	19,464	20,976
25 to 34	12,513	21,040	21,423	22,632
35 to 44	11,307	18,378	21,738	22,566
45 to 54	11,229	11,922	18,033	20,677
55 to 64	8,815	9,424	17,495	17,893
65 to 74	5,447	7,150	11,654	13,689
75 and over	2,994	3,931	5,180	7,979
Total	100,224	122,211	150,955	164,013
Females, all ages:				
0 to 4	9,718	10,198	10,568	11,252
5 to 15	21,932	22,691	23,714	24,889
16 to 24	16,049	15,577	18,793	20,248
25 to 34	12,765	20,750	20,985	22,154
35 to 44	11,819	18,524	21,545	22,345
45 to 54	12,040	12,695	18,436	21,024
55 to 64	9,883	10,934	19,175	19,479
65 to 74	8,031	9,626	14,737	17,056
75 and over	3,685	7,061	8,690	12,907
Total	105,922	128,056	156,643	171,354
Total, both sexes	206,146	250,267	307,598	335,367

Under current mortality conditions, such a fertility rate yields a net reproduction rate of 1.0; that is, each generation is exactly replaced by the next one. The composition of the population eventually becomes constant with respect to age and sex distribution as well as total size, except for the net immigration.

It is important to note that this population does not become a zero growth population for over 70 years. Also, the population assumes net immigration to the United States of 400,000 per year throughout the projection period; resulting in continual population growth. However, these projections do imply an eventual stabilization in the natural increase of the population at zero in about 70 years; that is, births and deaths become equal at that point. This implies that any further increase in population size after about 2040 would stem from net immigration or from mortality reduction more rapid than the gradual reductions assumed in these basic projections. For instance, the projections used here assume an annual net immigration of 400,000 giving a total population of 335 million by 2050; if zero net immigration is assumed, the corresponding population is 228 million.

This population must be converted to family types which first requires speculation of the future of such institutions of marriage and divorce. The family configuration assumes that childbearing will continue to be primarily limited to married couples. This may be an unrealistic assumption about value change over such a long period of time, yet it does not distort the family configuration. The estimates of the propensity to marry are presented in exhibit 5. As is readily seen, for some age cohorts a declining propensity to marry is likely. This is consistent with recent historical trends and apparent attitudes toward marriage.

EXHIBIT 5

ESTIMATES OF PROPENSITY TO MARRY BY AGE AND SEX

[Percentage of cohort married]

Sex/age cohort	1970	1990	2020	2050
Female:				
16 to 24	40.0	40.0	40.0	40.0
25 to 34	86.0	88.0	89.0	89.0
35 to 44	86.9	96.6	96.3	86.1
45 to 54	82.0	82.0	81.5	81.2
55 to 64	67.0	67.0	67.0	67.0
65 to 74	45.4	45.2	45.0	39.8
75 or over	20.0	20.0	20.0	20.0
Male:				
16 to 24	25.0	25.0	25.0	25.0
25 to 34	85.0	86.0	88.0	88.0
35 to 44	89.3	89.6	89.6	89.8
45 to 54	87.2	86.8	86.2	85.1
55 to 64	85.0	85.0	85.0	85.0
65 to 74	77.6	77.3	76.9	76.9
75 or over	61.0	61.0	61.0	61.0

Source: U.S. Bureau of the Census.

Given the marriage configurations, it then becomes necessary to consider the number of households these families represent, for it is the household rather than the family that is the unit of consumption. The rate of household formation was projected for each of the age cohorts. Again, this was done by inspecting the recent historical trends of household formation, accounting for both age and sex. These results are presented in exhibit 6. It is thought that single people will increasingly establish their own households (contrasted to living with their parents) and married couples will increase their propensity to establish independent households lightly. Offsetting what would normally be a greater increase in households formation is the perceived freedom of lifestyle in which married couples may be more likely to share communal living space.

Exhibit 6

HOUSEHOLD FORMATION RATE BY AGE AND MARITAL STATUS

[Percentage of each group forming own household]

Marital status and age	1990	2020	2050
Single:			
Under 25	30	40	40
25 to 34	50	60	60
35 to 44	70	70	70
45 to 54	70	70	70
55 to 64	60	60	60
65 to 74	60	70	70
75 or over	50	60	60
Married:			
Under 25	85	85	85
25 to 34	97	97	97
35 to 44	97	97	97
45 to 54	95	95	95
55 to 64	90	90	90
65 to 74	90	90	90
75 or over	80	80	80

The number of households by age of the head of household could then be calculated as shown in exhibit 7. Following this, the children that had previously been projected were distributed over the families, again consistent with both historical trends and reasonableness; for instance, no young children were assigned to an elderly couple. It was these families that formed the basis for construction of the consumption scenarios.

Exhibit 7

NUMBER OF HOUSEHOLDS BY FAMILY TYPE

[Millions of households]

Household type	1990	2020	2050
Single person household:			
Age:			
Less than 25	6.4	10.4	1.96
25 to 34	2.8	16.7	3.06
35 to 44	3.1	3.6	3.71
45 to 54	2.7	.63	4.83
55 to 64	3.0	5.3	5.46
65 to 74	4.1	7.7	8.96
75 or over	3.6	5.76	8.04
2 or more member household:			
Age of head:			
Less than 25	3.4	4.17	4.42
25 to 34	16.7	4.80	18.33
35 to 44	15.8	18.53	19.21
45 to 54	9.8	16.91	16.53
55 to 64	6.9	12.51	12.33
65 to 74	4.5	6.93	8.06
75 or over	1.5	1.72	11.36
Total	84.3	115.66	126.26

Personal Consumption Expenditure Scenarios

By using statements of consumption expenditures rather than per capita GNP, it is possible to translate figures of aggregate economic growth into statements of precise standards of living. It is also possible to define hypothetical standards of living for the population and to compute the aggregate cost for each, thereby deriving a hypothetical level of personal consumption expenditures. Comparisons between these hypothetical levels of personal consumption expenditures and the projected levels of personal consumption expenditures will provide insight into the likelihood of rising standards of living. These hypothetical personal consumption expenditure levels are referred to as consumption scenarios for the purpose of this study.

These consumption scenarios are statements of alternative demand or consumption, much of which represents a certain standard of living. These scenarios are neither projections of economic growth nor forecasts of personal consumption expenditures. They also say nothing about what levels of income will be associated with the given consumption figures, or how that income is likely to be obtained. The scenarios merely stipulate the level of funds [7] for the personal purchase of goods and services that would be necessary to provide specified standards of living to various segments of the population. Each scenario answers the question, "How much would it cost if all families had * * * ?" More specifically, each scenario answers the question, "What level of consumption is required to achieve a condition where all members of the U.S. population have a certain standard of living?"

Five consumption scenarios were developed by determining the dollar cost of each of five defined standards of living for the population as projected for each of the 3 years, 1990, 2020, and 2050. The five alternative standards of living were developed from the U.S. Department of Labor, Bureau of Labor Statistics hypothetical family budgets,[8] The Bureau of Labor Statistics computes budget estimates for an urban family of four: A 36-year old employed husband with considerable work experience, his nonworking wife, a boy of 13 and a girl of 8. The budgets are statements of the amount of money required to purchase specified goods and services at three different standards of living, entitled "low," "intermediate," and "high." The lower budget does not reflect poverty conditions, but rather the lower limit of spending necessary to achieve a minimum but adequate standard of living as defined by the Bureau of Labor Statistics. The budgets do not necessarily reflect how money is spent for current consumption to meet these precisely defined levels of living standards.

The style of living represented by the lower budget differs from that in the intermediate and higher budgets primarily because the "low budget" family lives in rental housing without air conditioning, performs more services for itself and utilizes the free recreational facilities of the community. The "high budget" family reflects a higher level of home ownership, more complete inventories of household appliances and equipment and more extensive use of services for a fee. For most of the items that are common to all three budgets, both the quantity and quality levels increase with the standard of living.

Medical care costs in the three budgets include a family membership in a group hospital and surgical insurance plan, plus a specified number of visits to physicians, provisions for dental and eye care, and prescriptions. The higher budget includes provisions for major medical insurance coverage as well.

The budget data show that food spending declines relative to income, accounting for roughly one-third of the consumption budget

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[7] All dollar figures in the analysis are in constant (1970) dollars.

[8] U.S. Department of Labor, Office of Information, "Autumn 1972 Urban Family Budgets and Comparative Indexes for Selected Urban Areas," U.S. Department of Labor: 73-253, June 15, 1973.

at the lower level and for roughly one-fourth at the higher level. In contrast, these proportions are practically reversed for housing and house-furnishings. Roughly one-seventh of the total is allocated to clothing and personal care at all three levels, and for transportation (one-tenth of the total), the proportionate differences between the levels are also small.

While the Bureau of Labor Statistics has derived the standard budgets for the family described above, it also provides for the conversion of this basic budget to budgets for other types of family units. For instance, a household of similar size except for an older head of household (age 55–64) requires 105 percent of the standard budget, but the family with a head of household under age 35 requires 77 percent of the standard budget. Exhibit 8 presents the conversion table used for this analysis. Using this conversion table and applying it to the actual budget by item, the consumption moneys required to meet the three standards of living by family type were calculated, as shown in exhibit 9. These figures, when employed with expected family configurations, form the basis for the construction of PCE scenarios.

A range of consumption budgets representing an improved standard of living was developed based upon the projections of family formations and configurations. These budgets were computed from BLS data, which describe the distribution of expenditures by goods and services category, and the 1970 income distribution of families. These budgets summed, then, are the consumption scenarios.

EXHIBIT 8

REVISED EQUIVALENCE SCALE FOR URBAN FAMILIES OF DIFFERENT SIZE, AGE AND COMPOSITION

Size and type of family	Age of head			
	Under 35	35 to 54	55 to 64	65 or over
1 person	35	36	32	28
2 persons, average	47	59	59	52
Husband and wife	49	60	59	51
1 parent and child	40	57	60	58
3 persons, average	62	81	86	77
Husband, wife, child under 6	62	69		
Husband, wife, child 6 to 15	62	82	88	81
Husband, wife, child 16 to 17		91	88	
Husband, wife, child 18 or over		82	85	77
1 parent, 2 children	67	76	82	75
4 persons, average	74	99	109	91
Husband, wife, 2 children, (older under 6)	72	80		
Husband, wife, 2 children, (older 6 to 15)	77	100	105	95
Husband, wife, 2 children, (older 16 to 17)		113	125	
Husband, wife, 2 children, (older 18 or over)		96	110	89
1 parent, 3 children	88	96		
5 persons, average	94	118	124	
Husband, wife, 3 children, (oldest under 6)	87	97		
Husband, wife, 3 children, (oldest 6 to 15)	96	116	120	
Husband, wife, 3 children, (oldest 16 to 17)		128	138	
Husband, wife, 3 children, (oldest 18 or over)		119	124	
1 parent, 4 children	108	117		
6 persons or more, average	111	138	143	
Husband, wife, 4 children or more (oldest under 6)	101			
Husband, wife, 4 children or more (oldest 6 to 15)	110	132	140	
Husband, wife, 4 children or more (oldest 16 to 17)		146		
Husband, wife, 4 children or more (oldest 18 or over)		149		
1 parent, 5 children or more	125	137		

Source: U.S. Department of Labor, Bureau of Labor Statistics, "Revised Equivalence Scale for Estimating Equivalent Incomes or Budget Costs by Family Type," Bulletin No. 1570–2 (GPO: Washington, D.C.) November 1968.

EXHIBIT 9

ALTERNATIVE STANDARDS OF LIVING BY FAMILY TYPE[1]

[In 1960 dollars]

Family type	Low		Intermediate		High	
	Before taxes	After taxes	Before taxes	After taxes	Before taxes	After taxes
Single person, less than 35	2,733	2,231	4,235	3,335	6,126.5	4,611
Single person, more than 55	2,437	1,990	3,777	2,974	5,464.0	4,112
Husband/wife less than 35	3,693	3,015	5,723	4,507	8,280.0	6,231
Husband/wife 35 to 55	4,505	3,678	6,982	5,498	10,100.0	7,602
Husband/wife less than 55	4,432	3,617	6,868	5,408	9,935.0	7,477
Husband/wife less than (1 child less than 6)	4,579	3,738	7,097	5,588	10,266.0	7,726
Husband/wife 35 to 54 (1 child 6 to 15)	6,130	5,004	9,500	7,480	13,743.0	10,343
Husband/wife less than 35 (2 children oldest less than 6)	5,244	4,281	8,127	6,399	11,756.0	8,848
Husband/wife 35 to 54 (2 children oldest less than 6)	5,835	4,763	9,042	7,120	13,080.0	9,845
Husband/wife 35 to 54 (2 children oldest 6 to 15)	7,386	6,029	11,446	9,013	16,558.0	12,462
Husband/wife less than 35 (3 children oldest 6 to 15)	6,943	5,667	10,759	8,472	15,564.0	11,714
Husband/wife 35 to 54 (3 children oldest 6 to 15)	8,494	6,933	13,163	10,365	19,042.0	14,331

[1] Derived from Bureau of Labor Statistics Household Budget Data and "Revised Equivalence Scale for Estimating Incomes or Budget Costs by Family Type, (Bulletin No. 1570–2) Department of Labor, Bureau of Labor Statistics (November 1968).

Initially three scenarios were generated: low, intermediate, and high. The low scenario addressed the question: All else being equal, how much additional money, over the current level of total PCE, must be available for consumption to raise all household units with incomes below the low budget up to the low level? The intermediate scenario addressed the question of: How much additional money is required to bring all those below the intermediate budget to the intermediate level? The high scenario addressed the question: How much additional money is required to bring all those below the high budget to the high level? However, it was felt that this view of income redistribution was unrealistic. Political and social constraints suggest an improved standard of living be computed for all segments of the population.

To accommodate the improved position of all individuals, two additional scenarios were constructed. A "low adjusted" consumption scenario was constructed which stipulated that *all* families currently below the low consumption budget level would be brought up to the low level, *all* units at the low level would be brought up to the intermediate level, and the budgets of others would be held constant. In the "intermediate adjusted" scenario, those families with consumption budgets below the intermediate level would be brought up to the intermediate level of consumption while those at or above the intermediate level would be brought to the high level.

These scenarios were constructed for three time periods of concern: 1990, 2020, and 2050. In this way, the computed consumption levels accounted for both a changing time horizon and population configuration. The cost of each scenario was computed with explicit consideration of both the total size and composition (and sex distribution) of the population in each of the three time periods.

The aggregate cost of each consumption scenario, that is, the total level of personal consumption expenditures required to satisfy each of the 5 scenarios, is presented in exhibit 10. In addition, the table displays the level of gross national product associated with each consumption scenario and the average annual rate of growth necessary to reach the designated level of gross national product. (The computation of total GNP was based on the assumption, explained above, that personal consumption expenditures are 63.5 percent of GNP.)

Comparison of Personal Consumption Expenditures Projections to PCE Scenarios

Each of the consumption scenarios stipulates the aggregate level of personal consumption expenditures necessary for the standard of living of one segment of the population to remain constant while that of another segment improves. Essentially, the low stationary scenario specifies the cost, in terms of increased aggregate personal consumption expenditures, of bringing those with a standard of living less than that represented by the BLS low budget up to the low budget level, while holding the standard of living of everyone else in the nation constant. The high-stationary scenario specifies the cost of bringing every family in the United States up to the high BLS level while allowing those above the high budget level to maintain their position of greater affluence.

Exhibit 11 summarizes the overall differences between the projected values of personal consumption expenditures and the values developed in the consumption scenarios. The entry in each cell indicates the percentage which the scenario level of personal consumption expenditures is of the projected level. (For each year, the entry in each cell was computed as the ratio: scenario PCE/projected PCE).

Exhibit 10

5 CONSUMPTION SCENARIOS

[In billions of 1970 dollars]

	1990			2020			2050		
	PCE	GNP	Growth rate necessary (percent)	PCE	GNP	Growth rate necessary (percent)	PCE	GNP	Growth rate necessary (percenty)
Standard of living scenario:									
Low stationary	1,176.86	1,853.03	3.25	1,627.07	2,561.91	1.96	2,192.76	3,452.62	1.59
Low adjusted	1,209.56	1,904.52	3.42	1,696.00	2,670.45	2.03	2,306.05	3,631.05	1.66
Intermediate:									
Stationary	1,274.92	2,007.43	3.70	1,827.54	2,877.56	2.19	2,520.93	3,969.34	1.77
Adjusted	1,334.71	2,101.57	3.92	1,955.15	3,078.49	2.35	2,732.85	4,304.02	1.87
High stationary	1,428.88	2,249.85	4.04	2,202.11	3,467.34	2.58	3,166.63	4,986.03	2.07

Exhibit 11

SCENARIO GNP AS A PERCENTAGE OF PROJECTED GNP

Scenario	1990				2020				2050			
	3	2.7	1	0	3	2.7	1	0	3	2.7	1	0
Low stationary	106	112	156	190	60	69	183	263	33	42	160	354
Low adjusted	109	115	160	196	63	72	191	274	35	44	168	373
Intermediate:												
Stationary	115	121	169	206	67	78	206	295	38	48	184	408
Adjusted	120	127	177	216	72	83	220	316	42	52	199	452
High stationary	128	136	189	231	81	94	248	356	48	61	237	512

This table, then, displays a comparison of projected and scenario values and, as such, suggests the increase in personal affluence which is likely to result from the combined circumstance of zero population growth and continued economic growth. Yet the figures also suggest the importance of ZPG because even at the highest assessed growth rate (3 percent), population growth will be such that few families will be able to improve their standard of living by 1990. It is only when the substantial effects of ZPG have begun to be felt that standards of living begin to rise. Hence, throughout the remainder of this century it is unlikely that, even with continued real economic growth and replacement level fertility, major advances will be made in improving the standard of living of the population unless real economic growth exceeds 3 percent.

A second conclusion that may be drawn from this analysis is the essentiality of maintaining economic growth, regardless of the stabilization of population size. Under assumptions of a zero growth economy, standards of living for all would fall, as measured by consumption of goods and services.

SUMMARY

Our analysis indicates that, while ZPG may facilitate improvements in the standards of living, it should not be viewed as the path to ever increasing wealth. Careful planning, and wise economic policy suggests that if growth continues at 2 to 2.5 percent annually, standards of living may continue to rise.

Two important questions are worthy of consideration: (1) Can real economic growth continue, and (2) will incomes be redistributed so that standards of living do in fact increase? These questions are not addressed in detail in this analysis but it does seem reasonable that economic growth can continue, albeit perhaps at reduced levels. Moreover, our analysis has indicated that even to maintain the current standard of living, economic growth must continue and that standards of living cannot be improved without economic growth. Most advocates of no or low economic growth overlook the fact that even with replacement level fertility population stability will not be achieved until well into the next century. Thus if economic growth were to cease while population size continued to increase, per capita wealth would decrease.

The PCE scenarios are merely tools which permit insight into the meaning of the alternative economic growth rates. The scenarios are not normative goal statements; they are not statements of the expected future nor do they represent an implicit argument that the distribution of increased income should be skewed in a way which would raise the standards of living of families in accordance with the scenario definitions. However, the scenarios do provide a framework for conjecture regarding the implications of the expected rate of economic growth in the context of a no-growth population. Two implications become apparent: the first concerns the implications of such growth for the distribution of wealth within the society; the second concerns the projected distribution of personal consumption expenditures across consumption scenarios.

With regard to the implications of the comparisons between personal consumption expenditures as computed in the scenarios and as projected, it is not logical to infer that the actual future distribution of personal consumption expenditures will reflect that required to achieve the demand stated implied in the scenarios. The availability of sufficient future wealth to improve dramatically the standard of living of lower income groups of the population does not suggest that national policy will favor such a distribution. However, should the economic growth rate be of sufficient magnitude, wealth itself may act as a forcing function. This would imply that as the rate of projected economic growth results in personal consumption expenditures which exceed those computed for the "expensive" consumption scenarios, a significant portion of that increased personal consumption may have to be accounted for by the provision of services to what are now lower income groups. The possibility of this being a necessity derives not only from the absolute value of the expected wealth, but from the possibility that a point of saturated demand will be reached by the more affluent segments of the population. It may well be that it is only through increased consumption by the lower income groups that economic growth can continue at all. (An alternative is, of course, that the Government, through a policy of taxation and increased foreign aid, will tax and export this affluence and decrease the aggregate level of expenditure for domestic consumption.) In sum, then, a comparison of projected growth of personal consumption expenditures and the five scenarios suggests that beginning shortly after the turn of the century, the increased per capita wealth of the population may force an improvement of the standard of living of the population as a whole, not by diminishing the standard of living of some while enhancing that of others, but rather by increasing the standard of living of the less affluent segments of the population. By the year 2050, it is likely that the improvement of standards of living, in the way suggested above, may have occurred.

Of course, the consumption budgets, interpreted as demand statements, imply that the individual economic sectors could in fact supply the levels of goods and services that are implied by the budgets. The budget then reflects pressure for increased production which could be placed upon production sectors of the economy. We can only speculate in the broadest possible way about the ability of these sectors to provide the specified levels. It is possible that such sectors as the housing and medical/health care sectors could not provide the level of services demanded of it.

In sum, our analysis has indicated that improvements in the standard of living (as measured by the consumption of goods and services) is possible with minimum levels of economic growth (i.e., >2 percent) under assumptions of zero population growth. These improvements, however, are unlikely to be experienced before the beginning of the next century. Finally, our analysis has indicated that economic growth is essential for an improvement in the standard of living as we currently define it.

THE LABOR FORCE, EMPLOYMENT, AND ECONOMIC GROWTH

By CHARLES T. BOWMAN*

SUMMARY AND FINDINGS

This paper reviews postwar changes in the size and composition of the labor force and the prospects for further change over the next 15 years. These changes are then related to the growth of potential output over the next decade. Finally, the impact of the changing industrial composition of the labor force on economic growth is considered. Five conclusions emerge from this study:

(1) The rate of growth of the labor force will begin to slow down in the next few years and by the 1985–90 period will be growing at only about two-fifths of the rate of the last 5 years. Labor force growth in the 1960's and early 1970's was abnormally high due to the influence of very substantial increases in fertility after World War II. Since the late 1950's the birth rate has fallen sharply and, as a result, the rate of growth of the labor force is now beginning to slacken. Furthermore, increases in female labor force participation rates which were a major factor in labor force growth in the postwar years are expected to exert a somewhat lesser influence over the 1980's.

(2) The proportion of teenagers and young adults in the labor force will fall sharply and the labor force will become considerably older over the 1980's. The sharp increase in the birth rate in the 1940's and 1950's led to a steady increase over the past 20 years in the proportion of the labor force in the 16- to 24-year-age group. As a result of subsequent declines in the birth rate this phenomenon is reversing itself and by 1990 the percentage of young persons in the labor force will be at its lowest level since the early 1950's.

(3) The shifting age distribution of the labor force should make attainment of a low overall unemployment rate successively easier from now to 1990. Since the probability of unemployment tends to decline with age the aggregate unemployment rate will have a tendency to fall, assuming that other factors are unchanged.

(4) A recovery in productivity and lower unemployment rates may keep the rate of growth in the GNP from reflecting the labor force slowdown until 1985, but a significant slowdown in

*Economist, Office of Economic Growth, U.S. Bureau of Labor Statistics. This paper is based on studies prepared as part of the Bureau of Labor statistics long-term projections program. In particular, the author wishes to acknowledge the work of Howard Fullerton and Paul Flaim of the Division of Labor Force Studies in preparing the labor force projections, and of Thomas Mooney and John Tschetter of the Office of Economic Growth on the industry employment projections.

GNP growth is likely by at least the late 1980's. The period to 1985 should see higher rates of growth in productivity and lower average unemployment rates than over the past few years. Consequently, growth rates should be somewhat higher than suggested by growth in the labor force alone. After 1985, however, a slowdown in the growth of GNP should become evident as these factors become less important.

(5) Shifts in the distribution of employment such as those from the farm to nonfarm sectors or from manufacturing to services are projected to continue but to be of lesser magnitude. In the eighties such shifts will not have a major impact on the growth of nonfarm productivity.

Introduction

The study of economic growth, particularly over a long time period, involves a number of factors which influence the rate at which an economy expands. These factors include, but are by no means limited to, the rate of increase and composition of the capital stock, technological progress embodied in new equipment, improved organization and work flow, and the economy's labor force, not only its overall size but also its composition in terms of training, education, and experience. Moreover, the interaction of these factors, the degree to which basic elements are substituted for or complement one another, is a vital dimension of the growth process. The focal point of this paper, however, is considerably narrower in scope. It deals with the impact on economic growth of changes in the size, age, and industrial employment of the labor force, although such a partial view is a necessary simplification of a complex process.

A principal focus of this paper is on the factors influencing the availability of labor: the rate of population change and the degree to which the population is involved in work, or the rate of labor force participation. The rate of population growth is influenced by a myriad of social, cultural, and economic factors. Labor force participation depends on the length and scope of formal education, the role of women in society, and provision for retirement and disability to cite a few of the more important elements. In the first section of the paper a review of the basic postwar trends in the size and age/sex composition of the population and labor force is presented.

In the next two sections the outlook for changes in the population and labor force over the next 15 years are considered along with a discussion of some of the impacts which these changes are likely to have on economic growth in the 1980's. Of course, other things equal, the rate of growth of GNP would vary directly with the rate of growth of the labor force. Other factors, however, such as the utilization rate of the labor force and its productivity do change over time in response to a large number of social, economic, and political influences. Thus, some results on these aspects of economic growth are presented. Finally, trends in the industrial structure of employment are examined in terms of their impact on economic growth.

I. Postwar Labor Force Developments

1. *The Birth Rate*

Turning to the first element affecting the supply of labor, the most far-reaching demographic development of the postwar years has been the very wide fluctuation in birth rates. After falling fairly consistently over the first four decades of this century, the birth rate began to rise around 1940, going from a low of 18.4 (births per 1,000 persons) in the 1930's to over 25 by the late 1950's. In the 1960's the birth rate again began to fall and has since declined to levels which are low even in comparison to the depression years. The consequence of these changes was not only a sudden temporary surge in the rate of population change but a significant shift in the age structure of the population.

The sudden increase in population growth in the 1940's and 1950's created a large bulge in the age distribution of the population. By the late 1950's those born in the early part of the baby boom era (mid-1940's) were reaching working age. As shown in table 1, the rate of change of the population aged 16 to 24 accelerated markedly in the 1960's. At the same time, the number of children under 16 stabilized and subsequently declined. By the 1970's the 25- to 34-year-age group had become the fastest growing segment of the population, although rates of growth in the younger brackets remained high as the last segments of the baby boom generation reached working age.

Although the initial impact of the large number of births recorded in the 1940's and 1950's is now lessening, the age distribution of the population and labor force will continue to be affected for many years as these birth cohorts mature. Some of the implications of the changing age distribution are considered below.

TABLE 1.—U.S. POPULATION [1] BY SELECTED AGE GROUPS, 1900–90

	Actual							Projected [2]		
	1900	1920	1940	1950	1960	1970	1974	1980	1985	1990
Number of persons (thousands):										
Total	76,094	106,461	132,122	151,684	180,671	204,879	211,909	222,769	234,068	245,075
Under 16	27,691	35,778	35,390	42,931	58,836	61,930	58,851	55,110	57,535	61,330
16 to 24	13,407	16,832	21,584	20,138	21,817	31,455	35,322	37,590	35,766	31,513
25 to 54	27,781	42,303	55,423	62,889	67,718	71,745	76,414	84,499	92,643	102,820
55 and over	7,125	11,548	19,725	25,726	32,300	38,749	41,322	45,570	48,124	49,412
Percent distribution:										
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Under 16	36.4	33.6	26.8	28.3	32.6	30.2	27.8	24.7	24.6	25.0
16 to 24	17.6	15.8	16.3	13.2	12.1	15.8	16.7	16.9	15.3	12.9
25 to 54	36.6	39.7	42.0	41.5	37.5	35.0	36.1	37.9	39.6	42.0
55 and over	9.4	10.8	14.9	17.0	17.9	18.9	19.5	20.5	20.6	20.2
16 and over	63.6	66.4	73.2	71.7	67.4	69.8	72.2	75.3	75.4	75.0
Annual rate of change from preceding period:										
Total		1.7	1.1	1.4	1.8	1.3	.8	.8	1.0	.9
Under 16		1.3	−.1	2.0	3.2	.5	−1.3	−.8	.9	1.3
16 to 24		1.1	1.3	−.7	.8	4.0	2.1	.9	−1.0	−2.5
25 to 54		2.1	1.4	1.3	.7	.6	1.6	1.7	1.9	2.1
55 and over		2.4	2.7	2.7	2.3	1.8	1.6	1.6	1.1	.5
16 and over		1.7	1.6	1.2	1.1	1.6	1.7	1.5	1.0	.8

[1] Total population on July 1, including the Armed Forces overseas.
[2] Series II.

Source: U.S. Bureau of the Census, Historical Statistics of the United States, Colonial Times to 1970, series A29–42; U.S. Bureau of the Census, Statistical Abstracts of the United States, 1976, table 3.

2. *Growth and Composition of the Labor Force*

As already noted, by the early sixties the upsurge of births recorded in the 1940's and 1950's provided a tremendous impetus to growth in the labor force concentrated in the younger age brackets. Preceding and later reinforcing this effect were sharp increases in female labor force participation rates—the second of the major elements which influence the supply of labor. Somewhat offsetting these trends, however, were slow but steady declines in male participation rates in most age groups.

Chart 1 illustrates the steady acceleration of the growth of the working age population and the labor force throughout the postwar years. By the first half of the seventies the labor force was increasing at an annual rate which was 2½ times as great as that of the early fifties. Between 1965 and 1975, the labor force increased by over 18 million persons, more than double the net change of the preceding 10 years.

