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In This Issue . . .

As population growth in the United States declines, the average age of the population is rising. In the first article of this *Review*, "On Maintaining a Rising U.S. Standard of Living into the Mid-21st Century," Keith M. Carlson examines whether this combination of slowing population and rising age composition bodes ill for maintaining a continuing rise in the nation's standard of living into the next century.

Using Bureau of Census population projections through 2050, along with historical relationships among population, employment, capital stock and output, Carlson calculates the growth rates of the capital stock that would be required to achieve certain rates of increase in the standard of living as measured by GNP per capita. He concludes that achieving a rising standard of living like the one we experienced from 1948 to 1989, 1.9 percent growth in GNP per capita, does not appear possible. A rising standard of living in the 1 to 1.5 percent range does appear achievable, however.

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In the second article of this issue, "The FOMC in 1989: Walking a Tightrope," Michelle R. Garfinkel examines the economic factors that influenced the Federal Open Market Committee's deliberations and decisions in 1989. In reviewing the FOMC's long- and short-run policy decisions, Garfinkel emphasizes how the FOMC sought to balance the risk of greater inflationary pressures against that of a weakening economy.

At the beginning of the year, the threat of a worsening of the underlying trend in inflation drove the formulation of policy. As evidence of a weakening economic expansion accumulated and the outlook for inflation appeared more promising, the FOMC shifted its primary focus to the possibility of a future slowdown in economic activity. The effect of this shift on policy, however, did not emerge immediately, for the FOMC understood that its interpretation of economic data was subject to great uncertainty, and it did not want to jeopardize either the progress that had been made toward achieving its ultimate goal of long-run price stability or its credibility as an inflation-fighter.

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A new theory, called chaos, which offers an explanation for the seemingly random behavior of economic and financial variables, has stirred up considerable interest recently.

In the third article of this *Review*, "A Methodological Approach to Chaos: Are Economists Missing the Point?" Alison Butler looks at how

economics is traditionally modeled and discusses why many of these models exclude, *a priori*, the possibility of chaotic behavior. Chaos is defined and its properties illustrated. The advantages and pitfalls of incorporating chaos into economic modeling are then discussed.

Butler finds that the study of nonlinear dynamics in general, and deterministic chaos in particular, may eventually provide economists with a deterministic explanation for variables that appear to be random.

* * *

In the last article of this issue, we print the Fourth Annual Homer Jones Memorial Lecture. This year's speaker, David Laidler, a professor of economics at the University of Western Ontario, reviews "The Legacy of the Monetarist Controversy." Laidler's paper has two broad themes. The first is that people working in monetary economics in the 1960s and '70s lost sight of the fundamental issues under debate. For example, while original monetarist arguments stressed long-run relationships between changes in the money stock and other variables, a generation of young economists re-estimated traditional relationships with quarterly data, found instability, and concluded that monetarist propositions had been rejected. Laidler views this conclusion to be misplaced because monetarists had never argued they could (or should) model the complicated short-run dynamics that lead to the long-run relationship of interest.

Laidler's second theme is that ideas from New-classical economics, which were seen originally as supporting monetarist thought, actually subverted it. In particular, the transmission mechanism between changes in money and other variables proposed by monetarists was different in fundamental ways from that proposed by New-classical analysis, and empirical studies eventually rejected important New-classical ideas. But by that time, Laidler argues, many economists had confused traditional monetarist principles with those of New-classical analysis. Laidler concludes that the legacy of the monetarist controversy is an uncomfortable one, with important issues yet to be resolved.

* * *

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.

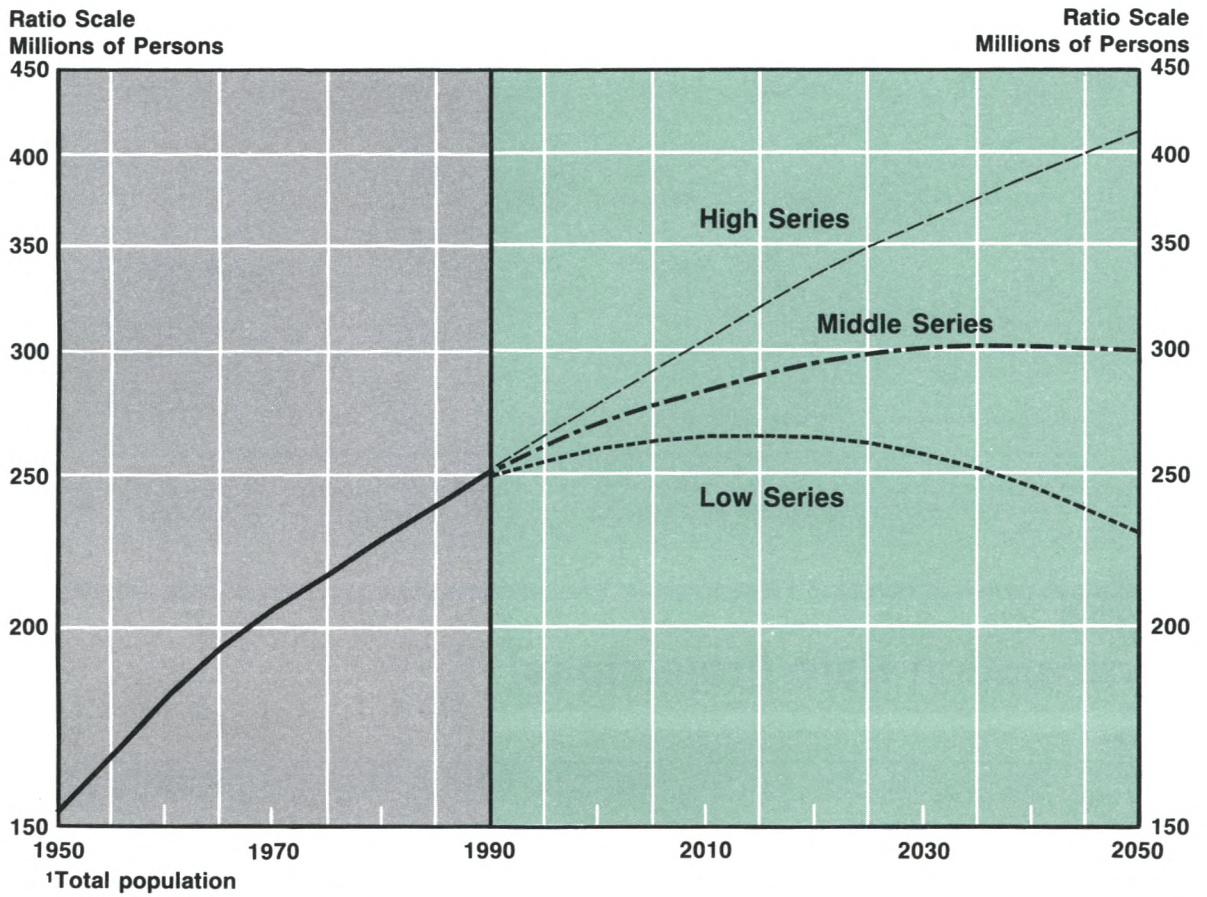
The Bureau of the Census projections are summarized in table 1 and figure 1. Declining population growth is not something new; it has been under way for a number of years. The total population grew at a 1.7 percent annual rate from 1950 to 1960, then slowed to a 1.3 percent rate in the 1960s, before 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]



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

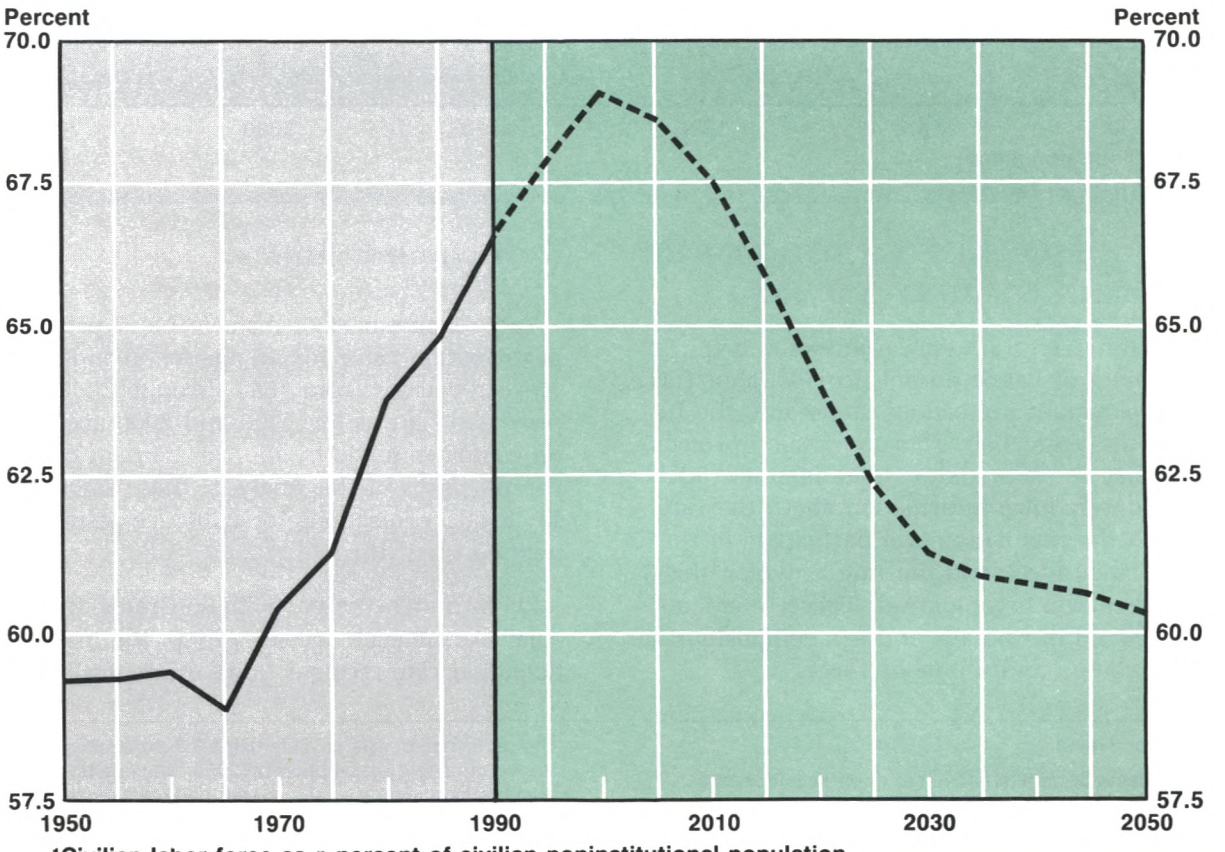
Historical and Projected Paticipation Rates[1]: 1950-2000

	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.

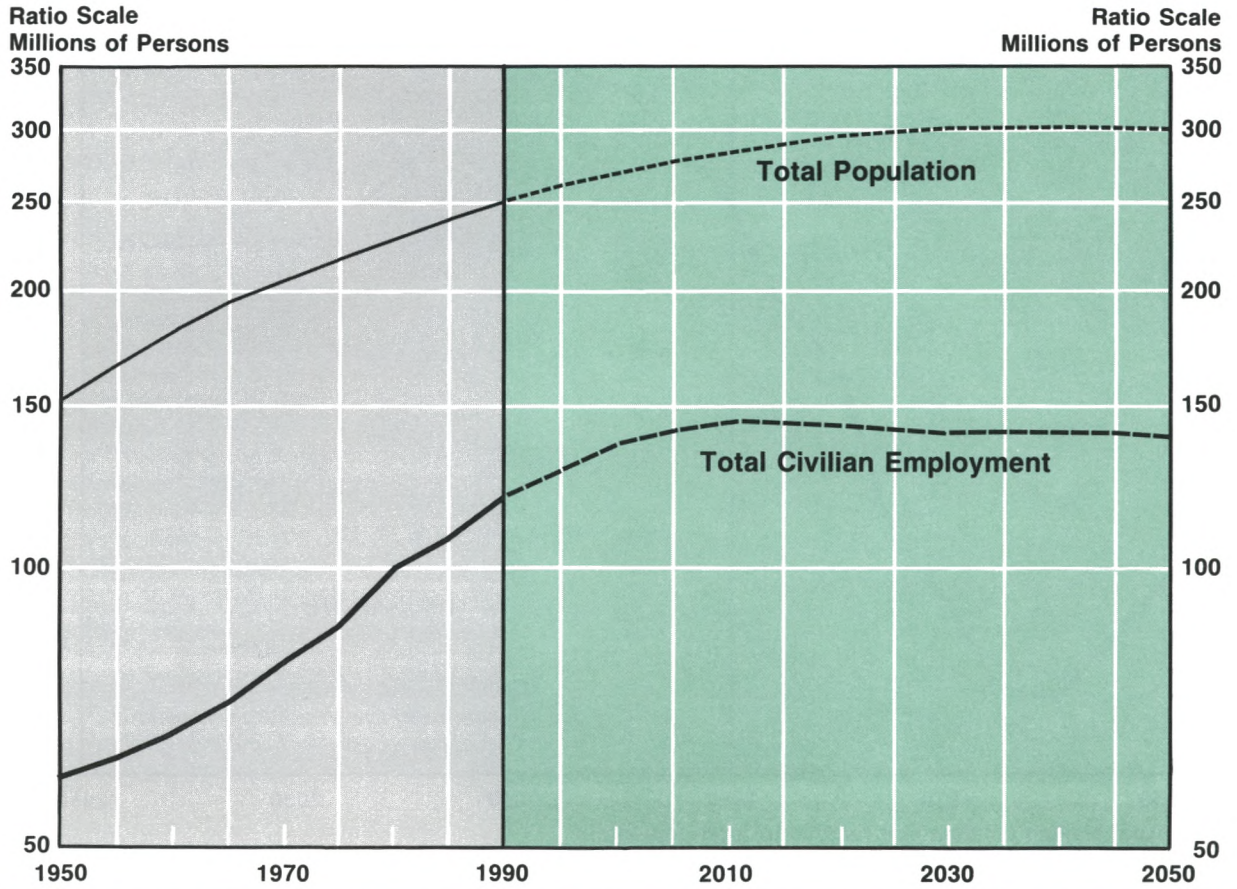
Figure 2

Participation Rate Projections[1]



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

Figure 3
Population and Employment



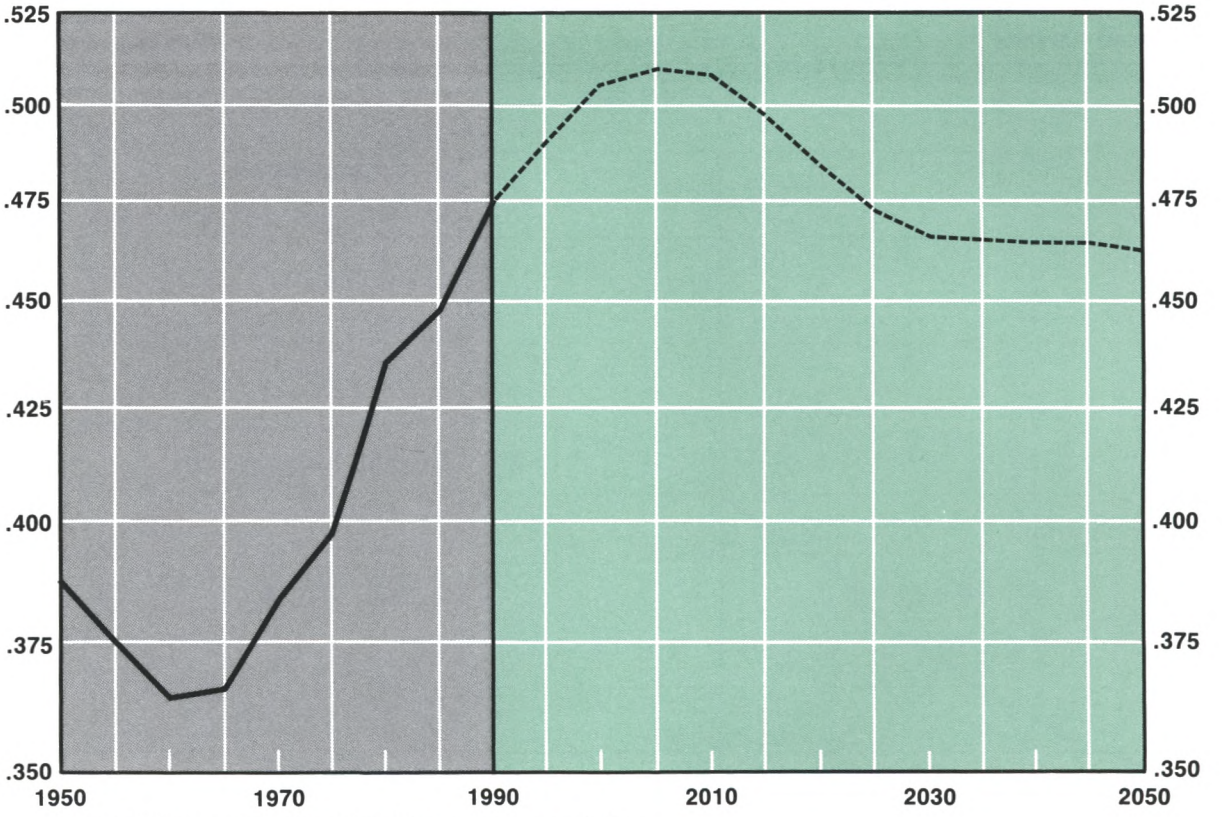
projection period because of the aging trend in the population (see figure 2). This projected decline in the participation rate after 2000 raises doubts as to whether the general standard of living can be sustained by a work force that is shrinking relative to population.

