Keith M. Carlson

Keith M. Carlson is an assistant vice president at the Federal Reserve Bank of St. Louis. Thomas A. Pollmann provided research assistance.

On Maintaining a Rising U.S. Standard of Living Into the Mid-21st Century

IN EARLY 1989, the Bureau of the Census released its latest population projections for the United States through 2080, showing slower growth in the total population from 1990 through 2035 and little growth thereafter.[1] At the same time, the median age of the U.S. population is projected to continue rising. The rising median age primarily reflects the aging of the baby-boom generation, those born between 1946 and 1964. Given these projections, it is natural to ask whether the United States will be able to maintain its standard of living into the next century. A typical example of such concern recently appeared in the "Labor Letter" column of the *Wall Street Journal*:[2]

> GRIM FORECAST: Most baby boomers "will find retirement at age 65 unaffordable" when they get there starting in 20 years, a survey of North American actuaries finds. They blame inadequate savings, tax incentives and too few workers.

The purpose of this article is to explore the arithmetic that underlies the broad economic implications of these population projections. This involves deriving projections of the civilian labor force and employment from the population projections. Achieving certain rates of increase in the standard of living means achieving certain rates of growth of the U.S. capital stock. The feasibility of these various capital stock requirements is examined in light of historical experience to assess the prospects for future economic growth.

POPULATION PROJECTIONS TO 2050

The Census Bureau has prepared population projections for the United States for the last 30 years.[3] In its most recent report, the Bureau constructed three basic projection series using

[1]Bureau of the Census (1989).

[2]*Wall Street Journal* (1989). For a general discussion of the challenges facing the U.S. economy in the future, see Council of Economic Advisers (1990), chapter 4.

[3]For a discussion of the forecast accuracy of population projections, see Bureau of the Census (1989), pp. 14-16. The bureau reports that, for a projection period of 15 years, the root-mean-square error of previous projected growth rates is 0.40 percentage points. The difference between the growth rate for its highest (lowest) projection series and the middle series for 1990 to 2005 is 0.34 (0.28) percentage points.

Table 1

Historical and Projected (Middle Series) Population Growth: 1950-2050

Period	Growth rate	Medial age in years (end of period)	Percentage of population 65 and over (end of period)
Actual:			
1950 to 1960	1.72%	29.4	9.2%
1960 to 1970	1.27	27.9	9.8
1970 to 1980	1.06	30.0	11.3
Projected:			
1980 to 1990	0.95	33.0	12.6
1990 to 2000	0.69	36.4	13.0
2000 to 2010	0.52	38.9	13.9
2010 to 2020	0.41	40.2	17.7
2020 to 2030	0.21	41.8	21.8
2030 to 2040	0.04	42.6	22.6
2040 to 2050	−0.07	42.7	22.9

three different assumptions about fertility rates, life expectancy and net immigration.[4] The differences in the fertility assumptions are chiefly responsible for most of the differences in the projections. The highest, middle and lowest series reflect the highest, middle and lowest assumptions, respectively, for each of these components.

The Census Bureau emphasizes that its highest and lowest population projections do not represent estimated confidence intervals based on statistical analysis. Instead, they are referred to simply as a "reasonable" high and low projection. The numerical exercises in this article concentrate on the middle series projection because the Census Bureau considers it the "most likely." In addition, the horizon of the population projections is the year 2050; this enables the study to focus on the retirement years of the baby-boom generation.

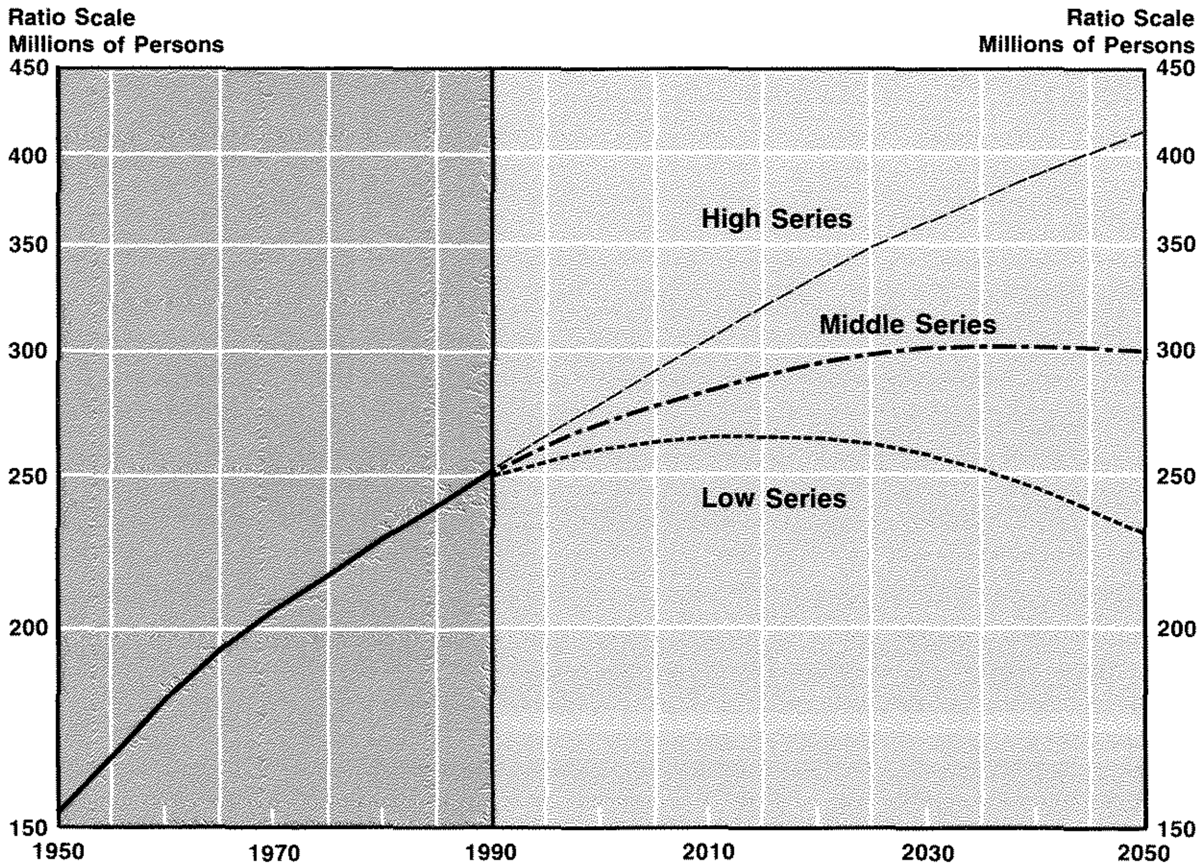
The Bureau of the Census projections are summarized in table 1 and figure 1. Declining population growth is not something new; it has been under way for a number of years. The total population grew at a 1.7 percent annual rate from 1950 to 1960, then slowed to a 1.3 percent rate in the 1960s, before slowing even further in the 1970s and 1980s. From 1990 to 2040, the Census Bureau projects a positive, but steadily declining population growth rate; after 2040 the population level itself is projected to decline.