Of course, the sharp acceleration in the rate of growth of the labor force was by no means uniform. There has been wide diversity in labor force behavior over time and, particularly, among specific age/sex groups (table 2). The heavy lines in the table serve to highlight those age/sex groups showing increases of 10 percent or more in a given 5-year period. In the 1950's large relative increases were predominantly centered in the femal age groups over 34. From the 1960–65 period on, the effects of the baby boom can be seen clearly in the large changes registered by younger age groups of both sexes, although relative changes are significantly larger for females than for males.

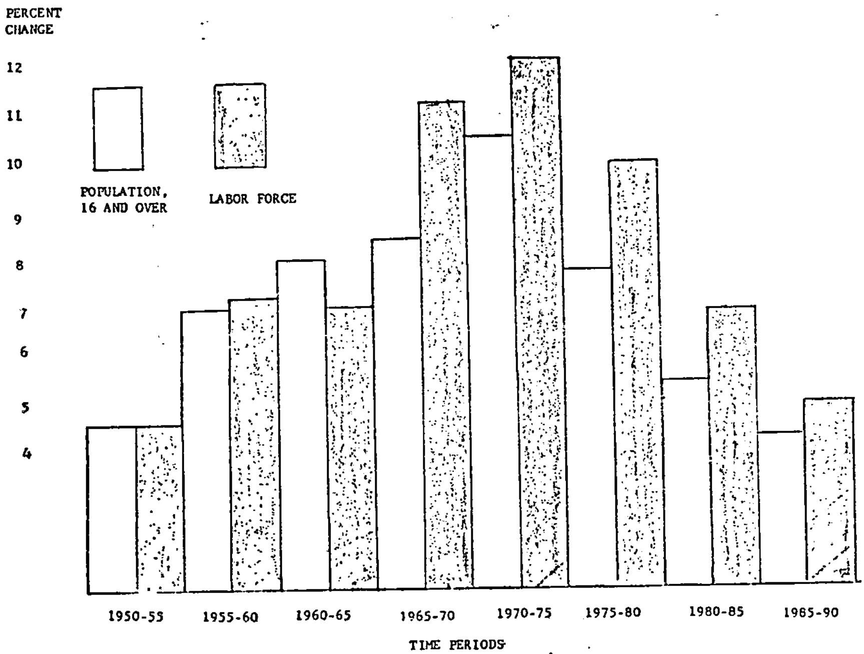

CHART 1.—Percent changes in the civilian noninstitutional population and labor force, 1950–90.

TABLE 2.—PERCENT CHANGE IN THE CIVILIAN LABOR FORCE BY AGE AND SEX, 5-YR INTERVALS, 1950-90

	Actual					Projected		
	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90
Males:								
16 to 19	−5.5	17.6	21.9	17.9	18.8	3.1	−14.8	−4.9
20 to 24	−30.5	28.0	18.7	16.7	29.6	9.1	−3.4	−14.4
25 to 34	2.7	−5.1	−3.4	14.2	22.5	18.1	10.0	2.9
35 to 44	8.2	3.5	1.4	−5.9	−1.7	12.8	22.3	16.8
45 to 54	8.9	8.3	4.9	3.7	.1	−5.1	−1.8	12.3
55 to 64	5.7	4.5	5.7	5.3	−2.0	4.2	−1.5	−6.4
65 and over	3.0	−9.5	−6.8	1.6	−12.0	−.8	−2.5	.5
Females:								
16 to 19	.6	19.2	22.3	28.9	24.7	4.6	−11.0	−3.0
20 to 24	−8.9	5.5	30.5	44.8	24.5	16.4	3.7	−9.2
25 to 34	3.9	−2.8	4.8	31.6	48.4	22.9	17.5	7.1
35 to 44	15.5	10.3	7.9	4.3	8.8	17.6	27.4	20.1
45 to 54	24.9	27.1	8.2	14.4	2.1	−1.0	2.3	15.3
55 to 64	30.0	24.9	20.1	15.8	2.2	9.1	2.4	−4.8
65 and over	33.6	16.6	7.5	8.2	−2.2	8.1	5.1	6.5

Source: Data for 1950-75 are based on the Current Population Survey (see January issues of Employment and Earnings, U.S. Bureau of Labor Statistics). Projected data are from H. N. Fullerton and P. O. Flaim, "New Labor Force Projections to 1990," Monthly Labor Review, December 1976.

These phenomenon, of course, are reflected in the shifting age and sex distribution of the labor force (table 3). As shown, over a 25-year span, males dropped from 70 to 60 percent of the labor force. Excluding the 16 to 24 age group, which expanded its relative size somewhat due to the baby boom, makes the decline appear even sharper. The age distribution exhibits the steady increase in the 16 to 24 age group over the past 20 years which had brought this group to nearly one-quarter of the labor force by 1975. The proportion over 25, of course, has declined over the same period as increases in female labor force participation by those over 25 have been overwhelmed by basic shifts in the age structure of population and the steady declines in male participation, this latter factor being most noticeable among older workers.

3. *Labor Force Participation Rates*

Along with the sharp swing in the birth rate, changes in labor force participation have been an outstanding feature of the postwar years. We have already seen some of the impacts which these changes have had on the overall growth and composition of the labor force. Table 4 identifies those periods which have seen sharp changes in the work patterns of specific age/sex groups in the population.

TABLE 3.—AGE/SEX DISTRIBUTION OF THE CIVILIAN LABOR FORCE, 1950–90

	Actual						Projected		
	1950	1955	1960	1965	1970	1975	1980	1985	1990
Both Sexes	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
16 to 24	18.6	15.0	16.6	19.0	21.5	24.0	23.9	21.2	18.5
25 to 54	64.3	66.8	65.3	62.9	60.9	60.6	61.4	65.0	69.0
55+	17.2	18.2	18.1	18.0	17.5	15.3	14.7	13.7	12.6
Males	70.4	68.4	66.6	64.8	61.9	60.1	59.0	57.9	57.3
16 to 24	11.5	8.6	9.9	11.1	11.7	13.1	12.8	11.0	9.4
25 to 54	45.7	46.5	44.2	41.7	38.9	37.3	37.2	38.6	40.4
55+	13.3	13.3	12.5	11.9	11.2	9.6	9.0	8.3	7.5
Females	29.6	31.6	33.4	35.2	38.1	39.9	41.0	42.1	42.7
16 to 24	7.1	6.4	6.7	7.9	9.8	10.9	11.1	10.2	9.1
25 to 54	18.6	20.3	21.1	21.2	22.0	23.3	24.2	26.4	28.6
55+	3.9	4.9	5.6	6.1	6.3	5.7	5.7	5.4	5.1

Source: Data for 1950–75 are based on the Current Population Survey (see January issues of Employment and Earnings, U.S. Bureau of Labor Statistics). Projected data are from H. N. Fullerton and P. O. Flaim, "New Labor Force Projections to 1990," Monthly Labor Review, December 1976.

TABLE 4.—CIVILIAN LABOR FORCE PARTICIPATION RATES BY AGE AND SEX, 1950–90

	Actual						Projected		
	1950	1955	1960	1965	1970	1975	1980	1985	1990
Both sexes	59.3	59.3	59.4	58.9	60.4	61.2	62.3	63.2	63.6
16 to 19	51.8	48.9	47.5	45.7	49.9	54.1	56.4	57.2	58.2
20 to 24	66.0	62.7	65.2	66.4	69.2	73.9	76.0	77.6	78.5
25 to 34	63.5	64.8	65.4	66.5	69.7	74.3	75.8	77.6	78.7
35 to 44	67.5	68.9	69.4	70.7	73.1	75.0	76.2	77.6	78.5
45 to 54	66.4	69.7	72.2	72.5	73.5	72.6	73.6	74.3	74.9
55 to 64	56.7	59.5	60.9	61.9	61.8	57.4	57.2	56.0	55.4
65 and over	26.7	24.1	20.8	17.8	17.0	13.8	12.9	11.9	11.3
Males	86.4	85.4	83.3	80.7	79.7	77.9	77.8	77.5	77.3
16 to 19	63.2	58.9	56.2	53.8	56.1	59.2	61.0	60.9	61.3
20 to 24	87.9	86.9	88.1	85.8	83.3	84.6	84.2	83.1	82.1
25 to 34	96.0	97.6	97.5	97.3	96.4	95.3	95.2	94.9	94.7
35 to 44	97.6	98.1	97.7	97.3	96.9	95.7	95.5	95.1	94.9
45 to 54	95.8	96.4	95.7	95.6	94.3	92.1	91.3	90.6	90.2
55 to 64	86.9	88.0	86.8	84.6	83.0	75.8	74.3	71.6	69.9
65 and over	45.8	39.6	33.1	27.9	26.8	21.7	19.9	18.0	16.8
Females	33.9	35.7	37.8	39.3	43.3	46.3	48.4	50.3	51.4
16 to 19	40.9	39.7	39.3	38.0	44.0	49.2	51.8	53.6	55.2
20 to 24	46.0	45.9	46.1	49.9	57.7	64.1	68.4	72.5	75.2
25 to 34	34.0	34.9	36.0	38.5	45.0	54.6	57.4	61.2	63.5
35 to 44	39.1	41.6	43.4	46.1	51.1	55.8	58.3	61.1	63.0
45 to 54	37.9	43.8	49.9	50.9	54.4	54.6	57.1	59.1	60.5
55 to 64	27.0	32.5	37.2	41.0	43.0	41.0	41.9	42.2	42.3
65 and over	9.7	10.6	10.8	10.0	9.7	8.3	8.1	7.8	7.6

Note: The population measures for historical versus projected years on which this table is based differ somewhat in definition. The differences, however, should have only a minimal effect on the comparability of the data shown in the table.

Source: Data for 1950–75 are based on the current population survey (see January issues of Employment and Earnings U.S. Bureau of Labor Statistics). Projected data are from N. H. Fullerton and P. O. Flaim, "New Labor Force Projections to 1990," Monthly Labor Review, December 1976.

For men, the trend in participation rates has been consistently downward for all age groups in the postwar period, although the decline has been far more dramatic for older males. Among those 65 and over, participation fell from 46 percent in 1950 to 22 percent in 1975 (table 4) while for those between 55 and 64 the rate went from 87 percent to 76 percent. Furthermore, the decline for these groups seems to have accelerated somewhat in the 1970's. Among men in the prime working age groups (25–54), declines have been more modest, ranging from 3.7 points for the 45 to 54 year olds to 1.7

points for those in the 25 to 34 year range. The trend among the youngest male group is less clear. The participation rate for teenagers fell rather sharply between 1950 and 1965 but has subsequently regained about one-half of that decline. For the next oldest group, 20–24, the decline has been uneven with increases in the 1955–60 and 1970–75 periods interrupting an overall downward movement. On the average, male participation in the labor force has fallen in the postwar years from 86 to 77 percent, a difference which translates into slightly over 6½ percent of the actual 1975 labor force.

By far the greatest changes in labor force participation have occurred among women. Although these changes have taken place over the entire postwar period and affected all age groups, there are two distinct periods of expansion in this period. As already noted, large relative changes in the labor force in the 1950's were concentrated in the female age group over 35 (table 2). These very large changes resulted, in large measure, from changes in participation rates. For women between 45 and 54, in particular, participation rates increased by some 12 points during the fifties (table 4). The groups 10 years younger and older also registered significant increases. By contrast, participation rates for younger females and for males in the same age groups were fairly constant through the fifties.

While participation rates of women over 45 began to show some signs of leveling off in the 1960's and 1970's, participation rates for younger women began to accelerate. Particularly in the last 10 years younger women have sharply increased their participation in the labor force. Women between the ages of 20 and 34 showed increases of about 15 points in these 10 years while teenagers and those between 35 and 44 increased their participation by about 10 points.

As a result of these basic shifts, participation rates of women overall have increased steadily over the postwar period; rising from 34 percent in 1950 to 46 percent in 1975. A change of this magnitude translates into almost 11 percent of the 1975 labor force.

One additional phenomenon stands out in table 4; namely, the relative constancy of the population wide participation rate. From 1950 to 1965 the overall rate fluctuated within a band of only 0.5 points. Since 1965 the rate has risen 2.3 points, historically a large change for a 10-year period, but still very small relative to the magnitude of the underlying changes in specific age/sex groups which have been described above. Actually, the overall rate has varied within a range of only a few points over the past 75 years.

In spite of this long-run trend, however, it seems fair to conclude that, in light of very significant underlying shifts in labor force behavior and in the absence of any theoretical reason for such shifts to operate in offsetting directions, there is no reason to expect this stability to continue indefinitely. In the next section we will consider the outlook for labor force growth over the next 15 years. While the influence of population movements will undoubtedly predominate, there is ample room for further shifts in labor force participation to significantly alter the rate of growth and composition of the labor force.

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II. Future Growth of the Labor Force

1. *Population Change*

The tremendous acceleration in the growth of the working age population which has characterized the years since 1960 will soon reach a peak. Chart 1 illustrates the sharp increase and the even sharper projected decline in the rate of growth of the population 16 and over. By the late 1980's the rate of change will have fallen to less than one-half of the peak level of the 1970's (table 1).

The population movement depicted in chart 1 is, of course, a consequence of the wide swing in birth rates noted above, which in turn created a large bulge in the age distribution of the population. During the 1940's and 1950's growth in the number of children (under 16) in the population accelerated sharply and as a result children increased their share of the total population from 26.8 to 32.6 percent. During the 1960's and 1970's these cohorts reached working age and teenagers and young adults (ages 16–24) became the fastest growing segment of the population. At the same time, increasingly lower birth rates led to actual declines in the number of persons under 16. In the late 1970's, growth in the 16 to 24 year age group will taper off and, by the 1980's, this group will be declining. In 1960, 16 to 24 years olds accounted for 12 percent of the population. By 1980 they will have reached 17 percent but the proportion will decline thereafter, dropping to 13 percent by 1990. During the remainder of the 1970's and increasingly during the 1980's, the baby boom cohorts will swell the prime-aged (25–54) groups of the population which, by 1990, will reach 42 percent of the population, compared to 35 percent in 1960.

Over the very long time span shown in table 1 the age distribution of the population changes rather dramatically. In the younger ages (under 25) there is a sharp decline from 54 percent of the population in 1900 to about 38 percent in 1990. The baby boom interrupted the decline in 1960's and 1970's but the 1990 proportion is considerably below historical levels. On the other hand, improvements in mortality have contributed to the steady increase in the proportion of those over 55 in the population, with the proportion stabilizing at about 20 percent in the 1970's and 1980's. The percentage of the population in the prime working age groups (25–54) is, of course, determined by these movements. This share rose from 37 percent in 1990 to 42 percent in 1940 and then fell by 1970 to 35 percent as the effects of the baby boom were felt. By 1990, this group will again represent 42 percent of the population.

The general shape of the population movements to 1990 outlined above is based on population projections produced by the Bureau of the Census.[1] From the point of view of the working-age population in 1990 the projections can be considered exact within a fairly narrow tolerance. This is so because all persons who will be in this group in 1990 are already born, and neither immigration nor changes in mortality can be expected to exert a major influence over this short a period.

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[1] Current Population Reports (U.S. Bureau of the Census, series p–25, No. 541, February 1975), series II.

The major uncertainty which surrounds population projections concerns fertility rates. Completed fertility for cohorts born in the 1930's was about 3.2 children per woman.[2] Based on birth experience to date and birth expectations data, it appears that later cohorts will have sharply lower completed fertility. The 1945 cohort, for example, is now projected to complete child bearing with an average of about 2.3 children per woman. The fertility level of later cohorts is, of course, subject to much greater variability since these women are still in or are yet to enter prime childbearing years. Consequently, the Census Bureau provided three basic population projections which differ in the underlying assumptions about the future movements in fertility. The series II alternative assumes that completed fertility will stabilize at 2.1 children per woman, a level which would eventually lead to cessation of population growth. The series I alternative assumes that fertility will remain low for those cohorts currently in childbearing ages but will then increase to a stationary level of 2.7. The final alternative, series III, is based on a continued decline in the fertility rate to 1.7 children per woman.

The three alternative fertility levels produce a range in the size of the total population in 1990 of about 22 million persons or 9 percent. By 1990 net population would be increasing at 1.2 percent per year under series I and at 0.5 percent per year under series III. While variations in population growth have no direct impact on the labor force over the 10 to 15 year time span characteristic of "long term" economic projections, such variations can influence the labor force activity of women and hence exert an indirect effect on the labor force. One attempt to take this possibility into account is discussed in the next section.

2. *Projected Growth and Composition of the Labor Force*

The Bureau of Labor Statistics has recently released a revised set of labor force projections to 1990 based on the series II Census Bureau population projections discussed in the preceeding section.[3] The new projections imply an upward revision in the female labor force of 11.4 percent and a partially offsetting decrease in the male labor force of 2.6 percent. The net result is an addition of slightly under 3 million persons to the previous projection of the 1990 labor force.

We have already noted that growth in the population of working age will taper off in the late 1970's. Chart 1 shows that the labor force will follow this general movement although increases in labor force participation will keep the rate of growth of the labor force significantly above that of the working age population throughout the period to 1990. The average annual rate of change in the civilian labor force is projected to drop from 1.9 percent between 1975 and 1980 to 0.9 percent in the second half of the eighties. This compares with a rate of increase of 2.3 percent over the past 5 years.

Table 2 highlights the growth of specific age/sex groups to 1990. The maturing of the baby boom cohorts results in very large changes for age groups over 24. On the other hand, the very low birth rates of recent years leads to actual declines for some of the 16- to 24-year-old

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[2] Ibid, p. 4.

[3] Fullerton, H. N. and Flaim, P. O., "New Labor Force Projections to 1990," Monthly Labor Review, December 1976.

groups. Finally, although the pattern of changes is very similar for the two sexes, rates of change for females are significantly greater throughout the period, although to a much lesser degree than in the recent past.

These changes result in a significant shift in the age and sex distribution of the labor force by 1990 (table 3). The proportion of the labor force in the 25- to 54-year age group will increase from 60.6 percent in 1975, the post-war low point, to 69.0 percent by 1990. Younger workers will drop from 24.0 to 18.5 percent and older workers from 15.3 to 12.6 percent. Women will continue to account for an increasing share of the labor force although the share will not be growing as fast as over the past 15 years.

In the past, BLS labor force projections have tended to fall short of actual growth in the labor force.[4] In these cases, as in the current set of projections, labor force participation rates of women were responsible for the major uncertainty. The revisions just published, for example, show an increase of 5 million in the projection of the 1990 female labor force as opposed to a decrease of 2 million in the male labor force.

The methods which are used to make labor force projections rely upon modified extrapolation of trends in the labor force behavior of narrowly defined demographic groups.[5] The resulting projections provide a great deal of valuable information on the changing age and sex composition of the labor force. The difficulty is that such methods cannot be expected to cope with the impacts of major socioeconomic changes. It seems fair to conclude that until the complex relationships among the economic and social factors with influence labor force activity are better understood and quantified major improvements over the BLS method are not to be expected.

One attempt is made in the current set of BLS projections to explicitly consider a factor which influences female participation rates, namely, fertility levels. By considering the labor force behavior of women with and without small children separately, alternative labor force projections, consistent with the census high and low fertility alternatives (I and II), are derived. The result is a range of about 2 million bracketing the basic series II-based projection.

Finally, in order to put the possible forecasting error in perspective, it is worth noting that the latest revision in the 1990 projections would, other things unchanged, result in an increase in the 1975-90 GNP growth rate of about 0.2 percent per year. While such a difference is significant, it would not change the basic conclusions regarding a fairly sharp slowdown in the growth of the labor force and a basic shift in its age distribution.

III. The Labor Force and Economic Growth

We have already seen that the rate of growth of the labor force will slow considerably over the next 15 years. How will this slowdown affect the growth of potential output over the period? While a change in the growth rate of the labor force taken by itself leads directly to a

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[4] For example see the discussion in Rosenblum, Marc, "On the Accuracy of Labor Force Projections," Monthly Labor Review, October 1972.

[5] Fullerton, H. N. and Flaim, P. O., op. cit., pp. 10-12.

change in potential output, many other factors can alter this relationship. A recent BLS study of the U.S. economy (table 5) to 1985 gives some idea of the contributions of these factors to economic growth.[6]

TABLE 5.—CHANGE IN GNP AND MAJOR DETERMINANTS, 1955-85

[In percent]

	Average annual rate of change [1]			
	Actual		Projected	
	1955-68	1968-73	1973-80	1980-85
Total labor force (includes military)[2]	1.5	2.1	1.8	1.2
Employed (persons concept)	1.5	1.8	1.8	1.4
Employed (jobs concept)[3]	1.6	1.6	1.8	1.4
Government (including military)	3.3	.3	2.7	2.6
Private	1.3	1.9	1.7	1.2
Private hours paid per job	-.5	-.4	-.3	-.3
Total private hours paid	.8	1.5	1.4	.9
Private nonfarm GNP per hour (1963 dollars)	2.6	2.0	2.2	2.6
Total GNP (1963 dollars)	3.8	3.4	3.7	3.6
Government compensation	3.3	1.1	2.2	2.5
Private GNP	3.8	3.7	3.8	3.7

[1] Compound interest rate between terminal years.

[2] Labor force data used in this table is based on a preliminary version of the labor force projections presented in sec. II. Growth rates based on the final version would differ by 0.06 to 0.08 percent.

[3] Employment on a jobs concept is a count of jobs rather than persons holding a job. Thus a person holding more than one job would be counted more than once.

Source: Bowman, Charles T. and Morlan, Terry H., "Revised Projections of the U.S. Economy to 1980 and 1985," Monthly Labor Review, March 1976, table 1.

Looking first at the overall rate of growth of the GNP there is practically no difference between the 1973-80 and 1980-85 periods in spite of a drop of 0.6 percent per year in the growth rate of the labor force. The reason for this is the impact of two offsetting influences, productivity growth and the unemployment rate. Between 1973 and 1980 the labor force and the number of employed persons grow at the same rate reflecting the completion of a long swing in the unemployment rate from 4.9 percent in 1973 to 8.5 percent in 1975 and then back to a projected level of 4.7 percent by 1980. After 1980, the BLS projections assume that the U.S. economy can be moved toward a 4-percent unemployment rate with appropriate Federal policies and this movement results in the number of employed persons growing more quickly than the labor force over the 1980-85 period. Thus, an increased rate of utilization of the labor force is one factor explaining the failure of the GNP growth rate to show the same slowdown as the labor force. Of course, the ability of the economy to reach and remain at 4-percent unemployment is a crucial assumption. While inflationary pressures have intensified over the last 2 to 3 years and made achievement of this level more difficult, the shifting age distribution of the labor force should be a positive factor. As an example, if unemployment rates for specific age groups remained at 1973 levels the shifting age distribution would by itself lower the overall rate by 1990. This result is simply a reflection of the fact that younger age groups with traditionally high unemployment rates will be declining relative to those with normally lower rates. Of course, the 1973 relationship among age specific unemployment rates may shift in an adverse way,

[6] Bowman, Charles T. and Morlan, Terry H., "Revised Projections of the U.S. Economy to 1980 and 1985," Monthly Labor Review, March 1976.

possibly due to the large concentration of people entering middle working age groups. While this possibility should not be ruled out, the persistence of the relationship between age and unemployment experience over a long period of time indicates that the shifting age distribution will be a positive factor in the eighties.

The second major factor to consider is productivity growth. Over the 1955–68 period output per hour in the private nonfarm sector increased by 2.6 percent per year, a rate which has been used commonly as representing the postwar trend. Between 1968 and 1973, however, productivity advanced by only 2 percent per year and, of course, declined in the 1974–75 recession. BLS projections for 1980 imply that the shortfall in productivity growth, relative to the 1955–68 trend, cannot be fully recovered. As a result productivity is projected to increase at 2.2 percent over the 1973–80 period. The crucial question for the post-1980 period is whether the U.S. economy will return to rates of increase similar to those experienced between 1955 and 1968 or will remain permanently below them.

The BLS projections assume that productivity will return to the higher trend rate in the 1980's and, consequently, this becomes a second factor offsetting the decline in the rate of growth of the labor force in the 1980–85 period. The reasoning behind this assumption is that such factors as the abnormal concentration of youth in the labor force and the high initial costs for required energy conservation and pollution control equipment will be worked through the system by 1980. Further, as is discussed in the following section, interindustry shifts are not expected to exert a major negative influence on productivity growth in the eighties. Of course, there are many uncertainties in this prognosis. In particular it depends on reasonably high levels of capital formation and research and development spending and in turn, on adequate structural and cyclical Federal edonomic policies to insure a stable economic environment with attractive investment opportunities.[7]

After 1985, growth of the labor force will fall off even more and, with the basic assumptions given above, the rate or economic growth should also fall. However, there are at least two factors which have to be taken into account. One is the degree to which average hours (paid) per job will continue to fall. A large part of the past decline is related to the increasing participation of women in the part-time labor force. It is quite likely that the propensity of women to work parttime rather than fulltime will lessen, and, as a result, arrest or at least dampen the decline in average hours. Another uncertainty is the degree to which the fairly sharp decline in younger workers will be offset by increased participation of female or older male workers, a factor which is not explicitly considered in the labor force projections. BLS is now in the process of preparing a detailed study of these and other factors affecting growth to 1990. On the basis of results obtained so far, the growth of full employment output would fall to the neighborhood of 3 percent in the 1985–90 period as compared with 3.6 percent over the preceeding 5 years.

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[7] Kutscher, R. E., Mark, J. E. and Norsworthy, J. R., "The Productivity Outlook to 1985," Paper prepared for Symposium on the Future of Productivity, November 16 and 17, Washington, D.C., pp. 4–7.

IV. The Industrial Structure of Employment and Economic Growth

Assuming that the labor force is fully employed, and that the projected trends in potential output are correct, it remains to see where the labor force will be employed. BLS projections (table 6) to 1985 indicate that about 12 million additional jobs will be added to the economy between 1973 and 1980 (1.7 million per year) and about 8 million between 1980 and 1985 (1.5 million per year).[8] This can be compared with 1.2 million per year growth in jobs between 1968 and 1973. The projected shifts in the structure of employment which are discussed in this section reflect changing patterns of final demand, differing sector-level productivity trends and changing technology, as well as public decisions on the size and nature of Government activity in the economy.[9]

TABLE 6.—TOTAL EMPLOYMENT BY MAJOR SECTOR, 1955–85

Sector	Actual			Projected	
	1955	1968	1973	1980	1985
THOUSANDS OF JOBS					
Total	65,745	80,984	89,654	[1]101,866	109,565
Government	6,914	11,845	13,739	16,800	19,350
Federal	2,187	2,737	2,663	2,900	3,000
State and local	4,727	9,109	11,075	13,900	16,350
Private	58,831	69,109	75,915	85,066	90,215
Farm	6,434	3,816	3,418	2,750	2,300
Nonfarm	52,397	65,293	72,492	82,316	87,915
Mining	832	651	674	788	823
Construction	3,582	4,038	4,821	5,178	5,798
Manufacturing	17,309	20,162	20,468	21,937	22,597
Durable	9,782	11,857	12,067	13,148	13,661
Nondurable	7,527	8,305	8,401	8,789	8,936
Transportation, communications, and public utilities	4,353	4,522	4,874	5,186	5,381
Transportation	2,918	2,871	2,955	3,049	3,081
Communication	832	986	1,177	1,308	1,423
Public utilities	602	665	742	829	877
Trade	13,201	16,655	19,432	22,457	23,187
Wholesale	3,063	3,894	4,424	5,029	5,109
Retail	10,138	12,761	15,008	17,428	18,078
Finance, insurance, and real estate	2,652	3,719	4,442	5,392	5,964
Other services	10,468	15,556	17,781	21,378	24,165
PERCENT DISTRIBUTION					
Total	100.0	100.0	100.0	100.0	100.0
Government	10.5	14.6	15.3	16.5	17.7
Federal	3.3	3.4	3.0	2.8	2.7
State and local	7.2	11.2	12.4	13.6	14.9
Private	89.5	85.3	84.7	83.5	82.3
Farm	9.8	4.7	3.8	2.7	2.1
Nonfarm	79.7	80.6	80.9	80.8	80.2
Mining	1.3	.8	.8	.8	.8
Construction	5.4	5.0	5.4	5.1	5.3
Manufacturing	26.3	24.9	22.8	21.5	20.6
Durable	14.9	14.6	13.5	12.9	12.5
Nondurable	11.4	10.3	9.4	8.6	8.2
Transportation, communications, and public utilities	6.6	5.6	5.4	5.1	4.9
Transportation	4.4	3.5	3.3	3.0	2.8
Communication	1.3	1.2	1.3	1.3	1.3
Public Utilities	.9	.8	.8	.8	.8
Trade	20.1	20.6	21.7	22.0	21.2
Wholesale	4.7	4.8	4.9	4.9	4.7
Retail	15.4	15.8	16.7	17.1	16.5
Finance, insurance, and real estate	4.0	4.6	5.0	5.3	5.4
Other services	15.9	19.2	19.8	21.0	22.1

Note: Employment covers self-employed, unpaid family workers, wage and salary workers, and private household workers. The employment is a count of jobs rather than persons holding a job. Thus persons holding more than one job would be counted more than once. Government employment is based on Bureau of Labor Statistics concepts and includes Government enterprises.

Source: Mooney, Thomas, and Tschetter, John, "Revised Industry Projections to 1985," Monthly Labor Review, November 1976.

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[8] Mooney, Thomas and Tschetter, John, "Revised Industry Projections to 1985," Monthly Labor Review, November 1976.

[9] The methods used to derive these projections are discussed in detail in "The Structure of the U.S. Economy in 1980 and 1985," BLS Bulletin 1831, appendix A.

Over the 1955–73 period Government increased its share of total employment by nearly 5 percent. All of this increase is due to the tremendous expansion of State and local government services such as education, welfare, and safety. The trend toward an increasing State and local sector is expected to continue but at a much lesser rate reflecting in part the easing of demands for educational services. This, of course, results from the changes in the population age distribution discussed above. The farm share of employment has fallen sharply from 9.8 percent in 1955 to 3.8 percent in 1973. The decline in this share is expected to continue although it is already at such a low level that it has little impact on the overall distribution of employment. There has been some evidence recently that at least the level of farm employment may stabilize particularly if foreign demand for U.S. farm products remains high. If this is so then the farm share may turn out to be slightly higher in the eighties than is now projected.