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?

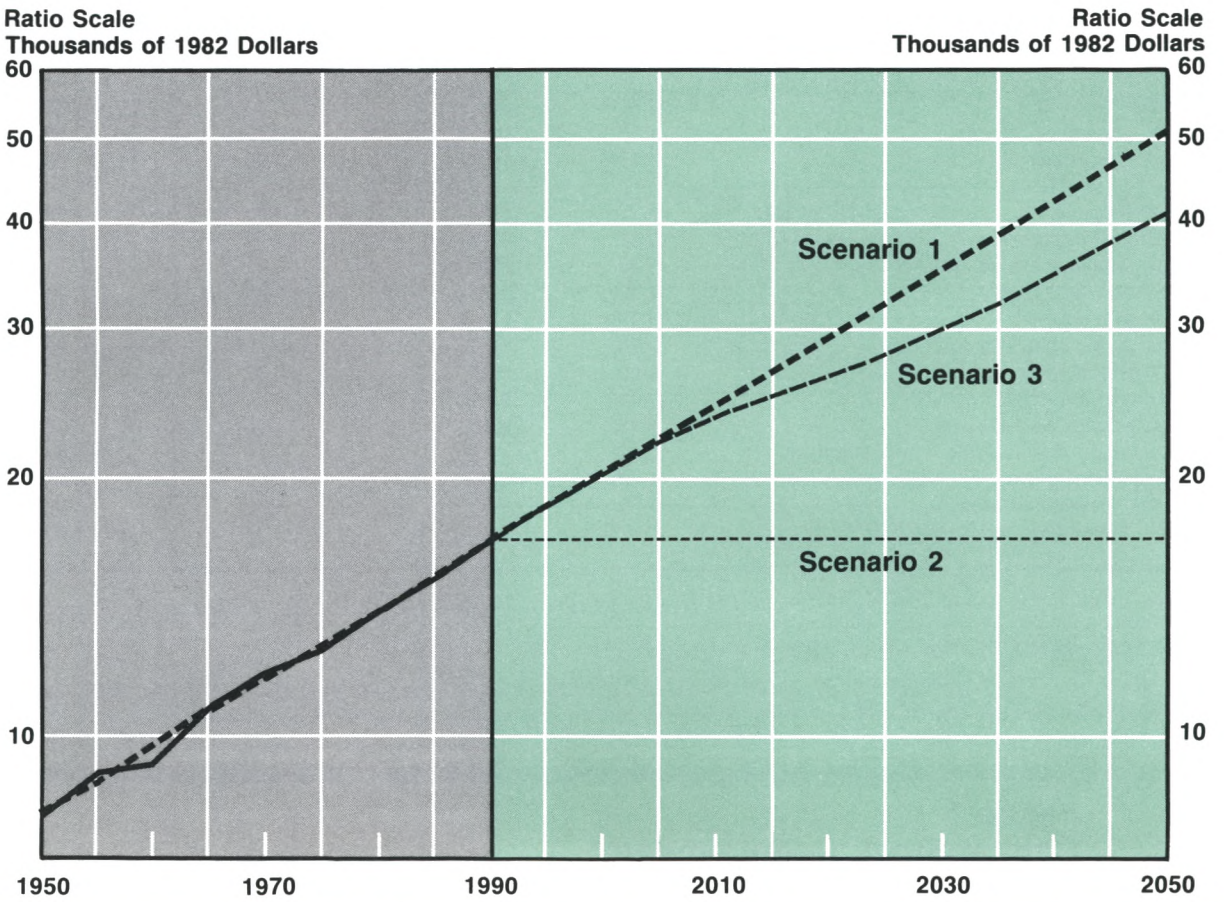
Scenario 2: what growth in the nation's capital stock would be required if real GNP/capita remained constant at its 1990 value? In this case, there would be zero growth (no change) in the nation's standard of living.

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]

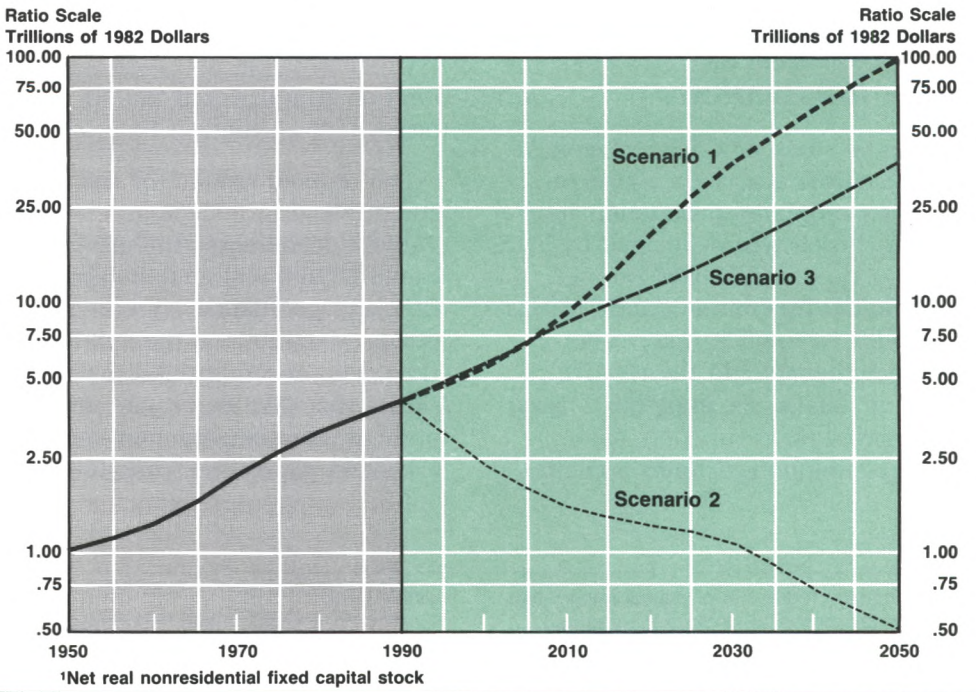
	Historical 1948-89	Projected: 1990-2050 Scenario 1 Trend growth in GNP/capita	Scenario 2 Zero growth in GNP/capita	Scenario 3 Trend growth in capital stock
Real GNP growth	3.27%	2.17%	0.30%	1.78%
Minus: population growth	1.30	0.30	0.30	0.30
Equals: per capita GNP growth	1.97[2]	1.87[2]	0.00	1.48
Or				
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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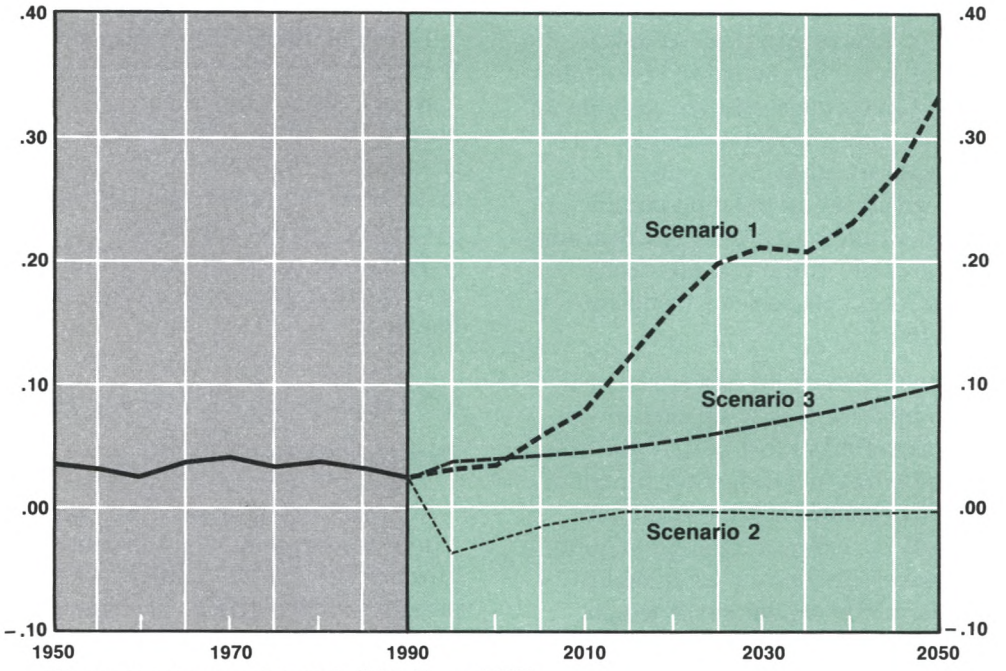
[10]Since the projections were for every fifth year starting with 1995, investment was calculated as:

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

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

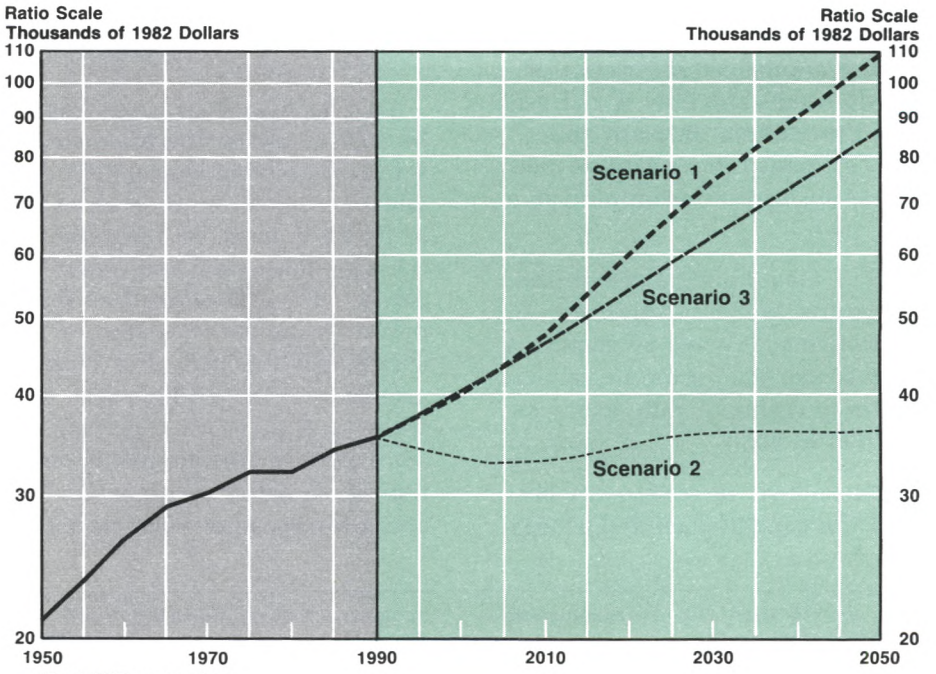
[11]In general, implied productivity trends shed little light on feasibility because they follow from the per capita GNP assumptions; productivity growth differs from per capita GNP growth by the difference between projected population growth and employment growth.

Figure 7
Investment Ratio[1]



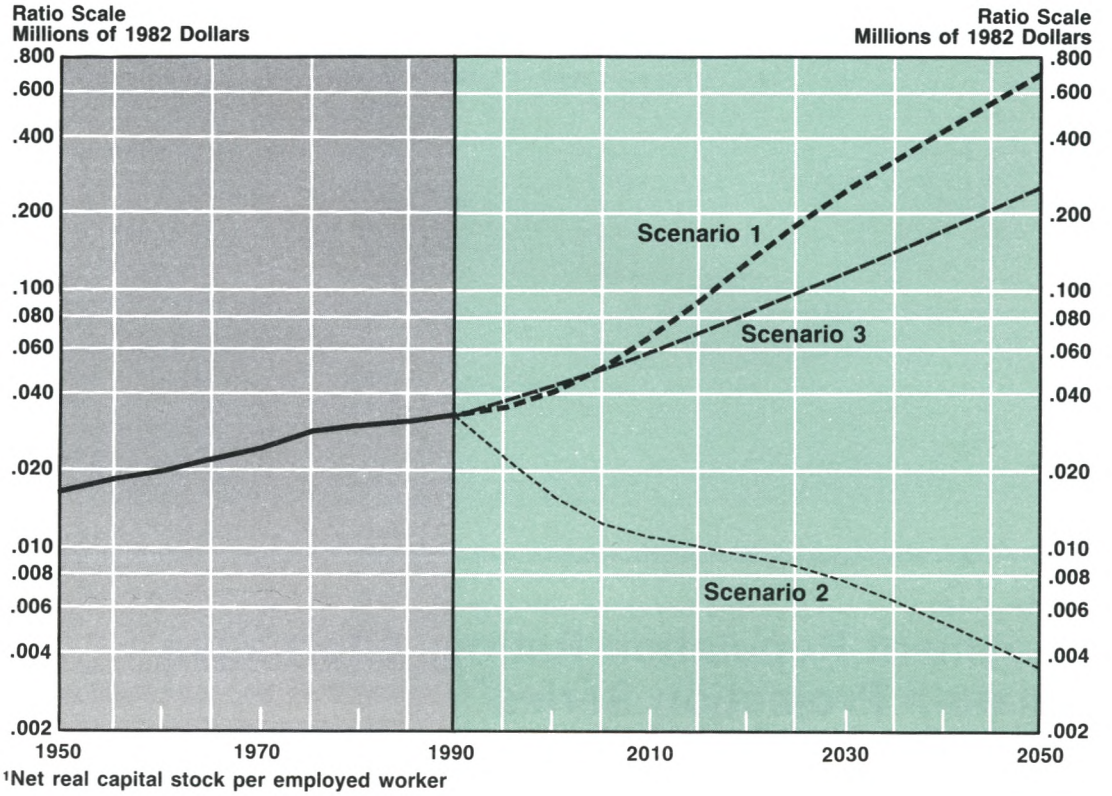
[1]Change in net real capital stock divided by real GNP