As table 1 shows, one notable feature of the projections is the expected aging of the population. The median age reached a post-1960 low of 27.9 years in 1970 and is estimated to reach 33 years in 1990, before climbing to 42.7 years by 2050. Hand in hand with this overall aging of the population is the rising proportion of the population that is age 65 and older.

The major issue of concern is whether slowing growth in the population, combined with the rising age composition, bodes ill for maintaining a continuing rise in the nation's standard of living.

[4]By combining the assumptions in all possible ways, there are 27 different population projections. In addition, the Census Bureau prepares three series with a zero net-immigration assumption. The middle series for net immigration starts with 600,000 persons per year and is reduced and kept at 500,000 persons per year after 1997. Compared with the zero net-immigration case, this increases the population estimate for 2050 by 49 million persons, or 19.5 percent. Each 100,000 net immigrants per year has the effect of increasing the 1990-2050 average population growth rate by about 0.05 percent. After 1998, the low net-immigration assumption levels out at 300,000 persons per year, and the high assumption levels out at 800,000 per year.

Figure 1
Population Projections[1]



[1]Total population

PROJECTIONS OF LABOR FORCE AND EMPLOYMENT TO 2050

Unfortunately, the Census Bureau and the Department of Labor do not provide labor force and employment projections as far into the future as the year 2050. Therefore, such projections must be estimated in some manner. Such projections require information about the rate at which the population will participate in the civilian labor force and the rate at which this labor force will be employed. These rates, in turn, depend on the age and sex composition of the population and the labor force.

Participation Rates

Table 2 summarizes historical and projected participation rates for 10 age-sex groups for 10-year periods from 1950 through 2000. The projected figures for 1990 and 2000 are based on estimates made by the Department of Labor.[5] For purposes of this analysis, these same age-sex group projections for 2000 are assumed to hold constant through 2050.[6]

Even though the participation rates are held constant for each age-sex group, the total participation rate changes quite dramatically in the

[5]Fullerton (1989).

[6]The effects of an alternative set of participation rate assumptions based on a continuation of recent trends were also examined. In particular, labor force participation of females between the ages of 16 and 64 was assumed to continue rising throughout the 2000 to 2050 period, with the participation rate of all females 3.7 percentage points above the basic assumption by 2050. These alternative assumptions increased the overall participation rate by about 2 percentage points by 2050 and reduced the required growth rate of the capital stock (for a given standard of living scenario) from 1990 to 2050 by 0.2 percent.

Table 2

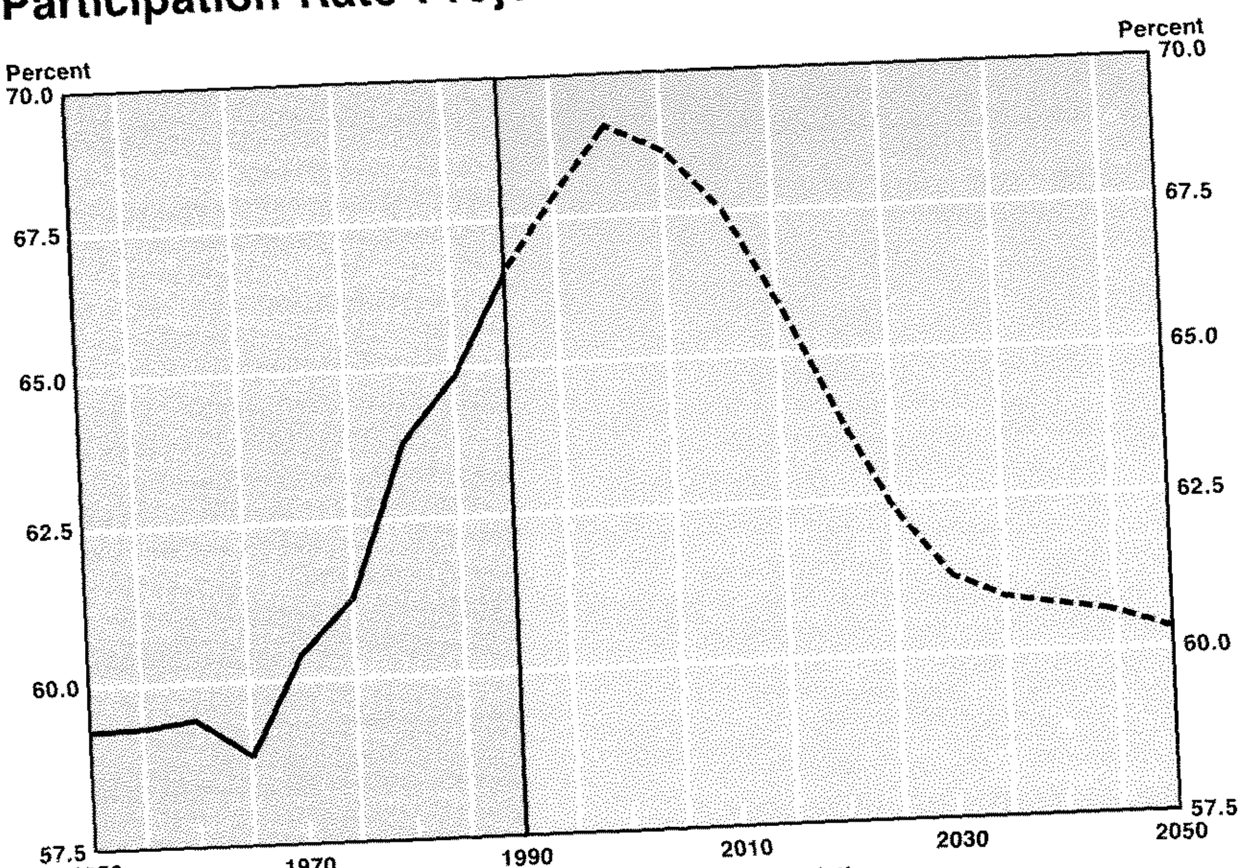
Historical and Projected Paticipation Rates[1]: 1950-2000