Within the nonfarm private sector employment shifts have not been quite as dramatic as with the farm and Government sectors. Nevertheless, there are a number of significant changes in the distribution of employment. Manufacturing dropped from 26.3 to 22.8 percent of total employment between 1955 and 1973 and is projected to drop further to 20.6 percent by 1985. Over the historical period the other services sector increased the most rapidly, just about matching the decline in the manufacturing share. Other services include such things as health and other personal services, business services, and the activities of nonprofit organizations. The trade sector is expected to reverse its slightly upward trend in the eighties as a result of the movement of consumer expenditures from goods to services. As can be seen in table 6, the other sectors are relatively small and, with the exception of the downward movement of the transportation share, do not exhibit any strong trends.

In a recent paper,[10] Kutscher, Mark, and Norsworthy explore the impact of some of these shifts (converted to hours) on private productivity. Their basic conclusions may be summarized as follows:

(1) The shift from the farm to nonfarm sectors contributed about 0.4 percent per year to productivity growth between 1947 and 1966. This effect is now exhausted and will have a negligible impact on productivity in the future.

(2) The effect of the shift to services in the postwar period has been small and has been a minor source of the slowdown in productivity since 1966.

(3) Some shifts within major sectors have been important determinants of productivity growth in these sectors. For example, the decline in household workers and other personal services matched by a rise in business services has contributed 0.3 to 0.5 percent per year to productivity growth in the other services sector. Positive results are also noted for transportation while negative impacts result for mining and manufacturing.

(4) In the period to 1985, shift effects are expected to operate in the same direction but will be somewhat smaller in magnitude. The overall effect on private productivity of the shifts described above should be about −0.3 percent per year, mostly due to the end of the movement away from farm employment.

[10] Kutscher, R. E., Mark, J. E., and Norsworthy, J. R., op. cit., pp. 12–13.

These findings support the assertion made in the preceeding section that projected changes in the industrial composition of employment will have little effect on the growth of nonfarm productivity. Thus, the outlook for productivity change will depend on other factors such as the age composition of the labor force or the impact of environmental regulations.

DIFFERENT ASSUMPTIONS, NEW TOOLS: A FUTURIST'S PERSPECTIVE ON EMPLOYMENT AND ECONOMIC GROWTH

By JAMES O'TOOLE*

SUMMARY

Traditional macroeconomic measures designed to achieve full employment through the stimulation of economic growth have created unwanted second-order consequences (such as environmental degradation) while failing to provide jobs for all who want and need them (even at official 4 percent "full employment" there are still millions of individuals who are chronically unemployed). But because public policy analysis is tied to traditional economic assumptions and tools, the Nation seems unable to create alternative, more effective policies. The traditional assumptions keep leading us back to the same flawed, traditional macroeconomic measures.

What seems to be needed as a first step to developing more effective policies is a new perspective on the problems of growth and employment, one that broadens rather than narrows the range of alternatives available to the Congress. Although there is currently some choice among policies, these choices are politically and socially unacceptable. We are given choices in painfully constrained either/or terms, such as jobs versus a clean environment or economic growth versus the quality of life. Any sensible person, however, wants both jobs and a clean environment.

The goal of the futurist is to identify more options for society, looking for ones that avoid politically unacceptable tradeoffs. When asked if he prefers option A or option B, the futurist responds: "Let me take a look at option C." Economic thinking unfortunately leads to a narrowing of options. The futurist is looking to develop new assumptions and tools that might open up more effective alternatives.

The cross-impact model described here is designed to enlarge upon the static and equilibrium models of economists. The model is dynamic, future oriented, holistic, sensitive to qualitative concerns, and nondeterministic. It allows the decisionmaker or policy analyst to play out the long-term and indirect consequences of a whole range of policy options, using any assumptions he wishes to test. For illustrative purposes, the model described here contains a dozen performance criteria of the kind that might be used in the evaluation of alternative national employment and growth policies. The measures chosen include such traditional economic indexes as inflation and productivity, but also include such qualitative measures as work satisfaction and environmental standards. Using nontraditional assumptions about the way the social and economic system works (and can work), there is an

*Doctor of philosophy, Center for Futures Research, Graduate School of Business Administration, University of Southern California.

analysis of the potential impacts of 8 alternative public policies on these 12 measures of the public interest.

The purpose of this exercise is not to run the cross-impact model in a computer (a task beyond the scope of this paper), not to predict the future (futurists do not believe the future can be predicted), and not to advocate any policy or set of policies (that is the responsibility of our elected representatives in the Congress). The purpose of this paper is to suggest an alternative method of analysis of how employment patterns might interact in the future with economic growth rates. No solution to the difficult problem of how economic growth is related to employment is presented here: The purpose is merely to suggest how the futurists's perspective might lead to different solutions than the economist's. At a minimum, this cross-impact exercise suggests the possibility of creating more effective full employment policies than would macroeconomic stimulation. The policies examined include:

1. The introduction of "appropriate" labor-intensive technologies.
2. A major public service employment act.
3. Public service jobs for teenagers only.
4. A German-style, active manpower policy.
5. A tax on gasoline.
6. A reallocation of Federal governmental expenditures.
7. The introduction of a dual minimum wage.
8. The introduction of employment tax credits.

Informally measuring these policies against a dozen performance criteria indicates that a German-style active manpower policy might have the greatest benefits and fewest side effects of the eight alternatives analyzed. In conclusion, the paper suggests that the Joint Economic Committee should formally review this alternative and the others using the cross-impact method and other sophisticated, future-oriented and holistic new tools of policy analysis.

A Scientific Revolution

The Western World is in the midst of a kind of scientific revolution. For 200 years, free economies have been guided by the "laws" of economics. But today, the behavior of observed economic phenomena is no longer consistent with the paradigm of the discipline of Adam Smith. As 15th-century observers were troubled by the lack of correspondence between the movement of the heavens and Ptolemy's Earth-centered model of the universe, many observers today note that full employment, efficiency, freedom, and equality do not emanate from the free play of a growth-oriented economy. While it is still too early for a new economics to have appeared (indeed, the Copernicus and Kepler of the new economics are nowhere in sight), there is nevertheless a large and growing body of criticism of the established discipline. This paper is a criticism of one of the most sacred assumptions of the ascendent economic paradigm: that employment flows as naturally from economic growth as pure water flows from mountain streams.[1]

[1] Although virtually all economists argue that growth is needed to absorb incremental increases in the labor force and to do away with existing unemployment, many do recognize "structural elements" that might preclude full employment stemming solely from economic growth.

NOTE.—This paper is abstracted from James O'Toole, "Work, Education, and the American Future," Jossey-Bass Publishers, Inc., San Francisco, 1977.

If one asks an economist how employment and economic growth are related, one receives a straightforward and simple answer. Arthur Okun has even developed a "law" to explain the relationship: For every 1-percent annual increase in the gross national product, there is an accompanying one-third of a percent decrease in the rate of unemployment.[2]

If one asks a futurist the same question, the answer will be more complicated (and even frustrating for those who are impatient for "the facts"). The futurist might answer the question in the following way: "With the possible exception of the relationship between supply and demand, there are no laws governing economics."[3] Unlike the natural sciences, the conditions under which economies operate are created by people, not by God. Thus, the relationship between growth and employment depends on the public policies a nation chooses to pursue.

The key to the futurist's perspective on public policy is thus the concept of choice. "But some economic assumptions are at least historically supportable," the more hardnose and practical among us might object. "Look at the tradeoff between inflation and unemployment—the futurist surely can't deny the fact that such a tradeoff exists." Clearly, there was—and to some extent, still is—a tradeoff between inflation and unemployment, Given the Keynesian policies that have been followed in the United States, Britain, and many other Western countries over the last quarter of a century, there will usually be such a tradeoff. But pursuing other policies will give other outcomes. For example, job creation efforts that do not rely on macroeconomic stimulation of the economy will probably not lead to inflation.

There are other things wrong with Okun's law and the other "answers" that economists might offer to our original question. Often, economic models leave out too many important considerations, such as the indirect and long-term consequences of growth on such qualitative concerns as the state of the environment. Most dangerously, the static and partial equilibrium models of economics often logically and inevitably lead one to an over-simple and erroneous policy conclusion. For example, pursuing the logic on which Okun's "law" is based, the one best way to cure unemployment is to increase economic growth. But, before leaping to that obvious conclusion, the futurist will demur and ask a few simple "what if" questions: What if the Nation stimulates economic growth? What would then be the consequences for the Nation on that whole range of quantitative and qualitative performance criteria by which the Nation gages how well the public interest is being served? (For example, what are the consequences of increased economic growth on the quality of our lives, on economic equality, on industrial efficiency, on technological innovation, and on the competitiveness of industrial organizations?) Then the futurist will ask a corollary question: "What if the Nation pursues an alternative policy to economic growth? What would the consequences then be for these same performance criteria?"

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[2] More precisely, for each percentage point by which real GNP growth falls below 4 percent, the rate of unemployment increases by one-third of a percent. For each percentage point of growth above 4 percent, the rate of unemployment decreases by one-third of a point. For a clear, nontechnical discussion see Lewis Beman, "The Slow Road Back to Full Employment," Fortune, June 1975.

[3] See Eugen Loebl, "Humanomics," Random House, 1976.

Traditional economic models will not permit the policy analyst to play the "what if?" game with great success. The problem with the economist's equilibrium model that influences much of the analysis of public policy in the United States is that it leads to the "tradeoff" game. (The rule of this game is: If you do this, you can't do that.)

Partially because we have internalized the rules of the trade-off game, national debates are increasingly waged in extreme either/or and win/lose terms:

Inflation versus employment.
Jobs versus a clean environment.
Equality versus quality.
Freedom versus order.
Equality versus efficiency.
Growth versus no growth.

Such a formulation of issues not only polarizes debate, it narrows the range of policy options that are considered. It may even lead to Solomon-like compromises between the two extremes which overlook innovative alternatives that might have better satisfied both of the conflicting parties.

Consequently, the futurist looks for ways to develop policies that avoid the consensus-destroying and politically unacceptable tradeoffs that unrealistically constrain social choice. In the last few years, futurists have turned their backs on the rationalistic assumptions of the economists, budgeteers and professional managers who dominate decisionmaking in the most important public and private institutions of the Nation. The traditional assumptions of these individuals optimize subsets of the system, while often throwing other and more important parts into chaos. For example, an economics professor at Harvard has caught the attention of the Nation's press and politicians with the assertion that the recent college graduates who cannot find good jobs are "overeducated." [4] His conclusion flows neatly from the constrained perspective of his discipline. Unfortunately, the only answer to the problem (as he identifies it) is to limit access to education—a "rational" solution that would run counter to the American commitment to free choice and equality of opportunity.

A futurist's perspective of the problem might differ from the economist's. Borrowing from the anthropological notion that issues should be analyzed in context of the whole of which they are a part, it would be difficult for the futurist to call most college graduates "overeducated." Looking at the issue in a perspective broader than simply their employment prospects, it is found that many of these young people do rather poorly in reading, writing and computation and that most are ill-equipped educationally for meaningful participation in family, community and leisure activities. If there is disequilibrium in the system, it is because these young people are underemployed. That is, their potential contribution to producing the goods and services that the world needs is being underutilized. Cutting back on educational opportunities is to throw the baby out with the bath water—it optimizes the work subpart of the system, while worsening the state of the more important other social and political institutions. If the problem is defined as underemployment, the solution is to more fully develop and utilize the education, training and talents of youth

[4] Richard Freeman, "The Overeducated American," New York: Academic Press, 1976.

to serve not only the needs of work, but of the social system in general. Holistic analysis then is needed to find truly effective solutions to national problems.

Such holistic analyses must include economics—which infuriates many progressive humanists who feel that the needs of people must be tended to regardless of cost or efficiency. Equally, the approach must include humanistic considerations—even though these do not fit into the elegant assumptions about human behavior that guide the thinking of economists (for example, "people work only to make money," "air and water are free goods," "the sum total of individual preferences adds up to an optimal collective decision").

The futurist's goal is to work toward policies that will allow the Nation to have its cake and eat it, too. Of course, in many cases, it is impossible to achieve this trick. But it is possible in more cases than is commonly assumed; and it is worth trying to achieve in almost all cases. Consequently, what may be needed are planning processes that help identify policies that permit the simultaneous pursuit of such goals as low unemployment and low inflation, a high quality of life and a high standard of living, freedom and equality. It is a matter of identifying our options, examining the consequences of various policy alternatives, agreeing on common goals, and developing strategies for achieving them. Of courses, nothing could be more difficult; but nothing is more important.

Clearly, the proposing and disposing of policy is quite rightly a political process in a democratic nation, and the analysis and planning required for developing effective policies for meeting the myriad problems of growth and employment constitute an agenda not for a single paper or author but for the millions of citizens of the Nation. Thus, it is not my objective here to advocate any specific programs or policies. With this caveat duly registered, for illustrative purposes, let us look at two public policies that might avoid difficult tradeoffs. The first would be designed to remove the wedge that has been driven between environmentalists on the one hand, and labor and industry leaders on the other. For example, because of pressures from unions and management, President Ford recently vetoed an important environmental bill on the grounds that it would cost many workers their jobs. It would seem desirable, then, to develop environmental policies that create jobs. There is some evidence that the banning of nonreturnable beverage containers would be a small step in this direction. Such a law might simultaneously clean up the environment, create jobs in the aggregate in the private sector, lower dependency on foreign bauxite, and save billions of kilowatts of electricity.[5] (Interestingly, the Senate recently turned down a bill that would have banned nonreturnable beverage containers. Instead it passed a bill to give States money to clean up litter. Not only did this decision fail to offer any incentive to prevent littering, it failed to internalize the cost of litter, thus placing the expense of cleaning up the environment on the back of the average American and not on the back of the litterbug where it belongs.)

The second example is directed at the inflation versus employment tradeoff. In West Germany, the Government offers a voluntary re-

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[5] Bezdek, R. and Hannon, B. "Energy, Manpower, and the Highway Trust Fund," Science, August 23, 1974, pp. 669–675.

training program to workers. The program appears to have lowered inflation by moving workers out of declining and into expanding industries, reduced unemployment by opening up the job slots vacated by workers who undergo training in the schools, and increased productivity and job satisfaction by enhancing the mobility of workers.[6]

Of course, there are problems with both of these examples. My purposes in citing them is only to suggest the necessity for breaking with the traditional ways of thinking that constrain our ability to cope with the complex problems of our day. We need to find ways to identify alternative programs that avoid the painful and politically unacceptable trade offs that are destroying what little value consensus remains in the Nation.

To identify and to measure these alternative policies requires a different perspective on public policy than the economist's. It is necessary to have a model of the society that is dynamic, future oriented, holistic, sensitive to qualitative concerns, and nondeterministic. What is needed is a kind of heuristic device that allows public policymakers to play the "what if?" game in an orderly and structured way. The human mind can only manipulate three or four variables at a time, but the system of relationships between growth and employment probably involves 50 or more key variables. Some of these variables are trends (like the gradual changes in the demographic structure of the work force) and some of these are events (like the introduction of a major public policy change). What is needed to answer the original question is not a machine that will predict the future, but a tool that will allow the decisionmaker to hold dozens of events and trends while playing the "what if?" game. Below I describe such a model. Before getting to it I should like to suggest its potential usefulness to the U.S. Congress.

Over the last two Congresses, the national legislature has become increasingly concerned with developing its planning capability. The institution of the Congressional Budget Office, the Office of Technology Assessment, and the introduction of "the foresight provision" in the House all attest to the growing concern and sophistication of the Congress in the area of planning. Proposals by Senators Humphrey, Javits, and others to initiate some kind of national indicative planning further illustrate this trend. But the will of the Congress is not matched by the capability of economic planners. Simply put, no one can predict the future of human behavior in the way natural phenomena can be predicted. What can be done is to improve the level of sophistication in the way we think about policy alternatives. We can do a better job of identifying the probable future consequences of public actions, and of identifying the trade offs and complementarities incumbent to each alternative. Economics, while the most valuable single discipline in this regard, is often an insufficient and even an inappropriate tool. Economists attempt to scientifically describe "how things work" with the intent of accurate prediction about the future. What is required in the realm of human affairs, however, is not unobtainable scientific prediction, but an identification of alternatives with an elaboration of what might occur as the result of each, and what is possible to achieve as the result of the most desirable alternatives.

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[6] Striner, H. "Continuing Education as a National Capital Investment," Washington, D.C.: W. E. Upjohn Foundation, 1972.

(In Europe, awareness of this difference has led to the formation of a Europe Plus Thirty Institute of 50 scholars who engage in futures research for the European Economic Community.)

A purpose of this paper is to attempt to demonstrate the difference between the economic and futurist perspectives on public policy. I am not able to "solve" the difficult problem of how economic growth is related to employment, but I hope to suggest how the futurist's perspective might lead to different solutions than the economist's.

A Cross-Impact Model

My colleague Selwyn Enzer at the U.S.C. Center for Futures Research has developed a unique tool for playing the "what if?" game.[7] It is an "interactive cross-impact model" that is designed to help decisionmakers to identify the consequences of a specific change in a policy on many key events and trends (which also interact independent of the change in policy). The model is based on the observation that a change in one area might have consequences five levels removed. For example, it is not obvious that a change in Arab-Israeli relations would affect the health status of San Franciscans, but here is how that chain of events actually developed:

1. A deterioration in Arab-Israeli relations led to
2. A refusal by the Arabs to sell oil to the U.S., which led to
3. A decrease in the amount of gasoline available to California motorists, which led to
4. A marked drop in driving, which led to
5. A decrease in air pollution as a result of auto emissions, which led to
6. A decrease in the death rate in San Francisco during the period of the Arab Oil embargo.

It is difficult to anticipate such a chain of events, but the purpose of the cross-impact model is to help decisionmakers to think in such logical sequences. But what is most important, the U.S.C. model allows decisionmakers to intervene in the model by testing the impacts of alternative policy options on appropriate measures. The measures can be social, economic, political, or technological. They can be quantitative as well as qualitative. Because of the nature of the model, it can bring out unintended and even counterintuitive consequences. The model also measures the cross-impact of events as well as trends (unlike the famous systems dynamics model used in the Limits to Growth study which only measured the relationships between trends). Moreover, the model permits the decisionmaker to intervene at various time intervals to review the status of the issue in question and to determine when changes would be most appropriate.

For illustrative purposes only, I have below constructed a simple cross-impact matrix which identifies 12 trends, the interaction of which will have much to do with shaping the relationship of economic growth and employment over the next decade. Where available,

[7] Selwyn Enzer, "Cross-Impact Methods in Assessing Long-Term Oceanographic Changes," Center for Futures Research, University of Southern California, 1975.

these are based on standard forecasts made in early 1976 by the Bureau of Labor Statistics (some of which I have extrapolated through the year 1990). Such Government forecasts are often unreliable, and the actual numbers should thus be treated with more than a grain of salt (an entire shakerfull would probably be appropriate). Below I describe each of these trends and explain why they were chosen and offer alternative explanations for how these might interact over the next 15 years. Then, I have identified eight different events that would have possible influence on these trends if they were to occur. These events are public policy alternatives to economic growth that are designed to decrease the rates of unemployment in the United States. I have assigned probabilities of the enactment of these policies, and suggest how they might interact with the key trends. Thus, I am only suggesting the impacts of events on trends. If we were to run a full model in the computer, we would also measure the cross-impact of events on events, of trends on trends and of trends on events. Thus, this illustrative exercise is incomplete. Moreover, because my estimates are so entirely judgmental, and because the B.L.S. forecasts are suspect, I have not even dignified the numbers by running them in the computer. But for the purposes of this paper, what is important is the illustration of the process by which the relationship of growth and employment is analyzed. It is the medium that is the message.

Twelve Employment Trends

The most likely future state of affairs is the "nominal future." If there are no major changes in public policy or major discontinuities in current trends, it is possible simply to extrapolate the future from present conditions using a series of accepted economic and statistical assumptions. In the field of employment, the Bureau of Labor Statistics undertakes such a series of extrapolations. The forecasts are the closest approximation to an official "nominal future." If one suggests that policy changes should occur, it is of some considerable value to show how these changes would lead to deviation from the nominal future.

On the accompanying chart, I have used BLS forecasts wherever available to describe the most likely employment future in the years 1980, 1985 and 1990. (In some cases, the forecasts are my own, or are simple extrapolations of BLS forecasts). The BLS forecasts are impressively sanguine: They see the economy growing at the rate of 6.2 percent for the next 5 years, leading to an unemployment rate of 4.7 percent and an inflation rate of 5 percent in 1980. By 1985, they forecast unemployment to drop to 4 percent in a steady growth economy. These forecasts are freighted with numerous implicit and explicit assumptions. The most important implicit assumption is apparently that the Federal Government can and will actively pursue traditional fiscal and monetary policies to stimulate growth and employment while holding inflation to acceptable levels.

NOMINAL FORECASTS OF MAJOR EMPLOYMENT TRENDS

Trends	1980	1985	1990
1. Labor force participation rate (1975=61.8 percent)	62.5	63.6	65.0
2. Unemployment rate (1975=8.5 percent)	4.7	4.0	4.0
3. GNP growth rate (1960-70=4 percent)	6.2	3.6	3.6
4. Inflation rate (CPI) (1975—9.1 percent)	5.0	5.5	6.0
5. Government employment as percent of total (1972=16.4 percent)	16.9	17.9	19.0
6. Productivity (output per man-hour) (1967=100, 1975=112.2)	121.2	130.9	141.0
7. White collar employment (as percent of total) (1975=61.8 percent)	64.8	66.3	67.8
8. Gross domestic private investment (1973=$202,000,000,000) (billions)	$366	$560	$855
9. Quality of environment (1975=100)	95	95	100
10. Quality of work life (1975=100)	90	100	105
11. Crime and delinquency (1975=100)	90	95	100
12. Family disorganization among poor (1975=100)	90	95	100

Below, I analyze these 12 employment trends, suggesting for each an alternative set of assumptions that would lead to different nominal futures. While accepting the BLS forecasts as the most probable future, I attempt to indicate how a futurist might try to invent a more desirable future by freeing himself from the traditional assumptions of how these trends will develop and interact with each other. The list of trends presented below is not intended to be rigorously taxonomic; it is merely suggestive of the kinds of measures of employment and growth that a futurist might use in a cross-impact analysis.

T1. *Labor Force Participation Rate*

This measure of the official size of the labor force is both important and controversial. It is important in that it is a guide to how many jobs might have to be created in coming decades. It is controversial in that it excludes millions of people who might want jobs if they were available. For example, it excludes labor force dropouts who have given up looking for work, students who stay in school because they cannot find jobs, people on welfare, and those who are in sheltered environments ranging from prisons to mental hospitals. The labor force participation rate is important also because it determines the rate of unemployment. Only those who are in the official labor force can be counted as either employed or unemployed. The relationship of the participation rate and the unemployment rate is not a simple one; indeed, it is quite fluid. For example, when new jobs are created they are often filled by people who are not in the official labor force. White, middle class women often are attracted into the labor force to take new jobs, while chronically unemployed black males remain unemployed.

Over the last decade, the total size of the labor force and the relative size of the force as a percentage of total population have grown remarkably. Pardoxically, as the economy created new jobs at a clip unprecedented in history, rates of unemployment also rose. The primary reason behind this phenomenon has been the entry of millions of women into the paid labor force. In 1950, the female labor force participation rate was 33.9 percent; by 1973 it was 44.7 percent. Most dramatically, the labor force participation rate of women with children (aged 6–17) went from 32.8 percent in 1950 to 52.6 percent in 1972. Between 1974–76 women accounted for almost the entire 1.7

million worker increase in the labor force. (However, most experts expect some levelling off of the female participation rate before it reaches that of men.)

The last decade has been marked by another significant shift in labor force participation: The coming of age of the postwar baby boom. In 1960, there were only 3.7 million white youth aged 16–19 in the labor force; by 1973 the figure was 6.6 million. As a consequence, teenage unemployment has become the largest single contributor to the high unemployment rates of the last 5 years. Fortunately, the demographic curve will peak by 1980, and age cohorts entering the labor force will become successively smaller.

In general the age profile of the labor force will change over the coming decades. In 1970, people under 25 comprised 23 percent of the labor force; by 1990 the fraction will have declined to 18 percent. During the same two decades, the percentage of workers aged 25–34 will expand from 21 percent to 27 percent, and the percentage of those aged 35–54 will contract by about 5 percent. The number of people reaching retirement age will grow until 1990, and will then contract until the baby boom starts to retire around 2010. So much for the facts on which the BLS makes its forecasts.

While these facts are about as uncontestable as any information that is available about the future, the consequences of these demographic facts are less clear. Possibly, more women workers will mean more competition with minorities and youth for scarce jobs. An aging population might adversely affect the housing and auto industries, thus lowering the rate of growth of the GNP. On the other hand, rates of savings might increase, thus creating investment capital needed for job creation and reducing demand for inflationary social services. For the individuals who compose the baby boom, their initial employment difficulties might be mirrored in less upward career mobility in their middle years. And, when they retire, they might find themselves inheriting a bankrupt social security system and an economy with low productivity because of an aged work force.

Such things might happen, but none of these outcomes is determined by any of the "facts" we have at hand. What is most important to our analysis is that the labor force participation rate is only influenced by these demographic factors. The rate can be manipulated by public policies and by changes in the definitions used by the Government. For example, by defining the care of one's own children as work, and calling voluntary activities in schools, hospitals, and communities work, the participation rate would be increased dramatically. On the other hand, the labor force can be reduced by removing penalties and disincentives for not working that lead to the reluctant employment of many millions of Americans including: Adults who would like to take a year or two off from their jobs to return to school; older people who would favor an earlier retirement age than 63 or 65; welfare mothers who would rather stay at home and raise their children than take the so-called incentive of a demeaning, poorly paying job; middle class mothers who would like to raise their children but feel pressures to work from the women's movement; and fathers who would rather stay home and take care of their children.

In short, the labor force is an artifact. Changing our assumptions about it will lead to different consequences for key performance criteria in the society and economy. Moreover, labor force participation is a product of social values about work and leisure. As I show below in T10, changes in attitudes about work can upset some of the hardest data we have about the future.

T2. *The Unemployment Rate*

Because the unemployment rate is a product of the labor force participation rate, it too is an arbitrary measure that can be manipulated by changing definitions or by changing policy. The measure is nevertheless at least some guide to how well the economy is functioning. But even when the official rate falls to the "full employment" level of 4 percent, the following problems remain:

Subemployment.—Working less than full time, full-year (and often for less than the minimum wage) is a chronic problem for many workers. It has serious consequences for the lifestyles and life chances of families when it afflicts heads of households.

Low-level employment.—Many disadvantaged and minority workers are trapped in jobs that offer them little in the way of dignity or self-esteem. These jobs are characterized by harsh and arbitrary discipline, unhealthy, unsafe or inhumane working conditions, low pay, and the absence of a career path.

Involuntary employment.—Many older people are forced to take jobs because they can not live on their retirement incomes; many heads of households are forced to moonlight because they can not attain a decent standard of family living on wages from primary jobs; and many women who prefer to stay home and raise their children are forced to take paid jobs because of Government eligibility requirements for social services.

Underemployment.—The underutilization of skills, training, and education of workers is fast becoming the major source of workplace problems in society. As the levels of educational attainment of the work force rise, discontent and alienation spread among more qualified workers who are forced to take jobs that were previously performed by those with lower qualifications.

In short, a lowered rate of unemployment is clearly desirable, but a lower rate does not by itself have positive impacts on such other performance criteria as productivity, the quality of working life or family disorganization among the poor. For rates of unemployment to be such accurate indicators, they would have to reflect the problems of the subemployed, involuntarily employed, underemployed, and the labor force dropout.

T3. *GNP*

The BLS assumes that increases in the GNP will correspond with decreases in unemployment. While accepting this relationship for purposes of establishing a nominal future, it is worth noting that a different set of assumptions is just as reasonable.

For example, in the future, the rate of unemployment may fall toward zero, even without much economic growth. Indeed, it is possible that within the next 30 years employment rates might fall to the frictional level, reflecting a situation in which demand for workers exceeds supply. The convergence of five trends makes such a zero growth-total employment future a distinct possibility:

1. Rising costs of energy may lead to the increasing substitution of labor for capital.
2. An increasing scarcity of capital in our "debt economy" may lead to more labor-intensive enterprises.
3. A continued shift from an industrial-based economy to a services basis would create more jobs.
4. Environmentalist pressures will exacerbate the shift away from capital-intensive, "dirty" industries (metals and mining, for example) toward "cleaner" labor-intensive health, education, and other services.
5. There will be a demographic shift culminating in about 30 years in which the ratio of retired to those in the labor force will be greater than ever before in American history.

T4. *Productivity*

The trend I have recorded in the matrix is a simple extrapolation of the rate of increase of productivity between 1970 and 1975, based on the BLS index of output per man-hour (1967 equals 100). To the economist, there is often a tradeoff between labor intensivity and productivity, and between satisfying work and productivity. Thus, given the assumptions of economists, the impact of more satisfying work, more white collar work and more government work might well be a reduction in national productivity. As a recent editorial in the Wall Street Journal put it:

> A society increases its standard of living primarily by increasing the capital input relative to the labor input. A worker can enjoy a sustained increase in his standard of living only if he becomes more productive. And sustained increases in productivity come from supplying better tools, that is, by investing more capital.

Of course, it is as close to fact as one can get to assert that the process of economic growth has occurred through the substitution of capital for labor. Historically, such growth has been at the core of much of mankind's social and political progress and economic development.

But in the future a counterargument may run as follows: If the further substitutions of capital for labor along the lines the Journal advocates leads to greater pollution, the inefficient use of energy and other scarce resources, increased inflation, unemployment (and, dissatisfying jobs for those lucky enough to find employment), in what real sense will this substitution enhance the standard of living?