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

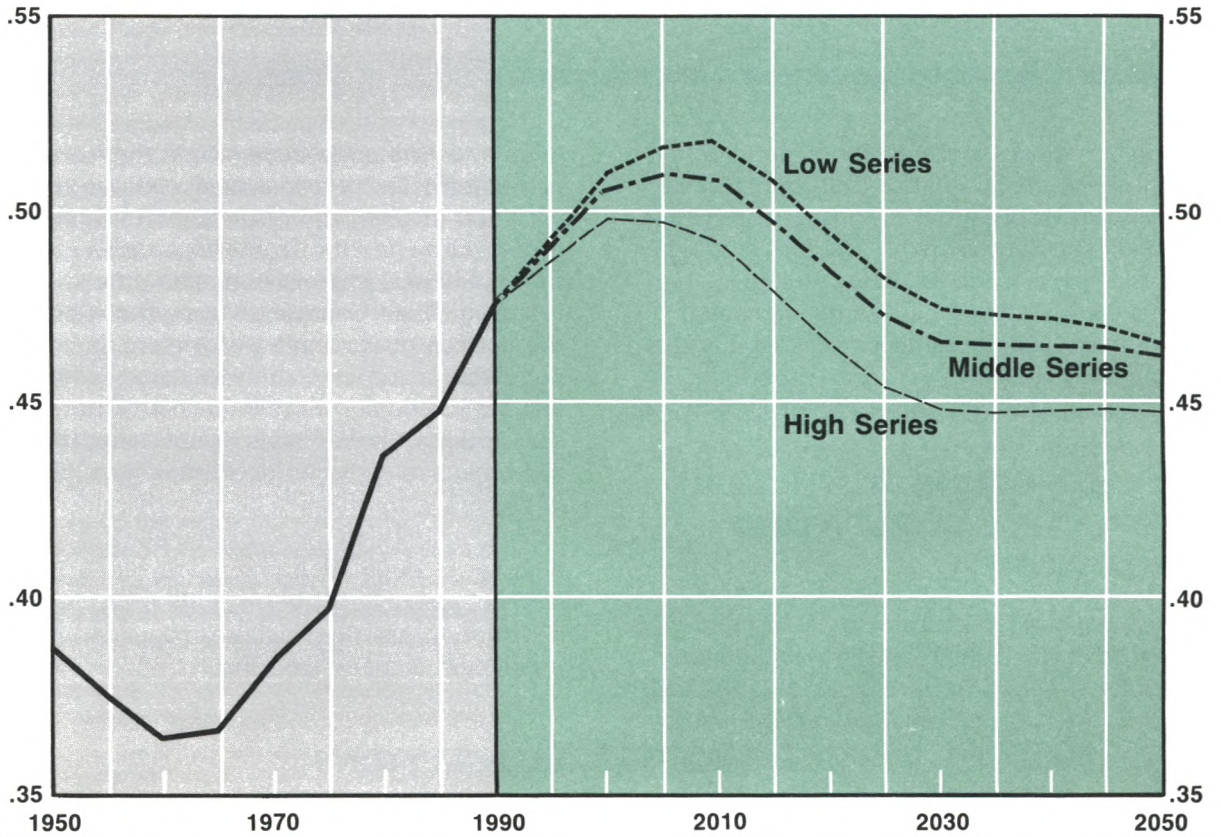
Achieving Historical Trend Growth of Real GNP Per Capita in 1990-2050: Alternative Population Projections

	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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[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 ϱ = .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.

Michelle R. Garfinkel

Michelle R. Garfinkel is an economist at the Federal Reserve Bank of St. Louis. Scott Leitz provided research assistance.

The FOMC in 1989: Walking a Tightrope

THE FEDERAL Open Market Committee (FOMC) sought to balance the risk of inflationary pressures against that of a weakening economy in 1989, the seventh year of the current economic expansion.[1] The changing relative intensity of these risks, as perceived by the FOMC (hereafter, the Committee), influenced the course of monetary policy throughout the year.

Because the Committee believed that long-run price stability is necessary to promote maximum sustainable economic growth over time, the perceived risks of inflationary pressures greatly influenced its decisions early in the year. As the year progressed, however, it became increasingly apparent to the Committee that the economic expansion was weakening. At the same time, the Committee's perception of the trend in inflation became slightly more optimistic. Accordingly, the weight that the Committee attached to reducing the risks of a slowdown in economic activity increased somewhat throughout the second half of 1989. Nevertheless, the Committee's concern about future price pressures and the importance of maintaining its own credibility as an inflation-fighter remained in the forefront of its deliberations.

This article reviews the formulation of monetary policy by the Committee in 1989. The discussion focuses on how changing economic conditions influenced the Committee's decisions as it balanced the risk of future inflation against that of a future slowdown in economic activity.

LONG-RUN OBJECTIVES

The Board of Governors of the Federal Reserve System reports to Congress twice a year on its annual growth rate targets for the monetary and debt aggregates. The one-year target periods run from the fourth quarter of the previous year to the fourth quarter of the current year. These reports are mandated by the Full Employment and Balanced Growth Act of 1978 (or the Humphrey-Hawkins Act). After its first meeting of the year in February, the Committee submits a report on its monetary and debt growth objectives for the current year. In July, upon reviewing the progress it has made toward achieving its objectives for the

NOTE: Citations to the Record refer to the "Record of Policy Actions of the Federal Open Market Committee" as published in various issues of the *Federal Reserve Bulletin.* Citations to "Report" refer to the "Monetary Policy Report to the Congress," which is also published in the *Federal Reserve Bulletin.*

[1]See the shaded insert on pages 18 and 19 for a description of the Committee's membership during 1989.

Organization Of The Committee

The Federal Open Market Committee (FOMC) consists of 12 members, including the seven members of the Federal Reserve Board of Governors and five of the 12 Federal Reserve Bank presidents. The chairman of the Board of Governors is traditionally elected chairman of the Committee. The president of the New York Federal Reserve Bank, also by tradition, is elected the Committee's vice chairman. All Federal Reserve Bank presidents attend Committee meetings and present their views, but only those who currently are members of the Committee are permitted to vote. In previous years, the four memberships that rotate among the Bank presidents were held for one-year terms commencing March 1 of each year. In 1989, however, the memberships were only for 10 months so that, starting in 1990, the one-year terms would be on a calendar-year basis. The president of the New York Federal Reserve Bank is a permanent voting member of the Committee.

Members of the Board of Governors at the beginning of 1989 included Chairman Alan Greenspan, Vice Chairman Manuel H. Johnson, Wayne K. Angell, H. Robert Heller, Edward W. Kelley, John P. LaWare and Martha R. Seger. Mr. Heller resigned as a member of the Committee during the year. His position was not filled during 1989.

The following Bank presidents voted at the meeting on February 7-8, 1989: E. Gerald Corrigan (New York), Robert P. Black (Richmond), Robert P. Forrestal (Atlanta), W. Lee Hoskins (Cleveland) and Robert T. Parry (San Francisco). In March, the Committee membership changed and the presidents' voting positions were filled by E. Gerald Corrigan (New York), Roger Guffey (Kansas City), Silas Keehn (Chicago), Thomas C. Melzer (St. Louis) and Richard F. Syron (Boston).

The Committee met eight times at regularly scheduled meetings during 1989 to discuss economic trends and decide the future course of open market operations.[1] As in previous years, telephone consultations occasionally were held between scheduled meetings. At the end of each scheduled meeting, a directive was issued to the Federal Reserve Bank of New York. Each directive contained a short summary of economic developments, the general economic goals sought by the Committee, its long-run monetary growth objectives, and instructions to the Manager for Domestic Operations at the New York Bank for the conduct of open market operations during the new intermeeting period. These instructions were stated in terms of the degree of pressure on reserve positions to be sought or maintained. The reserve conditions stated in the directive were deemed consistent with specific short-term growth rates for M2 and M3 which, in turn, were considered consistent with desired long-run growth rates for these monetary aggregates. The Committee also specified intermeeting ranges for the federal funds rate. These ranges provided one mechanism for initiating consultations between meetings whenever it appeared that the constraint on the federal funds rate was inconsistent with the objectives for the behavior of the monetary aggregates.

The Manager for Domestic Operations has the primary responsibility for formulating plans regarding the timing, types and amounts of daily buying and selling of securities in fulfilling the Committee's directive. Each morning the Manager and his staff plan the open market operations for that day. This plan is developed on the basis of the Committee's directive and the latest developments affecting money and credit market conditions, the growth of monetary aggregates, and bank reserve conditions. The Manager also consults with the Board's staff. Prevailing market conditions and open market operations that the Manager proposes to execute are discussed each morning in a telephone conference call involving the staff at the New York Bank, one voting president at

[1]No meetings were held in January, April, June or September.

another Reserve Bank and staff at the Board. Other members of the Committee may participate and are informed of the daily plan by internal memo or wire.

The directives issued by the Committee and a summary of the discussion and reasons for Committee actions are published in the "Record of Policy Actions of the Federal Open Market Committee." The "Record" for each meeting is released a few days after the next scheduled Committee meeting. It subsequently appears in the *Federal Reserve Bulletin*. In addition, "Records" for the entire year are published in the annual report of the Board of Governors. The record for each meeting in 1989 included:

(1) a staff summary of recent economic developments—such as changes in prices, employment, industrial production and components of the national accounts—and projections of general price, output and employment developments for the year ahead;

(2) a summary of recent international financial developments and the U.S. foreign trade balance;

(3) a summary of open market operations, growth of the monetary aggregates and bank reserves and money market conditions since the previous meetings;

(4) a summary of the Committee's discussion of the current and prospective economic and financial conditions;

(5) a summary of the monetary policy discussion of the Committee;

(6) a policy directive issued by the Committee to the Federal Reserve Bank of New York;

(7) a list of the members' votes and any dissenting comments; and

(8) a description of any actions regarding the Committee's other authorizations and directives, and reports on any actions that might have occurred between the regularly scheduled meetings.

first half of the year, the Committee decides whether to adjust or retain its target for the current year and establishes tentative targets for the following year. Shortly after the July meeting, a report of the Committee's decisions is submitted to Congress. Table 1 summarizes the Committee's long-run monetary growth objectives for 1989 as reported to Congress.

As was the case in the previous two years, the Committee did not establish a target range for M1 in 1989. The Committee believed that the unpredictable relation of M1 to economic activity and prices did not warrant reliance on this aggregate as a guide to the implementation of monetary policy.[2]

To underscore its commitment to resist future inflationary pressures and to make progress toward reasonable price stability, the Committee reaffirmed the 1989 targets for M2 and M3, 3 to 7 percent and 3½ to 7½ percent, respectively, that had been set tentatively in July 1988.[3] These target ranges for M2 and M3 were 1 and ½ percentage points, respectively, lower than those established for 1988.

The Committee also decided to maintain the 4 percentage-point spreads between the upper and lower bounds of the target ranges for the two broad monetary aggregates. Until two years ago, this spread had been 3 percentage points. The wider ranges were adopted in 1988 when the Committee concluded that the relations of M2 and M3 growth to economic growth and inflation had become considerably more variable and, therefore, that estimates of growth rates for these aggregates that would be consistent with the Committee's objectives for the economy were subject to greater uncertainty. Forecasting the appropriate growth rates was made more difficult by the Committee's uncertainty about the impact of future developments on thrift institutions and the subsequent effect on the

[2]Record (May 1989), pp. 357-58. See Hafer and Haslag (1988), who discuss the Committee's decision to omit a target range for M1.

[3]Report (March 1989), p. 108.

Table 1
The FOMC's Long-Run Operating Ranges

Date of meeting	Target period	Ranges M2	Ranges M3
June 29-30, 1988[1]	IV/1988-IV/1989	3-7%	3.5-7.5%
February 7-8, 1989[2]	IV/1988-IV/1989	reaffirmed	reaffirmed
July 5-6, 1989	IV/1988-IV/1989	reaffirmed	reaffirmed
July 5-6, 1989[3]	IV/1989-IV/1990	3-7%	3.5-7.5%

[1] Ms. Seger dissented. She wanted to retain the 4-8 percent target ranges for M2 and M3 at that time in light of the uncertainty about the economic outlook.

[2] Mr. Hoskins dissented. He believed that money growth should be toward the low end of the ranges if any reasonable progress were to be made in reducing inflation. In his view, establishing lower target ranges would emphasize the System's perseverance in reducing inflationary pressures.

[3] Mr. Keehn dissented. He favored reducing the target ranges to communicate the System's adherence to its anti-inflationary commitment.

growth of the monetary aggregates.[4] The wider target ranges were intended to give the Committee leeway to achieve its long-run objectives of maximum sustainable economic growth and, eventually, price stability.

By the early July meeting, M2 and M3 were growing at rates at or below the lower bounds of their respective target ranges. Through June, M2 growth was estimated to be 1 percentage point below its range and M3 growth was estimated to be at the lower end of its range. Nevertheless, in the context of recent declines in market interest rates, the Board's staff forecasted that the stronger growth exhibited by these aggregates since the middle of May would continue, thereby bringing the growth rates of M2 and M3 comfortably within their target ranges by the fourth quarter. Because it believed that these expected growth rates would be compatible with its objectives for economic growth and progress toward price stability, the Committee reaffirmed its 1989 targets for M2 and M3 in the July Report.[5]

Table 2
Target Ranges and Actual Money Growth in 1989

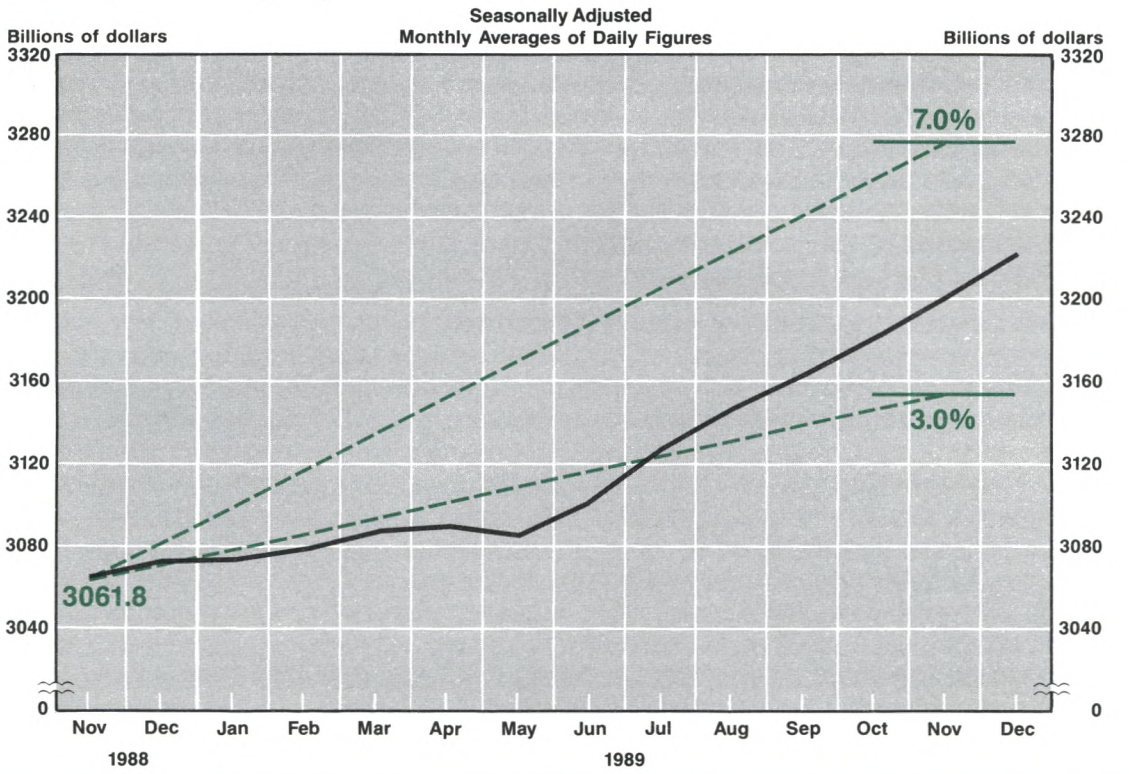
Aggregate	Target range[1]	Actual
M2	3-7%	4.6%
M3	3.5-7.5	3.3

[1]The target period for M2 and M3 growth is from IV/1988 to IV/1989.

[4]Record (May 1989), p. 357. The wide range of possible effects of future developments on thrift institutions and subsequent effects on money growth made the staff's money growth forecasts subject to considerable uncertainty. See Garfinkel (1989) for a discussion of the Committee's motivation for adopting the wider M2 and M3 target ranges.

[5]Report (August 1989), pp. 528-29. Also see Record (October 1989), p. 693. It should be noted that all money growth rates reported here are revised figures, as of February 21, 1990, incorporating the February 1990 benchmark and seasonal revisions. The reported numbers for M2 growth also incorporate the redefinition of M2 that now includes thrift overnight repurchase agreements.