	1950	1960	1970	1980	1990	2000
Males:						
16 to 19	63.2%	56.1%	56.1%	60.5%	58.0%	59.0%
20 to 24	87.9	88.1	83.3	85.9	85.4	86.5
25 to 54	96.5	97.0	95.8	94.2	93.6	93.0
55 to 64	86.9	86.8	83.0	72.1	67.3	68.1
65 and over	45.8	33.1	26.8	19.0	16.4	14.7
Females:						
16 to 19	41.0	39.3	44.0	52.9	54.4	59.6
20 to 24	46.0	46.1	57.7	68.9	72.9	77.9
25 to 54	36.8	42.9	50.1	64.0	74.3	81.4
55 to 64	27.0	37.2	43.0	41.3	45.4	49.0
65 and over	9.7	10.8	9.7	8.1	8.3	7.6
Total, 16 and over	59.2	59.4	60.4	63.8	66.7	69.0

[1]Civilian labor force as a percent of civilian noninstitutional population, which equals total population minus armed forces, institutionalized persons and persons under 16 years of age.

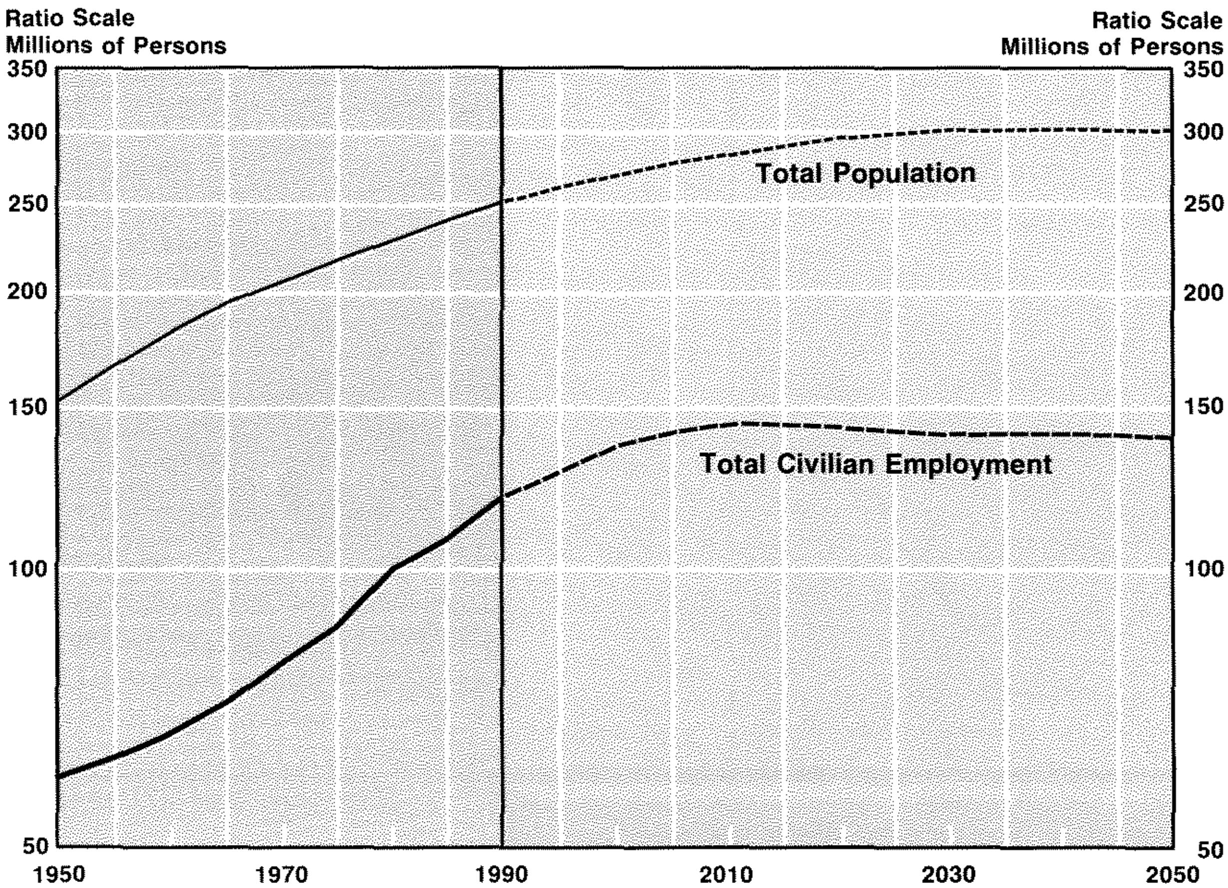
Figure 2

Participation Rate Projections[1]



[1]Civilian labor force as a percent of civilian noninstitutional population

Figure 3
Population and Employment



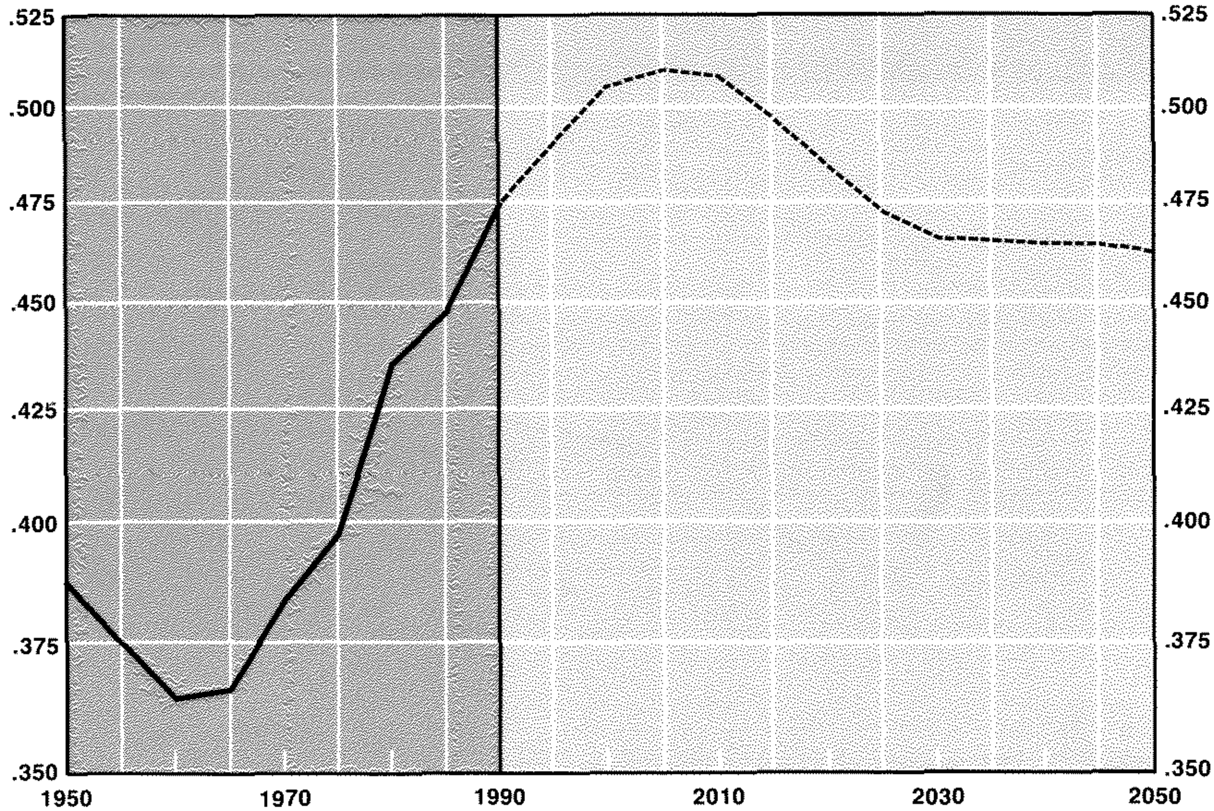
projection period because of the aging trend in the population (see figure 2). This projected decline in the participation rate after 2000 raises doubts as to whether the general standard of living can be sustained by a work force that is shrinking relative to population.