But what would happen to productivity if the economy were to become more labor intensive? E. F. Schumacher argues that the gross productivity of society can actually be increased by applying appropriate labor-intensive technologies.[8] Still, Schumacher's observations are likely to be of scant reassurance to the practical managers of American industry or to the politicians responsible for maintaining a vigorous and competitive economy. The unanswered question remains

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[8] E. F. Schumacher, "Small is Beautiful," Harper and Row, 1973.

jobs, perhaps but they are hardly likely to satisfy the new generation of affluent, educated workers. In addition to these criticisms of public employment, there is at least impressionistic evidence that private employment seems to be more innovative, flexible, and responsive to the individual needs of workers. For example, self-management and worker ownership are all but impossible in civil service jobs that, by necessity, must be, first and foremost, responsive to the voting public. It is not clear, then, that increases in public employment would have the same positive impact on such measures as job satisfaction, family disorganization, and productivity that increases in private employment might have.

T7. *White-Collar Employment*

The BLS forecasts that the percentage of American workers engaged in the categories of wholesale and retail trade, finance, insurance and real estate, government, and services will continue to increase at the expense of blue-collar employment in the industrial sector of the economy. The economist would assume that this trend would have (1) a negative impact on productivity and (2) a positive impact on the quality of working life. The first assumption is problematic, the second is probably fallacious.

Most white-collar jobs that are being created are not good, satisfying jobs. They are low or semiskilled. To help put this conclusion into perspective, it is useful to analyze the two fastest growing industries in the economy: Government and "miscellaneous service." In 1955, 10.5 percent of all jobs were in government; by 1975, the figure was 15.5 percent. In 1955, 15.9 percent of jobs were in services (cleaning, maintenance, police, health, provision of food, etc.); by 1972, over 20 percent of the workforce was in this industry (not to be confused with the "service sector" which includes all "white-collar" activities that do not produce goods).

Service industry jobs—such as working behind the counter at MacDonalds or punching IBM cards—are usually thought of as the representative occupations of a postindustrial economy. Some of these jobs are good jobs. For the worker who has been in an industrial job where he has been assaulted day in and out by the relentless clamor of a machine, the opportunity of taking a job in which the most salient characteristic is human contact would appear attractive, indeed. But most of the people who take the new service jobs are not transfers from industry; they are young people, many of whom have had at least some higher education. For them, service jobs appear to have many of the worst characteristics of blue-collar work (the jobs are dull, repetitive, fractionated and offer little challenge or personal autonomy). Indeed, these new jobs often lack the best characteristics of skilled blue-collar jobs (relatively high salary, security, union protection, the sense of mastery that comes from producing something tangible and needed by society). Thus the economy is creating a great number of clearly unattractive jobs. For example, between 1960–70, the number of orderlies and nurses aides increased by 420,000; the number of janitors by 530,000; and the number of busboys and dishwashers by 70,000.[12] Characteristically, such jobs offer low

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[12] Harold Wool, "The Labor Supply for Lower Level Occupations," Washington, D.C.: National Planning Association, June 1973.

salary—nearly 30 percent of all services workers earned less than $4,000 per annum and little in the way of career advancement. In hospitals, orderlies do not progress up a career ladder to become nurses; in hotels, chambermaids seldom advance to become desk clerks.

Moreover, many of the new jobs that statistically look like good jobs (health paraprofessionals, teachers' aides, and the new careers for technicians that require a 2-year A.A. or A.S. degree) also do not have career ladders, and are limited in their scope by the perogatives of the professionals in the jobs that supervise them. In reality, precious few of the new white-collar jobs that are being created are better than the old blue-collar jobs that are being replaced.

T8. *Gross Domestic Private Investment*

The figures in the matrix are extrapolations of estimates made by James J. Needham, president of the New York Stock Exchange. It is the most assumption-laden figure on the matrix. For example, Needham postulates that if the United States falls short of the $560 billion that he assumes is needed for private capital investment in 1985 there will be a shortfall of about a million jobs over the next decade.

One might arrive at different conclusions, however, if one assumes some different things about the availability of capital and its role in job creation.

Although many economic indicators seem to support the notion of a capital shortage, there remain certain logical inconsistencies with the notion. What is meant by the term shortage in an economic sense? Ultimately, no doubt, there is a real shortage of oil. That is, there is a finite amount in the ground. Because the total world reserve of oil is fixed, it is thus meaningful to speak of shortages and to advocate increasing the supply of alternative sources of energy as a policy response to the shortage. But only things in nature are in finite supply, while ideas, concepts and other human products are theoretically limitless. That is why talk about shortages of such things as capital jobs or social inventions has a certain naive ring to it.

This suggests the need for an alternative way of framing the problem. For example, it often turns out that apparently simple cases of shortages can be better understood and acted upon if they are seen as complex problems of maldistribution. Recent attempts to increase the supply of medical manpower illustrate this phenomenon. In the late 1960's, American medical schools made a concerted effort to gain a windfall increase in Federal aid by convincing the American public that there was an acute shortage of doctors. This alarmist tactic almost worked—until more thoughtful analysis showed that the problem is more a maldistribution of doctors by both specialty and geography than a general shortage across the board. That is, there are more than enough psychiatrists in Manhattan, but there are not enough pediatricians in the ghetto; there are so many radiologists in Los Angeles that they have to inflate their fees to keep their income above the so-called starvation level ($60,000 per annum), but there are not enough general practitioners in rural Iowa. Thus, what is called for is not simply more doctors, but a system of incentives to the medical schools to correct the problems of geographical and speciality maldistribution.

Talk about a capital shortage may be as misleading and nonoperational as talk about a shortage of doctors. No doubt, some capital is going to uses different than in the past—and these uses may not be in the long-range interest of the economy—but this is a problem of distribution, not of supply.

Walter Heller has put forth the argument (based on Brookings, Citibank and Data Resources studies) that the capital problems of America are not as great as cover stories in Business Week or editorials in the Wall Street Journal would have it. Heller shows that the ratio of business fixed investment to GNP has been rather steady since 1946, and has even climbed slightly in the last 2 years. Moreover, those who estimate the total capital needs of the Nation for the decade at $4 to $5 trillion are probably crisis-mongering; still, even these figures represent only 16 percent of GNP, about 1 percent over the average capital needs for the United States over the last 30 years. Heller readily admits that the U.S. rate of growth has not recently matched Germany's or Japan's, but they are still playing catch-up and Heller finds no evidence that their economies could retain their current rates of growth at our level or development and affluence. Finally, Heller points to studies that show that much of our growth comes not from heavy investments in expensive new machines, but from advances in knowledge.

Moreover, one's assumption about the capital requirements of the economy vary greatly with the scale of technology one has in mind and whether one expects that jobs will be created in the industrial or services sector. Capital requirements then, are maniputable variables, not determined or determining givens.

T9. *The Quality of the Environment*

Neither the BLS nor any other Government agency makes qualitative forecasts. Consequently, I have arbitrarily set the overall quality of the environment at an index of 100 for 1975, and have forecast that it will deteriorate 5 percent over the next decade as the result of reduced standards to meet energy and job needs. This is based on the prevalent assumption that there are tradeoffs between jobs and the environment and between energy production and use and the environment. Given current technologies and policies, such a tradeoff exists. However, given some of the policies outlined below (E1, E4, E5, and E6) such a tradeoff need not necessarily occur.

T10. *The Quality of Work Life*

The most basic assumption of manpower economics is that people work to make money. Under this assumption, any policy that increases the total number of jobs—regardless of the nature of the jobs—is desirable.

There is another assumption possible here: The quality of jobs is often as important as the quantity of jobs, particularly for young Americans. This assumption reflects the economic well being of most American workers who can now take for granted that tomorrow they will have meals on their tables, shirts on their backs, and roofs over their heads. While it would be incorrect to assume that people will be indifferent to money in the future, it would seem that money will not be the prime consideration in life for most Americans. In the past, the typical worker was by necessity primarily concerned with securing the basics of life. To an immigrant, a migrant from the South, and almost everyone who lived through the Depression, a good job is one that pays well and offers some security.

Young Americans do not share these experiences with their parents, and, consequently, their attitudes differ. Daniel Yankelovich has been polling young people for nearly a decade, and the he finds that male and female, white and black, white-collar and blue-collar, the under 30 generation wants and expects jobs that are meaningful (that is, contribute to others or to society), challenging, and offer the opportunity to learn and to grow.

The phrase "The Quality of Life" has come to symbolize the aspirations of this generation. Since people spend over half their waking lives on the job, the quality of working life is thus the most obtrusive manifestation of the overall quality of life. As a result, young people to a great degree look to realize a quality life on their jobs. Unfortunately, most jobs do not offer the challenge or the opportunity for growth that young people are seeking. It is not surprising to find, then, that young people are far more dissatisfied with their jobs than are their parents who have much lower expectations. Alarmingly, this dissatisfaction will no doubt be a greater problem for society in the future when the current generation of youth constitutes the majority of the work foice.

This shift in attitudes has created a growing problem of underemployment, which I have above defined as the underutilization of education, intelligence, training, skills and other human resources. Unlike unemployment which is cyclical in nature, underemployment appears to be a chronic condition in industrial economies. The evidence for this comes from quantitative comparisons of data concerning the educational attainment of the work force on one hand, and labor-market demand for educated workers on the other. What can be shown is explosive growth on the supply side in terms of educational attainment, and a rather static situation on the demand side in terms of the availability of jobs that actually require highly-qualified workers.[13]

In terms of supply:

The median educational attainment of blue-collar workers rose from 9.2 years of schooling in 1952 to 12.0 years in 1972;

College enrollment expanded from 2.6 million in 1952 to 8.4 million in 1972 (an increase of about 250 percent); and,

By 1980, 1 in 4 American workers will have a college degree.

In terms of demand:

In the highest skilled category of workers, between 1950 and 1970 demand grew from 7 percent to only 9 percent of the entire work force;

In 1948, 12.9 percent of the work force was in the category of "manager." By 1973, the percentage had grown to only 13.6 percent;

The average education required for all jobs increased from 10.0 years in 1940 to 10.5 years in 1970; and

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[13] O'Toole, "Work, Education and the American Future," Jossey-Bass, 1977, p. 36–70.

In 1980, less than 20 percent of all jobs will require a college degree.

As a consequence of the disjunction of these two categories of trends, there is now massive underemployment in the United States:

Something like 80 percent of all college graduates now take jobs previously held by those with lower educational credentials;

In 1958, less than 10 percent of college graduates took low-level jobs; in 1972 over 39 percent of graduates were forced to take bad jobs;

Between 1969 and 1974 the number of male college graduates working as salesmen increased by 50 percent and the number of women college graduates working as secretaries increased by 100 percent;

Starting salaries of college graduates are off about 25 percent since 1969; and

By 1985, there will be 2.5 college graduates competing for every choice job, leaving an annual "surplus" of 700,000 college graduates.

The possible impacts of underemployment on productivity, GNP, and other measures such as social and political alienation indicate that the quality of working life is an important aspect of any analysis of the future of growth and employment. On the matrix, I estimate that the quality of working life will deteriorate through the early 1980's, and will start to improve to current levels by 1985 as the result of (*a*) changes in demographics and (*b*) changes in the design of jobs to give workers more authority, challenge and satisfaction.

T11. *Family Disorganization Among the Poor*

The nature of jobs that are created is every bit as important for the poor and disadvantaged as it is for underemployed college graduates. Although many jobs provide the poor with the social, psychological, and economic rewards that make work so essential and meaningful to life, some jobs offer none of these rewards. Not only do they fail to provide the worker with minimal dignity, challenge, and economic resources, they may actually destroy an individual's self-esteem.

The nature of work, then, is a critically important variable in discussions of employment. Related to the nature of work is the stage in one's life when one takes a certain kind of job. For example, picking fruit is not a bad summer job for a student, but it is literally lethal for migrant farmers and their families. There is nothing wrong with working in an unsteady, low-paying job if one is young and single, but if one tries to marry and raise a family in such an economic condition, the odds are that the marriage will quickly dissolve.

The devasting consequences of the nature of work experience on family life have been documented in many community studies.[14] In many poor communities where men work in unsteady, low-paying, demeaning and dead-end jobs they are unlikely to have the self-

[14] O'Toole, "Watts and Woodstock," Holt, Rinehart and Winston, 1973.

esteem or social or economic wherewithal to hold a family together. In many poor communities, there is thus a high correlation among male subemployment, single-headed families and welfare case loads.

From the point of view of family formation, all jobs are not good jobs. Moreover, who works in a family is a crucial variable. In many poor black communities, women have been more employable than men. Important, however, is the fact that the availability of a job for a women with small children has little positive effect on family cohesion or other social problems related to employment and poverty. It is the fathers of young children who need paid employment. Ironically, welfare work incentive programs in the United States are designed to get jobs for mothers instead of finding jobs for fathers of welfare children. Work programs are not directed to the fathers because they are not on welfare themselves, even though they are the proximate cause of their family's welfare status. Punishing welfare mothers by making them take undesirable jobs has little or no positive impact on the familial or employment problems of the chronically disadvantaged. (Of course, these women also need the freedom to take a paid job if they choose.)

T12. *Crime and Delinquency*

When estimating the costs of unemployment, it is necessary to include all the factors, including the costs of poor mental and physical health, family disorganization, social and political alienation, and crime, and delinquency. Crime does not stem from unemployment, but it stands to reason that the option of a good job might dissuade some from a life of crime. Delinquency is related to unemployment in two ways: (1) Young people who cannot find jobs drift into delinquency out of boredom and peer pressure and (2) the children of broken families—caused in part by the inability of fathers to get good jobs—are more likely to be delinquent than children from cohesive families.

These, then, are 12 measures of employment and the economy, the interaction of which will determine the success or failure of current policies over the next 10 to 20 years. Let us now explore what might happen to these trends given alternative policies.

Eight Alternative Policies

After having chosen the key variables or trends that one would use to measure the future interactions of employment and growth, and after having extrapolated these trends to establish their nominal futures, one is then ready to play the "what if?" game in earnest. The game is played by testing the possible future effects of alternative policies on the nominal direction of the trends. Thus, we ask, "If we pursue course A, will the effect on employment be positive or negative?"

Below I have identified eight policy alternatives to economic growth and have estimated what their direct impacts would be on the 12 trends described above. The analysis is only suggestive of what would happen in an actual cross-impact exercise. Without probability runs in a computer, there is no identification of the important unintended and indirect cross-impacts or sequential chains of impacts that are the primary outcomes of the method. Moreover, the estimates of the impacts of the events—policies—on trends reflect nothing more than my personal biases and values. In actual usage, these estimates would be made by balanced panels of experts and by the decisionmakers themselves.

In what follows, I take the conventional forecasts of the nominal future and estimate the impacts of the eight policies using nonconventional assumptions. This may seem a bit like mixing apples and oranges, or measuring the distance to the stars in quarts. But if only traditional assumptions are used, it is likely that one will arrive at traditional outcomes. Experience shows that when proposed changes are evaluated only by the assumptions that led to the status quo, the changes are most often rejected.

At base, I am suggesting that traditional economic assumptions may be inappropriate to a changing and complex world, a world in which the citizenry no longer measures the performances of key institutions with a single, simple economic yardstick. For example, in the past the only measure of corporate performance was "industrial efficiency"—obtaining the maximum output at the lowest cost. But the economic concepts of "the one best way," "optimization," "maximization," and "industrial efficiency" are, as Daniel Bell has written, not the only concepts that impinge themselves on the industrial decisionmaking process in industry in the late 20th century. Industrial organizations are finding that society will not permit them to pursue a single goal (profit maximization). Indeed, as executives of most of the leading firms in America are beginning to recognize, businesses are becoming social institutions with many constituencies and many goals. As we see today, businesses are not only under pressure from stockholders to use capital efficiently in order to increase productivity and profits, there are new pressures, too: from conservationists to use processes that are environmentally sound; from the Government to use energy efficiently; from consumers to produce safe and durable goods; from unions and society to create jobs; and from workers to provide satisfying jobs.

But while the performance criteria for efficiency are changing, in some respects society is still guided by the dead-hand of traditional economic theory. As Lord Keynes wrote, "Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist." Let us examine how the assumptions of some defunct "academic scribbler of a few years back" (perhaps Keynes himself?) still influences economic thinking today. For example, take the issue of the choice of technology, an area that greatly influences the issues of employment and economic growth in the contemporary economy.

Many of the most basic and cost-sensitive practices of American industry are based upon assumptions formulated and promulgated by economists and industrial engineers. Managers have been almost entirely dependent upon the calculations of these specialists when choosing, designing and operating the technologies of production in their plants. This dependence is creating a new order of problems for management. For example, in many industries, (and, for myriad and different reasons), economists and engineers have often viewed energy as a "free" factor of production. Like air and water, energy was viewed as so "cheap" during the 1950's and 1960's that it was scarcely necessary to reckon its contribution to the cost of a product. Businessmen followed the advice of the experts and chose energy-intensive technologies whenever possible (as they had chosen technologies that made ample use of "free" clean air and water). The process was rational by the standards of the economists and engineers, and paid off in highly "efficient" and productive industrial methods.

Then came the reckoning. During the last decade it was discovered that clean air and water do, indeed, come at a price—often a high one. Today, managers are struggling to raise capital to install costly anti-pollution equipment. Many businessmen wonder if it would not in many cases have been cheaper to have chosen cleaner technologies in the first place. These weren't always available, but they might have been available had water and air not been viewed as free goods by those same economists who also always said: "There ain't no such thing as a free lunch."

And now, thanks to the cartelization of oil, American managers are finding that energy is not free, either. Many industries have chosen energy-intensive technologies on the assumption that the Government would keep the cost of energy low enough that it would not be a major cost concern in the future. Now, in many industries, once-efficient capital equipment is becoming increasingly expensive to operate as energy becomes ever more dear.

Another assumption on which many basic industrial practices are based is that technology, like the weather, is a given. Industrial engineers have often led managers to believe that there is only one way to efficiently produce a given product—the way it is currently being produced. Such technological determinism is fast becoming one of the most uneconomical assumptions of American industry. In most industries, technology is determined by engineers and managers, not by the laws of God or nature. For example, Volvo and Saab are now discovering that the assembly line came not from Our Maker, but from Henry Ford. Simply put, it is being discovered in many industries that there are more options in producing cars, computers, airplanes, appliances, and widgets than has been assumed.

There is thus ample reason (at least for the purpose of the analysis that follows) to suspend our faith in many traditional economic assumptions. Let us then examine the following eight policies and see what kind of effects each might have on employment and growth in the year 1985.

ESTIMATED IMPACTS OF EVENTS ON TRENDS

If these events were to occur	Then these trends might be altered by the factors shown below											
	Labor participation	Unemployment rate	GNP	Inflation	Government employment	Productivity	White collar	Private investment	Quality of environment	Quality of work	Crime, delinquency	Family disorganization
1985 nominal forecast	63.6	4.0	3.6	5.5	17.9	130.9	66.3	$560	95	100	95	95
1. Reduced technology	64.5	3.4	3.3	6.2	17.0	125.0	64.0	540	105	110	100	100
2. Public service employment	64.0	3.8	3.4	6.0	19.5	120.0	68.0	520	95	95	96	96
3. Jobs for youth	64.5	4.2	3.4	5.9	20.0	123.0	65.5	520	95	98	105	95
4. Active manpower	63.6	3.6	4.0	5.0	17.8	135.0	66.3	600	100	105	110	100
5. Tax on gas	63.6	3.9	3.5	5.8	17.9	128.0	67.0	550	105	100	95	95
6. Reallocation of Federal expenditures	63.6	3.8	3.6	5.5	17.8	130.0	66.3	580	100	105	100	100
7. Duel minimum wage	64.0	3.9	3.6	5.4	17.8	131.5	66.0	565	95	100	100	95
8. Employment tax credit	63.6	3.9	3.8	6.0	17.8	128.0	62.0	570	95	100	96	96

E1. *Reduce Technology*

The "Buddhist economics" of E. F. Schumacher have caught the imagination of millions of Americans during the last year. It is Schumacher's contention that a reduction in the scale of productive technologies would (*a*) increase the quality of the environment, (*b*) conserve energy and natural resources, (*c*) create higher quality products, (*d*) create many good jobs, and (*e*) restore the sense of community that has been lost in industrial society. Many Americans, including Governor Brown of California, now advocate applying Schumacher's policies in the United States. The cross-impact approach offers a convenient way to think through the consequences of a policy to reduce the scale of technology. On the matrix, we find that the policy has many positive attributes, but it also has some rather extremely negative ones. While Americans might well share Schumacher's values and goals, it seems that the Buddhist economics by which he intends to achieve these goals are impractical in the American context. Buddhist economics might lead America from its current smoggy, hectic, often alienating condition into an impoverished, unproductive, bureaucratic and authoritarian one. The most misguided aspect of Schumacher's argument is found in his general assertion that "small is beautiful." As stated, it is simply wrong in the American context. Small is not always more desirable than big. The "big, bad guys" at I.B.M., Sears, Xerox and Polaroid, for example, are the industrial leaders in protecting consumers, fighting pollution, in minority hiring and in providing their workers with interesting jobs, meaningful training opportunities, security, good pensions and a safe and healthy work environment. The small and middle size employers—the "Alpha" foundries and "Beta" chemical works that comprise the majority of American industry—are the ones primarily responsible for unsafe products, pollution and for providing workers with low salaries, long hours and harsh and arbitrary discipline. Not even a Buddhist would choose working for the Mom and Pop Iron Works if he had the option to also work for United States Steel. No doubt, corporate size is a major problem in the United States. The giant corporations wield—and often misuse—enormous political, social and economic power. But this doesn't always make big ugly, or small beautiful. Such conclusions are much too simple.

Nevertheless, for India, Bangladesh, Burma and for most of the Third and Fourth World, Buddhist economics are probably appropriate and desirable. In lands without a democratic heritage, without commitment to the rights of individuals, and without advanced economies there is little doubt that Schumacher's economics would be more appropriate than the current aping of the industrial growth policies of the West. And, for any economy at almost any state of development, it is probably desirable to move away from the polluting, resource-wasteful and dehumanizing middle-range technologies of the industrial revolution (such as the assembly-line and many of the so-called continuous process technologies). In countries with little or no capital base, it is probably sensible to move in the direction of the simpler technologies that Schumacher advocates. But in a post-industrial society such as the United States there is another option, one that Schumacher conspicuously and fatally overlooks. In the developed world, it often makes sense to move to even higher technologies (such

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as computers) because these create the wealth and productivity on which great numbers of workers engaged in services and low technology can be economically supported. Schumacher also fails to recognize that high technologies are often human-intensive as well as being capital-intensive. For example, computers and Xerographic equipment require the labors of an incredibly large number of scientists, engineers, managers, technicians, production workers, operators, sales people and repair people—people in good rewarding jobs.

On the cross-impact matrix I have indicated that the reduction of the scale of technology would increase the quality and quantity of jobs and the quality of the environment. At the same time there would be a decrease in GNP, productivity and private investment. Other measures not included on the matrix such as freedom, bureaucracy, and property rights would also be impacted negatively. At the same time there would be positive effects on the quality of goods and social and political alienation. Clearly, Buddhist economics is a mixed bag. But simply because Schumacher fails to recognize the importance of clean, human-intensive high technologies, does not mean that America can afford to ignore his significant insights about the interrelationships of growth, size, technology, economics, and work. Rather, America might make use of these insights by inventing a context for them that is appropriate to the American condition and experience For example, although the simple reduction of the scale of technology is an inadequate policy, incentives that also moved industry to high technology and away from middle range technologies would probably have many more positive impacts.

E2. *Public Service Employment*

Turning from the sublime to the shopworn, let us examine the most perennially popular policies for achieving full employment: (1) Macroeconomic stimulation; (2) increased manpower training, and (3) public service employment. While the first of these is a successful policy in many respects, it generates attendant social and environmental costs while leaving pockets of people chronically unemployed. The second policy is most often a case of self-deception; the problem is a shortage of jobs, not a shortage of skills. Public service employment is a different order of beast. It appears to be an appropriate but insufficient solution for the following reasons: (1) Most public service jobs go to the middle class and not to those who really need them; (2) measured by challenge, meaningfulness, and the opportunity to grow and to learn, private sector jobs are usually better than public sector jobs (see T5); (3) public service jobs are more costly and produce fewer benefits than alternative forms of expenditures (see E6); and (4) public service jobs expand the portion of the economic pie managed by Government and expand the portion of the workforce engaged in less productive white collar jobs, thus creating some inflationary pressures.

For all their liabilities, public service jobs are nevertheless popular with politicians and the public because they give the impression of forceful and direct action on the problems of unemployment. It is hard and slow work to create jobs that produce goods and services in actual demand, but it is easy and fast to start up training programs and public service employment. These programs are basically palliatives; they are far from being cures. Because they do not treat the causes of unemployment, they may even be counterproductive in that by alleviating the symptoms they remove pressures to act on the root causes. When unemployment reaches 7 or 8 percent, advocates of public service jobs are able to command a wide audience (and, are usually able to get a public employment bill passed in the Congress). Then, when unemployment slips back to the 5- or 6-percent level for cyclical reasons, public attention quickly turns to other areas of concern, satisfied that the prompt and wise leadership in Washington has adequately dealt with the problem. Consequently, true reforms are seldom considered, and the damaging problems of subemployment, low-level employment and involuntary employment remain and grow worse.

Event 2 assumes the introduction of a massive New Deal-scale public service program. Interestingly, the BLS forecasts that unemployment will be down to 4 percent by 1985 without such a program. Nevertheless, it is worth considering that such massive WPA-CCC-type programs might actually make more sense during periods of low unemployment than during periods of high unemployment. When the rate of unemployment is 7 percent, public service jobs go to temporarily unemployed middle-class workers, and to middle-class women who are attracted into the labor market. Even at a tight 4-percent rate some public service jobs will still go to the middle class, but it is more likely that the poor people who really need work will get it. At any rate, public service jobs are likely to have marginally positive effects on unemployment, crime, and family disorganization, and marginally negative effects on GNP, inflation, job satisfaction, productivity, and private investment.

E3. *Public Service Jobs for Youth*

Many individuals feel that public service employment should be targeted at those groups in greatest need, particularly at teenagers who have the greatest problems in the labor market. One such program that has been proposed is for a 1- or 2-year public service program for all youth after graduation from high school. During this voluntary interregnum between high school and college, youth would engage in tasks needed by the society. Although the various proposals for such a program take many different forms, almost all would have positive effects on the rates of teenage unemployment and delinquency, and on the life and job satisfaction of youth. The chief negative effects might be an increase in the rate of adult unemployment and inflation and a decrease in GNP, productivity, and private investment.

E4. *Active Manpower Policy*

This policy would be similar to certain aspects of the West German approach to achieving full employment. For example, the Government might provide incentives to private industry to start up labor-intensive industries, particularly in regions of high unemployment. Such a plan would require some kind of limited indicative planning effort by the Federal Government to be successful. With information derived from such a plan, the Government would seek not simply to create more jobs (which basically just increases the labor force participation rate and does little to alleviate the chronic and hidden problems of unemployment). Instead, the Government would attempt to: (1) facilitate the withdrawal from the paid labor force of reluctant workers; (2) increase the mobility of workers; and (3) increase flexibility in the job market. The idea is to use market mechanisms to achieve a better fit between individual desires and industrial needs. Programs that did the following would help achieve such a goal:

Reduce institutional rigidities in the labor market, such as seniority rules.

Remove all Government regulations in which employment is a prerequisite for social services. For example, make unpaid individuals engaged in raising children eligible for social security benefits.

Provide a program of midcareer worker training or sabbaticals that covers school tuition and a substantial part of foregone income.

Provide programs that allow workers to taper off before re- retirement. For example, allowing 55-year-olds to work 4-day weeks and 60-year-olds 3 days, et cetera. Conversely, those over 65 would be permitted to work without penalty if they so elected.

Provide human-depreciation tax allowances or employment tax credits linked to ratio of employment to fixed plant and equipment. Both policies (and others like them) would encourage labor-intensive processes in industries.

Provide more part-time jobs and job sharing. For example, currently the Pitney-Bowes Company permits two mothers to split one job to free them both to spend time with their children. At some universities, a husband and wife may split one faculty appointment.

Establish a system of domestic "Fulbrights" for people who would like to take a year or two away from their regular jobs to engage in some kind of public service. Xerox has such a program for its employess.

Provide a guaranteed minimum annual income.

Stop massive immigration except for political or humanitarian reasons.

Permit cities to charter and operate banks. These banks would underwrite loans to individuals or groups wishing to start nonprofit or cooperatively owned businesses that met the employment needs of an underserved group or community. For example, businesses would be eligible if they offered meaningful employment to the aged, youth, or minorities, or if they provided such groups with training to do meaningful but rare types of work, such as skilled crafts and repairs.

If the German experience is at all relevant to American conditions (admittedly, there are some important structural differences between the two economies), it is possible to design programs that lead to full employment and low inflation without limiting growth. Such a proactive manpower policy reduces the direct role of Government in jobs, while it increases its role in providing economic incentives based on indicative planning forecasts. Most important, because the policy does not rely on macroeconomic stimulation, it might have only a minimal effect on inflation.