Figure 1
Money Stock (M2)



The July Report also stated that the 1989 target ranges for M2 and M3 would be extended tentatively to 1990. While the Committee recognized that a further reduction in the growth of the monetary aggregates would be more consistent with attaining price stability over time, many members believed that more rapid M2 growth might be necessary to promote reasonable growth in economic activity in 1990. Reductions in the ranges would increase the likelihood of making policy appear unpredictable by increasing the possibility of a reversal later or of having to tolerate growth rates exceeding the lower target ranges. The targets for 1990 could be adjusted in February, if appropriate.[6]

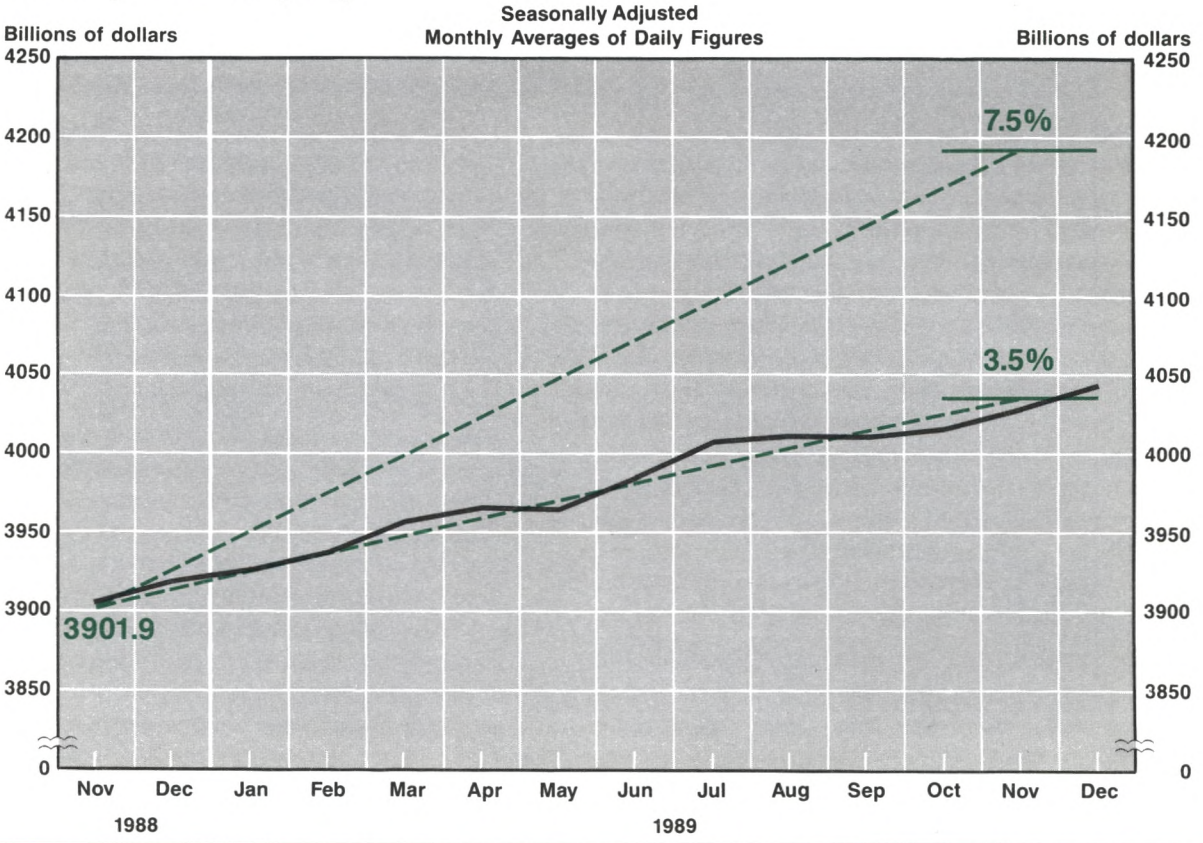
Table 2 indicates that the actual rate of growth in M2 during 1989, 4.6 percent, was close to the middle of its target range. The actual rate of growth in M3, 3.3 percent, however, was slightly below the lower bound of its target range. The growth rates varied considerably during the year as illustrated in figures 1 and 2, which show the monthly averages of (revised) daily figures, respectively, for M2 and M3. As discussed below, these variations had some influence on the Committee's short-run policy decisions.

SHORT-RUN POLICY OBJECTIVES

Each year, the Committee holds eight regularly scheduled meetings to review incoming data and assesses the current economic environment and the prospects for the future course of the economy. Based on this information, the members determine what changes, if any, should be made in short-run monetary policy to achieve the Committee's long-term goals. At the close of each meeting, the Committee issues a domestic policy directive to the Federal Reserve Bank of New York. This directive serves as the basis for day-to-day implementation of policy in the inter-

[6]Record (October 1989), pp. 693-94.

Figure 2
Money Stock (M3)



meeting period by the Manager for Domestic Operations, who is responsible for executing the directives. As usual, the directives issued during 1989 primarily emphasized the degree of restraint on reserve positions (maintain, increase or decrease) that was considered by the members to be consistent with the Committee's money growth targets and goals for the economy.

Maintaining the approach used since October 1982, the Federal Reserve System followed a borrowed-reserves operating procedure. This procedure translates the degree of reserve restraint specified in the directive into a target for borrowed reserves (reserves borrowed from the Federal Reserve Banks). For example, under this procedure, an instruction to increase the degree of pressure on reserve positions would imply a higher target for borrowed reserves (adjustment plus seasonal borrowings) and a higher federal funds rate for a given discount rate.[7]

Toward the end of 1988 and continuing into 1989, however, this operating procedure was complicated by the unstable relation between the demand for borrowed reserves and the federal funds rate. Specifically, the willingness of depository institutions to borrow reserves, for given federal funds and discount rates, was declining unexpectedly. At the December 1988 meeting, the Committee considered the possibility of adjusting the operating procedure to shift the focus

[7]The positive relation between borrowed reserves and the federal funds rate follows from economic theory. Specifically, the demand for borrowed reserves (the "borrowings function") is negatively related to the opportunity cost of borrowing from the discount window. This cost equals the spread between the discount rate (the interest rate paid by depository institutions for borrowed reserves from Federal Reserve Banks) and the federal funds rate (the interest rate paid for reserves borrowed from other depository institutions). For a discussion of the implementation of monetary policy under the borrowed-reserves operating procedure, see Gilbert (1985) and Thornton (1988).

of policy implementation to the federal funds rate, but the members generally agreed that adhering to the current procedure would be appropriate given its advantages.[8] Nevertheless, the Committee believed that the uncertainty about the relation of borrowings to the federal funds rate warranted flexibility in implementing monetary policy. Hence, some of the directives issued in 1989 were written with the understanding that flexibility would be permitted in conducting day-to-day policy so as to achieve the Committee's objectives, given the changing conditions in the market for borrowed reserves.

Furthermore, the Committee maintained the flexibility in short-run policy adopted in previous years because of uncertainty about the relations of monetary aggregate growth to output growth and inflation. The Committee believed that short-run policy should be decided not only on the basis of the behavior of the monetary aggregates, but on the basis of indicators of inflationary pressures, economic growth and the changing conditions in domestic financial and foreign exchange markets.[9]

In addition to the desired degree of reserve pressure, the directives indicated potential modifications in the intermeeting period, and the expected growth rates of M2 and M3 conditional on the desired reserve restraint. Each directive also established a monitoring range for the federal funds rate. The Chairman could initiate a Committee consultation if, during the intermeeting period, the federal funds rate were to move out of that range. Over the past several years, however, such consultations have been initiated because of unexpected economic and financial developments.

The following discussion reviews each FOMC meeting chronologically. It focuses on the important economic developments of 1989, showing how they influenced the Committee's formulation of short-run policy objectives. Table 3 summarizes the directives issued in 1989. Table 4 shows the actual (revised) intra-year growth rates in M2 and M3, as well as those rates expected by the Committee.

February 7-8 Meeting

Economic data reviewed at this meeting suggested that, abstracting from the direct impact of the previous year's drought, economic growth continued at a fast pace. The marked increase in total nonfarm payroll employment in January was widespread and the civilian unemployment rate of 5.4 percent was only marginally above December's rate of 5.3 percent. Industrial production rose sharply in December and January and the industrial capacity utilization rate in January exceeded its average rate over the fourth quarter of the previous year.[10]

Indicators of inflation at the beginning of 1989 showed hardly any change from 1988. Although the producer price index rose sharply in December, the behavior of the consumer price index, excluding food and energy, was perceived to be in line with its pattern in 1988.[11] Labor costs, particularly wages and salaries, rose appreciably faster than one year earlier, however.

As instructed by the Committee's last directive in 1988, the degree of pressure on reserve positions was increased at the beginning of the previous intermeeting period. During this period, the average level of adjustment plus seasonal borrowings was slightly above $500 million and the federal funds rate rose to about 9 percent from about 8½ percent. As other market interest rates rose, the growth of the broader monetary aggregates, particularly M2, weakened in January.[12]

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[8]Record (April 1989), pp. 295-96. Also see, for example, Record (May 1989), p. 359. The particular advantage of the current operating procedure mentioned in the Committee's discussion was that it permits "greater scope for market forces to determine short-term interest rates." [Record (April 1989), p. 296.] Such a procedure, however, can be less effective in maintaining short-term control over the money stock if the borrowings function is subject to unexpected shifts that are not quickly identified and reflected in changes to the borrowings assumption. See Thornton (1988) for a discussion on the advantages and disadvantages of this procedure.

[9]Report (March 1989), p. 108.

[10]Record (May 1989), p. 353. Industrial production rose at annual rates of 4.4 percent and 3.5 percent, respectively, in December and January. The Board's measure of the total industry capacity utilization rate in January was 84.3 percent, up from the previous quarter's average of 84.1 percent.

[11]Ibid., pp. 353-54. The annual growth rate of the seasonally adjusted producer price index for finished goods was 3.3 percent in December, while the seasonally adjusted consumer price index for all urban consumers rose at an annual rate of 4.1 percent. Excluding food and energy, the latter index rose at an annual rate of 4.9 percent.

[12]Ibid., p. 354. In January, M2 rose sluggishly at an annual rate of 0.5 percent and M3 rose at an annual rate of 2.4 percent.

Table 3
The FOMC's Short-Run Operating Ranges for 1989

Date of Meeting	Target period	Expected growth rates M2	Expected growth rates M3	Degree of reserve pressure[1]	Intermeeting federal funds range
February 7-8, 1989[2]	December 1988-March 1989	2%	3½%	maintain (+)	7-11%
March 28, 1989[3]	March-June	3	5	maintain (+)	8-12
May 16, 1989[4]	March-June	1½	4	maintain	8-12
July 5-6, 1989[5]	June-September	7	7	slightly reduce	7-11
August 22, 1989[6]	June-September	9	7	maintain (−)	7-11
October 3, 1989[7]	September-December	6½	4½	maintain (−)	7-11
November 14, 1989[8]	September-December	7½	4½	maintain (−)	7-11
December 18-19, 1989[9]	November 1989-March 1990	8½	5½	slightly reduce	6-10

[1]A '+' indicates an expectation that during the intermeeting period developments were more likely to warrant an adjustment toward restraint than toward ease. The opposite is true for a '−'.

[2]Messrs. Hoskins and Parry dissented. Mr. Hoskins thought that an immediate move toward greater monetary restraint would be appropriate to put policy on a course toward price stability in the longer run. Mr. Parry stressed that, since economic growth had exceeded its long-run, noninflationary rate, inflationary pressures were already increasing. In their view, without an immediate increase in restraint on reserve positions, inflationary pressures would intensify and thereby make the task of achieving the Committee's anti-inflationary goal more difficult.

[3]Ms. Seger dissented. Although maintaining the existing degree of reserve pressure was appropriate in her view, she believed that the bias toward monetary restraint was undesirable in light of the lagged effects of appreciable tightening that had been undertaken earlier along with current indications of slower economic growth.

[4]Mr. Melzer dissented, advocating prompt action to ease the degree of reserve pressure slightly. Pointing to the past two years of slow money growth, he stressed that the current high inflation would be reduced eventually and that, in the absence of an easing action, the risks of a recession would be augmented. Reaching the System's non-inflationary goal would be hampered if, in response to a recession, monetary policy were to aim at a quick recovery.

[5]Ms. Seger dissented. She favored a greater degree of easing that, in her view, would be necessary to promote reasonable economic growth in the following years.

[6]Mr. Guffey dissented. He could accept an unchanged policy. But he believed that a directive that was biased toward ease was not appropriate given that the chances of a weakening of the economic expansion appeared to be essentially the same as the chances of a strengthening of the expansion while, in his view, the current and expected future inflation rates were not acceptable. Furthermore, such a bias toward ease could lessen confidence in the Committee's commitment to achieve long-run price stability.

Table 3 continued

The FOMC's Short-Run Operating Ranges for 1989

[7]Mr. Guffey and Ms. Seger dissented. Mr. Guffey believed that the bias toward easing reserve pressure in the intermeeting period was not appropriate, for he was concerned that inflation in the future would remain unacceptably high. Ms. Seger pointed to signs of a weakening economy and indicated that some immediate easing would be necessary to sustain the expansion. She believed that such a policy would be consistent with the Committee's long-term objective of price stability.

[8]Ms. Seger dissented. In her view, signs of a weakening in economic activity, particularly in the manufacturing sector, warranted an immediate further easing of reserve pressure.

[9]Messrs. Angell and Melzer dissented, favoring an unchanged policy. Mr. Angell believed that a policy of easing reserve restraint based on recent indications of a weakening in economic activity was not warranted. To the extent that the impact of monetary policy is realized with a lag, in his view, policy should be based on forward-looking indicators of economic activity. Further, he believed that an easing of policy at this time, given past policy, could have an unfavorable impact on the System's credibility in pursuing a goal of price stability. Mr. Melzer noted that policy had been eased considerably over the past six months and, given the sufficient liquidity in the economy, he did not believe that further easing was desirable. He also was concerned that, in light of the current and projected growth of the monetary aggregates, easing of policy at this time would hamper the System's ability to make progress toward its long-term goal of price stability.

Table 4

Actual and Expected Rates of Money Growth

	M2		M3	
Period	Expected	Actual	Expected	Actual
December 1988-March 1989	2%	1.9%	3½%	4.0%
March 1989-June 1989[1]	1½-3	1.9	4-5	2.9
June 1989-September 1989[2]	7-9	8.2	7	2.7
September 1989-December 1989[3]	6½-7½	7.7	4½	3.2

[1]At the May 16 meeting, the Committee lowered its expectation for M2 and M3 to 1½ percent and 4 percent, respectively, from 3 percent and 5 percent.

[2]At the August 22 meeting, the Committee's expectations for M2 growth were revised from 7 percent to 9 percent.

[3]The Committee's expectation for M2 growth was revised from 6½ percent to 7½ percent at the November 14 meeting.

The Board's staff expected that economic activity would continue expanding in 1989 at a more modest pace than it had in 1988. Assuming that monetary policy would attempt to contain the inflationary pressures predicted by the staff, the staff's forecast pointed to pressures in financial markets that would tend to dampen growth in domestic spending. In addition, the staff expected that foreign demands would provide less of an impetus to domestic output growth than in 1988. Given the relatively low margins of unutilized labor and high capacity utilization rates, the staff predicted additional price pressures in the current year.[13]

In the Committee's discussion of policy implementation, many members indicated that economic growth appeared to be balanced, but most members expressed concern about the prospect of greater inflation. A majority of the members, however, saw no need for an immediate change in policy in light of the data available for review, the appreciable recent tightening in policy and their perception that the credibility of the Committee's commitment to fight inflation was high. These members were willing to wait for additional evidence confirming their fears of greater inflation before tightening policy further.[14]

[13]Ibid., pp. 354-55.

[14]Ibid., p. 358.