Total Civilian Employment

One must also make a projection of total employment, given the projections of population and the labor force. Neither the Census Bureau nor the Department of Labor make employment projections by age-sex group. So, for purposes of this analysis, 1989 employment rates are assumed to hold constant throughout the projection period for each of the 10 age-sex groups. Applying these employment rates to the changing age distribution of the labor force yields projections of total civilian employment.[7] The result of these total employment projections is charted in figure 3 along with the middle-series population projection from figure 1. The ratio of total employment to total population is shown in figure 4. Continuing a trend that began in the 1960s, the working proportion of the population is projected to rise until 2005; it then declines until 2030 before leveling off in 2050. Changes in the employment-population ratio after 2000 reflect only the changes in the age-sex distribution of the population.

[7]An age-sex adjusted employment (unemployment) rate is also derived. For the middle series population projection, the age-sex adjusted employment rate rises slowly from 94.7 percent in 1989 to 95 percent in 2050. The adjusted unemployment rate falls from 5.3 percent in 1989 to 5 percent in 2050. The resulting implications for capital stock growth are not very sensitive to these employment rate assumptions. For example, a 97 percent employment rate assumption in 2050 would reduce the required growth in the capital stock by about 0.1 percent.

Figure 4
Employment-Population Ratio[1]



[1]Total civilian employment relative to total population

ALTERNATIVE STANDARD-OF-LIVING ASSUMPTIONS

To assess the economic implications of these projections on the standard of living, one must define and measure the standard of living. An admittedly crude, but commonly used, measure of the standard of living is GNP per capita. It does not capture changes in the distribution of real income among the population, but, for an economically advanced country like the United States, it is deemed useful in sketching the prospects for future economic growth. Three scenarios are developed:

Scenario 1: what growth in the nation's capital stock would be required to keep real GNP/capita growing at about 1.85 percent per year, its actual growth rate from 1948 to 1989?

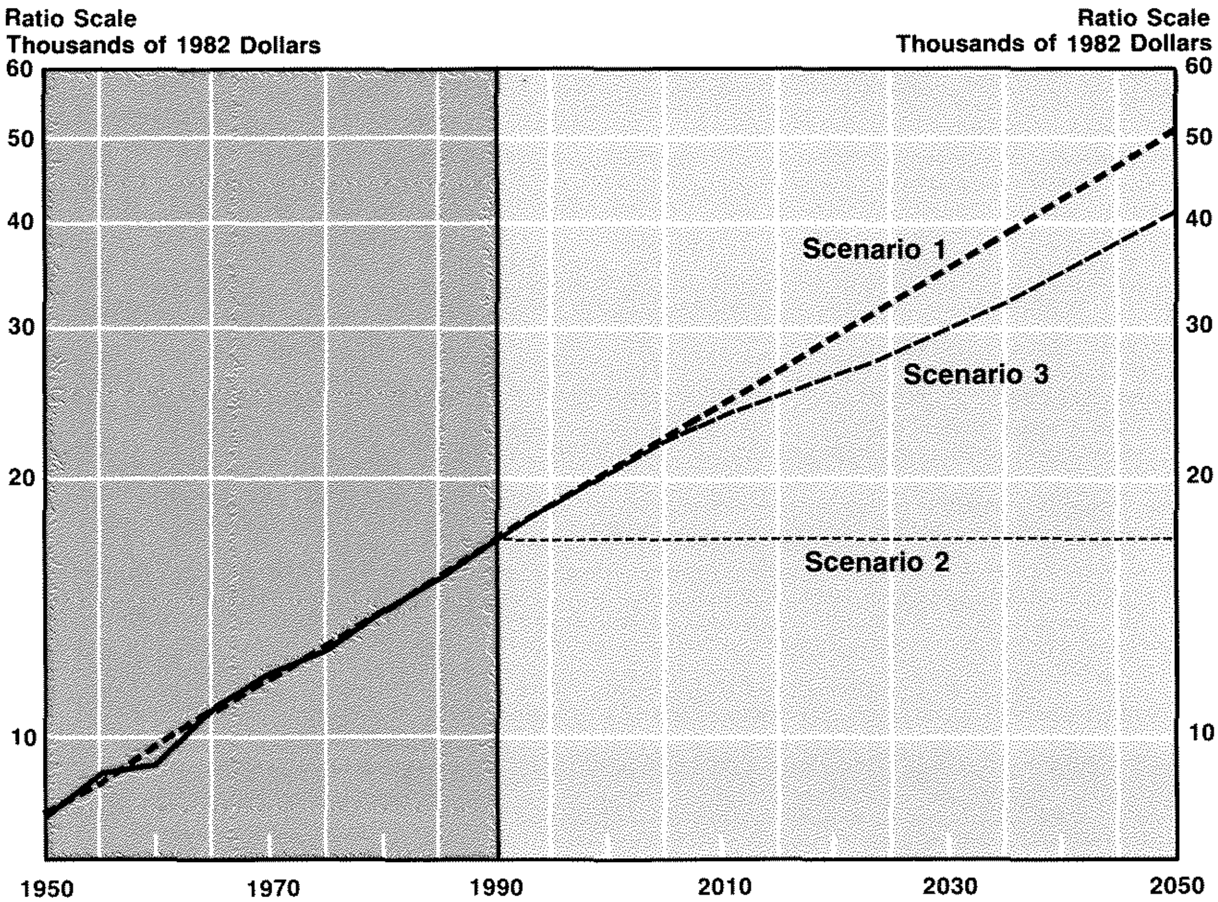
Scenario 2: what growth in the nation's capital stock would be required if real GNP/capita remained constant at its 1990 value? In this case, there would be zero growth (no change) in the nation's standard of living.