E5. *Tax on Gas*

It has been suggested that $1 a gallon tax on gasoline (and a corresponding tax on other fossil fuels) would lead to the conservation of energy and to the development of alternative energy sources. A second order consequence of the tax would be the substitution of some labor for capital, thus lowering the rate of unemployment. The tax should also have a strong positive effect on the quality of the environment. But it might negatively affect GNP, inflation, productivity, and private investment, and would certainly have negative effects on economic equality unless accompanied by some form of negative income tax rebate for the poor.[15]

E6. *Reallocation of Federal Expenditures*

Every dollar spent by Government has an effect on job creation. It has been suggested that it is possible to plan Government expenditures is a way that maximizes job creation per dollar spent. Apparently, the differences in the number of jobs created varies considerably from one Government program to another. The following table (drawn from several sources) illustrates the number of jobs created for each $1 billion spent by the Federal Government:

51,000 jobs if spent on highway construction.
55,000 jobs if spent on defense contracts.
60,000 jobs if spent on CETA-like public service programs.
76,000 jobs if spent on public housing construction.
84,000 jobs if spent on health programs (not construction).
85,000 jobs if spent on water treatment plants.
90,000 jobs if spent on educational programs (not construction).[16]

Such analysis is incomplete. It does not tell us if the United States needs more highways or teachers. That is a judgment that must be made through democratic processes. Nevertheless, the list indicates the potential value of informing the democratic decisionmaking process with more reliable estimates of the job effects of public expenditures. As there are now environmental-, technological-, and energy-impact statements that accompany proposed legislation, there might also be an employment-impact statement. Such a statement would include estimates not only of the quantity of jobs that might be created with alternative expenditures but also of their quality. For example, health care expenditures might create many dead end custodial jobs, while defense expenditure might create large numbers of satisfying jobs in the crafts.

The cross-impact model is a potentially useful tool if job creation becomes an important consideration in the allocation of Federal expenditures. The model can help to identify job creation trade-offs and complementarities with other such important measure as the quality of the environment, productivity, and defense needs.

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[15] See James O'Toole, "Energy and Social Change," MIT Press, 1976, for a discussion of inflation and energy prices.
[16] See O'Toole, 1977, pp. 82–83 for sources.

E7. *Dual Minimum Wage*

Many economists argue that the minimum wage is an obstacle to the creation of jobs. Since the abolition of the minimum wage has a zero possibility of enactment because of opposition from labor unions, it is now suggested that a dual minimum wage (with a lower level for youth) would achieve the same positive effects as policy E2, but would be more economically efficient because it would create jobs in the private rather than in the public sector. The problem here seems to be the danger of locking youth into a low paying and dissatisfying secondary labor market from which they are unlikely to escape, particularly if they are from minority backgrounds.

E8. *Employment Tax Credit*

Because most economists argue that incentives work better than penalties, it is often suggested that employment tax credits might encourage the private sector to create jobs, much as investment tax credits encourage industry to install new capital equipment (that may lead to the elimination of some jobs). A column in the Wall Street Journal recently contained a proposal for a $2,000 tax credit for each new job created in the private sector. The negative effects of such a policy would seem to be in the areas of inflation, productivity, and efficiency.

Conclusion

I have played the "what if?" game using my own assumptions, and have come to the conclusion that policy E4—an active manpower policy—would probably have the greatest benefits and the fewest negative side effects of the eight alternatives analyzed. If a cross-impact analysis were actually to be used by the Joint Economic Committee, the outcome would be more detailed, complex and, perhaps, different. For example, the nominal future, alternative policies and estimated cross-impacts could be generated by a balanced, expert panel in whose judgments the committee had some confidence. Then, the model would actually be run in the computer to see what the consequences would be of the occurrence of one, two, or more of the events on the forecasted trends.

Then, the committee could test alternative policies using alternative assumptions. It is probable, of course, that there would be significant differences in assumptions held by various Members of the Congress (between, for example, those who favor a stronger role and those who favor a weaker role for the Federal Government). In light of this problem, it is possible to include value differences explicitly in the analysis, rather than to strive for unobtainable objectivity. Using available tools and methods, it has been shown possible to perform several parallel future analyses, each of which reflects a different value orientation or viewpoint. In effect, the consequences of different value positions can be illustrated on objective measures of performance and, similarly, the implications for various stakeholders of each option can be specified. An approach such as this serves not only to clarify the alternatives, but may also reveal important areas where common interests can be served despite different value positions because of the even-handed fashion in which policy consequences can be illustrated. The cross-impact technique, then, can lead to the identification of commonly-held values. Thus, it could help to identify policies that avoid politically unacceptable trade-offs.

No doubt it is unrealistic to expect that Members of the Congress would have the time to sit down and play the "what if?" game. But, it is not unrealistic to expect those who advise the Congress to do so. Indeed, because the traditional economic policies have not solved the problems of unemployment, inflation, the environment and steady growth, it would seem irresponsible for those who advise the Congress not to explore alternative policies. To do so effectively will require new analytical tools and different assumptions.

In conclusion, the cross-impact model cannot predict the future, nor can it invent more appropriate policies for employment and growth. As the developer of the USC cross-impact model, Selwyn Enzer, notes, the model itself makes no more substantive contribution to policy analysis than a chessboard makes to a game of chess. Thus, we should be careful not to become overly infatuated with the hardware of futures research. It is the futurist's perspective that is important—a perspective that can help to free policy analysis from the crippling constraints of the anachronistic economic paradigm to which it is currently chained. The futurist's perspective does not offer an alternative paradigm, it merely helps to free us to explore new and more effective policies. It simply frees us to see that we have more choices than we had previously assumed—a small contribution, perhaps, but essential to the creation of a new economics.

HUMAN CAPITAL AND ECONOMIC GROWTH: RETROSPECT AND PROSPECT

By STEPHEN P. DRESCH*

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SUMMARY

This paper is addressed to two focal questions: Will a continuation of substantial increases in educational attainments (human capital accumulation) result in increases in national income comparable to those attributed by growth accountants to past changes in the educational attainments of the labor force? Will the historical relationship between education and individual income continue to be observed in the future? The general conclusions are fundamentally negative in both regards.

A review of the various mechanisms by which education (human capital) enters into production suggests that increased investment in education can generally induce only a temporary increase in the rate of economic growth. And whatever the relationship between education

*Institute for Demographic and Economic Studies, Inc., a private operating foundation, New Haven, Conn.

and economic growth, because greater educational attainments can be achieved only at a price (sacrifices of alternative uses of resources, including student time), there must eventually come a point beyond which more human capital will not be preferred to less.

Furthermore, the anlaysis finds that individuals will adequately take into account most of the potentially important contributions of education to productivity and growth as they make decisions regarding the private investment of resources in human capital. Also, public policies already discriminate seriously in favor of investment in education: In addition to direct educational subsidies to students and institutions, income taxation biases the composition of investment toward human capital, while economic policies which permit intolerably high levels of unemployment artificially inflate the income gains associated with education and simultaneously deflate the apparent costs of education. In this context, education does not appear to be a prime candidate for incorporation into an active growth policy, much less an auspicious cornerstone for such a policy.

The dynamic process underlying the dramatic increases in educational attainments which have characterized the last several decades is examined, the consequences for individual career histories and for absolute (if not relative) intergenerational social mobility are highlighted, and the pessimistic prospects for the remainder of the 20th century are delineated.

The paper concludes that over the last half century a remarkable confluence of events has led to rapid and sustained growth, submerging potential social disequilibria. However, the next 30 years will witness a general process of social and economic adjustment to past developments, an adjustment which, in the context of the preceding period of expansion, holds the prospect of severe social disruptions:

The rate of population growth, especially of the adult population, will decline dramatically.

As a result of the reduced rate of population growth, a pervasive process of aging will occur, affecting virtually all sectors and occupations but appearing in a particularly pronounced form in those sectors and occupations in which the highly educated are disproportionately represented.

Rates of change in the sectoral distribution of employment will decline markedly; however, even damped changes in the relative importance of different sectors may, in the context of a very low rate of labor force growth, displace significant numbers of workers, especially the highly educated, for whom displacement will be most traumatic.

Persistent saturation of the highly educated labor market and the career disruptions experienced by the highly educated will lead to major changes in patterns of schooling behavior; schooling will cease to provide a mechanism for intergenerational vertical mobility and improvement in material welfare, and in fact, for a significant fraction of the population, children may well achieve significantly lesser material welfare than their parents.

The demographic and economic-technological developments outlined above will have important implications in a number of socially significant dimensions, for example, for the structure and functions of the family, for the legal system, and for the educational sector.

Emerging exigencies will call into question a broad range of current public policies and programs, especially in the areas of taxation, employment, and education.

Thus, although the role of human capital as an underlying cause of economic growth is ultimately concluded to be tertiary and tenuous, the historical relationships between education and economic growth are of immense social significance. Fundamental and socially traumatic disruptions and dislocations in these relationships can be anticipated to characterize late 20th century America, leaving very few untouched as career patterns and traditional mechanisms of social and economic advancement are altered and undermined.

Dealing with these developments, it can be suggested, will be vastly more difficult than achieving the much more limited, albeit important, goals of the Employment Act of 1946, notwithstanding the recurrent (and unacceptable) failures of economic policy over the past 30 years. And certainly as a sine qua non for a public policy which would respond humanely and nonrepressively to the deep and pervasive frustrations which will infect large segments of the American population, the commitments of the Employment Act of 1946—the achievement and maintenance of high levels of employment—must be realized. Continued or recurrent periods of economic stagnation and consequent high rates of unemployment will only exacerbate the potentially disruptive tendencies of the coming decades.

1. Human Capital and the Sources of Growth

Why economic growth occurs at all is a question which has fascinated economists since the infancy of the discipline. From the contemporary vantage point growth is viewed almost as the norm, albeit a norm which it is increasingly argued cannot be sustained; in contrast, the classical view, which has been definitively superceded by the now conventional "neoclassical" perception only in the period since the Second World War, considered the norm to be the stationary state, a condition in which all relevant variables (income, population, etc.) would have unchanging values over time. Whatever factors might, in the short run, induce increases in economic welfare would, over the long term, set in motion forces which would eventually restore the system to a stationary position, although one which might, unless one were a strict Malthusian, exhibit higher levels of income that that which had preceeded it.[1]

The fact was, of course, that over a relatively prolonged period economic growth had occurred. While this could hardly be considered a refutation of the existence of an ultimate stationary state, it did at least suggest that alternatives to that rather uninspiring outcome be considered. The search for such an alternative focused on the mechanism which it was argued would lead to the stationary state. Oversimplifying somewhat, consider an economy with a stable labor force (population); output per worker would increase as a result of positive net investment; but as capital per worker increased, the rate of return to capital would decline; as the rate of return approached

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[1] For a discussion of the origins and substance of the concept of the stationary state in classical economics, see Joseph A. Schumpeter, "History of Economic Analysis" (New York: Oxford University Press, 1954), pp. 562–570.

zero, the incentive to investment would disappear, and the stationary state would be achieved. The capital stock, labor force, and levels of income and output would remain constant over time.

The neoclassical alternative involved, essentially, giving the stationary state an upward tilt. If, e.g., the labor force increased at a given rate, then the capital stock could increase at the same rate without forcing a reduction in the rate of return to capital. Obviously, this could give rise only to aggregate economic growth, not to growth in output per worker. Thus, a second source of upward tilt in the stationary state was added, technological change. With increases in the productivity of the basic factors of production (labor and capital), output per worker, per capita income and consumption, and other related indices of economic welfare would then rise, ultimately, at the rate of technological advance.[2]

This concept of technological advance had two significant strengths: First, it accorded well with common sense; even the most unsophisticated could see that an ever more complex and powerful technology was the driving force of expansion in a modern, industrial economy. Second, it was given a certain indirect, empirical-scientific verification with the discovery that only a fraction of the observed growth in national income could be accounted for or explained by concomitant increases in the flows of services of the economist's traditional factors of production; the remainder, the unexplained residual, became the measure of the rate of technological advance.[3]

Unfortunately, however, technological advance was, and is, a black box, a fundamentally ill-defined and ill-understood nexus of processes by which production techniques are improved or superceded, new products are introduced, and as a result, economic welfare is enhanced.[4] Thus, from the vantage point of growth policy, of prescribing mechanisms by which to influence the rate of economic growth, technological advance has been a rather sterile construct, one which has served as little more than a rather nebulous object of faith.

Only in the identification of the components of growth does significant advance appear to have occurred over the last two decades. As best exemplified by Edward Denison's graillike quest for the sources of economic growth, growth accounting has progressively narrowed the unexplained residual.[5] By implication, the isolation of several basic elements comprising the unexplained residual suggests that to

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[2] Although there were a number of precursors, for example, Frank P. Ramsey, "A Mathematical Theory of Saving," Economic Journal (December 1928), the seminal contributions were provided by Robert M. Solow, "A Contribution to the Theory of Economic Growth," Quarterly Journal of Economics (February 1956), and "Technical Change and the Aggregate Production Function," Review of Economics and Statistics (August 1957).

[3] Again, see Solow, "Technical Change and the Aggregate Production Function."

[4] This fact has led to recent attempts to model directly the evolutionary process of economic change, most notably by Richard R. Nelson and Sidney G. Winter, "Growth Theory from an Evolutionary Perspective: The Differential Productivity Puzzle," American Economic Review (May 1975), and "Neoclassical versus Evolutionary Theories of Growth: Critique and Perspectives," Economic Journal (December 1974). Their work is distinguished from that of Schumpeter, who pioneered in developing an evolutionary conception of economic growth [see Joseph A. Schumpeter, "The Theory of Economic Development" (Cambridge, Mass: Harvard University Press, 1934), and "Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process" (New York: McGraw-Hill, 1939)], by its stress on empirical representation of the process or mechanisms of change.

[5] See Edward F. Denison, "The Sources of Economic Growth in the United States and the Alternatives Before Us" (New York: Committee for Economic Development 1962), "Why Growth Rates Differ: Postwar Experience in Nine Western Countries" (Washington, D.C.: Brookings Institution, 1967), and "Accounting for United States Economic Growth, 1929-69" (Washington, D.C.: Brookings Institution, 1974).

this degree growth has been explained, and with explanation there comes at least the possibility of an active growth policy.

Of the various sources of growth which have been identified by the growth accountants, one of the most important and quantitatively significant is education. Changes in the educational composition of the labor force (increasing educational attainments) have been found to account for a greater fraction (about 22 percent) of the 1929–69 growth rate of output per worker than any factor except the residue of the unexplained residual ("advances in knowledge and not else where classified," to which Denison attributes over 47 percent of the growth rate of output per worker). Of the contribution of total labor input to the growth of aggregate national income, education accounts for almost one-third. Primarily because of declines in average hours of work, Denison has estimated that the contribution of labor input to the growth of output per worker would have been negative (−0.18 percent per year or a cumulative −7 percent between 1929 and 1969) had educational attainments not increased.[6]

The apparent magnitude of this relationship has contributed to the policy interest accorded to education, an interest which has been reinforced by the association of educational attainment with individual earnings. As an indication of the magnitude of the latter relationship, Jacob Mincer and Barry Chiswick each conclude that approximately one-third of the variance in male earnings can be attributed to differences in years of school completed.[7] Notwithstanding uncertainties regarding the precise magnitude of the impact of education on earnings or even the actual directions of causality, such an important and observable correlate of individual income and status necessarily becomes a focus of public as well as scholarly attention:[8] Two important but separable aspects of the historical relationship between education and earnings are discussed in greater detail in appendix I of this paper.

The association between education and income (individual and aggregate) has drawn attention to the qualitative characteristics of the population and labor force more generally. Thus, the concept of investment in human capital has been extended to include not only education and related types of training and skill formation, but also such other means of improving the welfare and productivity of the individual as health and medical care. In contrast to education, however, the evidence concerning the apparent benefits of investments in these other areas is much less definitive.

Improvements in diet, public health (including immunization against infectious diseases) and sanitation are generally credited with the increases in life expectancy which have occurred over the last century; on the other hand, increased availability of medical care per se appears to have contributed little to reductions in mortality and morbidity.[9] Thus, although significant future improve-

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[6] Denison, "Accounting . . .," pp. 136.

[7] Jacob Mincer, "Schooling, Experience and Earnings" (New York: Columbia University Press, 1974); Barry R. Chiswick, "Income Inequality: Regional Analyses with a Human Capital Framework" (New York: Columbia University Press, 1974).

[8] See, for example, Christopher Jenks et al., "Inequality: A Reassessment of the Effect of Family and Schooling in America" (New York: Basic Books, 1972).

[9] For evidence on these issues, see Charles T. Stewart, Jr., and Corazon M. Siddayao, "Increasing the Supply of Medical Personnel: Needs and Alternatives" (Washington, D.C.: American Enterprise Institute for Public Policy Research, 1973), pp. 57–63, and other sources cited therein.

ments in welfare and productivity may derive from continued investments in public health (including research) and in public awareness of the consequences of diet and other aspects of life style (for example, the consumption of tobacco, alcohol, and other drugs, licit and illicit) for health status, augmenting the resources devoted to individual health maintenance is unlikely to have observable consequences either for individual income and welfare or for aggregate growth.[10] For this reason, the present discussion is restricted to investments in human capital which take the form of education, defined broadly to include not only formal schooling but also other more-or-less formal modes of training and skill development.

Within this context, the essential issue of this paper concerns the conditions—social, demographic, economic, and technological—under which the expectations associated with human capital can be anticipated to be realized: Will a continuation of substantial increases in educational attainments result in increases in national income comparable to those attributed by growth accountants to past changes in the educational composition of the labor force, and will the historical relationship between education and individual income continue to be observed in the future? These questions, which provide the focus for the fourth section of this paper, can be meaningfully addressed only if two prior issues can be illuminated: First, what are the mechanisms by which education (human capital) enters into production and economic growth? Second, given these mechanisms, are there aspects of the human capital-growth relationship which are not adequately represented in individual human capital investment decisions and which thus require policy intrusion if optimal rates of human capital formation and economic growth are to be achieved? These questions provide the focuses for sections 2 and 3, respectively. To simplify the discussion, human capital formation will generally be identified with schooling; the basic conclusions, however, will apply to any other form of training or skill acquisition.

From a serious examination of the foregoing issues, it will hopefully be possible to extricate the issue of public policy toward education, and human capital formation more generally, from the virtually sacerdotal terms in which policy discussions in this area have been conducted in the past and to provide a more fundamental basis for adapting public policy to the exigencies of the emerging future.

2. Characterizing the Relationship Between Human Capital and Economic Growth

Despite the significance generally accorded to the association between education and income (individual and aggregate), remarkably little serious attention has been devoted to the precise mechanisms by which education generates economic returns. The essential issue concerns the manner in which education, or human capital generally, enters into production. Several fundamentally different models, or conceptualizations, of this relationship can be suggested:

[10] This does not deny the possibility of significant benefits which might derive from major changes in the organization of medical care delivery, especially as these might serve to improve the information available to individuals in the areas referred to above.

Education as Labor Augmentation

One possibility is that educated labor is simply more efficient than uneducated labor, that is, that an educated worker can produce more than an uneducated worker and hence represents a greater number of efficiency units of labor. This is essentially the Dension model, in which relative wages are utilized as indixes of the relative efficiency of different schooling classes of workers.[11] A critical implication of this view is that relative earnings of different schooling classes of labor will be invariant with respect to their relative numbers; increasing the proportion of the labor force which is highly educated will not drive down the relative earnings of the highly educated. Alternatively stated, the contribution to total output of an additional educated worker, assuming concomitant increases in the capital stock, will not decline with increases in the relative numbers of educated workers.

The only question with respect to schooling in this model is whether the greater efficiency of the more educated worker outweighs the costs of additional schooling. If, for example, a more highly educated worker is 1.5 times as efficient as (earns 1.5 times more than) a less educated but otherwise comparable worker, then acquisition of the education will be justified as long as its cost is less than 50 percent of the lifetime earnings of the less educated worker.[12]

If the costs of education are the same for everyone, that is, there exist no differences in aptitudes or abilities which render some persons more costly to educate, then if a given level of schooling is economically justified, it will always be efficient to educate more persons to that level. If, alternatively, the costs of education do vary, for example, with ability, then there will be a point beyond which it will not be desirable to educate a greater share of the labor force. For the marginal educated (uneducated) worker, the cost of education would just equal the income gain associated with that education. This is indicated in figure 1 by the intersection of the incremental earnings function (horizontal because the relative earnings of the highly educated do not decline with an increase in their labor force representation) with the rising cost-of-education function (depicting the increase in the per-worker cost of education as less easily educated workers are educated).

Education as a Third Factor

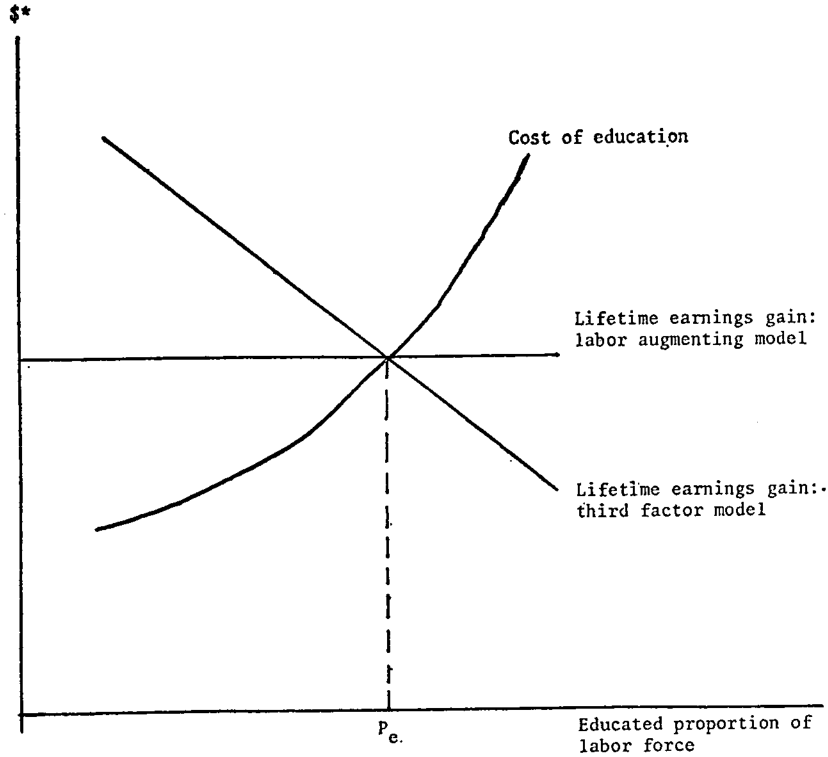
An alternative model views more highly-educated, human-capital-intensive labor as qualitatively distinct from less educated labor. Under this assumption, the relative earnings (and relative productivity) of more highly educated labor will decline with an increase

[11] This is also one possible interpretation of the labor-augmenting, Harrod-neutral technological change incorporated in the standard neoclassical, golden-age growth model; see, for example, Edmund S. Phelps, "The Golden Rule of Accumulation," American Economic Review (September 1961). An explicit incorporation of education within tha confines of this type of model is provided by Zvi Griliches, "Notes on the Role of Education in Production Functions and Growth Accounting," in W. Lee Hansen, ed., Education, Income and Human Capital (New York: Columbia University Press, 1970), pp. 71–115.

[12] Note that both the costs of education and lifetime earnings, to be comparable, must be discounted to a common point in time at a rate equal to the rate of return on alternative investments.

in the educational attainments of the labor force.[13] When educated persons are relatively scarce, they contribute greatly to output, but as they become more plentiful the relative contribution of an additional educated worker declines.

FIGURE 1.—Determination of efficient educated proportion of the labor force.



p_e: Efficient educated proportion of labor force

*Present values.

As in the labor augmenting model, it will be efficient to upgrade the educational attainments of the labor force to the point at which the cost of educating an additional worker just equals the gain in lifetime income he will derive (appropriately evaluating both costs and income gains). However, in addition to the possible increase in costs of educating an additional (less easily educated) worker as a greater fraction of the labor force is educated, providing the limit to the economically justifiable level of human capital investment in the labor-augmenting

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[13] In alternative variants this type of model has been developed by S. Bowles, "Aggregation of Labor Inputs in the Economics of Growth and Planning: Experiments with a Two-Level CES Function," Journal of Political Economy (January/February 1970), J. Tinbergen, "Substitution of Graduate by Other Labor," Kyklos (1974), and P. R. Fallon and P. R. G. Layard, "Capital-Skill Complementarity, Income Distribution and Output Accounting," Journal of Political Economy (April 1975), and underlies the educational adaptation model developed in S. P. Dresch, "Demography, Technology, and Higher Education: Toward a Formal Model of Educational Adaptation," Journal of Political Economy (June 1975).

model, in the third-factor model the decline in relative earnings (productivity) implies a further brake to efficient increases in educational attainments. As the educated proportion of the labor force rises, the relative productivity of educated workers will decline while the costs of education will rise. Again, the efficient educational composition will be reached when the (now-declining) incremental earnings function intersects the rising cost-of-education function, as also depicted in figure 1, with the marginal educated (uneducated) worker reaping no net gain from investment in his human capital.

Thus, the essential implication of both the labor augmenting and third-factor models is that there exists an efficient educational composition of the labor force, albeit an efficient composition which may change over time in response to underlying changes in technology. While there may well be earnings and productivity gains associated with a more highly educated labor force, these gains are purchased at a price. For the individual and, to the degree to which the calculus is distinct, for society, soon or late there comes a point beyond which additional education is not worth the additional cost, a cost which takes the form of foregone alternative uses of resources.

In this light, what can be said of the relationship between education and economic growth? First, if the educational composition of the labor force is suboptimal, then in the short run the rate of growth can be increased by increasing the flow of resources to education, thus increasing the relative representation of the highly educated. However, once the efficient educational composition of the labor force is reached, any further increase in educational attainments will actually reduce the rate of growth. Thus, there may be growth gains associated with reductions in the gap between the actual and the efficient educational composition of the labor force, but these will be only temporary; once the gap is eliminated no gains, in fact, only losses, will attach to further investment in education.

Second, if the relative demand for highly educated labor increases over time in response to underlying changes in technology, then secular increases in educational attainments will be justified on efficiency grounds, i.e., either the incremental earnings function will rise or the cost-of-education function will decline. However, it is conceptually incorrect to attribute the growth due to an advancing technology to changes in educational attainments induced by that advance in technology. Again, if an increased demand for highly educated labor, brought about by technological change, serves to increase the gap between the actual and the efficient educational composition of the labor force, then increases in educational investments will contribute to a temporary increase in the rate of growth. However, if the gap remains constant, then increases in educational levels, while a necessary condition for growth, cannot be considered the "source" or "cause" of growth.

As will be discussed in section 4, technological advance, clearly, has induced a large number of major changes in the economy, e.g., a shift of employment from agricultural to nonagricultural sectors. But, it is as absurd to attribute economic growth to an increase in educational attainments as it would be to attribute that growth to a decline in the relative number of farmers. Thus, between 1929 and 1969 the agricultural share of the labor force declined from 20 percent to 4 percent, while real earnings and output per worker increased dramatically in both agricultural and nonagricultural sectors; however, in the absence of the concomitant changes in agricultural technology which occurred over this 40-year period, an instantaneous 1929 decline of this magnitude in the relative number of agricultural workers would have implied not growth but mass starvation. While an equally miraculous conversion of the labor force from its 1929 educational composition to that of 1969 would perhaps not have had quite such dire consequences (except for possibly increased efficiency in the conduct of crime), its contribution to economic well-being would be equally questionable, and certainly would have fallen short of the instantaneous 17-percent increase in output per worker suggested by Denison's estimates.[14]

Both the labor augmenting and third factor models of education and production are fundamentally static, i.e., they concern relative productivity in the context of a given state of technology. This technology may indeed change over time, but education itself is not viewed as altering the technology in use. An alternative characterization, which cuts across these essentially static conceptions, conceives of education in the explicit context of a dynamically changing technology. Again there are conceptually distinct alternatives.

Education as a Source of Technological Advance

This model conceives of the change in technology as itself a consequence of highly educated labor.[15] First, major technological advances are often the product of scientific undertakings which require the efforts of the highly educated. And because it may not be possible for the "inventor," the contributor to knowledge, to capture the full economic benefits of his contribution to an improved technology (and even if it were possible it would not be socially efficient), i.e., because of the external or social benefits of additions to knowledge, the "free market" can be expected to devote suboptimal resources to scientific, knowledge-enhancing activity, implying a suboptimal rate of technological advance and economic growth.

This is often considered to be a justification for providing subsidies to education, implicity subsidizing scientific activities through lower wages and greater availability of higher educated labor inputs. It can be argued, however, that this is a highly inefficient mechanism by which to subsidize scientific-technological undertakings. Clearly, much of the benefit of the subsidy is diffused to nontechnological-scientific sectors and activities which employ the highly educated. If scientific and technological knowledge is the objective, efficiency—with respect to both (*a*) the distribution of highly educated personnel between different activities and (*b*) the utilization within any sector or activity of different categories of labor and of other inputs—requires that scientific-technological activities be directly subsidized. Direct subsidies to these activities themselves would then generate wage incentives which would draw appropriate numbers of persons into the

[14] Denison, "Accounting . . .," p. 136, attributes 0.41 percentage points of the 1929–69 annual growth rate of output per worker to changes in educational attainments of workers in the private, nonresidential business sector. Compounding this rate over 40 years implies a 17-percent increase in output per worker attributable to increased educational attainment.

[15] This model, in its several variants, is critically discussed in Stephen P. Dresch, "An Economic Perspective on the Evolution of Graduate Education" (Washington, D.C.: National Academy of Sciences, 1974), pp. 6–16.

highly educated class, as discussed further below (sec. 3 and app. II) and would encourage efficient utilization of high-cost, highly educated labor. In contrast, under a regime of indirect subsidies, all employers of the highly educated are indiscriminately subsidized, in proportion to their capacity to utilize the highly educated; also, because they do not bear the costs of education (in the form of higher wages for the more highly educated, reflecting the cost of education), all employers have an incentive to utilize highly educated labor inefficiently, i.e., more intensively (relative to the less educated) than would be justified if wages did reflect the costs of education. Thus, even the current rate of scientific-technological effort could be maintained at a lesser real resource cost if lower echelon labor were substituted for what is, under the current regime, artificially underpriced high level labor.

A second, related argument is that, because much fundamental scientific-technological work takes place within educational institutions, especially universities, increasing the flow of people through these institutions, thus requiring an increase in their scale, will increase the rate of growth of knowledge and of technological advance. Even if many of the new recruits into education enter the less research-intensive components of the system, the demand for faculty will increase the scale of graduate education, conducted primarily in research intensive environments, and will thus indirectly encourage scientific activity.