Some members advocated an immediate tightening of reserve conditions to contain any future inflationary pressures. In their view, without immediate action, the task of achieving price stability could become more difficult. Other members expressed concern that additional pressure on reserve positions could aggravate the financial conditions of many thrift institutions and highly indebted firms. In addition, further restraint might add to the recent unusual strength of the dollar.[15] Although the recent slow growth of the monetary aggregates was thought to indicate future restraint on price pressures, some members cautioned that a shortfall from targeted ranges would be a matter of concern.[16]

At the end of the meeting, the Committee adopted a directive that called for an unchanged degree of pressure on reserve positions, with a possible increase or decrease depending on forthcoming information about inflationary pressures, the strength of business expansion, growth in the monetary aggregates and developments in foreign exchange and domestic financial markets. As table 3 indicates, however, there was a "bias" toward restraint, and the members called for "remaining alert to potential developments that might require some firming during the intermeeting period."[17] In light of the continuing uncertainty about the relation of the demand for borrowed reserves to the federal funds rate, the directive was issued with the explicit understanding that flexibility would be needed in implementating monetary policy. Given the contemplated reserve conditions, the Committee expected the annual growth rates for M2 and M3 to be around 2 percent and 3½ percent, respectively, from December to March. The directive left the range for the federal funds rate unchanged at 7 to 11 percent.[18]

March 28 Meeting

During the intermeeting period, additional pressure was placed on reserve positions, in light of incoming data indicating greater inflationary pressures. Also, on February 24, the Board of Governors approved a 50 basis-point increase in the discount rate to 7 percent. From the time of the increase in the discount rate to this meeting, the federal funds rate rose nearly 75 basis points to slightly above 9¾ percent. Other market interest rates, especially those on shorter-term securities, also rose. As the demand for borrowed reserves appeared to fall, the borrowings assumption was lowered as a technical adjustment. The average of adjustment plus seasonal borrowings during the six-week period just before this meeting fell to about $450 million. Although the monetary aggregates appeared to gain some strength in February and March, their growth was viewed as sluggish relative to that in the previous year.[19]

The information available for review at this meeting suggested that economic activity expanded considerably in the first quarter. Total nonfarm employment advanced sharply in February and the civilian unemployment rate fell to 5.1 percent. Only part of the employment gain was attributed to the unusually mild weather during the first two months of the year.[20]

There were, however, indications of a slight weakening of the economic expansion. For example, preliminary data suggested that industrial production remained flat and capacity utilization rates fell slightly in February.[21] Furthermore, growth in consumer spending slowed in the first two months of the year from its vigorous pace during the last quarter of 1988. Although the data indicated that the nominal U.S. merchandise trade deficit improved in January, the value of exports fell. But the observed net rise of the trade-weighted value of the dollar over the intermeeting period was attributed largely to the rise in market interest rates stemming, in part, from restrictive actions taken during that period.[22]

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[15]Ibid., pp. 358-59. As a measure of the relative strength of the dollar in foreign exchange markets, the Federal Reserve Board constructs a trade-weighted index using the currencies of Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland and the United Kingdom. The trade-weighted index rose about 6 percent over the intermeeting period.

[16]Ibid.

[17]Ibid., p. 359.

[18]Ibid., pp. 359-60.

[19]Record (July 1989), p. 503. M2 rose at annual rates of 1.8 percent and 3.5 percent, respectively, in February and March. M3 rose at annual rates of 3.3 percent and 6.2 percent, respectively, during those same two months.

[20]Ibid., p. 502. The civilian unemployment rate in February has been revised upward to 5.2 percent.

[21]Ibid. Revised data indicate that industrial production actually fell in February at an annual rate of 2.5 percent.

[22]Ibid., pp. 502-03. The trade-weighted index of the value of the dollar in foreign exchange markets rose approximately 1.5 percent over the intermeeting period.

Price pressures appeared to gain some strength in the first two months of 1989. The observed increases in price indexes were thought to be due chiefly to energy and food prices. Even excluding these components, however, the producer and consumer price indexes rose sharply in January and February.[23]

The Board's staff predicted that the pace of economic expansion would slow considerably from the pace in 1988. The forecast assumed that monetary policy would restrain the inflationary tendencies in the economy. Such a policy could put additional pressure on financial markets and involve slower growth in consumer spending and business fixed investment.[24]

The members generally agreed that, in light of mixed evidence about the strength of economic expansion and the uncertain prospects for the future, an unchanged policy would be acceptable. Some members, who preferred an immediate tightening of reserve conditions, believed that inflationary pressures could intensify given the apparent momentum in economic activity. These members, however, were willing to wait for additional information that tended to confirm their fears. Most members believed that the unusual strength of the dollar in foreign exchange markets would dampen price pressures. Furthermore, as suggested by earlier experience, the sluggish growth in the monetary aggregates lessened the likelihood that inflation could gain much strength in the future.[25]

As table 3 shows, the Committee adopted a directive that did not call for a change in policy but that permitted a policy adjustment during the intermeeting period more readily toward restraint than ease. Open market operations were to be conducted with some degree of flexibility because of the continuing uncertainty about the relation of the demand of borrowed reserves to the federal funds rate. Growth in M2 and M3 were expected to be around 3 percent and 5 percent, respectively, from March to June. The intermeeting range for the federal funds rate was increased 1 percentage point to 8 to 12 percent, "in light of the tightening of reserves since the February meeting and the related increase in the federal funds rate."[26]

May 16 Meeting

Aside from the slightly firmer reserve conditions due to the greater-than-expected reserve flows related to April tax payments, reserve conditions hardly changed in the intermeeting period. During this period, the average of adjustment plus seasonal borrowing rose to about $565 million, while the rate at which federal funds traded rose slightly to around 9-7/8 percent. Other market interest rates, especially short-term rates, fell over the intermeeting period, however. Estimated growth of the monetary aggregates was sluggish, with the cumulative growth of M2 since the fourth quarter of 1988 well below the lower bound of the Committee's target range and that of M3 just above the lower limit of its target range.[27]

Economic data reviewed at this meeting suggested that the expansion of economic activity had moderated in recent months. Growth in total nonfarm employment edged downward in March and April, while the civilian unemployment rate climbed from 5.0 percent in March to 5.3 percent in April. In addition, growth in consumer spending maintained the much slower pace established in the first part of the year relative to that in 1988. Industrial production grew in April, but, from December to April, it grew more slowly than it had in 1988. Much of the April growth was attributed to an increase in automobile assemblies after a weak first quarter and a rebound in the output of other consumer goods. Although the total capacity utilization rate rose slightly in April, it remained below its January rate.[28]

There were indications, however, that the momentum in economic activity had not been en-

[23]Ibid. The seasonally adjusted producer price index for finished goods rose at annual rates of 13.9 percent and 7.8 percent, respectively, in January and February; excluding food and energy prices, it rose at annual rates of 6.2 percent and 7.2 percent, respectively, in January and February. Similarly, the seasonally adjusted consumer price index for all urban consumers rose at annual rates of 7.2 percent and 5.1 percent, respectively, during the first two months of the year; excluding food and energy, this index rose at annual rates of 5.9 percent and 4.8 percent.

[24]Ibid., p. 504.

[25]Ibid., p. 505.

[26]Ibid., p. 506.

[27]Record (September 1989), pp. 626-27. In April, M2 and M3 grew at annual rates of 1.0 percent and 2.6 percent, respectively.

[28]Ibid., p. 625. The annual growth rate in the industrial production index rose from 1.7 percent in March to 8.9 percent in April. During that month, the total capacity utilization rate rose 0.4 percentage points from the previous month to 84.2 percent.

tirely lost. Capital business spending rebounded after falling in the last quarter of 1988. Furthermore, although the nominal U.S. merchandise trade deficit widened in February, the average deficit for the first two months of 1989 remained below that for the fourth quarter of 1988, with the value of exports growing more rapidly than that of imports. Despite the slight deterioration in the external trade balance in February and the general downward movement in interest rates more recently, the dollar gained further strength in the intermeeting period.[29]

The recent behavior of the price indexes did not ease the members' fear of future inflation. Rather, price level movements were interpreted by the members as an indication that inflationary pressures were rooted deeply in the economy. Although the producer price index grew more slowly in March and April than in the earlier two months of the year, the consumer price index grew at a slightly faster pace in the first quarter of 1989 than in the previous quarter. Increases in food and energy prices contributed to the observed increases in measured inflation, but were not the sole driving force of the perceived upward trend in inflation.[30]

The staff's projection changed little from that prepared for the previous meeting. Growth in economic activity was expected to be slower than in 1988. The forecast indicated that prices at both the consumer and producer levels would increase at somewhat faster rates in 1989. In the staff's view, monetary policy that attempted to contain such inflationary pressures, should they materialize, would imply greater pressure on financial markets. In addition to a continuation of sluggish growth in consumer spending, the staff expected that growth in business capital spending would retreat from its fast pace in the first quarter.[31]

Uncertainty about the impact of previous restrictive policy actions on inflation and the pace of economic growth dominated the discussion at this meeting. Whether monetary conditions were sufficiently restrictive to contain future inflationary pressures without precipitating an excessive slowing of economic growth remained unclear. Although one member believed that an immediate easing of reserve pressure would be both necessary and desirable to improve the prospects for adequate monetary growth to sustain the economic expansion, others feared the risks associated with such a policy—that is, of having to reverse the easing if the monetary aggregates were to accelerate unduly and price pressures were to intensify later.[32]

In the discussion about possible adjustments to monetary policy in the intermeeting period, most members agreed that no bias—either toward restraint or ease—would be appropriate. While one member believed that policy should be particularly alert to behavior of the monetary aggregates that could warrant some easing, others believed that the deeply rooted inflationary pressures called for a bias toward restraint. A number of members expressed concern that the absence of a bias toward restraint might give an incorrect signal that the Committee was moving away from its anti-inflationary commitment.[33]

At the end of this meeting, the Committee issued a directive that called for an unchanged degree of pressure on reserve positions. Depending on forthcoming information, a move to some restraint or ease would be acceptable during the intermeeting period. The Committee believed that continuing uncertainty about the relation of the demand for borrowed reserves to the federal funds rate warranted continuing flexibility in the implementation of monetary policy. The Committee expected that the contemplated reserve conditions would be consistent with M2 and M3 growing at 1½ and 4 percent annual growth rates, respectively, from March to June. The intermeeting range for the federal funds rate was kept at 8 to 12 percent.[34]

July 5-6 Meeting

Late in the intermeeting period, incoming information tended to confirm earlier indications

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[29]Ibid., pp. 625-26. The value of the dollar relative to the other G-10 currencies appreciated about 4 percent over the intermeeting period.

[30]Ibid., p. 626. The seasonally adjusted consumer price index for all urban consumers rose at annual rates of 6.1 percent and 8.1 percent, respectively, in March and April. Excluding food and energy prices, this price index rose 4.8 percent and 2.9 percent. The producer price index for finished goods, excluding food and energy, rose at annual rates of 2 percent and 1 percent.

[31]Ibid., p. 627.

[32]Ibid., pp. 628-29.

[33]Ibid., p. 629.

[34]Ibid.

that the economic expansion had slowed so that the prospect of weakening inflationary pressures seemed more promising. Furthermore, the monetary aggregates continued to exhibit slow growth and the dollar had gained considerable strength earlier in the intermeeting period. Accordingly, a slight lowering of the pressure on reserve positions was sought. Before this easing, however, a technical upward revision had been made to accommodate unusual strength in seasonal borrowing. Over the six-week period ending June 27, the average of adjustment plus seasonal borrowings was around $550 million, and the federal funds rate edged down to 9½ percent. Other market interest rates, especially those on long-term securities, also fell. The observed decline in the level of the broader monetary aggregates during May was interpreted as a reversal of the temporary rise in transaction accounts related to April tax payments.[35]

Confirming earlier evidence, the information available for review at this meeting suggested that the economic expansion had slowed considerably from its pace in 1988. While the civilian unemployment rate fell to 5.2 percent in May, growth in total nonfarm employment was relatively weak. Preliminary data indicated that, in May, growth in industrial production was modest and the total capacity utilization rate had fallen back to its March level.[36] While business capital spending appeared to make further gains in the second quarter, growth in consumer spending remained sluggish. Further, the significant improvement in the nominal U.S. merchandise trade balance during April stemmed chiefly from a considerable drop in imports with only a slight increase in exports.[37]

Price pressures persisted despite the indications of slowing economic expansion. Increases in food and energy prices, however, made large contributions to the increases in the producer price index and, to a lesser extent, in the consumer price index.[38] Nevertheless, the growth in labor costs appeared to have maintained its momentum from the middle of 1988.

The Board's staff revised its forecast for economic growth in the second half of the year downward from that made earlier in the year. The staff's forecast now suggested less inflation than was previously expected, though more inflation than had been experienced in 1988, and continued growth in labor costs in 1989. This inflation outlook took account of the persistent strengthening of the dollar that was expected to dampen inflationary pressures. The forecast, however, also pointed to slightly more favorable inflationary conditions in 1990 than were previously expected.[39]

In the context of a weaker outlook for economic growth, the members generally believed that a further reduction in the degree of pressure on reserve positions would be appropriate. Although there was some disagreement about the timing and the extent of such easing, most members agreed that they could accept an immediate slight reduction in reserve pressure. In the view of many members, a greater move toward ease could have an undesirable effect on inflationary expectations, thereby putting upward pressure on long-term interest rates. A substantial move toward ease might have to be reversed if inflationary pressures subsequently intensified.

Nearly all believed, however, that the easing should be implemented immediately given the slowing pace of economic expansion and the sluggish growth of the broader monetary aggregates. Although some members preferred a directive that was biased toward restraint to maintain the credibility of the Committee's anti-inflationary commitment despite the easing of policy, others advocated a bias toward ease to communicate the Committee's belief that the risks

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[35]Record (October 1989), p. 691. Revised data indicate that in May, M2 declined at an annual rate of 1.6 percent and M3 rose sluggishly at an annual rate of 0.2 percent. In June, the annual growth rates in M2 and M3 rebounded to 6.5 percent and 6.0 percent, respectively.

[36]Ibid., p. 689. Revised data indicate that the industrial production index fell at an annual rate of 0.8 percent in May, while the total capacity utilization rate in May, which fell to 84.0 percent from 84.2 percent in April, was above the rate of 83.8 percent in March.

[37]Ibid., pp. 689-90. Despite the improvement in the external balance, the value of the dollar relative to the other G-10 currencies fell on net about 3 percent over the intermeeting period. After having risen sharply in the first half of the period, the trade-weighted index of the value of the dollar declined appreciably over the second half.

[38]Ibid., p. 690. But, even excluding food and energy prices, the seasonally adjusted producer price index advanced sharply, rising at annual rates of 7.2 percent and 8.2 percent, respectively, in May and June. Similarly, the seasonally adjusted consumer price index, excluding food and energy components, rose 5.8 percent and 2.8 percent, respectively, in May and June.

[39]Ibid., p. 691.

of an undesirable shortfall in economic growth were substantial. Most members agreed that, given the prevailing uncertainty, they could accept an unbiased directive.[40]

As table 3 shows, the directive issued by the Committee at the close of this meeting called for an immediate and slight reduction in the degree of reserve pressure. Further easing or some tightening was considered to be appropriate depending on future developments. Conditional on the contemplated reserve conditions, the Committee expected that both M2 and M3 would grow at an annual rate of 7 percent from June to September. Given the easing of reserve pressure in early June and that specified in this directive, the monitoring range for the federal funds rate was lowered 1 percentage point to 7 to 11 percent.[41]

August 22 Meeting

As instructed by the Committee at the close of the previous meeting, the degree of pressure on reserve positions was reduced at the beginning of the intermeeting period. Toward the end of July, the degree of reserve restraint was eased further, in light of incoming data that indicated a continued weaker economic expansion and a slight reduction in inflationary pressures. At the beginning of the intermeeting period, however, the assumed level of adjustment plus seasonal borrowing was increased as a technical revision prompted by a projected rise in seasonal borrowing during the summer months. Hence, the average of adjustment plus seasonal borrowings over the six-week period ending August 22 rose to approximately $600 million despite the easing actions taken during this period. Nevertheless, the federal funds rate fell 50 basis points to around 9 percent. Preliminary data indicated that, in July, growth in the monetary aggregates gained considerable strength, which appeared to continue into August.[42]

The data reviewed at this meeting reinforced the earlier evidence of a moderate economic expansion. The data, however, suggested less weakness in the expansion than they had toward the end of July. Nonfarm payroll employment made considerable advances in June and July. The civilian unemployment rates for these months, 5.3 percent and 5.2 percent, respectively, were close to the average unemployment rate during the first five months of the year. In addition, preliminary data indicated that industrial production rebounded in July after having fallen in May and June.[43] Industrial capacity utilization maintained its high rate, although the rate for manufacturing in July was well below that in January. Moreover, growth in consumer spending in the second quarter was stronger than originally estimated, and the observed narrowing of the nominal U.S. merchandise trade deficit reflected not only a notable decline in the value of imports, but a marked jump in the value of exports.[44]

The recent behavior of price indexes suggested somewhat less inflation primarily because of appreciable declines in food and energy prices. Preliminary data indicated that, while the consumer price index rose in both June and July, the increases were modest, and the producer price index for finished goods fell.[45] Wage growth over the past several months did not appear to deviate from previously established trends.