Scenario 3: what would the growth in GNP/capita be if the capital stock grew at its 1948-89 trend rate? This is an intermediate case, between scenario 1 and 2.

Figure 5 depicts these alternative standard-of-living assumptions graphically.[8]

[8]Note that graphing scenario 3 gets ahead of our story: with regard to GNP per capita, it is a result rather than an assumption.

Figure 5
Real GNP Per Capita



Capital Stock Implications

Deriving the capital stock or GNP per capita specified in the scenarios described above requires the use of an estimated production function. The function chosen was developed by Rasche-Tatom (1977) and updated in Tatom (1988). This production function is Cobb-Douglas in form and includes an implicit time trend (proxy for technical change) and the relative price of energy (for details, see appendix). Based on this estimated production function, each standard-of-living assumption includes a component of growth equal to 0.81 percent per year because of an implicit time trend.[9]

The derived results for the capital stock are summarized in table 3 and shown in figure 6. Table 3 decomposes the growth of GNP per capita in two ways: (1) its simple components, GNP and population, and (2) the contribution of resource inputs and the employment-population ratio. The decomposition for the 1948-89 period shows that GNP per capita grew rapidly, in part, because employment growth dramatically exceeded population growth. For the 1990-2050

[9]This estimate of technical progress is of critical importance in deriving the estimates of capital stock requirements. The estimate of 0.81 per year is optimistic; estimating the production function with a zero-one dummy suggests that technical progress has been only 0.45 percent annually since 1968.
Energy price shocks have important effects on GNP and the standard of living, but for these projections the relative price of energy is assumed to be unchanged from its 1989 value. Generally, such shocks cannot be predicted.

Table 3
Decomposition of Per Capita GNP Growth[1]

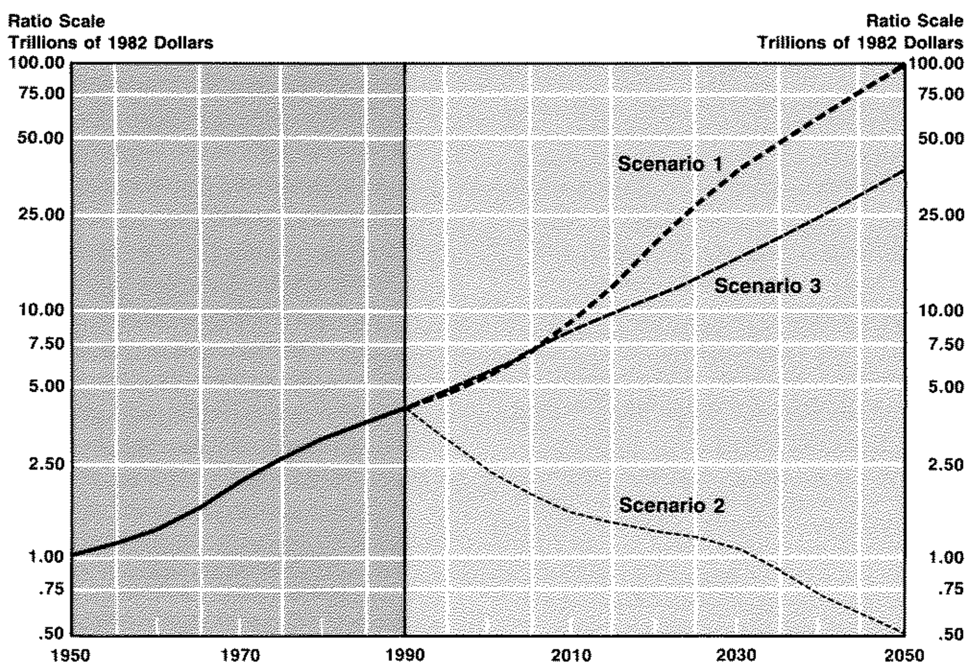
	Historical 1948-89	Projected: 1990-2050 Scenario 1 Trend growth in GNP/capita	Scenario 2 Zero growth in GNP/capita	Scenario 3 Trend growth in capital stock
Real GNP growth	3.27%	2.17%	0.30%	1.78%
Minus: population growth	1.30	0.30	0.30	0.30
Equals: per capita GNP growth	1.97[2]	1.87[2]	0.00	1.48
Or				
Real GNP growth	3.27	2.17	0.30	1.78
Technical progress	0.81	0.81	0.81	0.81
Plus: employment contribution	1.36	0.21	0.21	0.21
Employment growth	1.72	0.26	0.26	0.26
Times: elasticity	(0.79)	(0.79)	(0.79)	(0.79)
Plus: capital stock contribution	0.76	1.14	−0.70	0.76
Capital stock growth	3.60	5.45	−3.33	3.60
Times: elasticity	(0.21)	(0.21)	(0.21)	(0.21)
Minus: employment growth	1.72	0.26	0.26	0.26
Plus: change in employment-population ratio	0.42	−0.04	−0.04	−0.04
Employment growth	1.72	0.26	0.26	0.26
Minus: population growth	1.30	0.30	0.30	0.30
Equals: per capita GNP growth[3]	1.97[2]	1.87[2]	0.00	1.48

[1] Some components do not add to total because of rounding or production function error.

[2] Rates calculated from initial year to terminal year, which differs from rate in text which is trend rate fitted to 1948-89.

[3] $\dot{X} - \dot{P} = (\dot{X}-\dot{L}) + (\dot{L}-\dot{P})$, i.e., productivity growth plus change in employment-population ratio. The contribution of the change in the relative price of energy was zero historically, and zero by assumption for the projection period.

Figure 6
Capital Stock Requirements[1]



[1]Net real nonresidential fixed capital stock

period, the employment and population projections place a greater burden on capital stock growth in achieving GNP growth.