While it is certainly true that an expansion in education is likely to encourage research and knowledge production, this alone can hardly be taken as a justification for expansion of the educational enterprise. A given increase in research activity can clearly be achieved directly at a lesser real resource cost. Research and education may be interdependent in production, i.e., an increase in the scale of either may reduce the relative cost of a marginal increment of activity in the other, but the relationship can certainly not be characterized as one of strict complementarity, in which to acquire additional wool requires that one produce additional mutton. Thus, again, direct subsidization of research, permitting the educational enterprise to find its own appropriate scale and relationship to research, is required if resources (for both research and education) are to be efficiently allocated.

A third, and very different perception, is that a large fraction of technological change occurs in an unorganized manner, deriving out of the day-to-day activities of persons whose primary function is not per se technological or scientific. A worker preforming his job conceives a change in a production process which increases productivity, a manager arrives at a new, more effective mode of production organization, etc.

While this type of development is probably a nontrivial source of productivity advance, there is little evidence that it is related in any direct way to education. Experience, native intelligence, and a capacity to conceive of old relationships in a new manner may be much more critical to this type of fortunate accident than education. Thus, if technological advance is the accidental byproduct of individuals at work (or play), then it is not apparent that inducing increases in educational attainments is at all effective in increasing the likelihood of these fortunate accidents; this may in fact represent a totally exogenous, uncontrollable source of growth. Furthermore, if the charge of many critics is correct, that is, if formal education results in greater future income by rendering individuals more passive, docile and controllable, that is, more accepting and less questioning of the status quo, then a policy of encouraging increases in educational attainments may actually result in a declining rate of these growth-enhancing accidents, since these rely ultimately on those who are unconventional and unacceptant of the status quo and are thus capable of imagining new and untried processes and arrangements.[16]

Education and the Incorporation of New Technology

While education may not itself constitute the source of new technology, the rate at which technological advances are incorporated into production processes may well be a function of the educational attainments of the labor force.[17] At any point in time the "technology in use" will fall short of the "technologically possible." A more highly educated labor force may result in a reduction in this gap between the actual and the possible. Most briefly stated, the more educated may be more efficient in dealing with, adapting to and incorporating change and in responding to new opportunities.

As in the case of the gap between the actual and the efficient educational compositions of the labor force in the labor augmenting and third factor models, however, narrowing this gap between the actual and potential technology will provide only a temporary increase in the growth rate. Given the lag in the incorporation of new technology, whether that lag is great or small, the growth rate will depend on the basic rate of advance in technology. Only over the period during which the gap is reduced, and the technology in use is brought closer to the boundaries of the technologically feasible, will the growth rate be greater than that which would be implied by the fundamental, underlying rate of technological change.

And, again, increased investment in human capital, for the purpose of narrowing the technological gap, is not a free good. Only if the benefits of a closer approximation to the technologically possible outweigh the costs of education is greater human capital investment justified. In short, there is an optimal degree of technological lag, beyond which it is not desirable to move. Beyond that point further investment, whether in physical or human capital, designed to bring about further improvements in the technology in use will actually serve to reduce levels of income and output.

In summary, a number of interrelated but distinct mechanisms can be suggested by which investment in human capital will influence the level of productivity and income and alter, but perhaps only temporarily, the rate of economic growth. It is important to recall, however, that the productivity and growth gains which may be associated with human capital are invariably purchased at a price. The resources devoted, for example, to education will in general have alternative uses, and their value in these alternative uses will rise as the relative flow of resources to human capital formation increases. It would thus be surprising indeed if there did not come a point beyond which

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[16] For very different approaches to this issue, see, for example, Herbert Gintis, "Education, Technology and the Characteristics of Worker Productivity," American Economic Review (May 1971); Paul Goodman, "Compulsory Mis-education" (New York: Horizon Press, 1964); and Ivan Illich, "Deschooling and Society" (New York: Harper & Row, 1972).

[17] See Richard R. Nelson and Edmund S. Phelps, "Investment in Humans, Technological Diffusion and Economic Growth," American Economic Review (May 1966).

more human capital would not be preferred to less. There apparently exists a common misconception that the more advanced is invariably superior to the less advanced. But, as suggested in the discussion of the technological gap, lesser technological obsolescence is not necessarily to be preferred to greater obsolescence. The same is true of the educational attainments of the labor force. The more educated may indeed be more economically valuable than the less educated, but that increase in value is not a free good; unless the benefits of additional education (or other training) are greater than its costs, an investment in education does not represent a net economic gain. Beyond some point, even the marginal educated worker would be better off if the resources devoted to his human capital formation were instead invested in a machine and he were then given title to the flow of income which that alternative investment would generate.

3. Growth Effects and the Investment Decision Process

If the foregoing is accepted as a reasonably comprehensive compilation of the various contributions of education (human capital) to productivity and economic growth, the central question which arises concerns the degree to which these consequences enter into individual human capital investment decisions. The essential issue is this: If the growth-related consequences give rise only to private benefits, benefits captured by the human-capital-embodying individual, and if individuals tend to make "rational" human capital investment decisions, unemcumbered by arbitrary, capricious or inappropriate constraints, then there will be only limited need for public policy intrusion into the human capital investment process. On the other hand, if many of the growth consequences represent benefits which are not captured by the individual, or if individual behavior is severely constrained (by market failures, the impacts of taxation, biases in perceptions related, for example, to social class identifications, etc.), then public intrusion may be required if even an approximately optimal allocation of resources to human capital formation is to be achieved.

The Basic Human Capital Model

As developed in appendix II, the economist's basic human capital model, an idealized characterization of the human capital formation process, views the individual as surveying the full range of alternative opportunities (immediate entry into the labor force continued schooling, other training,* * *) and then selecting that option which offers the greatest net lifetime benefits (pecuniary and nonpecuniary income, less the costs of education or training.) According to this model the individual will continue to invest in education up to the point at which the costs of additional education just equal the benefits which are expected to result. An important implication of the model is that the labor market will at least tend toward an equilibrium state in which, for otherwise comparable individuals, lifetime earnings net of the costs of education and training will be equal regardless of the amount of embodied human capital. Differences in income will be just offset by differences in the costs of education and training.

Apart from correctable capital and insurance market failures (discussed in the appendix), it appears that there exist no significant external objective barriers to human capital investment behavior corresponding to that assumed by this model. However, actual behavior may diverge markedly, resulting in significant departures from an optimal allocation of resources to human capital formation. The most important apparent impediment to optimal human capital formation, and especially to that involving education, arises from social class constraints on individual action and from related class-imposed biases in individual perceptions of the benefits of education. Clearly, for most individuals the choice process is highly constrained, in fact if not in principle. Most middle-class children and young adults, for example, consider college not as an option but as the only option; conversely, persons from low income households may view college as an option which is only remotely available, if it is available at all.

The important issue, however, is not the degree to which class identifications influence or constrain individual action, but the degree to which these class influences interfere with the equilibration of the labor market, with labor market equilibrium defined, as discussed above, in terms of equality at the margin in lifetime earnings net of the costs of education and training. Class influences can be anticipated to inject a certain inertia into labor supply responses to, for example, an increasing demand for the highly educated; that is, changes in the rate of investment in human capital will not continuously maintain or instantaneously restore longrun labor market equilibrium in the face of changing demands for different types of knowledge and expertise; rather, induced investment in human capital will operate slowly over time to move the system toward the new equilibrium. To the degree to which public policy intrusions can facilitate a more rapid process of equilibration, they may well be justified.

However, in light of the substantial fixed, or sunk, costs—of physical plant, trained personnel, and so forth—associated with expansion of human-capital-forming institutions, especially schools, colleges, and universities, a dampened adjustment to changes in labor market demands, by avoiding overreaction in the direction of either expansion or contraction, may actually be socially desirable.

But even apart from the possible benefits of dampened adjustment, it is not clear that any conceivable policy intrusions would lead to a more efficient path of adjustment. As indicated by prior attempts at "manpower planning," our knowledge of the determinants or relative labor market demands for workers with different types and levels of education, training, and experience is so rudimentary that an attempt at an active manpower policy is as likely to be destabilizing as stabilizing.[18] And it must be considered that an active manpower policy, one which directly attempts to channel the individual into that education, training, and work which is most consistent with his "aptitudes, abilities, and personal preferences," on the one hand, and social and economic "needs," on the other, is not only likely to be less efficient

[18] See, for example, Richard B. Freeman, "The Market for College Trained Manpower: A Study in the Economics of Career Choice" (Cambridge, Mass.: Harvard University Press, 1971); and Richard Freeman and David W. Breneman, "Forecasting the Ph.D. Labor Market: Pitfalls for Policy (Washington, D.C.: National Academy of Sciences, 1974).

than reliance on individual action but is also fraught with the danger of even greater and more pernicious inequities, for example, invidious educational-occupational tracking from an early age on the basis of arbitrary measures of individual aptitudes and interests which may bear no relationship to actual performance in later schooling or in work, and a generally paternalistic control over individuals which is likely to bear most heavily on the most deprived, those least capable of manipulating "the system"—schooling, manpower planning, and so forth—in their own interest.

In short, although the human capital model provides a highly rarefied conception of individual behavior, there appear to be no major respects in which the outcome predicted by the model will diverge, over the intermediate term, from actual developments, apart from the possible impact of restricted access to capital markets. The adjustment process may indeed be less than instantaneous, but the implied inefficiencies are probably less than would be associated with any attempt to intervene actively to channel individuals into "shortage" and away from "surplus" areas. With tax policies which effectively capture a significant share of the "rents" accruing to the more highly educated in a period of excess demand for highly educated labor, the inequities associated with the inertia of the adjustment process can be greatly reduced. In this context, the most desirable policy is one which facilitates, but does not attempt bias, direct or constrain, individual choice.

A Digression on Unemployment

One of the most important but also most often overlooked influences on individual human capital investment decisions, and especially those involving schooling, is unemployment. Current and anticipated future unemployment experience enter into critical components of both the benefits and costs of human capital investment:

(1) Postschooling earnings differentials. The greater the additional income expected to result from higher levels of educational attainment, the greater will be the incentive to acquire additional schooling; and

(2) Schooling-period earnings of comparable labor force participants. The earnings which an individual sacrifices when he chooses schooling over labor force entry represent perhaps the single greatest cost of education. The greater the expected earnings associated with labor force entry, the less will be the incentive to continue in school.

A significant but almost entirely ignored source of the relatively higher expected earnings of the highly educated is their greater insulation from effects of cyclical variations in the rate of economic activity. For a variety of reasons, related to the "overhead" character of the functions performed by the more highly educated, their greater "firm-specific" knowledge and skills, et cetera, the unemployment rate of highly educated persons is significantly less cyclically sensitive than that of the less educated. Thus, the higher the expected course of future unemployment rates, the greater will be the expected earnings differential between the more educated and the less educated. In consequence, a person who would not find education a preferred alternative if unemployment rates were expected to be low might well find it to be preferred if recurrent periods of high unemployment are expected to characterize the future, as they have characterized the past.

The net earnings loss entailed by the choice of schooling will also be sensitive to the rate of unemployment, but in this case it is the current rather than the expected future rate of unemployment which is important. Given the expected earnings of a young, less-educated worker, assuming that he is employed, the higher the likelihood that he would be unemployed were he not in school, the less is the expected earnings loss entailed by the choice of school. A period of high unemployment, then, is conducive to greater investment in schooling.[19]

Table 1 presents rough, indicative estimates of the relative impact of high and rising unemployment rates on the effective cost of schooling, identifying the reduction in the expected earnings of 18- and 19-year-old high school graduates which can be attributed to unemployment over the period 1969 to 1976; the associated unemployment rates are presented in table 2. This unlegislated, off-the-budget program of "invisible support" clearly provides significantly greater implicit stipends to most students than any formal Federal program of student assistance. Furthermore, changes in these unemployment scholarships are closely associated with movements in the proportion of young people enrolled in school, rising over the 1969–71 recession period, declining with the 1971–73 recovery, and rising dramatically with the severe post-1973 economic contraction. With the stabilization of this invisible support (at admittedly extremely high levels relative to 1969 and even to 1973), no significant change in enrollment rates can be expected in 1976.

TABLE 1.—UNEMPLOYMENT SCHOLARSHIPS, 1969–70

	1969	1970	1971	1972	1973	1974	1975	1976
Male:								
White	$574	$840	$928	$766	$744	$980	$1,171	$1,053
Nonwhite	1,259	2,151	1,642	1,591	1,709	2,467	2,047	2,961
Female:								
White	601	727	885	770	585	874	929	923
Nonwhite	1,453	2,027	2,202	3,366	2,229	1,480	2,202	2,021

Source: Derived from statistics on (a) 1969 to 1976 September unemployment rates of 18- and 19-yr-old high school graduates, by race and sex (U.S. Bureau of Labor Statistics), presented in table 2, and (b) 1974 moeny incomes of full-time, full-year workers, 18- to 24-yr-old high school graduates, by sex (U.S. Bureau of the Census)—$7,365 for males and $5,463 for females.

TABLE 2.—SEPTEMBER UNEMPLOYMENT RATES OF 18- AND 19-YR-OLD HIGH SCHOOL GRADUATES, 1969–76

[In percent]

	1969	1970	1971	1972	1973	1974	1975	1976
Male:								
White	7.8	11.4	12.6	10.4	10.1	13.3	15.9	14.3
Nonwhite	17.1	29.2	22.3	21.6	23.2	33.5	27.8	40.2
Female:								
White	11.0	13.3	16.2	14.1	10.7	16.0	17.0	16.9
Nonwhite	26.6	37.1	40.3	45.7	40.8	27.1	40.3	37.0

Source: U.S. Bureau of Labor Statistics, "Employment and Earnings" (October 1969–75 issues, table A–3); 1976 figures forthcoming.

[19] The picture is complicated somewhat by the fact that expected part-time earnings as a student must be deducted from expected earnings as a full-time labor force participant. Thus, if during a period of high unemployment it became sufficiently more difficult to find a part-time than a full-time job, it is conceivable that the net foregone earnings costs of schooling would actually rise rather than decline. However, in light of the extreme cyclical sensitivity of unemployment rates of young, full-time labor force participants and of the relatively low wage rates characterizing part-time employment, it would be expected that the foregone earnings cost of schooling would decline with increases in the unemployment rate.

It should also be noted that, to the degree to which temporary or short-term increases in the rate of unemployment lead to upward revisions in individual expectations concerning the future course of unemployment rates, the effect of high unemployment on schooling choices is magnified. First, the immediate earnings loss entailed by the choice of schooling is reduced. Second, as a result of the now higher expected rates of future unemployment, anticipated to bear disproportionately on the less-educated, the relative lifetime earnings gain associated with education is increased. On both counts even temporarily high rates of enemployment can be expected to encourage further schooling on the part of significant numbers of young people who, in a more stable, full-employment environment would have considered work a preferrable alternative.

Thus, in addition to the social and economic costs conventionally identified with the failure of national economic policy to maintain even approximately full employment must be added the possibly serious overinvestment in education to which high and sustained unemployment may lead, especially in the context of a labor market exhibiting strong tendencies toward equilibrium in relative demands for and supplies of different educational and skill classes of labor.

A Digression on Income Taxation

It is often argued that policy intrusion into the human capital investment process is required by the effects of income taxation on individual investment decisions. Income tax consequences are commonly put forth as a specific justification for educational subsidies, either to institutions or students.

Taxation of the income from capital assets can indeed be demonstrated to impinge upon the rate of investment. Specifically, an income tax serves to drive a wedge between pretax and posttax rates of return to capital, and if the savings rate is at all interest-rate responsive, this will result in suboptimal rates of savings and investment. This effect of an income tax is well known and generally accepted. The important issue here, however, is not whether income taxation results in absolutely suboptimal investment in human capital, but rather whether income taxes discriminate disproportionately against investment in human capital relative to investment in physical capital. That is, does income taxation lead to a nonoptimal composition of investment by favoring physical relative to human capital?

In fact, there are differences in the tax treatments afforded these very different types of assets. Most notably the physical capital investor is permitted to deduct depreciation from gross capital income in determining taxable income, while the human capital investor appears to be denied the opportunity of depreciating his investment in himself. But, on inspection it appears that human capital actually is afforded even more favorable tax treatment than other capital assets. The physical capital investor is permitted only to depreciate his asset over its useful life, that is, he cannot claim the entire cost of the investment as a deduction from income at the time the investment is made. The human capital investor, however, to the degree to which the cost of his investment takes the form of foregone earnings, is indeed permitted to instantaneously depreciate his investment. Earnings which are not received are also not taxed; if we view the individual as investing the earnings which he would have received had he not been in school—in an on-the-job training program, and so forth—in additions to his own human capital, in effect paying himself for the time and effort devoted to human capital formation, then the tax system in effect permits him to deduct from these implicit earnings the cost of his schooling—training, and so forth. Only the out-of-pocket costs of education or training—exclusive of subsidies and also of living costs, since the latter are already counted in foregone earning—are never depreciated for tax purposes.

But these costs, even if education were not subsidized, would not exceed more than one-half of the total cost of the human capital investment and probably in most cases no more than one-quarter of the total. Thus, in exchange for no depreciation allowance for one-fourth to one-half of the cost of the investment, the human capital investor is permitted instantaneous depreciation on the other one-half to three-quarters of the investment.

There is a possible offset to this discrimination of the income tax in favor of education. Because the income tax is nominally progressive, of two individuals receiving identical lifetime incomes, the one who receives that income in equal installments will pay a lower effective rate of tax than the one who initially has lower income but experiences continuous income growth; the latter's lesser rate of tax in low income years is more than outweighted by the higher rate of tax in higher income years. Thus, the highly educated, who experience significant earnings growth over the working lifetime, would incur relatively higher effective tax liabilities than the less educated, who reach a relative earnings plateau early in their careers, even if their lifetime incomes, net of educational costs were identical. However, this relative discrimination of a progressive tax is not likely to offset fully the otherwise favorable income tax treatment of human capital. First, the income tax is actually much less progressive than it appears.[20] Second, because a highly educated individual receives his highest income after a long period of labor force experience, the real present value of his higher tax is actually much lower than it nominally appears, i.e., its impact on the rate of return to human capital is greatly eroded by the fact that it is imposed only far in the future.

Further reinforcing the prohuman capital impact of the tax system is the fact that a significant proportion of the return to human capital investment takes the form of nonpecuniary benefits; in contrast, these benefits will constitute a negligible or nonexistent component of the return to physical capital. But, nonpecuniary benefits escape taxation by definition. Not only are they not included in income and hence are not subject to income taxes; in addition, they are not counted as part of consumption and hence escape consumption taxes, for example, excise and sales taxes. Thus, it can be reasonably concluded that present tax laws provide substantial inducements to human capital investment, seriously discriminating against other forms of investment.

Finally, as discussed in appendix III, an income tax (and especially a progressive income tax) significantly reduces the risks associated with human capital investment, greatly dampening the effective deviations of actual from expected lifetime income. In effect, the

[20] Joseph Pechman, "Federal Tax Policy" (Washington, D.C.: The Brookings Institution, 1971).

Government shares in the risk that the return to an investment will be less than expected, in exchange for a share of any return above that expected; in this sense the Government can be viewed as performing a risk-pooling function comparable to that performed in other contexts by private insurance or by optimal portfolio diversification, insurance and diversification which are generally not available to human capital investors.[21] This risk-reducing effect of the income tax would not discriminate in favor of human capital relative to alternative investments were it not for the fact that (*a*) the risks associated with human capital investment are generally greater than the risks of other invesments with comparable yields, and (*b*) many individuals are apparently "risk-averse," preferring assets with lower but more certain returns to assets with higher but less certain returns. Subjected to an income tax, a risk-averse individual will choose to invest more heavily in risky human capital, relative to alternative, less risky assets, than would otherwise be the case. Thus, the tax system, in addition to directly discriminating in favor of human capital relative to other investments, also compensates at least in part for the failures of capital and insurance markets as these impinge upon human capital investment.[22]

Not only do these discriminatory features of the income tax lead to possibly adverse changes in the composition of investment, specifically to relatively excessive investment in human relative to physical capital, and thus to a loss of output; perhaps even more fundamentally, they create a potentially serious horizontal inequity: Of two persons who initially receive identical "inheritances," the one whose comparative advantages, for example, superior intelligence, lead him to invest in human capital ultimately reaps a higher return than his fellow for whom the best alternative is investment in physical or financial wealth. Similarly, the effective progressivity of the tax system is eroded, since those who become more highly educated on average experience higher income, whether by reason of that education, of superior intelligence, or for other reasons.[23] As Harry Johnson has commented in a related context: "Superior intelligence or skill is undoubtedly more economically useful than the absence of it, but discriminating in favor of it by fiscal subsidization will not necessarily produce a more democratic and poverty-free or egalitarian society." [24]

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[21] For a discussion of capital and insurance market failures as these relate to education and human capital formation, see Marc Nerlove, "Some Problems in the Use of Income-Contingent Loans for the Finance of Higher Education," Journal of Political Economy (February 1975).

[22] For a general treatment of this issue, see Franco Modigliani and Merton H. Miller, "The Cost of Capital Corporation Finance and the Theory of Investment," American Economic Review (June 1958).

[23] The foregoing panoply of discriminatory allocative and distributional effects of the income tax as it relates to education serves to reinforce the already strong argument which can be made for a shift from taxation of income to taxation of consumption, specifically in the form either of a direct progressive expenditures tax as advocated by Nicholas Kaldor, The Expenditure Tax (London: George Allen & Unwin, Ltd., 1955), or of a nominally regressive value-added tax coupled with an appropriate system of rebatable tax credits rendering the system as a whole more progressive than the nominally progressive income tax. Of course, the central argument in favor of the expenditure tax relates to neutrality vis-a-vis the division of income between consumption and savings and thus its stimulation of savings and investment. Also it should be obvious that an expenditure tax would not eliminate that discrimination in favor of human capital investment resulting from the relative significance of non-pecuniary benefits, since these would as completely escape an expenditure tax as an income tax.

[24] Harry G. Johnson, "The Alternatives Before Us," Journal of Political Economy (May/June 1972, pt. II).

Growth Effects and Investment Decisions

Accepting the basic human capital model as a stylistic representation of actual human capital formation behavior and predictive of at least the intermediate-term directions and tendencies of human capital accumulation, will individuals take into account adequately the various growth consequences of human capital investment which were discussed in the preceding section of this paper?

Under both of the static models of the education-production-growth relationship, third factor and labor augmenting, the benefits of education are fully reflected in the earnings differential separating more and less educated workers. Thus, because the benefits are entirely private (captured by the investing individual), the human capital model should lead to an appropriate flow of resources into schooling (and human capital formation more generally).

The picture is complicated somewhat, even in the case of the labor augumenting and third factor models, if the relative efficiency of (and demand for) the highly educated rises over time as a result of underlying technological changes. In this case, deviations of actual behavior from that hypothesized by the human capital model (social class rigidities, the failure of expectations concerning future benefits to accurately reflect objective likelihoods, etc.) may well imply a lagged adjustment of the educational composition of the labor force. However, if the relative gap between the actual and the efficient educational composition of the labor force is constant, then this lag in the adaptation of educational attainments to labor market demands will not retard the rate of growth. A narrowing of the lag would produce a temporary increase in the growth rate; but in light of the dangers associated with overt manpower planning, as discussed above, it would appear that active policy intrusions, employing discriminatory fiscal incentives and/or legal compulsion in order to reduce the lag, would involve substantial and fundamental social as well as economic risks which would more than outweigh any possible benefits.

If education is itself a direct source of technological advance, for example, through research, then it will indeed involve external benefits which will not be reflected in the variables entering the human capital model. However, as has been suggested, if the actual source of technological advance is scientific and technological research and development, it is more appropriate (efficient) to subsidize that activity directly, regardless of the relationships which might exist between research and development, on the one hand, and either educational attainments of the labor force (as inputs into research) or the educational sector (colleges and universities as loci of technological and scientific effort), on the other. And technological advance as an accidental byproduct of other human endeavors may not be amenable to stimulation through increased educational attainments; greater investment in education might in fact serve to retard innovation if, as many critics have charged, the predominant function and effect of education is to socialize individuals to more readily accept the status quo and existing arrangements of production.

With respect to the rate of incorporation of new technology, it would appear that there may be externalities which are not reflected in the human capital model. Specifically, early innovators encourage the general and widespread adoption of new techniques through either a "demonstration effect" and/or "creativc destruction" (elimination of laggards via bankruptcy). The private payoff to innovation is provided by the supranormal profits which accrue to the innovator, excess profits which are wiped out as emulation proceeds. The social benefits, however, include the emulation and generalization of a superior technology which follow innovation. Thus, the more rapid the emulation, the greater the social benefit but the less the private benefit to the innovator. On this ground, it would appear that some subsidy to education is justified if indeed education in fact encourages innovation.[25] However, it must be recalled that the only benefit of more rapid innovation is the earlier incorporation of new technology. Ultimately the rate of growth is invariant with respect to the technological gap, whether it is large or small. Thus, the benefit of earlier innovation must be weighted against the cost.

Also, the possibility of alternative mechanisms for influencing the rate of innovation and diffusion must be considered. For example, changes in industrial organization can greatly reduce the importance of individual, enterpreneurial innovation. Thus, under a small-scale, largely self-sufficient, locally oriented organization of agriculture, innovation by a great many individual farmers was critical to the increase in agricultural productivity. However, with the increasing importance of large-scale agriculture supply organizations (seed, fertilizer, and equipment manufacturers) and the development of the Agricultural Extension Service, innovation in agriculture has been largely routinized. Thus, education of large numbers of individuals is not the only mechansim by which innovation can be encouraged, and other mechanisms may well be found to be more efficient.

In short, with what would appear to be limited exceptions, the full range of economic benefits of education are represented in variables to which the human capital model attributes importance as determinants of the flow of resources to human capital formation. Therefore over the intermediate term individual decisions concerning human capital investment can be expected to result in a tendency toward optimal rates of human capital formation, from a private perspective and also with reference to the consequences of human capital for national economic growth.

Thus, the place of education (human capital) in a national growth policy must ultimately be considered tertiary and tenuous. Relative demands for various education and skill classes of workers clearly change as growth proceeds, as will be considered more concretely in the following section. However, in the main this must be viewed more as a consequence than as a cause of growth. The contribution of investment in human capital as itself a source of growth will be primarily to bring about temporary increases in the growth rate, not an increase in the underlying rate of technological advance, the fundamental determinants of which are not significantly illuminated (and may actually be confused) by explicit reference to human capital as a

[25] For supportive evidence on this issue, see Finis Welch, "Education in Production," Journal of Political Economy (January/February 1970).

"source" of growth. Furthermore, the benefits of education, as either a concomitant or a cause of growth, will be largely reflected in the variables which the human capital model suggests are critical to human capital formation. Thus, education does not appear to be a prime candidate for incorporation into an active growth policy, much less an auspicious cornerstone for such a policy.

4. Education and Growth: Retrospect and Prospect [26]

If the role of education as an underlying cause of economic growth is apparently tertiary and tenuous, the relationship between growth and education has been of great social and economic significance. Major economic technological and demographic changes have interacted to induce dramatic increases in educational attainments of the population, reflecting a persistent excess demand for highly educated labor generated by a succession of unique developments in two interrelated dimensions:

(1) Industrial composition, the radical change in the sectoral distribution of employment which has occurred over the recent past, especially since 1945.

(2) Population dynamics, the demographic profile of the period since 1920, characterized by the succession of (*a*) severely depressed birth rates during the 1920's and 1930's, (*b*) the explosion of births following World War II, and (*c*) the steady decline in fertility which has occurred since 1960, approaching and even falling below zero-population-growth (ZPG) fertility rates in the early 1970's.

This section examines these developments and their consequences, with the college educated as the special focus.

Changes in the Composition of Economic Activity, 1929–69

Table 3 presents growth rates and employment shares by sector for the full period 1929–69 and for the subperiods 1929–48 and 1948–69.[27] Growth in total employment over the period, at an average rate of 1.4 percent per annum, was relatively evenly distributed between the subperiods, with an average annual growth rate of 1.3 percent in the first and 1.5 percent in the second. By contrast, the rate of change in the sectoral composition of employment, although significant in both periods, was much greater in the second, as the differential subperiod growth rates of the rapidly expanding (and contracting) sectors indicate. Thus, over the entire period the 11 most rapidly expanding sectors (defined as those with mean annual growth rates in excess of 2 percent) increased their share of total employment from 39.0 to 67.2 percent; but of this 28.2 percentage point gain, 10.2 points were added during the first period, 18.0 during the second.

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[26] The first parts of this section are adapted from Dresch, "Demography, Technology * * *".
[27] Edward F. Denison, "The Shift to Services and the Rate of Productivity Change," Survey of Current Business (October 1973), p. 35.