The staff expected that, during the rest of the year, growth in the nonfarm economy would maintain its pace from the first half of the year and then grow more slowly in 1990. With interest rates falling since the spring and the recently observed substantial job gains, consumer spending was expected to exhibit greater strength in the coming months. The forecast indicated that business capital spending would continue to make a large contribution to economic growth. Partly because of the earlier strength-

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[40]Ibid., p. 695.

[41]Ibid., p. 696. In this instance, there was no mention of the uncertainty revolving around the relationship between borrowings and the federal funds rate and, therefore, no reference to flexibility in monetary policy implementation.

[42]Record (December 1989), p. 813. Growth in M2 accelerated from 6.5 percent in June to 10.3 percent in July. The annual growth rate in M3 rose less dramatically from 6.0 percent in June to 6.9 percent in July.

[43]Ibid., p. 812. Revised data, however, indicate that industrial production rose at an annual rate of 3.4 percent in June and fell at an annual rate of 0.8 percent in July. The July civilian unemployment rate has been revised upward to 5.3 percent.

[44]Ibid., pp. 812-13.

[45]Ibid., p. 813. The seasonally adjusted producer price index for finished goods rose at an annual rate of 1.1 percent in June and fell at an annual rate of 4.1 percent in July. But, excluding the food and energy prices, this index rose at an annual rate of 8.2 percent in June and fell at an annual rate of 1.9 percent in July.

ening of the dollar in foreign exchange markets, however, foreign trade was not expected to be a significant source of economic growth. In addition, although expected further declines in food and energy prices suggested that price pressures could weaken in the coming quarter, the staff expected no substantial improvement in the inflationary trend through 1990.[46]

With evidence that the economic expansion had stabilized at a "provisionally acceptable pace" and that inflationary pressures were not gaining strength, the members generally believed that the current degree of reserve pressure should be maintained, at least in the early part of the intermeeting period. An unchanged course for policy was also justified by the observation that growth in M2 and M3 recently had gained sufficient strength to place these aggregates in their target ranges.[47]

Discussing possible adjustments in policy during the intermeeting period, many members expressed the belief that, if future developments were to warrant a change in policy, the direction of change would most likely be toward some ease. Some members, however, preferred not to incorporate such a presumption in the directive. In their view, the "risks to the economy were more evenly balanced." That is, the direction of change in policy justified by developments in the intermeeting period was just as likely to be toward restraint as it was toward ease. Further, these members believed that a bias toward ease could "lead to a misreading of System policy in the context of an unacceptably high rate of inflation."[48]

The directive issued at the end of this meeting specified no immediate change in policy, as table 3 indicates. Despite some members' reservations, the directive included a bias toward ease. The Committee expected M2 and M3 to grow at annual rates of about 9 percent and 7 percent, respectively, from June to September. The intermeeting range for the federal funds rate was kept at 7 to 11 percent.[49]

October 3 Meeting

Over the intermeeting period, reserve conditions displayed no noticeable change. The average of adjustment plus seasonal borrowing during the four weeks ending September 20 fell slightly to about $550 million, and the federal funds rate fluctuated within a narrow range centered around 9 percent. Although M2 growth was strong, M3 growth had unexpectedly lost some of its strength in August and preliminary data suggested that this slower growth had continued into September.[50]

The data available for review at this meeting reaffirmed earlier projections, that the economic expansion had continued at a moderate pace in the third quarter. Nonfarm payroll employment generally made considerable advances after allowing for the effects of strike activity. Nevertheless, there were hardly any job gains in manufacturing industries, and the civilian unemployment rate in August and September was close to 5¼ percent. Further, after increasing moderately in August, industrial production fell slightly in September.[51] The industrial capacity utilization rate, however, remained relatively high. While growth in business capital spending seemed to have slowed in the third quarter, consumer spending continued to exhibit considerable strength. With the value of imports declin-

[46]Ibid., p. 814. Over the intermeeting period, the value of the dollar relative to the other G-10 currencies rose approximately 2.7 percent, almost offsetting the previous net decline. Even so, the trade-weighted value of the dollar was below the highs reached in June.

[47]Ibid., pp. 815-16. Although the staff predicted that M2 and M3 growth would slow considerably from the current pace, the growth in the aggregates was expected to remain comfortably within their target ranges. These forecasts for money growth as well as those made subsequently in 1989, however, were subject to great uncertainty as a result of the uncertainty revolving around the resolution of thrift institution insolvencies and the responses of thrift institutions to recently enacted legislation. These factors were expected to dampen growth in the broader monetary aggregates, particularly that in M3. Thus, any observed weakness in the growth of these aggregates would not be interpreted as evidence of a slowing economy. Ibid., p. 816.

[48]Ibid., p. 816.

[49]Ibid., pp. 816-17.

[50]Record (January 1990), pp. 18-19. The slowing of the growth of the monetary aggregates was especially evident in M3. M2 grew at annual rates of about 7.8 percent and 6.5 percent, respectively, in August and September; M3 grew at an annual rate of 1.4 percent in August and was flat in September.

[51]Ibid., p. 17. The annual rate of growth of the industrial production index fell from 5.2 percent in August to -1.7 percent in September. Revised data indicate that the civilian unemployment rate in August and September was 5.3 percent.

ing by more than the value of exports, the U.S. merchandise trade deficit improved further in July.[52]

The price indexes continued to indicate a lower rate of inflation. In August, producer prices fell and the consumer price index was unchanged.[53] The upward trend in labor costs, however, did not appear to change on a year-to-year basis.

The staff's forecast for economic growth in the remaining part of 1989 and 1990 were essentially unchanged from those made for the previous meeting. Growth in business capital spending was expected to slow from its pace in the first half of the year, however.[54] Most members believed that, although economic activity would continue to expand in the coming quarters, the pace of the expansion would more likely slow than build momentum. While the members generally expected some weakening in inflationary pressures, only a few thought this weakening might be appreciable. A number of members expressed concern that progress would be constrained considerably if economic activity were to build momentum. Furthermore, the members believed that the recent fall of the value of the dollar in foreign exchange markets would add to future upward pressure on prices.[55]

Most members thought that an unchanged policy would be appropriate in the near term. The focus of policy continued to be that of gradually reducing inflation over time and a steady policy course seemed consistent with that objective, at least for the time being.[56] Growth in the monetary aggregates was expected to moderate from the rapid pace since the middle of the year, given an unchanged policy. Most members believed, however, that future developments would more likely require ease than restraint in the intermeeting period. Nevertheless, the recent depreciation of the foreign value of the dollar warranted caution in undertaking any easing adjustments.[57]

The directive issued at the end of this meeting was written with the understanding that a downward technical adjustment to the borrowings objective might be appropriate, if, as expected, seasonal borrowings were to drop in the intermeeting period. The reserve conditions contemplated by the members were thought to be consistent with M2 and M3 growing at annual rates of 6½ percent and 4½ percent, respectively, between September and December. The monitoring range for the federal funds rate was unchanged at 7 to 11 percent.[58]

November 14 Meeting

Reserve conditions were eased in mid-October. For a short period after the sharp drop in stock prices on October 13, an accommodative provision of reserves was undertaken while financial markets remained highly sensitive and volatile. Around the same time, in keeping with the previous meeting's directive, a decision was made to implement some easing on a more permanent basis. Incoming data, indicating an increased risk of a weakening in the business expansion, also prompted additional easing early in November. Furthermore, in light of a perceived decline in adjustment plus seasonal bor-

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[52]Ibid., pp. 17-18.

[53]Ibid., p. 18. The decline in producer prices, however, was driven largely by a continued decline in energy prices. In August, the seasonally adjusted producer price index for finished goods fell at an annual rate of about 3.1 percent, but, excluding energy and food, this index rose at an annual rate of 6.1 percent. The seasonally adjusted consumer price index excluding energy and food, however, rose only 1.9 percent in August. In their discussion about the outlook for inflation, the members commented that the recent declines in food and energy prices that had dampened price inflation might be temporary. Ibid., p. 20.

[54]Ibid., p. 19.

[55]Ibid., pp. 19-20. The trade-weighted value of the dollar relative to the other G-10 currencies fell 2.7 percent over the intermeeting period. A fall in the value of the dollar, holding all else constant, increases the attractiveness of U.S.-produced goods to foreign importers and U.S. individuals. The resulting shift in demand can create domestic price pressures. A fall in the value of the dollar can also increase the costs of production for those U.S. firms relying heavily on imported intermediate goods, thereby creating additional price pressures. See Hafer (1989) for a detailed discussion of the link between inflation and a dollar depreciation.

[56]Ibid., p. 20. There was also a concern that, given the recent G-7 meeting, an easing of policy would be mistakenly interpreted as an action to lower the value of the dollar. The Committee believed that monetary policy should not be used as an instrument for achieving a given objective for the dollar in foreign exchange markets if that objective were not compatible with domestic policy objectives. In the view of some members, if recent intervention by G-7 and other nations were to result in a lower value of the dollar, the inflationary consequences would hamper the Committee's ability to achieve its long-run goal of price stability. Ibid., pp. 20-21.

[57]Ibid., p. 21.

[58]Ibid., pp. 21-22.

rowings, several technical adjustments in the borrowing assumption were made during the intermeeting period. From early October to this meeting, actual borrowings fell from about $635 million to about $200 million. With most market interest rates falling, the federal funds rate declined from about 9 percent to 8½ percent in the intermeeting period and growth in the monetary aggregates gained strength in October.[59]

The data reviewed at this meeting indicated that the economic expansion had continued at a moderate pace. Nonfarm employment gains were considerable in October and the civilian unemployment rate did not budge at 5.3 percent. The data also suggested, however, that the strength of expansion was not evenly distributed throughout the economy. For example, most employment gains occurred in the service sector, while manufacturing employment declined. In addition, industrial production dropped appreciably in October, though much of the decline was attributed to several incidents that tended to disrupt production temporarily (the Boeing strike, the earthquake and the hurricane).[60] The data also showed that retail sales had fallen and the growth of business capital spending had weakened. Furthermore, with the value of imports rising and the value of exports falling in August, the U.S. merchandise trade deficit had risen to its highest level thus far in 1989.[61]

The recent behavior of price indexes were consistent with a slight reduction in inflationary pressures. The percentage rise in producer prices fell in October and, excluding energy and food, had hardly changed.[62] But the data did not suggest any slowing in the growth of labor costs.

In light of the temporary disruptions to production, the staff's forecast pointed to a further slowing in growth in the fourth quarter and a rebound in the first quarter of 1990. On net, the staff predicted that economic growth would continue at a sluggish pace in the coming quarters. Although continuing growth in consumer demand was expected to contribute to economic activity in the near term, consumer demand was expected to weaken subsequently. Further, the forecast indicated that the sluggish pace in the growth of business capital spending would continue and that net exports would not make a significant contribution to the economic expansion. The staff's forecast did not suggest, however, any substantial improvement in the underlying trend in inflation.[63]

Most members agreed that the data pointed, on balance, to a sustained economic expansion, although growth had weakened recently. But there was no strong consensus among the members about the future outlook. While some members expected that the risks of a stronger-than-desirable expansion and a weaker expansion were evenly balanced, others expected a greater likelihood of either a stronger or considerably weaker economic expansion activity, and still others believed that the chances of an economic expansion close to the economy's potential in the future were not remote.[64] Similarly, some members believed that progress on improving the underlying inflation trend might be achieved given the recent behavior of the price level indexes and other factors, though others saw that such progress, if any, would be small over the next several quarters.[65]

Although the economic expansion appeared to be slowing, most members advocated a steady policy with no immediate change in the degree of pressure on reserve positions. Such a policy was considered to be consistent with the Committee's goals of promoting a sustained economic expansion while making progress toward reducing inflation in the long run. Moreover, members believed that the recent and expected growth in the monetary aggregates did not warrant any

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[59]Report (February 1990), p. 56. The annual rates of growth of M2 and M3 rose to 7.1 and 1.4 percent, respectively, in October. This acceleration was not as pronounced as that in M1 whose annual growth rate rose from 3.9 percent in September to 8.3 percent in October.

[60]Ibid., p. 55. The industrial production index fell at an annual rate of about 4.1 percent in October.

[61]Ibid., pp. 55-56.

[62]Ibid., p. 56. Revised data indicate that the seasonally adjusted producer price index for finished goods rose at an annual rate of 6.5 percent in October. Excluding food and energy components, it rose at a 2.0 percent annual rate.

[63]Ibid., p. 57.

[64]Ibid., p. 57. The recent depreciation of the dollar in foreign exchange markets was expected by some members to provide a source of improvement in the nation's trade deficit, especially in light of the observed strength in economic activity experienced recently by other industrial nations. Such an improvement would provide additional strength to the U.S. economic expansion.

[65]Ibid., pp. 57-58.

adjustment in policy. Hence, as table 3 shows, the directive issued at the close of this meeting did not call for any change in policy.[66]

Most members, however, believed that the possibility of weakening in the economic expansion exceeded the possibility of excessive growth and, accordingly, that future economic developments would more likely warrant subsequent easing actions than tightening actions in the intermeeting period. Those members who believed that the likelihood of excessive growth was evenly balanced against the likelihood of weakening in the expansion indicated that they could accept a directive containing a bias toward ease in the intermeeting period. But some emphasized the need for approaching possible easing adjustments with caution so as not to detract from any progress that could be made in eventually approaching the Committee's goal of reasonable price stability.[67]

The members expected M2 and M3 to grow at annual rates of 7½ and 4½ percent, respectively, between September and December. The monitoring range for the federal funds rate was maintained at 7 to 11 percent.[68]

December 18-19 Meeting

During the intermeeting period, policy aimed to maintain a steady (or unchanged) degree of reserve restraint. Technical adjustments in the borrowings assumption were made twice in the period in light of ongoing declines in seasonal borrowing. During the first two weeks of December, adjustment plus seasonal borrowings averaged about $130 million, down from the average of about $400 million during the two previous weeks. Meanwhile, the federal funds rate remained at about 8½ percent and other market interest rates changed little during most of this period. Preliminary data indicated that the growth in the broader monetary aggregates picked up during November and remained robust in the first part of December.[69]

The information available for review at this meeting suggested that the economic expansion in the fourth quarter had slowed from its pace earlier in the year. Although total nonfarm payroll employment made considerable gains in November, these gains were concentrated in the service, trade and financial sectors, with continuing losses in manufacturing. The November civilian unemployment rate, 5.4 percent, was at its highest level since January. Industrial production in November rebounded from its previous decline driven by earlier strike activity among other factors.[70] Upon adjusting for these factors, industrial production appeared to have fallen, on average, in recent months. In addition, although nominal retail sales rebounded in November, sales had hardly changed from their average in the third quarter, and data indicated a weakening in business capital spending. With imports up sharply and exports virtually unchanged, the nominal U.S. merchandise trade deficit rose considerably in October after having fallen slightly in September.[71]

Estimated movements in price indexes continued to suggest a slight weakening in inflationary pressures. For example, the producer price index, based on preliminary data, fell in November. This decline, however, was partly attributable to sharp reductions in energy prices.[72] Although average hourly earnings had fallen in November, the underlying trend in labor cost growth was not expected to change given the results of the recent collective bargaining activities.[73]

The staff's forecast had not changed substantially from the previous meeting. It pointed to a slowing in the economic expansion in the fourth quarter with a rebound in the first quarter of 1990. The magnitude of the rebound was expected to be limited by anticipated declines in motor vehicle production. Economic growth for the rest of 1990 was expected to be driven primarily by moderate growth in consumer spending. Net exports were expected to make a small

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[66]Ibid., p. 58.