As figure 6 shows, the differences in the necessary capital stock among the alternatives are huge by 2050. Expressing these requirements in terms of rates of change of the capital stock from 1990 to 2050 (also shown in table 3), the differences are more understandable. To achieve the 1948-89 trend growth rate in real GNP per capita, given the population-employment projections, would require a 5.45 percent average rate of growth in the capital stock, much faster than the 3.60 percent trend rate of growth from 1948-89.

The second alternative of no growth in real GNP per capita implies a steady decline in the capital stock. This reflects most clearly the role of technical change in the production function. A combination of declining capital stock and continuing growth in technical change is quite implausible, however. If the rate of technical progress were zero, the capital stock would have to rise slightly at a 0.44 percent average rate, rather than fall, to keep the standard of living constant at the 1990 level.

Investment Ratio

An alternative way of examining these results is to look at the annualized first difference of the capital stock relative to GNP, that is, the investment ratio.[10] The annualized difference of the capital stock represents the flow of net real nonresidential fixed investment in plant and equipment. The investment ratio averaged 3.06 percent during 1948-89, with a maximum value of 4.29 percent in 1966.

The impossibility of maintaining a rise in the standard of living at the 1948-89 trend rate becomes obvious in figure 7; it would require a sharp and continuing increase in the investment ratio after 2000. The investment ratio averages 16 percent from 1995 to 2050.

The no-growth alternative, of course, implies a steady decline in the capital stock and a negative investment-GNP ratio. If technical progress were zero, however, the capital stock requirements would be higher. An average investment ratio of 0.42 percent would be required for 1995-2050 under such assumptions.

The final alternative—a capital stock that continued to rise at its 1948-89 trend rate—implies a slowly rising investment ratio that reaches 10 percent by 2050, still well above any value it reached during 1948-89. For this scenario, the growth of per capita real GNP varies over the projection period depending on the projected growth rate of employment; however, it averages about 1.48 percent from 1990 to 2050 (see figure 5).

OTHER ANALYTICAL RATIOS

Productivity of Labor

Another way to assess the likelihood of alternative assumptions is to examine their implied productivity trends relative to historical experience. These trends are shown in figure 8. Scenario 1 implies a growth rate for productivity of 1.90 percent from 1990 to 2050, much faster than its 1.52 percent trend rate of growth from 1948-89. The no-growth scenario requires only a 0.04 percent rate of increase in productivity. Scenario 3 yields a growth rate of productivity of 1.52 percent, or the same as the trend rate from 1948-89.[11]

Capital-Labor Ratio

An examination of capital-labor ratios can also be used to assess the feasibility of the three standard-of-living alternatives. The implied capital-labor ratios for these scenarios, summarized in figure 9, must be interpreted with care. Over the 1948-89 period, the capital-labor ratio rose slowly, at a 1.85 percent annual rate. More significantly, however, its rate of increase has declined over this period, from a 3.2 percent growth rate from 1948-58, to a 2.1 percent rate from 1958-75, to a 0.6 percent rate of growth since 1975. With this pattern in mind, calculation of capital-labor ratios for the alternative scenarios does not yield clear-cut conclusions.

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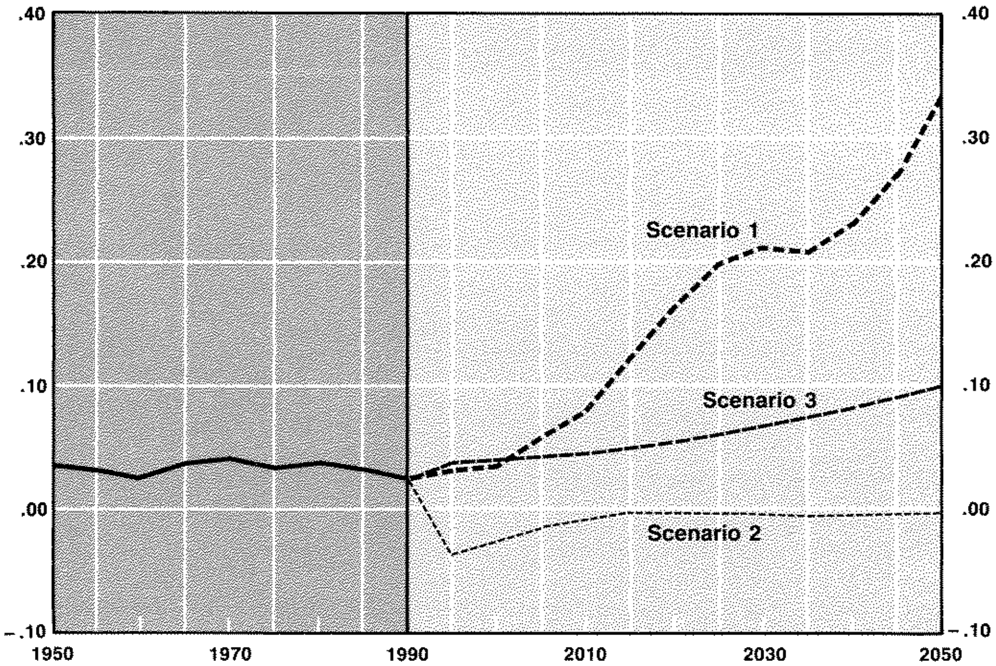
[10]Since the projections were for every fifth year starting with 1995, investment was calculated as:

$$\Delta K_t = ((K_t/K_{t-5})^{0.2} - 1) \cdot K_t .$$

This was divided by the level of GNP in year t to get the investment ratio.