TABLE 3.—EMPLOYMENT CHANGE BY SECTOR, 1929–69, AND COLLEGE-EDUCATED SHARE OF LABOR FORCE, 1970

	Mean annual growth rate (percent)			Share of total employment			College educated in 1970[1] (percent)
	1929–48	1948–69	1929–69	1929	1948	1969	
All industries	1.3	1.5	1.4	1.0	1.0	1.0	12.9
Farms	–1.5	–3.6	–2.6	.194	.114	.039	2.9
Argicultural services, et al	.8	.8	.8	.005	.005	.004	8.2
Coal mining	–.7	–6.3	–3.7	.044	.009	.002	1.7
Other mining	1.2	.2	.7	.008	.008	.006	12.0
Construction	1.8	1.3	1.6	.050	.055	.054	3.9
Food, kindred products	2.8	–.1	1.3	.023	.031	.023	5.1
Textile-mill products	.3	–1.3	–.6	.027	.023	.013	3.4
Other nondurable manufacturing	1.8	1.4	1.6	.065	.071	.070	8.5
Durable manufacturing	2.5	1.6	2.1	.116	.146	.152	7.9
Transportation	–0	–.6	–.3	.066	.051	.033	4.2
Telephone and telegraph	1.4	1.4	1.4	.012	.012	.012	5.2
Radio, TV broadcasting	13.1	4.4	8.5	.000	.001	.001	21.7
Electric, gas, sanitary	.4	1.2	.8	.011	.009	.009	8.3
Wholesale trade	2.2	1.6	1.9	.038	.045	.047	9.9
Retail trade and auto services	1.7	2.7	2.2	.131	.143	.186	4.4
Banking	.3	4.1	2.3	.008	.007	.012	12.2
Other finance, insurance, real estate	1.3	2.6	2.0	.026	.026	.033	17.4
Hotels and lodging places	1.1	1.1	1.1	.011	.011	.010	4.2
Personal services	1.1	.8	.9	022	.021	.018	2.2
Miscellaneous business and profit services	4.3	6.1	5.3	.006	.011	.030	28.6
Miscellaneous repair services	3.5	1.0	2.2	.003	.004	.004	5.5
Motion pictures	2.2	–.9	.6	.003	.004	.022	13.3
Other amusements	.1	2.5	1.3	.006	.005	.006	6.2
Medical and other health	2.2	4.9	3.6	.016	.019	.040	18.6
Legal services	.6	2.7	1.7	.004	.004	.005	52.1
Educational services	2.3	4.5	3.5	.007	.008	.016	42.4
Nonprofit organizations	3.2	3.5	3.4	.008	.011	.017	16.3
Private households	–2.1	–.6	–1.3	.051	.027	.017	1.0
Government, government ent	4.0	3.6	3.8	.069	.116	.181	34.5
Estimated actual college educated (percent)				5.2	6.7	12.9	
Hypothetical college educated (percent)[1]				7.5	9.5	12.9	

[1] Obtained by applying percentage college educated by sector in 1970 to sectoral distributions of employment in 1969, 1948, and 1929.

Sources: Denison, "The Shift to Services . . ."; U.S. Bureau of the Census, "U.S. Census of Population: 1970, vol. 2, Subject Reports, pt. 7B, Industrial Characteristics" (Washington, D.C.: Government Printing Office, 1973), pp. 11–22

Only a casual review of the most rapidly expanding sectors is necessary to grasp the significance of their expansion for the higher-education sector. While estimates by sector of the college-educated proportion of the labor force are available only for 1970, these data indicate that of the 11 rapid growth sectors, 4 exhibited college-educated proportions less than the mean for the entire labor force; but, of the 5 sectors in which the college educated comprised over 20 percent of the labor force, 4 were rapid growth. On the whole, the most rapidly expanding sectors were clearly the most intensive employers of the college educated.

Admittedly, educational attainments of personnel in most sectors have probably increased over this period. Changes in products, the introduction of new products, changes in production processes, and changes in the nature and complexity of economic organization all combine to constitute a pervasive increase in technological (including organizational) sophistication, explaining at least in part the substantial increases in the educational attainments of the labor force. However, as indicated by table 4, the intersectoral shift in output and employment which has occurred over this 40-year span accounts for most of the change in the college-educated share of the labor force.

TABLE 4.—INTER- AND INTRA-SECTORAL COMPONENTS OF GROWTH IN COLLEGE-EDUCATED SHARE OF LABOR FORCE, 1929, 1948, AND 1969

A. PERCENTAGE OF LABOR FORCE COLLEGE EDUCATED

Year	Actual	Hypothetical [1]	Ratio of actual to hypothetical
1929	5.2	7.5	0.70
1948	6.7	9.5	.70
1969	12.9	12.9	1.0

B. COMPONENTS OF CHANGE

	Percentage point	Percent of total change	Percent of component
For 1929–48	1.5	19	
For 1948–69	6.2	81	
Total 1929–69	7.7	100	
Allocable to interindustry employment shift: [1]			
1929–48	2.0	26	37
1948–69	3.4	44	63
Total	5.4	70	100
Residual allocable to intraindustry change in percent educated:			
1929–48	–.5	–6	–22
1948–69	2.8	36	122
Total	2.3	30	100

[1] Assume college educated proportions by sector in 1929, 1948, and 1969 equal to observed 1970 values.

Source: Derived from table 3.

Between 1929 and 1969 the college-educated proportion of the labor force increased from 5.2 to 12.9 percent, a gain of 7.7 percentage points. To assess the effect of the change in the interindustry composition of employment, the 1970 estimates of college-educated proportions by sector were applied to the 1929 and 1948 distribution of employment by sector, generating hypothetical educated (meaning college educated) shares of the labor force in these years.

Of the 7.7-point gain in the educated share over the full period, 5.4 percentage points are accounted for by the change in sectoral composition. Only a residual 2.3 percentage points can be explained by general intrasectoral increases in relative employment of the college educated. Thus, of the overall change, 70 percent can be allocated to intersectoral shifts and only 30 percent to residual increases in educational attainments within sectors. Clearly, for the period as a whole the dominant factor underlying the increase in the relative representation of the college educated is the rapid growth of education-intensive industries.

The full significance of this change, however, derives from its very peculiar timing. Rather than evolving smoothly over the entire 40-year span, over 80 percent of the total increase in college-level educational attainments occurs after 1948. That the postwar period was one of more rapid change in economic structure is hardly surprising. Between 1929 and 1948 a succession of major events intervened to prevent the apparent continuation and realization of the economic and technological tendencies which had become operative earlier. For example, the depression of the 1930's constituted a sharp disruption in the growth of the service sectors and in the rapid decline of such traditional sectors as agriculture and mining. Similarly, the economic impact of the war was to temporarily reverse the trend away from primary raw materials and manufacturing industries. Thus, it is only in the postwar expansion that the accumulating changes in economic and technological structures could be effected.

As a result, of the 5.4 percentage-point increase in college-level educational attainments due to intersectoral shifts in employment over the full period, only 2 points (37 percent) occur prior to 1948, as against 3.4 points (63 percent) between 1948 and 1969. Thus, the increase in demand for college-educated labor due to changes in the sectoral composition of employment is overwhelmingly a phenomenon of the postwar period.

Notwithstanding this concentration of the intersectoral shift effect in the post-1948 period, the effect of intrasectoral increases in educational attainments is even more extremely concentrated in the postwar period. Specifically, the sectoral representation of the college educated did not undergo any general change between 1929 and 1948; in both years actual educated shares of the labor force were just equal to 70 percent of the hypothetical educated shares (obtained by applying 1970 proportions of the college educated to actual sectoral distributions of employment).

Thus, if for the sake of argument it is assumed that the hypothetical educated share in 1929 and 1948 represented employer demands at prevailing wage differentials, then the gap between actual and hypothetical educated shares, representing an excess demand for the college educated, widened by 0.5 percentage points between 1929 and 1948, a deficit in college-educated personnel equal to −6 percent of the 7.7 percentage-point total increase in the college-educated share between 1929 and 1969, or −22 percent of the total 2.3-point increase due to the intrasectoral increases in educational intensities. In short, between 1929 and 1948 the educated share of the labor force actually lost ground relative to the overall gain between 1929 and 1970.

It might be argued that this failure of general levels of educational attainment to increase between 1929 and 1948 was primarily a product of the depression. Thus, the high rates of unemployment in the 1930's reflected a temporary excess supply of all types of labor and might have been expected to have greatly reduced the incentive for (and ability of) young entrants into the labor force to obtain college educations. Actually, this does not seem to have occurred. The average annual rate of enrollment growth did in fact decline from 6.1 percent during the 1920's to 3.1 percent during the 1930's, but this is primarily explained by an even more substantial decline in the growth rate of college-age cohorts (18 to 24) from 1.7 to 0.7 percent. As a result, enrollment as a proportion of the age cohort increased from 7.2 percent in 1930 to 9.1 percent in 1940. The most important factor explaining the failure of college enrollments to decline over the course of the depression is the impact of high rates of unemployment on the foregone earnings cost of college attendance.[28] If anything, labor-market conditions served to perpetuate school attendance.

[28] This interpretation is supported by evidence on cyclical movements in Canadian secondary schools enrollment rates provided by J. Crean, "Foregone Earnings and the Demand for Education: Some Empirical Evidence," Canadian Journal of Economics (February 1973).

In any event, had the depression not retarded the intersectoral developments which provided the primary basis for the increases in the educated share of the labor force observed over the full period, then enrollment would have increased at a much more rapid rate between 1930 and 1940. Given the decline in the growth rate of college-age cohorts, a more substantial increase in the proportion enrolled in college would have taken place than was actually observed. The observed increase in the proportion enrolled was just consistent with the limited change in the sectoral composition of employment which did take place over the decade of the 1930's.

The significant point is that the depression, the trend during the 1930's in the size of college-age cohorts (due to changes in immigration laws and to the low birth rates during and after World War I), and World War II together produced a discontinuity in the broad trend of developments between 1929 and 1969 which could not be easily and quickly accommodated in the period of immediate postwar readjustment.

Destabilizing Consequences of Population Dynamics

The postwar adjustments were rendered particularly difficult by the radical decline in completed fertility rates following World War I compounded by the depression-induced demographic disruptions of the 1930's. While completed fertility rates had followed a somewhat erratic but declining path prior to 1920, the remarkable decline in births during the 1920's and 1930's led to an absolute contraction in the size of college-age cohorts after World War II. The growth rate of the 18- to 24-year-old age group, which had averaged above 1 percent between 1900 and 1940, declined to −0.2 percent in 1940–50 and −0.3 percent in 1950–60. Thus, just as the economy was able to incorporate the technological and organizational changes which had been held in abeyance by depression and war, the age group for which educational attainments were subject to modification began to contract significantly. Although college enrollment relative to the 18- to 24-year-old population experienced radical increases between 1940 and 1960 (from 9.1 to 20.5 percent), the decade of the 1950's witnessed the lowest average rate of enrollment growth in this century, 1.9 percent. Thus, between 1940 and 1960, while the proportion of young people enrolled in college increased by 125 percent, the college-educated proportion of the adult population increased only by 67 percent, from 4.6 to 7.7 percent.

The dramatic postwar increase in enrollment rates, then, can be seen as a consequence of two factors: (1) The sudden effectuation of a previously unobserved change in labor-market demand, submerged and delayed by the economic impacts of depression and war, and (2) a marked decline in the size of college-age cohorts, similarly at least partially a product of the events of the 1930–45 period. The full consequences of this increase in the college attendance rate, however, depended also on the demographic events which followed the war: the postwar baby boom and the continuing high fertility rates of the 1950's. After declining at an annual rate of −0.3 percent between 1950 and 1960, the 18- to 24-age group increased at a rate of 4.5 percent per annum from 1960 to 1970. Correspondingly the rate of growth of college enrollment increased from 1.9 to 8.5 percent; while the proportion of the age cohort enrolled increased from 20.5 to 30.6 percent.

Thus, the postwar period has been one in which previously repressed economic and technological forces became effective precisely at a time (the late 1940's and 1950's) when demographic factors were least conducive to significant changes in the overall educational composition of the adult population, generating substantial increases in the rate at which the contracting educationally malleable age cohorts were in fact educated. The momentum of this movement toward higher college attendance, however, reached its peak just as the emaciated college-age cohorts born in the 1930's were replaced by the swollen cohorts of the postwar baby boom.

Effectively, after the war the excess demand for college-educated persons drove up the proportions of the relevant age cohorts educated. But, it is this proportion which has served as a critical determinant of the rate at which later cohorts are educated. Thus, as the size of these cohorts suddenly and discontinuously increased after 1964 (reflecting the first major bulge in births in 1946), the inertia in the system, operating through the proportions educated, forced up disproportionately the number of persons educated.

As a result of the rapid increase in the size of college-age cohorts relative to the adult (over age 25) population and of the concomitant rise in the rate at which these cohorts were educated, the college-educated proportion of the total adult population, which had increased gently from 4.6 percent in 1940 to 6 percent in 1950 and 7.7 percent in 1960 (that is, by between 1.4 and 1.7 percentage points per decade), quickly climbed to 11 percent in 1970 (an increase of 3.3 percentage points over the decade) and further to 12 percent in 1972. Subject to very little prediction error, a further increase to 15 or 16 percent by 1980 can be anticipated, for a total gain of 4 or 5 percentage points over the decade 1970–80.

Thus, the inertia generated in the rapid expansion of the period approximately 1950–65 carried the system forward at an accelerating rate between 1965 and 1970, due to the discontinuous increase in the size of college-age cohorts. In its origins the expansion process reflected a suddenly operative excess demand for the college educated, while in its latter phases (after 1965) the dominant factor has been the rapid expansion in the supply of educationally malleable labor, the educational attainments of which are determined by an excess demand existing in the past but quickly being eliminated.

The consequences of this rapid increase in the supply of highly educated labor, in the face of virtual stability and possibly even adverse changes in the sectoral composition of employment after 1970, is the recent emergence of a saturation of the highly educated labor market, a saturation already reflected in a decline in earnings differentials associated with higher education.[29] In the 1980's, especially, barring the continuation of inordinately high rates of unemployment, this deterioration in incentives for college attendance and completion will induce a significant decline in the rate of college-going on the part of young people. From a peak of perhaps one-third of 24-year-olds college educated in 1980, this proportion may decline to 15 percent in the early 1990's. In conjunction with a 13 percent decline

[29] Richard B. Freeman, "Overinvestment in College Training?" Journal of Human Resources (Summer 1975).

in the size of the 18- to 24-year-old age grouped between 1980 and 1990, reflecting the post-1960 decline in fertility rates, college enrollment over the decade may decline as much as 50 percent.

In fact the enrollment decline may occur sooner and be even more precipitous as the labor market is glutted with the outpouring of young people artificially induced into college as a result of the inordinately high unemployment rates which have characterized the period since 1973. Under more stable, approximately full-employment economic conditions, enrollment in the mid- and late-1970's could be expected to have been relatively stable, producing a flow of young, highly educated labor force entrants which would have generated a slowly accelerating deterioration in employment opportunities of the highly educated. With the discontinuous increase in enrollment produced by the recession, a much more sudden process of high level labor market deterioration can be expected as the economy recovers. A deterioration of the magnitude which can be anticipated will almost inevitably be translated into massive changes in patterns of high school and college persistence.

Social Consequences

The process of secular economic development described above, characterized by a shift of activity toward sectors differentially employing the highly skilled and educated, has had three consequences of fundamental importance. First, it has resulted in intergenerational increases in economic welfare and social status. Second, it has concentrated an increasing fraction of the labor force in occupations characterized by sustained earnings growth over the working lifetime. And third, because the shift in the composition of economic activity has taken place in a context of overall growth in the labor force, with only isolated exceptions changes in the composition of activity have not resulted in severe career disruptions for persons in sectors experiencing relative decline.

As discussed in appendix I, education has constituted a significant mechanism of intergenerational social mobility, even if relative intragenerational status has been basically static across generations. Thus, as employment has shifted toward more education-intensive industries, children have on average enjoyed absolutely higher status than their parents, even if their status relative to their peers is no greater than that of their parents relative to parental peers.

The fundamental precondition for this process of upward shifting status distributions, the progressive, unidirectional change in the composition of employment which has occurred over the 20th century, has been a reflection primarily of the extreme decline in the relative importance of agricultural employment, with the agricultural share of the labor force contracting from 19 percent in 1929 to less than 4 percent in 1969, and to a lesser extent of the relative growth of government, which increased its share of employment over the same period from 7 to 18 percent. While particular sectors may expand or contract greatly, no individual sector is of sufficient relative magnitude as to produce a comparable shift in the overall composition of employment within the foreseeable future, and current indications are that no significant change in sectoral composition will be observed between 1970 and 1980.[30]

[30] Denison, "The Shift to Services. . . ."

This slowing of the upward shift in the aggregate status distribution will be reinforced by the low and declining rate of attrition, that is, death and retirement, from the ranks of the high status labor force. As in the case of any population which has experienced rapid growth, the concentration of the population in relatively young age groups produces an extremely low rate of disappearance. Thus, as the highly educated population has rapidly expanded since 1965, as a result of the inflow of increasingly highly educated members of the war and postwar birth cohorts, the age 25–34 proportion of the college-educated 25–64 population has, in consequence, increased from 35 percent in 1960 to 40 percent in 1970, and can be expected to reach 55 percent in 1980. (See table 5.) The relative share of this young age group can be expected to decline to 44 percent in 1990 and to 23 percent in 2000, as a result of declining rates of college attendance in response to deteriorating employment opportunities facing the highly educated; however, the clot in the age distribution of the highly educated population, created by the inflated (in size and in educational attainments) birth cohorts of the 1940's and 1950's, will serve to maintain a very low (1.1 percent) rate of attrition between 1980 and 2000. Only as the war and postwar cohorts begin at last to experience significant mortality in late middle age will "replacement" provide substantial opportunities for young people.

TABLE 5.—HYPOTHETICAL AGE DISTRIBUTIONS FOR VARIOUS STABLE GROWTH RATES; POPULATION AGE DISTRIBUTIONS BY EDUCATIONAL ATTAINMENT, 25 TO 64 POPULATION BASE

[College educated (E) versus noncollege educated (U)]

	Hypothetical stable growth (percent)					Actual, United States									
						1960		1970		1980		1990		2000	
	0	0.7	1.4	2.1	5	E	U	E	U	E	U	E	U	E	U
25 to 34	26.8	29.5	32.3	35.2	47.1	35.5	26.6	40.0	25.4	54.7	31.5	44.3	31.3	22.7	30.7
35 to 44	26.2	26.9	27.5	27.9	28.0	30.5	28.8	25.1	25.6	21.7	23.2	34.6	28.9	37.9	27.7
45 to 54	24.9	23.8	22.7	21.5	16.1	21.4	25.1	21.0	27.0	13.3	22.8	13.4	20.7	28.9	24.9
55 to 64	22.1	19.7	17.5	15.5	8.7	12.6	19.5	13.9	22.1	10.4	22.5	7.7	19.1	10.5	16.8
Median age	(44)	(43)	(41)	(40)	(36)	(39)	(43)	(39)	(44)	(33)	(42)	(36)	(41)	(42)	(41)
Attrition rate	2.7	2.4	2.1	1.8	1.0	1.4	2.4	1.6	2.6	1.2	2.6	1.1	2.5	1.1	2.0

Note: Post-1970 educational attainment projections from S. P. Dresch, "Demography, Technology and Higher Education: Toward a Formal Model of Educational Adaptation," Journal of Political Economy (June 1975).

Thus, it can be reasonably anticipated that over the next 25 years opportunities facing cohorts of young people will deteriorate, resulting in downward shifts in the relative status of successive generations. In a traumatic reversal of historical experience, children born to persons entering adulthood in the 1950's and 1960's will, on average, experience relatively lower status than their parents. This will reflect both declining educational attainments induced by the saturation of the highly educated labor market and contracting career opportunities facing those who do, in fact, complete educational programs.

The reference to contracting career opportunities brings into question the second of the indicated consequences of the process of secular development which has occurred over the last quarter century: the concentration of an increasing fraction of the labor force in careers traditionally characterized by sustained advancement and earnings growth over the working lifetime. In contrast to the less educated, who reach an earnings (and status) plateau early in the career, the more highly educated have in the past experienced substantial advancement over the course of their careers, as reflected in the high correlation between earnings and years of labor force experience. This phenomenon which has been explored intensively in the literature, appears to be related to the opportunities available to the highly educated for continuing improvements in personal competencies and skills.[31] The pronounced nature of this relationship between experience and earnings (status) and the fact that it has persisted over a prolonged period has led to the expectation that such a relationship will also be observed in the future. Furthermore, as increasing proportions of successive cohorts have entered the ranks of the highly educated, this expectation has been shared by a larger and larger fraction of the population.

However, analysts of the relationship between earnings and experience (and individuals themselves) have failed to recognize the importance of relative labor market stability for the lifetime career experiences of the highly educated. In a regime characterized by equiproportionate increases in the supply of and demand for the highly educated, career patterns will be stable over time. However, if the supply of highly educated labor increases much more repidly than demand, as occurs after 1970 in the United States, then career patterns observed under previously existing conditions of a persistent excess demand for highly educated labor may not be realized in the future. In particular, as the highly educated are progressively substituted for the less educated, opportunities for continuous improvements in skills and competencies, and thus for advancement, will contract. The primary impact of this contraction will be felt not in the early years of labor force involvement, when earnings are relatively equal across educational groups, but in later years when the lifetime earnings experiences of the highly educated will more closely approximate those of the less educated than of their highly educated predecessors. That is, not only will the saturation of the highly educated labor market reduce the lifetime income differential separating the more and less educated; it will achieve this through a reduction in the growth of income over the working lifetime, i.e., through a downward rotation in the lifetime earnings profile.

Both of the foregoing phenomena derive from (*a*) a slowing of the rate of change in the sectoral composition of employment and (*b*) demographic factors which, in conjunction with previous labor market developments, have served to significantly inflate the educational composition of the younger members of the labor force. Together these imply a serious, persistent saturation of the labor market. However, an independent effect on individual career experiences will be exerted by the dramatic decline in the aggregate rate of growth of the population and labor force over the next quarter century. In the past, a rapid rate of population growth, averaging 1.4 percent per annum between 1900 and 1970, has permitted radical changes in the relative distribution of population and employment (over industries, regions, etc.) without significant absolute contractions in sectors experiencing relative decline. In short, growth and contraction were relative; in absolute terms, with isolated exceptions, growth alone was the rule. Thus, changes in composition have, in general, been achieved at the growth margin. Industries increasing in importance have grown through attraction of

[31] Mincer, "Schooling, Experience and Earnings."

a disproportionately large share of young persons entering the labor force, while contracting sectors have attracted a declining fraction of new entrants. In only unusual cases have absolute contractions occurred, and even in many of these sectors, contraction has not actually displaced established workers since the rate of decline has rarely exceeded the normal rate of attrition (death and retirement).

As indicated by table 3, the foregoing is especially descriptive of industries disproportionately employing the highly educated, for example, school and college teaching. However, over the next several decades, as the aggregate growth rate declines and as education-intensive sectors "mature," even dampened intersectoral shifts in employment can be expected to displace significant numbers of highly educated workers. Not only will displacement become a phenomenon of the highly educated, it will also be a more traumatic phenomenon for the highly educated because their "next best alternative" employment may require a relatively greater sacrifice in earnings and status than has been true of the less educated. Thus, an increasing number of highly educated persons may find the basis for their superior status and earnings, and even for their self-identity, destroyed by changes in the composition of economic activity, changes which cannot be accommodated through a rapidly contracting growth margin. Again, teaching is a good example.

The most general consequence of these three phenomena (reduced rates of intergenerational mobility, a decline in individual career mobility of the highly educated, and an increase in the incidence of career disruption, especially of the highly educated) is that work will become increasingly problematic for a growing fraction of labor force participants and in particular for actual and potential members of the highly educated labor force.[32] Many young people who, under conditions comparable to those which prevailed during the 1960's, would have attended college will not do so. Those who are most thoroughly socialized to perceive of education as the only route to adulthood and who thus do become educated ultimately will find their postcollege career experiences significantly less rewarding than they had expected on the basis of the experiences of their predecessors.

With a lag, probably short, this will be translated into an increasingly problematic relationship of students to education. The perception of deteriorating opportunities may lead some persons to invest more and more heavily in educational success of a traditional sort, out of the hope that this will be converted into an increased probability of later career success. For others, however, the growing perception of futility, of the deteriorating vocational value of education, may lead to progressively more aimless wandering over the educational landscape.

For persons in the labor force, especially the highly educated, the progressively more severe barriers to career development and the increasing rate of career disruption may induce a frustration which will translate into a decline in the role of work as a source of self-identity and fulfillment, creating an anomic void the dimensions of which can at this point hardly be perceived. And in contrast to the blue-collar subjects of the worker dissatisfaction literature, [33] for

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[32] For an insightful discussion of this development, see Seymour B. Sarason, Ester Sarason, and Peter Cauden, "Aging and the Nature of Work," American Psychologist (May 1975).

[33] "Work in America," a report of a special task force to the Secretary of Health, Education, and Welfare (Cambridge, Mass.: M.I.T. Press, 1973).

whom rising material welfare has at least partially compensated for the inadequacy of work and for whom expectations of work were less inflated to begin with, the highly educated dispossessed will find their material expectations underfulfilled as well.

While reduced rates of vertical career mobility will be largely unavoidable, individuals can be expected at least to attempt to mitigate the consequences of career disruptions. Assuming the maintenance of reasonably full employment, reductions in employment in some sectors will be compensated by increases in others, and to the degree to which expanding sectors exhibit an effective demand for training and expertise this demand will be filled increasingly by established members of the labor force rather than by newly educated labor force entrants. The premium attached to expertise will have been reduced to the point that a growing fraction of young people will not consider the benefits of schooling worth the costs; older educated workers, however, will face only the incremental costs of additional specialized training, not the entire cost of a complete educational program. Thus, the participation in education of already highly educated but displaced workers will increase, with the emphasis on advanced, specialized training required for career change, while participation of the young will decline.

5. Conclusion: Education, Society, and Economy in Late 20th Century America

The recent past (for present purposes roughly the last half-century) has witnessed a series of rapid economic, technological and demographic changes, changes which have had pervasive consequences for the totality of the American social order. However, in contrast to the economist's characterization of "balanced" or "Golden Age" growth, these changes and their social concomitants have not been even, uniform and mutually accommodating. Rather, notwithstanding superficial appearances to the contrary, the process of development has been markedly uneven and discontinuous. A remarkable confluence of events has led to rapid and sustained growth, submerging potential social disequilibria. However, the next 30 years will witness a general process of social and economic adjustment to past developments, an adjustment which, in the context of the preceding period of expansion, holds the prospect of severe social disruptions:

The rate of population growth, especially of the adult population, will decline dramatically.

As a result of the reduced rate of population growth, a pervasive process of aging will occur, affecting virtually all sectors and occupations but appearing in a particularly pronounced form in those sectors and occupations in which the highly educated are disproportionately represented.

Rates of change in the sectoral distribution of employment will decline markedly; however, even damped changes in the relative importance of different sectors may, in the context of a very low rate of labor force growth, displace significant numbers of workers, expecially the highly educated, for whom displacement will be most traumatic.

Persistent saturation of the highly educated labor market and the career disruptions experienced by the highly educated, will lead to major changes in patterns of schooling behavior; schooling will cease to provide a mechanism for intergenerational vertical mobility and improvement in material welfare, and in fact, for a significant fraction of the population, children may well achieve significantly lesser material welfare than their parents.

Thus, in a fundamental sense the short and intermediate-term future can be viewed as a period of social transition, in which the consequences of preceding developments are socially internalized and underlying disequilibria become apparent and, more or less divisively, are resolved.

The demographic and economic-technological developments outlined above will have important implications in a number of socially significant dimensions, for example, for the structure and functions of the family, for the legal system, and for the educational sector. Unfortunately, in none of these areas is current understanding sufficient to provide a concrete basis for projecting future developments and for identifying policies which would most effectively mitigate the potentially serious social consequences of these developments. However, it should be obvious that emerging exigencies will call into question a broad range of current public policies and programs, expecially in the areas of taxation, employment, and education.

Thus, if the contribution of human capital to economic growth is ultimately concluded to be of questionable policy significance, the historical relationships between education and economic growth are of immense social significance. Fundamental and socially traumatic disruptions and disclocations in these relationships can be anticipated to characterize late 20th century America, leaving very few untouched as career patterns and traditional mechanisms of social and economic advancement are altered and undermined. Dealing with these developments, it can be suggested, will be vastly more difficult than achieving the much more limited, albeit important, goals of the Employment Act of 1946, notwithstanding the recurrent (and unacceptable) failures of economic policy over the past 30 years. And certainly as a sine qua non for a public policy which would respond humanely and nonrepressively to the deep and pervasive frustrations which will infect large segments of the American population, the commitments of the Employment Act of 1946, the achievement and maintenance of high levels of employment, must be realized. Continued or recurrent periods of economic stagnation and consequent high rates of unemployment will only exacerbate the potentially disruptive tendencies of the coming decades.

Appendix I. Human Capital and Intergenerational Wealth Transfers and Mobility

Public concern for education in its relationship to individual income has two separable aspects. First, education represents a significant fraction of the effective wealth ownership of the middle and upper-middle classes. Apart from owner-occupied housing the only significant wealth of even relatively affluent households is human capital, that is, the differential earnings which have accrued historically to the more highly educated. Furthermore, except at the highest income levels, the only significant wealth transfer from parents to children has taken the form of parental investment in the human capital of the child, an implicit inheritance by means of which the parent generation has contributed to the enhanced well-being of its offspring.

The importance of this role which education has come to play should not be underestimated. As an apparently critical determinant of earnings, education constitutes one of the primary bases of social status and class identification. And as the only quantitatively significant form of intergenerational wealth transfer, it constitutes the mechanism by which status is sustained or enhanced across generations. Thus, any substantial decline in the relative earnings of the more highly educated would imply a corresponding reduction in effective wealth ownership of the middle classes and would simultaneously deprive parents of a mechanism by which to make intergenerational transfers, thus eroding social status intergenerationally. The result would be a significant increase in the concentration of wealth (human and nonhuman) and a fundamental change in the terms of the relationship between the generations.

The second policy-related aspect of this historical education-earnings relation ship involves income distributional considerations. In the absence of an effective social commitment to a more equal distribution of income and wealth, American society has attempted to realize its ostensible commitment to democratic-egalitarian principles of equaity and equality of opportunity predominantly intergenerationally, that is, via policies which offer at least the prospect that the children of poor parents will enjoy higher income and social status than their parents.

Although the issues of social status and social mobility, as these are influenced by education, have been the subject of intensive debate over the last decade, the purview of the discussion has been notably restricted. Two related questions, addressed in a virtually timeless, ahistorical context, have provided the focus for analysis: First, what factors determine an individual's relative status within his generational (age) cohort? Second, to what degree does relative status of the parent within the parent cohort influence the relative status of the child within the offspring cohort? In short, the focus has been on the degree of intergenerational transmission of intragenerational status.