[67]Ibid., pp. 58-59.

[68]Ibid., pp. 59-60.

[69]Record (Federal Reserve Press Release, February 9, 1990), pp. 4-5. The annual rate of growth in M2 increased slightly to 7.5 percent in November, while the annual growth rate in M3 nearly tripled to 4.0 percent.

[70]Ibid., p. 1. The annual growth rate of the industrial production index rose to 3.4 percent in November. It should be noted that the November civilian unemployment rate has been revised to 5.3 percent.

[71]Ibid., p. 2-3. Total industry capacity utilization having not changed in November from October at 83.1 percent was 1 percentage point below its level a year earlier.

[72]Ibid., pp. 3-4. Revised data indicate that the seasonally adjusted producer price index actually rose at an annual rate of 1.1 percent in November. Excluding food and energy, this index rose at an annual rate of 3.0 percent.

[73]Ibid., p. 4.

contribution to the economic expansion in 1990. Further, while the staff anticipated that pressures on labor and other resources for production would lessen slightly, no large changes in the underlying trend of inflation were expected.[74]

The members generally agreed that there was considerable evidence that the economy's growth had weakened and would likely remain at a sluggish pace in the near term. Although a number of members thought that some strengthening in the economic expansion in 1990 was a reasonable expectation, most believed that the chances of a weakening were "sufficiently high to justify an immediate move to slightly easier reserve conditions."[75] Those advocating this policy change believed that such a move would not jeopardize the System's credibility of adhering to its long-run goal of price stability, as price pressures and business conditions appeared to have weakened.

Others less optimistic about the potential progress toward reducing inflation favored an unchanged policy. Skepticism about this progress was partly driven by the recent decline of the dollar and the possibility that, if economic activity were to rebound in the next year, inflationary pressures could gain considerable strength.[76] Those advocating an unchanged policy emphasized that maintaining current reserve conditions would be sufficient to ensure a continuation of the expansion with an easing of pressure on productive resources, and that "further easing might overcompensate for current weakness in the economy at the cost of delaying progress toward price stability."[77] Nevertheless, most of these members, recognizing the risks of an additional weakening in the economy, could accept a policy that sought an immediate but slight easing of the degree of pressure on reserve positions. In their view, given such a policy, it was highly unlikely that further easing would be warranted during the intermeeting period.[78]

As indicated in table 3, at the close of this meeting, the Committee issued a directive calling for a slight easing of reserve conditions. This directive did not reflect a presumption about the direction of possible adjustments in the intermeeting period. The Committee expected that the annual rates of growth of M2 and M3 would be 8½ percent and 5½ percent, respectively, from November 1989 to March 1990. In addition, given the easing of reserve conditions in recent months and the further easing stipulated in this directive, the Committee lowered the monitoring range for the federal funds rate 1 percentage point to 6 to 10 percent.[79]

CONCLUSIONS

During 1989, the economic data available for review at FOMC meetings prompted Committee members to shift their primary concern from the risks of inflation to the risks of a slowdown in economic activity. At the beginning of the year, the threat of a worsening in the underlying inflationary trend drove the formulation of policy. As the evidence of a weakening economic expansion accumulated and the outlook for inflation appeared to become less threatening, the Committee became more sensitive to the risks of a future slowdown in economic activity. Because the Committee understood that its interpretation of the data was unavoidably subject to great uncertainty, however, it took what it perceived to be a conservative approach to reacting to this information in an effort to balance these risks. This approach was also motivated by the Committee's ultimate goal of eventually achieving reasonable price stability and its desire to maintain its own credibility as an inflation-fighter.

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[74]Ibid., p. 5-6.

[75]Ibid., p. 10.

[76]Ibid., pp. 9-10. Over the intermeeting period, the trade-weighted value of the dollar relative to the other G-10 currencies fell about 2.8 percent.

[77]Ibid., p. 10.

[78]Ibid., pp. 11-12.

[79]Ibid., pp. 13-15.

Alison Butler

Alison Butler is an economist at the Federal Reserve Bank of St. Louis. *Lora Holman provided research assistance. The author would like to thank William Barnett and Jennifer Ellis for helpful comments and suggestions.*

A Methodological Approach to Chaos: Are Economists Missing the Point?

"A very slight cause which escapes our notice determines a considerable effect which we cannot fail to see, and then we say that this effect is due to chance."

—Poincaré

THERE IS INCREASING interest among economists in a new field of study that may offer an alternative explanation for the seemingly random behavior of many economic variables. This research, which originated in the physical and biological sciences, concerns a phenomenon called deterministic chaos.[1]

Contrary to the common usage of the word, chaos in this context describes the behavior of a variable over time which appears to follow no apparent pattern but in fact is completely deterministic, that is, each value of the variable over time can be predicted exactly. In fact, one "chaologist" describes chaos as ". . . lawless behavior governed entirely by law."[2]

To demonstrate the difficulty in determining whether a variable is random or chaotic, figures 1a and 1b show two time series of a variable; one series is a random variable, whose actual value cannot be known with certainty, and the other is a chaotic variable, whose value can be predicted with certainty. Even the most practiced observer, however, would have difficulty determining which of these series, if any, is not random. As a result, most economists would model or estimate both time series as random processes. The chaotic series is described by a very simple deterministic equation and identified later in this paper.

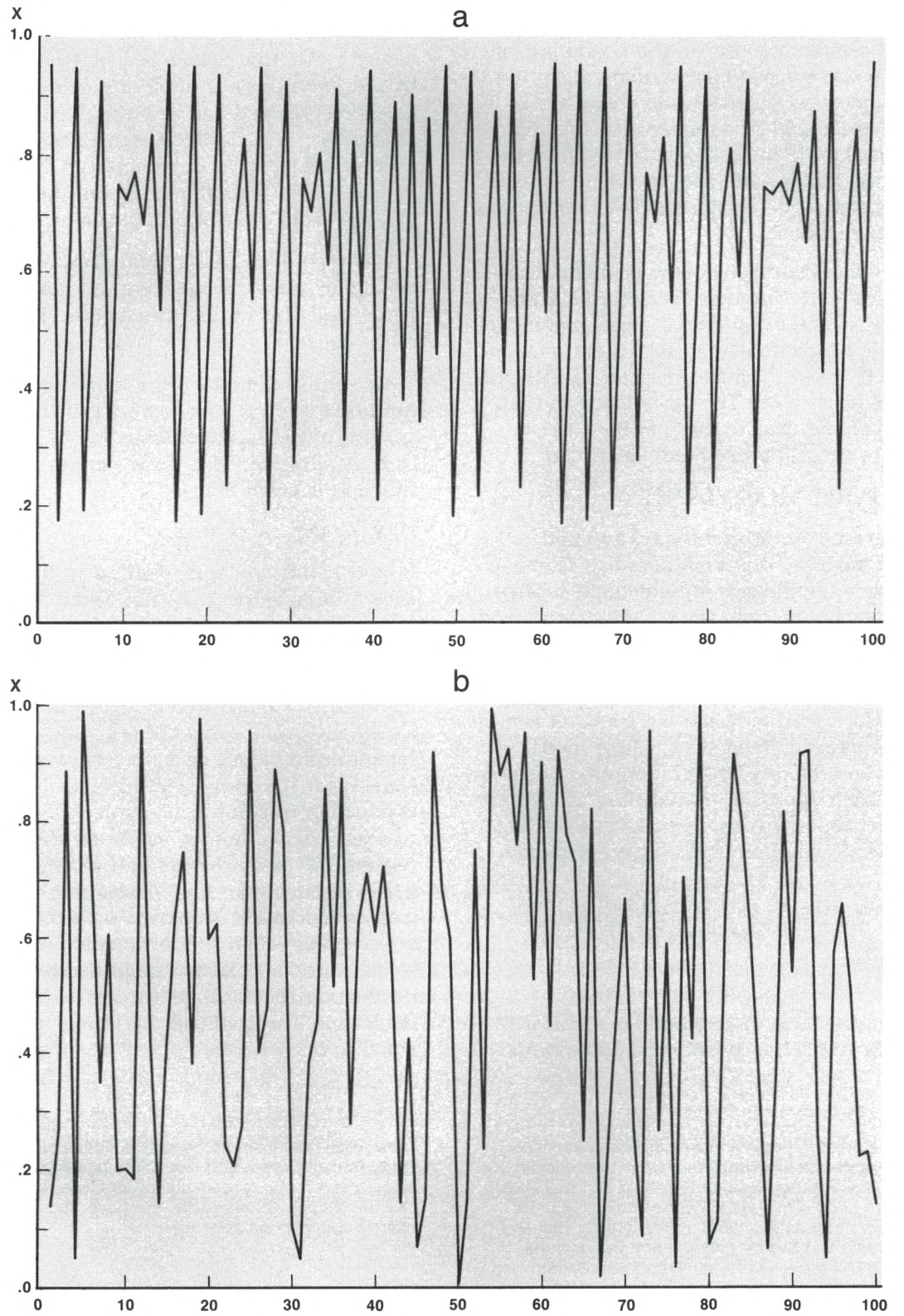
Often, behavior that cannot be explained by standard theories and modeling techniques is attributed to random forces, even when there is no theoretical reason to do so. This paper argues that economists are perhaps not using the appropriate types of models and empirical techniques to explain the behavior of some economic variables and that the choice of methodology needs to be more closely examined.

The study of chaos is a recent phenomenon in the biological and physical sciences and is just

[1]The terms "deterministic chaos" and "chaos" are used interchangeably here, although deterministic chaos is the more precise description.

[2]Stewart (1989), page 17.

Figure 1
Random or Chaotic?



now beginning to be applied to economics. Unfortunately, many of the empirical tests for chaos are imprecise and, because of mathematical constraints, the theoretical models used to generate chaos are generally limited to systems with only one or two explanatory variables. Both of these factors restrict the usefulness of applying chaos to economic systems. Nevertheless, the theory of deterministic chaos has attracted a great deal of attention, both in the popular press and in academic circles. The discussion that follows attempts to clarify some of the issues and suggests some ways to incorporate chaos into economics.

This article first reviews how economic variables typically are modeled by describing and evaluating several techniques of economic modeling using a simple model of output and population growth.[3] Next, chaos is defined and its properties demonstrated. The advantages and pitfalls of applying the theories of chaos to economics are then discussed and illustrated.

ECONOMIC MODELING

There are many different ways to build economic models. Four such possibilities are examined here for the case in which all variables are completely deterministic.[4] The types of models examined here are static linear, static nonlinear, dynamic linear and dynamic nonlinear. A further distinction, which proves to be significant, is also drawn between discrete and continuous time dynamic models. A simple model of output, where labor is the only input, is used to illustrate each approach to modeling as well as the restrictiveness of many common modeling techniques. In addition, focusing on economic modeling allows us to show that chaotic dynamics can only arise in certain types of models that have often been excluded, *a priori,* by economists.

Static Models

The simplest type of economic model is a static linear model, in which variables do not change over time and are related in a proportionate manner. Consider, for example, the following simple production function, which has only labor as an input:

$$(1)\quad Y = AN \quad A > 0,$$

where Y is output, which is completely consumed by workers (there is no saving or investment), N is labor employed and A is the productivity parameter. This equation states that output is positively related to the amount of labor employed. Given the value of A and the labor supply, the exact value of output can be determined.

This type of model is highly restrictive; any change in labor changes output by a constant percentage. Hence, the production function exhibits constant returns to scale.

Allowing the model to be nonlinear (that is, not necessarily proportionate) provides a more general model in which equation 1 is a special case. An example of a nonlinear production function is given by:

$$(2)\quad Y = AN^{\alpha} \quad A > 0,\ \alpha > 0.$$

If $\alpha = 1$, this model is identical to the one shown in equation 1. By not restricting α to equal one, however, this model can be used to examine the case in which output can vary disproportionately with respect to changes in labor. This is illustrated in figure 2, which shows the relationship between output and labor for different values of α (for simplicity, $A = 1$). Notice that if α is between zero and one, the production function exhibits decreasing returns to scale (that is, output increases less than proportionately with respect to a change in labor); if α is greater than one, production is characterized by increasing returns to scale (output increases more than proportionately with respect to an increase in labor). Empirical tests of actual production relationships can be performed to determine if α is actually different from or equal to one.

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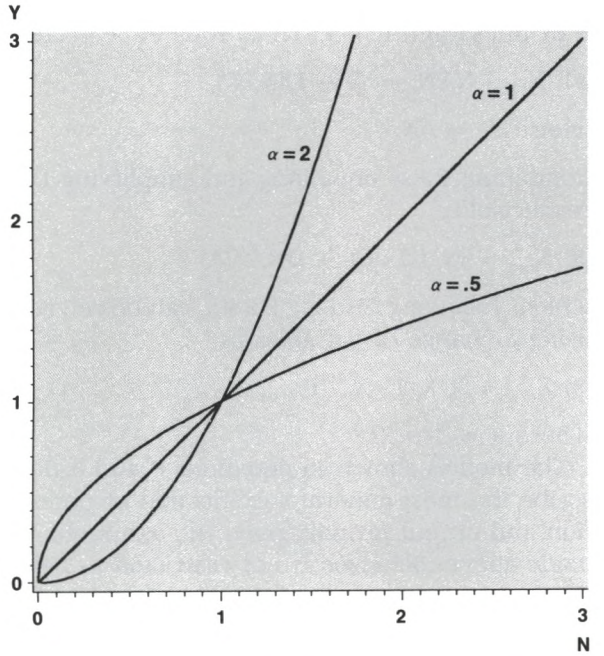
[3]There is a growing body of theoretical literature incorporating chaos into many different types of economic models. These models include Benhabib and Day (1981), Deneckere and Pelikan (1986), Grandmont (1985), De Grauwe and Vansanten (1990), Kelsey (1988), Day and Shafer (1985) and Stutzer (1980). For surveys of the theoretical literature, see Kelsey (1988) and Baumol and Benhabib (1989).

[4]There is also a burgeoning field in stochastic (random) modeling, which incorporates the assumption of randomness used in econometric models into the theoretical literature. Recent papers also look at the properties of chaos in the presence of a random component [see, for example, Kelsey (1988)]. For simplicity, this paper focuses only on purely deterministic systems.

Figure 2
Linear vs. Nonlinear Production Functions
$Y = AN^{\alpha}$



Linear Dynamic Models

One disadvantage of these static models is that they can be used to describe the relationship between output and employment only if the labor force or population remains constant over time.[5] Suppose instead that we want to examine the behavior of output over time as it is related to a continuously changing labor force. A standard equation borrowed from Haavelmo (1954), used to describe the growth of the labor force where that growth is dependent on the level of output, is given by:

$$(3)\quad \dot{N}(t)/N(t) = C - DN(t)/Y(t) \quad C > 0,\ D > 0,$$

where C and D are constants, and a dot over a variable means the change in the variable with respect to a very small change in time. This type of equation is called a differential equation.

Equation 3 states that the percentage rate of change of the labor force [$\dot{N}(t)/N(t)$], where time is continuously changing, equals the difference between the rate of birth, C, and the rate of death, given by $DN(t)/Y(t)$, where $N(t)/Y(t)$ is the number of individuals who have to subsist on each good at time t.

Using the linear production function given in equation 1 and substituting it into equation 3 provides a linear specification of the percentage change in the population:

$$(4)\quad N(t)/N(t) = C - D/A.$$

Notice that when the production function is linear the rate of death, D/A, is constant.