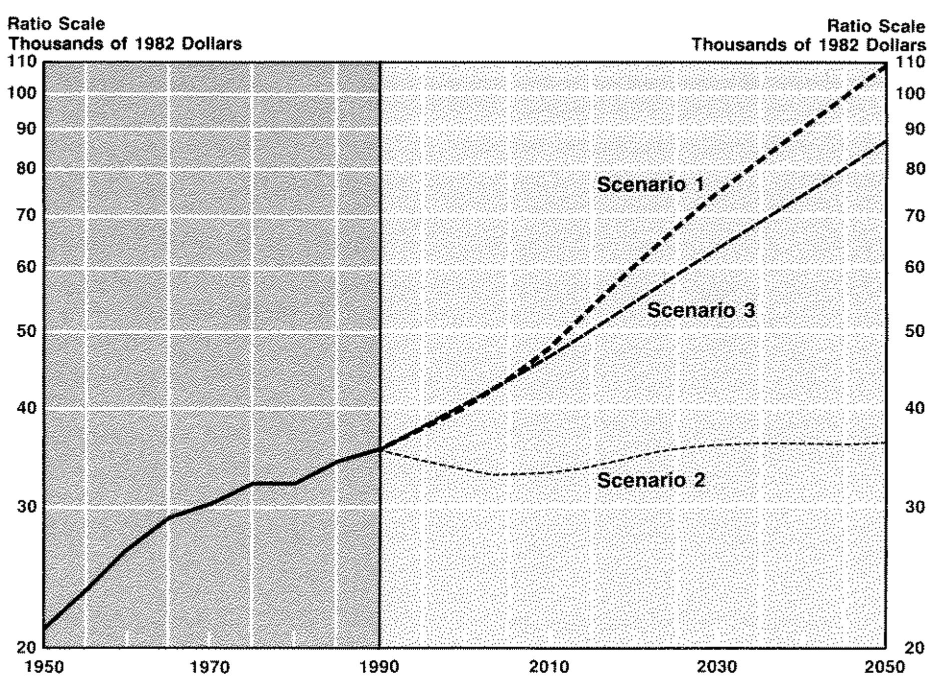
[11]In general, implied productivity trends shed little light on feasibility because they follow from the per capita GNP assumptions; productivity growth differs from per capita GNP growth by the difference between projected population growth and employment growth.

Figure 7
Investment Ratio[1]



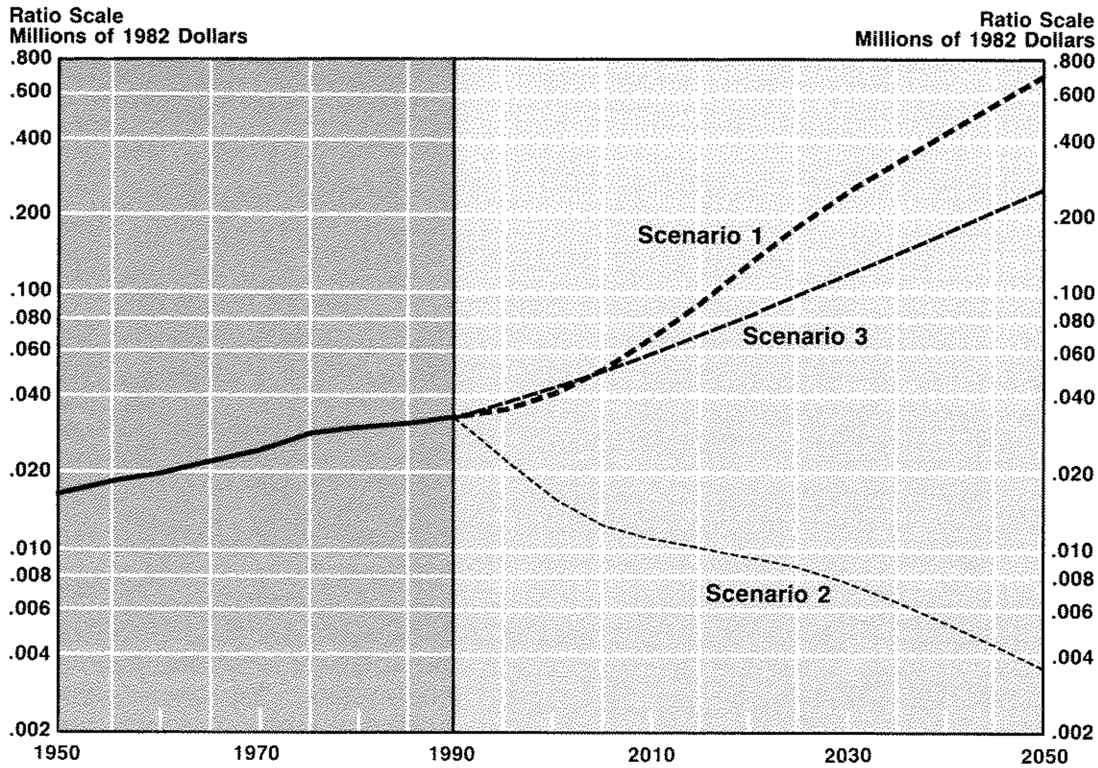
[1]Change in net real capital stock divided by real GNP

Figure 8
Productivity[1]



[1]Real GNP per worker

Figure 9
Capital-Labor Ratio[1]



[1]Net real capital stock per employed worker

Scenario 1 requires a rise in the ratio to 5.18 percent a year from 1990 to 2050, much faster than that which occurred even during the 1948-58 period. The zero-growth case does not match historical experience at all. The trend-growth-of-capital scenario requires a rise in the capital-labor ratio of 3.34 percent per year. While this is in line with the early post-war experience, it is much faster than the more recent experience.

CAPITAL REQUIREMENTS FOR ALTERNATIVE POPULATION PROJECTIONS

The capital stock requirements associated with the Census Bureau's high and low population projections are summarized in table 4. The basic assumptions about participation rates, unemployment rates and the production function are the same as used above for the middle-series population projection. The high-series population projection is 38 percent higher than the middle projection in 2050, while the low-series projection is 23 percent lower. Despite this wide variation in population, the capital requirements do not differ greatly from those derived with the middle-series projection. The differences are relatively small because, as shown in figure 10, the pattern of movement of the employment-population ratio over the 1990-2050 period differs very little across the alternative projections. This ratio is the key factor underlying the crucial importance placed on capital stock growth in achieving the particular growth rates in per capita income that were examined. In fact, the high series population projection requires the largest capital stock, because its projected age distribution has the smallest proportion of the population actually working.

CONCLUSIONS

The growth of the nation's output depends on the growth of its labor force, its capital stock