The central conclusion is well-known: Relative status is remarkably persistent across generations; furthermore, such interventions as education have little independent impact on relative status.[34] Cast in these terms, a socially very important phenomenon has been largely ignored. This is the shift over time in the overall status distributions of successive generational cohorts. Stability in relative intragenerational status has been combined with general increases in status from generation to generation. Although a child may not have high status relative to his peers, he may yet have high status relative to his parents.[35] Even if the status of a person relative to others of his generation is determined entirely by the status of his parents relative to others of the parent's generation, still if the overall status distribution has shifted upward over time, then the perception of social mobility is not purely illusory. Thus, at least in the economic environment of the last half-century, education has provided a mechanism by which an avowed national commitment to equality could be served.

Appendix II. The Human Capital Model and Individual Investment Decisions

To identify the important elements which must be incorporated into a systematic analysis of the causes and consequences of changing investments in education, it is useful to briefly review the economist's basic model of human capital formation.

Consider an individual with a past history of schooling and specified aptitudes and abilities, facing a spectrum of alternative future activities. For purposes of simplicity, let us assume that he faces two alternatives: (1) A further period of schooling, after which he enters the labor market, and (2) immediate entry into the labor market. In each case he has expectations concerning his likelihood of unemployment, his earnings and the qualitative, nonpecuniary aspects of his employment (status and prestige, etc.) over his working lifetime. In addition, he places a certain value of the nonemployment-related consequences of education (the benefit he attaches to simply being in school, post-schooling status independent of his particular employment, the contribution of education to his performance as a parent or consumer, etc.). On what basis should he decide between the two activities? A rational choice-investment model would state that he should

[34] For example, Jenks et al., "Inequality * * *."

[35] In the United States this increase in the absolute status of the lower classes has been reinforced by an enhancement of relative status as migration and immigration, domestic and international, have replaced one lower tier group by another.

select that activity which gives him the highest level of lifetime satisfaction, taking into account all of the benefits and costs associated with each available option. Thus, the following elements would be involved in his choice calculus:

(*a*) Considering only the period of time after leaving school (should schooling be the selected option), the difference in his expected earnings (adjusted for anticipated unemployment) with and without the additional schooling. The present value of this earnings differential is denoted by E.

(*b*) Considering only the period of schooling itself, the earnings loss necessitated by the choice of schooling (adjusted for unemployment and for earnings which he would expect from part-time work while in school). The present value of these foregone earnings is denoted by F.

(*c*) The net benefit derived from simply being in school (which might be negative if he actively disliked school), the value of which is denoted C.

(*d*) The net nonpecuniary benefit of schooling (employment-related and other) derived over the postschooling lifetime, the value of which is denoted B.

(*e*) The out-of-pocket costs of education (tuition, books, etc., but specifically not including living costs), denoted by, T less any direct subsidies contingent on being in school, denoted by S.

The rational choice model would then dictate that schooling should be the selected option if and only if the sum of the benefits $(E+C+B)$ is greater than the sum of the costs $(F+T-S)$. In fact, as will be discussed, there is substantial ground for believing that actual behavior diverges significantly from this rational model (although the importance of these divergences remains to be determined); however, it is useful as a first approach to consider the factors which enter into the determination of the variables which the rational model views as critical to educational behavior.

Lifetime Earnings Differentials

Clearly, any increase in the earnings gain associated with schooling will render the choice of schooling more attractive. Secular developments (economic, technological, etc.) which influence the differential have been discussed in Section 4 of the text. Also the importance of unemployment experience of those with more education, an almost entirely ignored source of the relatively higher expected earnings of the highly educated, has been discussed in Section 3. However, another aspect of the lifetime earnings differential is often ignored: opportunities for human capital formation outside of formal schooling. Clearly, there exist alternative mechanisms for acquiring economically valuable training and skills. However, the availability of these alternatives may be critically reduced by legal and institutional constraints imposed on the labor market. For example, a particular skill might be most effectively acquired through employer-provided on-the-job training. However, if the skill is sufficiently general, once trained the employee could sell the skill elsewhere, to an employer who would not have to bear the costs of training. Under these conditions, an employer will be willing to provide the training only if the cost is effectively borne by the employee, in the form of a training-period wage rate less than the employee's value to the employer by an amount equal to the cost of training.[36] But the existence of a minimum wage law may foreclose the possibility of shifting the costs of training to the employee, with the result that employer-provided training will not be offered, thus forcing the employee to obtain the training in a less efficient manner, e.g., in school, or to forego the training entirely, accepting a job which does not offer opportunities for skill upgrading and which will, as a result, provide lower lifetime earnings. Thus, the paradox is that a minimum wage law may result in lower lifetime income (net of the costs of education or training) for significant numbers of workers. Similar effects will be exerted by licensing and related requirements which establish a specified program of schooling as a prerequisite for entry into a particular occupation.

Foregone Earnings

Factors influencing the expected earnings of young, school-age persons in the labor force, and especially unemployment, have been discussed in Section 3 of the paper. In addition, the adverse, discriminatory consequences of mandatory school attendance laws and of child labor laws as these arbitrarily impinge on the em-

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[36] Gary S. Becker, "Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education" (New York: Columbia University Press, 1975), pp. 19–26.

ployment opportunities of young people should at least be mentioned. These simply compound the adverse effects of legal-institutional constraints on non-schooling modes of human capital formation.

NONPECUNIARY BENEFITS OF SCHOOLING

In addition to the income gains associated with higher levels of education, significant nonpecuniary benefits are perceived by many persons to flow from education. During the period of schooling certain "lifestyle" benefits may be derived. And in the period after schooling the advantages of prestige, of more desirable working conditions, etc., inure to the benefit of the more highly educated. Concerning these benefits relatively little can be said. But it should be noted that many of these benefits may be quite "real"; for example, strong evidence suggests that education has significant positive consequences for health status and for parental effectiveness (as reflected, e.g., in the schooling performance of children).[37]

Beyond this, however, it would appear that many of the ostensible nonpecuniary benefits represent primarily class preferences and perceptions. Thus, children of more educated parents are socialized to perceive of education as a source of satisfaction in and of itself, to value the lifestyle concomitants of the schooling period, and to engage in postschooling patterns of consumption and behavior for which schooling is a prerequisite. To some degree the perception of these benefits may be more correctly attributed to the parents, leading them to make greater transfers to children in an in-kind (schooling) form than they would be willing to make in the form of general purchasing power. In either event, as a reflection of class preferences greater expenditure on education is simply a consequence of the generally greater level of consumption and the concomitant difference in composition of consumption open to the more affluent, indistinguishable from their differential consumption of other luxury goods. To the degree to which nonpecuniary benefits do in fact reflect class perceptions and values on the part of either parents or children, it would be expected that persons most thoroughly internalizing those values would be least sensitive to adverse changes in, e.g., the earnings gain associated with education.

OUT-OF-POCKET COSTS OF SCHOOLING (EXCLUSIVE OF DIRECT SUBSIDIES TO STUDENTS)

Three particularly important observations can be made regarding the direct costs of schooling. First, these costs obviously will be highly sensitive to public policies regarding subsidization of educational institutions. However, the most important consequence of institutional subsidy policies is probably not for the absolute cost of schooling but for the relative costs of different forms of schooling, or more generally, of human capital formation; that is, public (especially state) subsidy policies create a differential incentive to attend publicly-subsidized institutions. Especially at the post-high school level, this has operated to constrain human capital formation to more-or-less conventional schooling, simply because such alternatives as employer-provided training have not been subsidized.

Discrimination in favor of schooling, through educational subsidies, is, as, noted above, reinforced by direct discrimination against alternative modes of human capital formation, especially work, as reflected in, e.g., (*a*) the toleration of intolerably high levels of unemployment, (*b*) the imposition of minimum wage laws which reduce the availability of training which does not involve schooling, and (*c*) the enforcement of restrictions on entry into various occupations imposed by collusive, monopolistic unions and "professional" associations.

Second, direct costs of schooling may vary with other activities of educational institutions. For example, between the late 1950's and late 1960s the costs of a university education were at least somewhat dampened by the concomitant expansion of graduate education and research. This simply reflects interdependencies between these different activities: The rapid growth of graduate education created an expanding pool of low-wage, lower eschelon faculty for undergraduate education. Such factors, obviously, will be more critical for some components of the education system than others.[38]

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[37] See, e.g., Michael Grossman, "The Demand for Health: A Theoretical and Empirical Investigation," (New York: Columbia University Press, 1972); Arleen Leibowitz, "Home Investments in Children," Journal of Political Economy (Part II, March/April 1974). For other non-earnings effect of education, see: Robert T. Michael, "The Effect of Education on Efficiency in Consumption" (New York: National Bureau of Economic Research, 1972), and "Education and the Derived Demand for Children," Journal of Political Economy (Part II, March/April 1973); and Lewis C. Solmon, "The Relation between Schooling and Savings Behavior: An Example of the Indirect Effects of Education," in F. T. Juster, ed., "Education, Income and Human Behavior" (New York: McGraw-Hill, 1975).

[38] For a discussion of these interdependencies, see Stephen P. Dresch, "An Economic Perspective on the Evolution of Graduate Education" (Washington, D.C.: National Academy of Sciences, 1974).

Third, the costs of education relative to the costs of other goods and services will depend upon the rate of expansion of the educational establishment. Expansion at a rate greater than that of other activities will create excess demands for personnel and other specialized inputs, driving up their wages and prices. Conversely, relative contraction should result in a relative decline in the costs of education. Thus, the extremely rapid expansion which accompanied the passage of the greatly inflated postwar-baby-boom cohorts through the educational system let to significant increases in the relative cost of education. The intermediate future, which will witness declines in the school-age population and possibly also in rates of school attendance, should be a period of relative stability or decline in educational costs.[39]

Direct Student Subsidies

The effects of such subsidies are quite obvious; by reducing the effective cost of education they will lead some individuals to choose schooling who, in the absence of the subsidy, would have chosen to work. As in the case of institutional subsidies, however, the most important consequence of student subsidies may be to influence the choice between alternative modes of human capital formation. Constrained to schooling, these subsidies discriminate against such alternatives as on-the-job training, although as discussed above, training provided by the employer also has real costs for the individual, i.e., a wage differential related to the cost of training.

Section 3 of the text has addressed the issue of the degree to which growth-stimulating and other possible economic effects of schooling are reflected in the variables which the human capital model preceives to be important to individual decisions concerning education and training. It is important, however, to consider the possible consequences of possible constraints on individual action which would lead to deviations of actual behavior from the stylized behavior assumed by the human capital model. For this purpose it is useful to assume, provisionally, (1) that any benefits or costs of education or training, e.g., contributions to economic growth, which are not reflected in the expected wage differential have been appropriately conpensated through student or institutional subsidies, (2) that no legal-institutional constraints exist which would bias the level or form of human capital investment, and (3) that socially optimal rates of present and future unemployment will be achieved.

Under these assumptions, the socially optimal level and composition of investment in human capital would be that which would result if the rational choice model applied in all individual decisions concerning education or training. This solution would be optinal in the sense that no individual could be made better off through the acquisition of more or different human capital. Any alternative for any individual would involve additional costs greater than the additional benefits (pecuniary and nonpecuniary).

Thus, to state that this solution is optimal is also to assert that, with respect to the embodiment of human capital, it is equitable. If all individuals were identical in aptitudes and abilities, then lifetime earnings (again, pecuniary and nonpecuniary) net of the costs of education and training would be equal; differences in levels of investment in human capital would be just compensated by differences in earnings, and any individual would be indifferent between more or less education or training.[40] In fact, the existence of differences in aptitudes and abilities would create differences in net lifetime earnings. However, it would still be true that anyone given the choice between additional education or training and an unrestricted grant equal to the cost of that human capital investment would choose the grant.

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[39] Such institutional arrangements as tenure may dampen the cost-depressing effects of stability or contraction of the educational enterprise; however, for this and other reasons, it can be anticipated that severe pressures will be exerted on these institutional rigidies, as discussed in Stephen P. Dresch, "Educational Saturation: A Demographic-Economic Model," AAUP Bulletin (Autumn 1975), and "Research, Graduate Education and the University," Educational Record (Summer 1974).

[40] This, of course, is an equilibrium statement.If the relative demand for a particular type of training or skill experienced a discontinuous shift, then any lags in the human capital investment process would imply differences in relative lifetime incomes. These differences in opportunities would lead to continuing flows of individuals from areas of excess supply to areas of excess demand, a process which would continue until the relative returns were equalized. The effective operation of this type of adjustment process has been demonstrated by Richard B. Freeman, 'The Market for College Trained Manpower: A Study in the Economics of Career Choice" (Cambridge, Mass.: Harvard University Press, 1971), and "Overinvestment in College Training?" Journal of Human Resources (Summer 1975), and by Stanley D. Nollen, "The Supply and Demand for College Educated Labor" (unpublished Ph.D. dissertation, University of Chicago, 1974).

Of course, society might view the resultant distribution of income as inequitable; however, the appropriate response would be not to attempt to alter the human capital embodied in individuals but rather to engage in the direct redistribution of income from those with high income and wealth (whether derived from superior ability, the inheritance of physical or financial wealth, or simply blind chance) to those with inequitably little command over economic resources. To attempt to utilize human capital investment as a device for achieving greater equity, confusing an "equitable" distribution of human capital with an equitable distribution of income or wealth, would be inefficient: the beneficiaries themselves could be made better off if given an equivalent unrestricted transfer (or alternatively, beneficiaries could be made equally well off with a lesser transfer).[41]

If we accept, at least for the sake of argument, that the rigorous application of the rational decision model would lead to socially optimal investment in human capital, are there reasons to believe that actual human capital investment behavior leads to markedly suboptimal results? Decomposing this question, are there constraints on individual action which would lead to suboptimal results, and/or do individuals fail to accurately perceive and act upon the benefits and costs of human capital investments? The latter question is discussed in Section 3 of the text.

Apart from the legal-institutional constraints previously discussed, inadequate or nonexistent access to capital markets constitutes the most serious barrier to investment in human capital. The most important benefits of education and training derive over the course of the individual's (working and nonworking) lifetime, while the costs, whether out-of-pocket or foregone earnings, must be met at the time the investment is made. The basic human capital model assumes that these costs can be financed through the capital market at interest rates no higher than would be incurred for any other investment, the returns to which involved comparable risk and the risks of which could be shifted (at a price) to those most willing to bear it.

In fact, capital market access on the part of the potential human capital investor is severely constrained. The only collateral of the borrower is his future income (pecuniary and nonpecuniary), attachment of which is precluded by Constitutional prohibitions against involuntary servitude. As a result, capital is available, if at all, only at inordinately high rates of interest as compared to the return to other assets. The resultant inefficiencies are compounded by the inability of the borrower to insure against the possibility of a low return to his human capital investment.

Apart from the difficulty of insuring against risk, effective access to capital markets for human capital investments is available to persons from higher income families, who can borrow within the family at interest rates no greater than those available on other assets. This is true even if the family's wealth is in a relatively illiquid form, e.g., owner-occupied housing, since this wealth can be used as collateral for a loan. For a person from a low income family, however, capital market access is effectively foreclosed. Thus, the inefficiencies implied by capital market imperfections have definite equity implications.

The suboptimal levels of investment in human capital, especially on the part of low income persons, which result from capital market failures, could in principle be compensated via educational subsidies, appropriately keyed to family income to reflect differential intrafamily access to capital. Such subsidies, however, are unnecessary if devices for perfecting the operation of capital and insurance markets can be devised. While beyond the scope of the present discussion, in fact there appear to be no insuperable barriers to significantly improving the functioning of capital and insurance markets.[42]

If this is in fact a correct assessment, then there are substantial grounds for preferring capital market interventions to compensatory subsidies, since such subsidies may well introduce other, equally pernicious inefficiencies and inequities. Need-based subsidies to education (human capital formation) represent both selective wealth transfers and also artificial reductions in the costs of education as perceived by the recipients. It is the latter characteristic by which the subsidies

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[41] It has been argued that those who make the transfers (taxpayers) themselves derive utility from the greater educational attainments of the beneficiaries, thus justifying the tying of the transfers to education. However, I would suggest that the primary motivation to these restricted transfers is the belief that the educational investment will "pay off." This is reinforced by the reasonable expectation on the part of many of the contributors (those of the middle class) that their children will in fact reap a disproportionate share of the benefits, thus negating or at least substantially reducing any net redistributive effects of educational subsidies; See W. Lee Hansen and Burton A. Weisbrod, "Benefits, Costs and Finance of Public Higher Education" (Chicago: Markham, 1969).

[42] See Dresch, "An Economic Perspective * * *," "Appendix: Capital and Insurance Markets and Investment in Graduate Education," pp. 67-76; and Nerlove, "Some Problems in the Use of Income-Contingent Loans . ."

compensate for the consequences of inadequate capital markets. Even if the subsidies were just sufficient to compensate for capital market inperfections, and hence did not lead to distortions in the level or composition of human capital investment, they would still constitute discriminatory wealth transfers to beneficiaries (students or other human capital investors) relative to nonbeneficiaries (persons, especially the less able, not investing in human capital) from identical family income-wealth backgrounds. This source of inequity is only compounded by the fact that persons from families with comparable income and wealth may not receive comparable "inheritances", or implicit access to capital, while persons from families with very different income and wealth may not receive correspondingly different access to funds for human capital investments. That is, contrary to the assumption underlying conventional "needs analyses", family income and wealth may not provide a very accurate index of the resources available for investment in education or training; as the dilemmas associated with the independent student indicate, it is very difficult to determine the degree to which resources actually are available to an individual. Especially in light of the possibly serious efficiency consequences of arbitrary subsidies, inducing under-or overinvestment in different forms of human capital, the general conclusion would seem to be that policies regarding income and wealth distribution should, to the degree possible, be divorced from policies regarding education and human capital formation, and specifically that "access to human capital (education, etc.)" should not be confused with the entirely separable issue of "access to wealth."

Appendix III. Risk Aversion, Income Taxation, and Investment in Human Capital

If all individuals were *risk neutral,* then the only consideration with respect to a possible human capital investment would be its expected rate of return. However, if individuals are *risk averse,* the variance of the expected rate of return also becomes relevant to the investment decision. That is, a risk averse individual will prefer a lower to a higher expected-rate-of-return asset, if the variance of the lower expected rate of return is sufficiently smaller than that of the higher expected rate of return.

An income tax imposed at an effective marginal tax rate τ^* will reduce the expected rate of return to an asset from a pretax value of ρ to a posttax value of $(1-\tau^*)\ \rho$. However, it will reduce the variance of the expected rate of return by the square of $(1-\tau^*)$, i.e. from σ^2 to $(1-\tau^*)^2\ \sigma^2$. For example, if $\tau^*=0.1$, i.e., a ten percent marginal tax rate, then the expected rate of return will be reduced to ninety percent of its original value $(1-0.1)$ and the variance to eighty-one percent of its original value $[(1-0.1)^2=0.81]$.

To assess the potential effect of this reduction in variance, consider a taxpayer who must distribute his wealth between two assets, human capital with an expected return ρ_h and variance σ_h^2 and asset z with expected return ρ_z and variance σ_z^2. For the moment assume, first, that returns to asset z are in a form which escape the tax, e.g., nonpecuniary income or the implicit services of owner-occupied housing. Second, assume that human capital has both a higher expected rate of return and a higher variance than asset z, i.e., $\rho_h > \rho_z$ and $\sigma_h^2 > \sigma_z^2$; it might be noted that both inequalities (and especially the second) are generally descriptive of the comparison of human capital to other assets.

Clearly, the imposition of the tax reduces the expected rate of return of human capital relative to that of asset z; *ceteris paribus* this would be expected to reduce the proportion of his portfolio which the individual would choose to hold in the form of human capital. However, the tax liability reduces both the expected return and variance of returns to human capital, and the latter effect will dampen and possibly even fully offset the effect of the reduction in expected return.

Consider the trade-off existing between expected return and risk, which can be expressed as the increment in additional return, β, which can be acquired in exchange for accepting a unit increase in risk (variance). In the absence of the tax, this trade-off is defined by

$$\beta=\frac{\rho_h-\rho_z}{\sigma_h^2-\sigma_z^2} \tag{6}$$

Imposition of the tax at an effective rate τ^* on human capital returns but not on the returns to asset z alters this trade-off to β^*:

$$\beta^*=\frac{(1-\tau^*)\rho_h-\rho_z}{(1-\tau^*)^2\sigma_h^2-\sigma_z^2}$$

Whether and to what degree this discriminatory taxation of the returns to human capital is unfavorable to human capital investment will depend on the specific values of the various parameters. Specifically, imposition of the tax (more rigorously, a change in the effective tax rate) will be favorable to human capital if the increment in return which can be acquired by accepting a unit increment in risk is increased, i.e., if $d\beta^*/d\tau^*>0$, where

$$\frac{d\beta^*}{d\tau^*}=\frac{(1-\tau^*)^2\rho_h\sigma_h^2+\rho_h\sigma_z^2-2\,(1-\tau^*)\rho_z\sigma_h^2}{[(1-\tau^*)^2\sigma_h^2-\sigma_z^2]^2}$$

If, for convenience the mean and standard deviation of the expected return to asset z are expressed as proportions of the mean and standard deviation of expected returns to human capital, i.e.

$$\rho_z=\delta_1\rho_h;\text{ and }\sigma_z=\delta_2\sigma_h,\text{ or }\sigma_z^2=\delta_2^2\sigma_h^2,$$

then the above expression becomes

$$\frac{d\beta^*}{d\tau^*}=\frac{\rho_h[(1-\tau^*)^2-2\,(1-\tau^*)\,\delta_1+\delta_2^2]}{\sigma_h^2[(1-\tau^*)^2-\delta_2^2]^2}$$

This expression will be positive if the bracketed term in the numerator is positive; while this will be true for a range of values $\delta_2\gtreqless\delta_1$, it might be noted that it will necessarily be positive for all $\delta_2\geq/\delta_1$, e.g., for $\delta=\delta_2=\delta_1$ this term becomes $[(1-\tau^*)-\delta]^2$. This last result is interesting, first, because the condition $\delta_2>\delta_1$ will be found to be particularly critical in a related regard and also because available empirical evidence suggests that, across assets, this condition is generally fulfilled, i.e., that a reduction in asset risk is acquired at the cost of a more than proportionate reduction in expected return.

In effect, imposition of the tax at the effective rate τ^* rotates the risk return function around the point (σ_z^2,ρ_z), reflecting the movement of the point (σ_h^{*2},ρ_h^*) in response to the change in the tax rate, where σ_h^{*2} and ρ_h^* are the posttax variance and expected return to human capital, the taxed asset:

$$\rho_h^*=(1-\tau^*)\rho_h$$

$$\sigma_h^{*2}=(1-\tau^*)^2\sigma_h^2,\ \sigma_h^*=(1-\tau^*)\sigma_h$$

To determine the locus of points (σ_h^{*2} and ρ_h^*), the latter can be expressed as a function of the former,

$$\begin{aligned}\rho_h^*&=(1-\tau^*)\rho_h(\sigma_h/\sigma_h)\\&=\sigma_h^*(\rho_h/\sigma_h)\\&=(\sigma_h^{*2})^{1/2}(\rho_h/\sigma_h)\end{aligned}$$

with the characteristics

$$\frac{d\rho_h^*}{d(\sigma_h^{*2})}=(\sigma_h^{*2})^{-1/2}(\rho_h/\sigma_h)/2>0$$

and

$$\frac{d^2\rho_h^*}{d(\sigma_h^{*2})^2}=-(\sigma_h^{*2})^{-3/2}(\rho_h/\sigma_h)/4<0,$$

i.e., the function relating the posttax expected rate of return to the posttax variance will be positive and concave from below, as indicated in Figure 2.

Consider specifically the value of ρ_h^* when $\sigma_h^{*2}=\sigma_z^2=\delta_2^2\sigma_h^2$, denoting this value by $\rho_h^{*(\delta_z)}$

$$\rho_h^{*'(\sigma_z)}=\delta_2\rho_h$$

and

$$\frac{\rho_h^{*(\sigma_z)}}{\rho_z}=\frac{\delta_2}{\delta_1}>1\text{ if }\delta_2>\delta_1.$$

That is, the point $(\sigma_z^2,\ \rho_z)$ will lie below the locus of points $(\sigma_h^{*2},\ \rho_h^*)$ if the relative standard deviation of the expected return to z is greater than its relative return. In this case, imposition of the tax at rates

$$(1-\delta_2)\lesseqgtr\tau^*\lesseqgtr(1-\delta_1)$$

will result in an absolutely lower relative variance in the posttax return to human capital, while its expected rate of return will remain higher. In short, human capital would become the clearly superior asset; if the returns to the two assets are uncorrelated, then a rational investor would choose to hold only human capital after imposition of the tax at an effective rate fulfilling the foregoing condition.

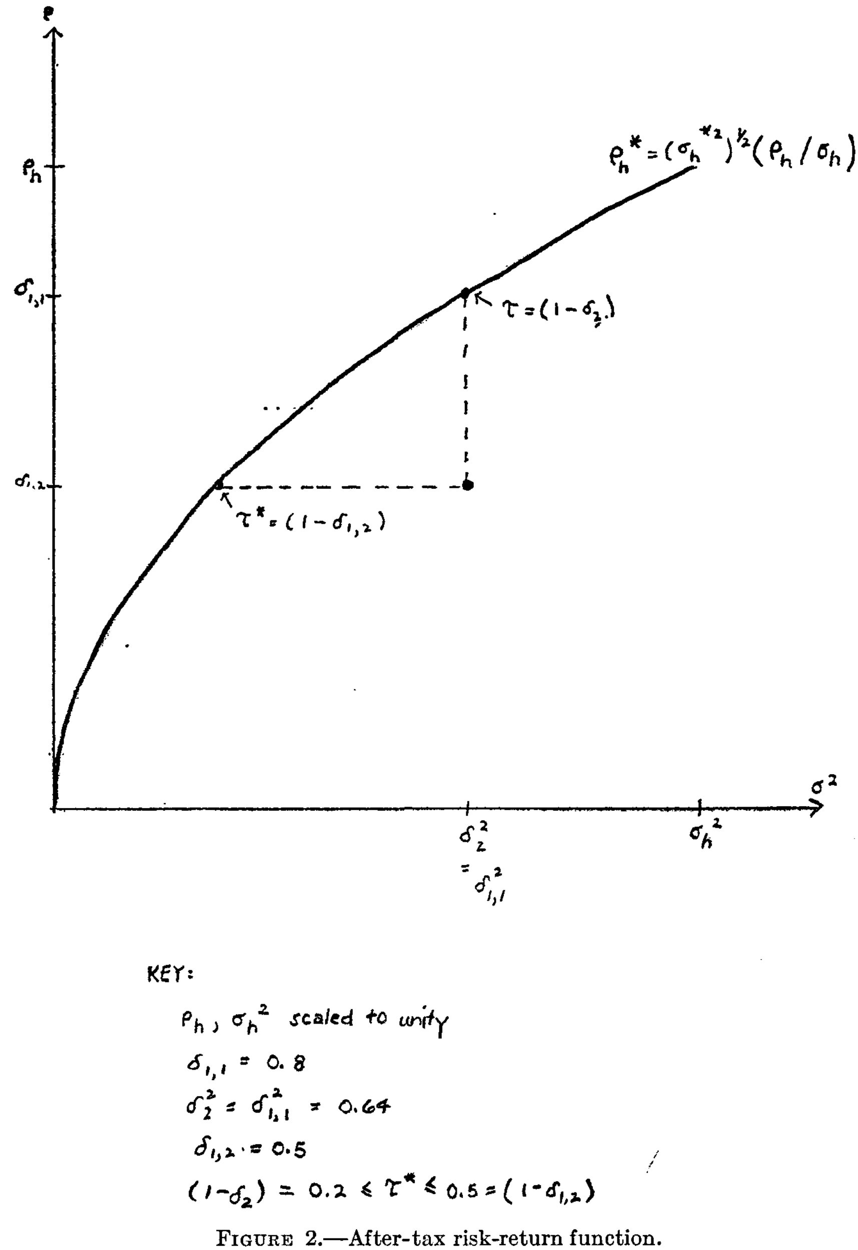

FIGURE 2.—After-tax risk-return function.

In any event, if $d\beta^*/d\tau^*>0$, then imposition of the tax will generally lead a risk-averse investor to alter the composition of his portfolio. The substitution effect will clearly be in favor of the otherwise higher risk asset. If the marginal rate of substitution between risk and return is invariant with respect to the level of return, i.e., if the marginal utility of money is constant and the individual's indifference curves in the risk-return space are vertically parallel, there will be no income effect, and the net effect will be to shift the composition of the portfolio toward human capital. If, as is more likely, the investor becomes less risk-averse at higher rates of return, i.e., at any variance the marginal rate of substitution declines (the indifference curves become flatter) at higher rates of return, the income and substitution effects will both operate to increase the proportion of the portfolio devoted to human capital.

In the more general case, in which the returns to all assets are subjected to the tax, the results are even clearer. The risk-return function now becomes

$$\beta^*=\frac{(1-\tau^*)(\rho_h-\rho_s)}{(1-\tau^*)^2(\sigma_h^2-\sigma_s^2)}=\frac{\rho_h(1-\tau^*)(1-\delta_1)}{\sigma_h^2(1-\tau^*)^2(1-\delta_2^2)}$$

for which

$$\frac{d\beta^*}{d\tau^*}=\frac{\rho_h(1-\delta_1)}{\sigma_h^2(1-\tau^*)^2(1-\delta_2^2)}>0$$

for all values of δ_1 and δ_2 less than unity. In short, if the returns to all assets are subjected to tax, then the existence of the tax will necessarily lead a risk-averse investor to shift his portfolio composition in favor of higher return-higher risk assets, e.g., human capital.

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