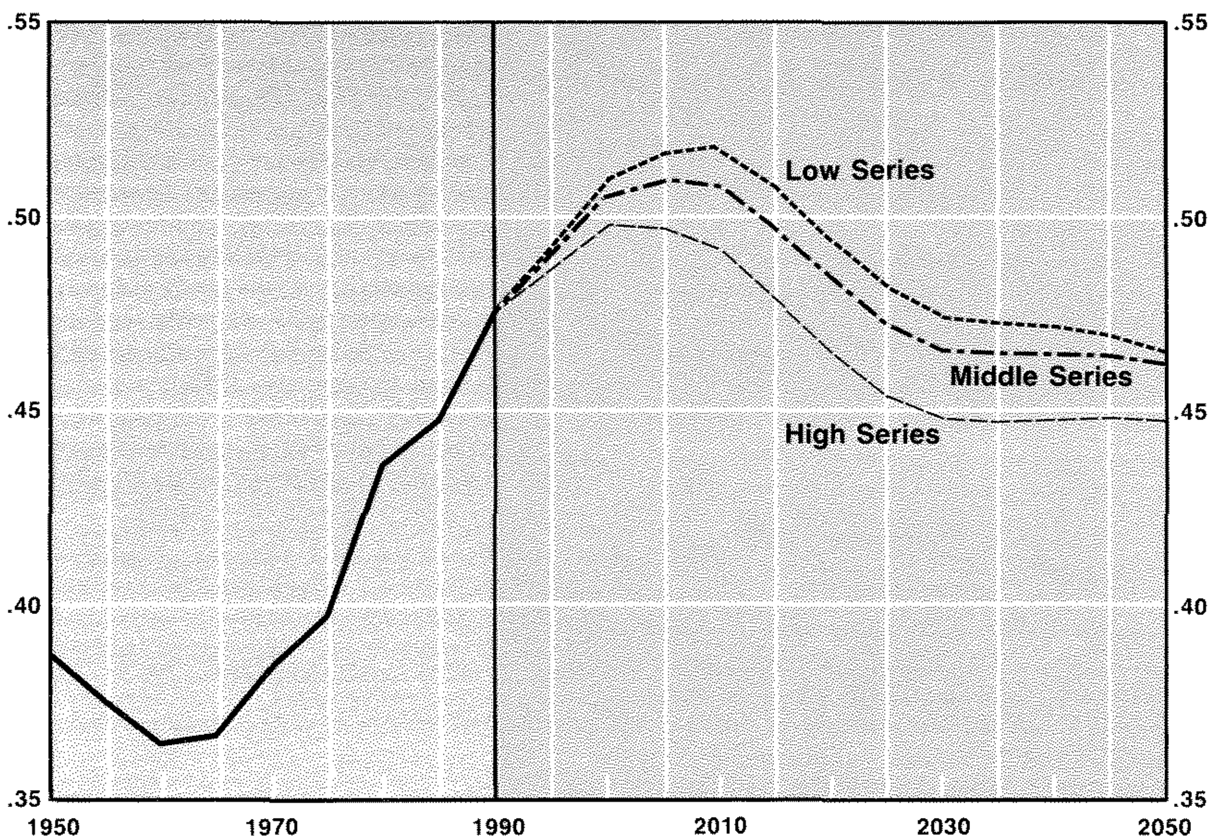
Table 4

Achieving Historical Trend Growth of Real GNP Per Capita in 1990-2050: Alternative Population Projections

	Low population series	Middle population series	High population series
Population	−0.13%	0.30%	0.83%
Total civilian employment	−0.17	0.26	0.74
Real GNP	1.73	2.17	2.70
Capital stock	4.89	5.45	6.17
Investment ratio[1]	13.69	16.02	19.93

[1] Change in capital stock as a percent of real GNP: average for 1995-2050

Figure 10
Employment-Population Ratios: Alternative Population Projection Series



and technical progress. The Census Bureau has released projections of U.S. population into the 21st century. Their middle projection shows slowing growth in the population through 2040, followed by a slight decline in the population itself for the rest of the outlook period. They also project that the median age of the population will rise steadily, implying that the work force as a proportion of the total population will eventually decline. Can a rising standard of living be achieved in the face of such projections?

The conclusions derived from the study are as follows:

(1) Achieving a rising standard of living at the rate experienced from 1948-89 does *not* appear possible. Based on an estimated technical progress of 0.8 percent per year, the nation's capital stock would have to grow at a 5.5 percent average annual rate from 1990 to 2050, well above its 3.6 percent rate of growth from 1948 to 1989. Achieving this higher capital stock growth would require an investment-GNP ratio that reaches 33 percent by 2050.

(2) Maintaining the 1990 standard of living at a constant level requires that the capital stock decline at a 3.3 percent rate. This case was not intended to be taken seriously; it is presented solely to show, given this analysis, why zero growth (or less) is an unlikely possibility.

(3) Continued growth in the capital stock at its 1948-89 trend rate yields a growth rate in per capita real GNP of 1.5 percent. However, to achieve this would require a steadily rising investment-GNP ratio that reaches 10 percent by 2050. While achieving this ratio would be unusual, the required ratio would be within the range of historical experience until 2015.

Left unexamined in this study is an analysis of the prospects for saving.[12] Capital stock requirements will not be achieved unless resources are released for investment by abstaining from present consumption. By using historical trends in realized investment-GNP ratios, however, an approximate determination of feasible growth paths was possible. Increasing the standard of living at the 1948-89 pace appears impossible. On the other hand, achieving a rising standard of living in the 1 to 1.5 percent range appears achievable in light of historical experience.

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Wall Street Journal, November 7, 1989.

[12]Demographic projections should produce a rise in the saving rate as the baby-boom generation matures, before falling as they reach retirement age. Such projections are tenuous, however, as pointed out by Aaron, Bosworth and Burtless (1989), p. 139: "Demographic trends appear to bear little relation to past rates of private saving . . ."

Appendix
Production Function

The production function used in this study is a version of the one originally developed by Rasche and Tatom (1977) and modified and updated in Tatom (1988). It is a Cobb-Douglas function with labor, capital and energy specified as resource inputs. GNP (in 1982 dollars) was estimated as a function of total civilian employment, net real nonresidential fixed capital stock adjusted for capacity utilization and the relative price of energy. Using annual data for 1954-89 (omitting the early post-war years and the Korean War), the following estimate was obtained where dln is the first difference of the logarithm (t-values in parentheses):

$$\text{dln}\left(\frac{X}{KU}\right) = \underset{(3.88)}{.0081309} + \underset{(19.85)}{.787}\ \text{dln}\left(\frac{L}{KU}\right) - \underset{(-2.35)}{.041}\ \text{dln}\ P$$

$\bar{R}^2 = .930$ DW = 1.952
SE = .010 $\varrho = .189$

X = GNP in 1982 dollars
K = net nonresidential fixed capital stock in 1982 dollars
U = Federal Reserve capacity utilization rate (manufacturing)
L = total civilian employment
P = relative price of energy (ratio of producer prices of fuel, related products, and power to the GNP implicit price deflator)

This estimated production function was solved for ln KU and used to derive estimates of the capital stock for the alternative assumptions making use of the GNP estimates implied by those alternatives and the total employment estimates derived from the population projections. The 1989 values of the relative price of energy (=.577) and the capacity utilization rate (=.839) were held constant during the projection period in the derivation of the net real capital stock.