Solving equation 4 yields the following solution for the population:

$$(5)\quad N(t) = Ke^{(C-D/A)t},$$

where K is an arbitrary constant.[6]

This solution has the property that, unless the rate of birth (C) is *exactly* equal to the rate of death (D/A)—in which case the population will equal K—the population will either rise exponentially or fall to zero. This result is highly restrictive, however, because the likelihood of either the two rates being identical or the population increasing infinitely is, in reality, very small. In other words if $C \neq D/A$, the system is unstable.[7] Unfortunately, in models of other types of economic variables, results that greatly restrict the possible values of the parameters of the models are not uncommon. In addition, because of the complexity of many economic models, the implications of restricting the value of the parameters to determine the solution or to ensure a

[5]For expositional ease, the terms "population" and "labor force" are used interchangeably.

[6]Equation 4 is solved by the variable separable method of solving differential equations found in most calculus books. K is the constant of integration, which can be determined by choosing an initial condition.

[7]In fact, stability is an important issue which is frequently ignored or abstracted from in economics. Stability is important because, for example, an unstable equilibrium is not a sustainable equilibrium. Stability is also important in the choice between linear and nonlinear models. Linear models have three possible cases: stable converging dynamics (such as when C = D/A in the model above), unstable dynamics (when $C \neq D/A$) and cyclical dynamics, which is the least common of the three. In nonlinear models, however, cyclical dynamics are far more common, and exploding dynamics may not occur. Thus, it is also important to consider the desirable and realistic stability properties when choosing a model. Obviously the nonlinear case is more general and the most realistic for variables that exhibit cyclical variation. For the purpose of this paper, however, the issue of stability is ignored.

stable solution are not always as obvious as in the population growth model. Because linear differential equations are far simpler to solve than nonlinear differential equations, and because their solutions are more often stable and easier to interpret, however, they are used in economic models more often than may be appropriate.

Nonlinear Dynamic Models

Combining the nonlinear production function given by equation 2 with the description of population growth given in equation 3 provides a less restrictive model of population growth:

$$(6)\ \dot{N}(t)/N(t) = C - DN(t)^{1-\alpha}/A.$$

Unlike equation 4, equation 6 allows the labor force to vary more or less as the current labor force changes. Unfortunately, the price of the generality provided by such nonlinear differential equations is that most either cannot be solved or have solutions so complex the results cannot be interpreted. Not surprisingly, economists often avoid these types of models.

The model used here, however, was chosen for its tractability and can be solved for the value of labor at any time t.[8] All that is necessary for a stable solution is that the production function exhibits decreasing returns to scale ($0 < \alpha < 1$). Regardless of the value of the other parameters, if α is between zero and one, the population will reach a stable equilibrium level. Hence, in contrast to the dynamic linear model discussed previously, the results of this model are more realistic and provide a more general description of population and output growth.

Discrete Models

One problem with using continuous time models in economics is that data are available only in distinct intervals (daily, weekly, monthly, etc.). One approach typically taken by economists, therefore, is to convert these continuous time models into discrete time models. Discrete dynamic models are called *difference* equations; they measure time in distinct intervals rather than the *differential* equations used above, which measure time continuously. Equation 6 can be transformed into a difference equation by letting the rate of change of N (previously given by $\dot{N}$) equal the difference between the value of N at time t and t + 1. Thus, equation 6 becomes

$$(7)\ (N_{t+1} - N_t)/N_t = C - D(N_t/Y_t),$$

where $Y_t = AN_t^{\alpha}$.

Combining these equations and simplifying the result yields:

$$(8)\ N_{t+1} = N_t\,[(1+C) - DN_t^{1-\alpha}/A],$$

which, following Stutzer (1980), can be rewritten using a change of variables as

$$(9)\ X_{t+1} = k\,X_t(1 - X_t^{1-\alpha}),$$

where $k = 1 + C$.[9]

The models shown in equations 8 and 9 describe the most general specification of population and output growth given the assumptions made above. Behavior is not restricted to being linear, nor is population or output restricted to remaining constant over time. On the other hand, as noted earlier, these more general models often cannot be solved or have solutions without any economic interpretation. Nevertheless, unless there are theoretical reasons for assuming relationships are static or linear, dynamic nonlinear models, which provide the most general specification of behavior, should at least be considered in economic analysis. Although generality for its own sake is not a desirable goal, using a more general model would be appropriate when simpler models have solutions that are highly unrealistic or when parameters have to be restricted beyond reason (as in the model presented here). In addition, if economists want to test their models and results empirically, then these variables should be modeled in the form in which they are estimated—discrete form.[10] As it turns out, these types of nonlinear dynamic models can exhibit chaos.

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[8]For the solution and discussion of this model, see Haavelmo (1954), pp. 24-29.

[9]Allowing $N_t = [A(1+C)/D]^{1/(1-\alpha)}\,X_t$ only changes the scale of the population and has no effect on the general characteristics of the solution. For further discussion of this procedure and the solution, see Stutzer (1980).

[10]Although the model given by equation 6 is stable in continuous time, it is not necessarily stable in discrete time since in discrete time this model can generate chaotic dynamics for certain parameter values. Differential equations can also exhibit chaos, although only in more complicated models. This is discussed in greater detail later.

AN INTRODUCTION TO THE THEORY OF CHAOS

The possibility that chaos exists in economic variables has strong implications for the way in which economics is modeled. For example, some variables that appear to be random processes, like one of the variables shown in figure 1, might in fact not be random at all; instead it might be completely explained using the appropriate deterministic model. This section demonstrates the properties of chaos, using a simple model.

In the most general sense, the term chaos is used to describe the behavior of a variable over time that appears random but, in fact, is deterministic; more precisely, given the initial value of the variable, all future values of the variable can be calculated with exact precision.[11] In contrast, the value of a random variable can never be predicted with certainty.

More formally, a function is chaotic if, for certain parameter values, the following two conditions hold: First, the function never reaches the same point twice under any defined interval of time. In this case, the function is said to exhibit *aperiodic* behavior. Second, the time path is sensitive to changes in the initial condition, so that a small change in the value of the initial condition will greatly alter the time path of the function.[12]

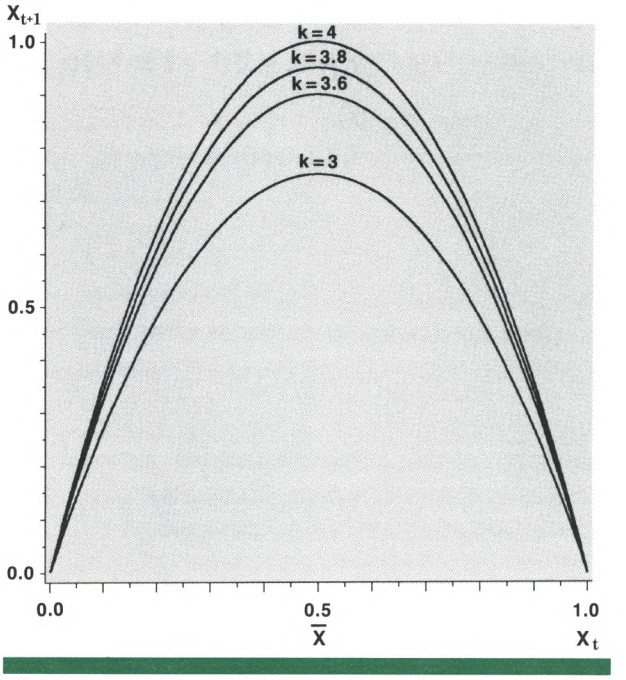
Chaos only arises in certain types of nonlinear dynamic systems, although not all nonlinear dynamic equations are chaotic. Moreover, equations that can be characterized as chaotic need not exhibit chaos for all parameter values. Rather, functions that can exhibit chaos will do so only for certain parameter values. This is explained by example below.

And Now for Something Completely Different . . .

The properties of chaos can be demonstrated using a simple mathematical equation, called the logistic growth equation. While this model has no particular economic interpretation, it is the simplest model that exhibits chaos and provides reasonably interpretable graphical results. This equation is given by:

Figure 3
The Logistic Growth Curve For Various Values of k

$X_{t+1} = kX_t(1 - X_t)$



(10) $X_{t+1} = k\,X_t(1-X_t),\ 0 < X_t < 1,\ 0 < k < 4.$

Equation 10 describes the time path of a variable, X (which for expositional purposes is called a population), that is a function of its previous value and a parameter k. To demonstrate chaotic behavior in this simple framework, the value of X can only take on values between zero and one. The value of k, the only parameter in the equation, is called the "tuning" parameter; it determines the steepness of the function. Figure 3 shows the function given in equation 10 for various values of k. Increases in the population below $\bar{X}$ increase future values of X more than proportionately. Past this point, the population begins to decrease.[13] For larger values of k,

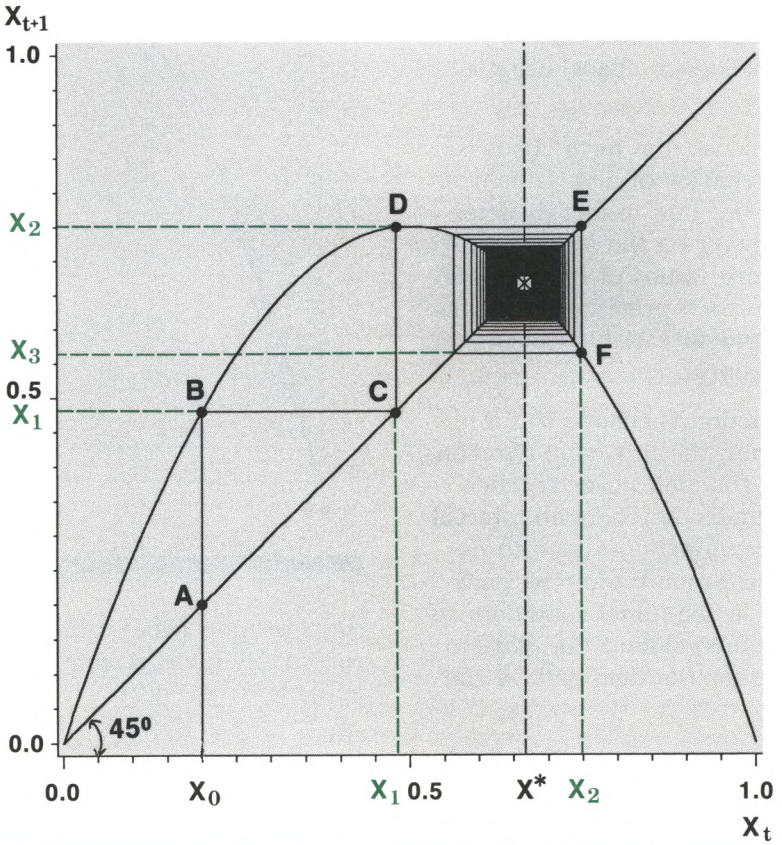
[11]For simplicity, only single-variable equations are discussed. Although chaos exists in multivariate economic systems, tests for chaos in these systems are just beginning to be developed, and the mathematics of such systems are extremely complex.

[12]There are many different characterizations of deterministic chaos, but they all include the one used here. For more rigorous definitions and discussion of the different definitions, see Li and Yorke (1975), Brock and Dechert (1988) and Melese and Transue (1986). For a good mathematical description of chaos and the mathematical tools used in the theory of chaos, see Devaney (1989).

[13]This behavior is similar to that of a total product curve where, once the marginal product becomes negative, further increases in an input decreases output.

Figure 4
A Stable Time Path for a Logistic Growth Curve

$X_{t+1} = 3 X_t (1 - X_t)$
$X_0 = .20 \quad t = 1 \text{ to } 500$



the absolute value of the rate of change of X is larger.

For certain values of the tuning parameter ($k \leq 3$), the system is stable; this means the population will reach some sustainable steady-state value which differs from $\bar{X}$.

Figure 4 illustrates how the time path for X_{t+1} is solved graphically. The parabola represents equation 10 when k is equal to three; all values of X_t and X_{t+1} must lie on this curve. The 45-degree line depicts the points where $X_{t+1} = X_t$, which is required for a steady-state equilibrium. In this example the initial value (when t = 0) is .20. To determine the value of X_1, draw a line between the initial value (X_0) and the parabola (line segment X_0B). To find the value of X_2, set $X_t = X_1$ by drawing a line from point B to the 45-degree line (point C). Then draw a straight line from point C to the parabola. This is the value of X_2 (point D). This process, called iteration, can be used to determine as many subsequent values of X as is desired, once the initial value is determined.[14] As we can see in figure 4,

[14]Notice that X_{t+1}, which must always lie on the parabola, can be either above the 45-degree line (as in point D) or below it (as in point F). For precision, the equation is solved numerically and then graphed.

the population appears to be converging to a steady-state equilibrium value at 2/3 (X^*).

If the value of k increases past three, however, the equilibrium point becomes unstable and the time path exhibits a two-period cycle, where the variable alternates between two values. Further increases in k produce a four-period cycle (that is, the time path repeats the same sequence of numbers every fifth iteration), then an eight-period cycle, and so on, with the periodicity increasing by 2^n (n = 1,2,3, . . .). If k increases past a certain point called the "point of accumulation" (for this function, it occurs at k = 3.5700), the time path enters into a region in which the function can exhibit chaos.[15] In the chaotic region (3.57 < k < 4 for this function), there can be both an infinite number of periodic cycles and an infinite number of initial conditions that produce an aperiodic time path.[16] Using this simple example, we can demonstrate some of the properties of chaos in graphical form.

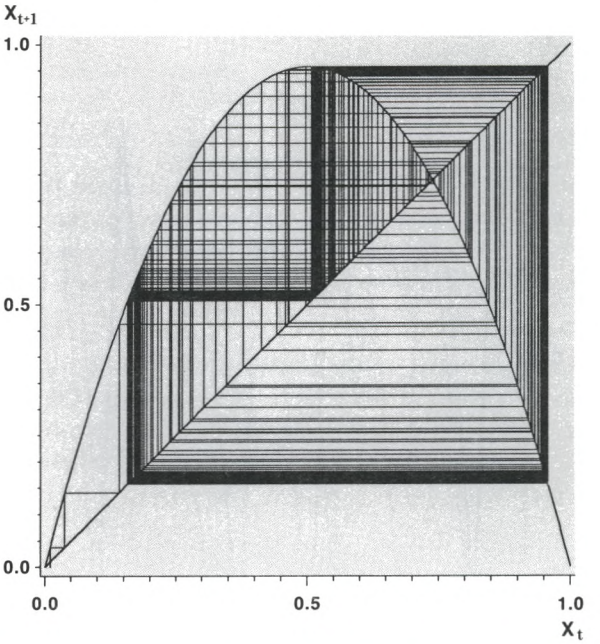
Properties of Chaos

An example of aperiodic behavior is seen in figure 5. The first 500 iterations are shown in this figure (that is, t = 1, 2, . . . 500), and *no single point is ever reached twice.*[17] In fact, no matter how many times this equation is iterated, X_t never has the same value twice.[18] If the data are plotted as a time series, it would look similar to figure 1a, the chaotic series in figure 1, and one might conclude that the data are generated by a random process, such as figure 1b, because they follow no obvious pattern. This is not the case here; the data in figure 1a and figure 5 were generated from models without a random component and therefore are completely deterministic.

The other characteristic of a chaotic function is that its time path is sensitive to the choice of initial values. An example of how changing the initial condition can affect the time path is shown in figure 6. In this figure, the values of X_t are plotted against time, as in figure 1. This diagram demonstrates how changing the initial value, X_0, at the fourth decimal place (from .0101 to .0100) causes the time paths generated by equation 10 to deviate substantially from each other.[19] Although not all sections of the time path differ as dramatically as the one shown here, figure 5 graphically demonstrates that the choice of an initial condition or, for forecasting purposes, the choice of a time interval (that is, determining where to start the sample), can greatly alter the results. In fact, despite

Figure 5
A Logistic Growth Curve Exhibiting Chaos

$X_{t+1} = 3.82840\ X_t(1 - X_t)$
$X_0 = .0101 \quad t=1 \text{ to } 500$



[15]This process of increasingly complex periodicity is called bifurcation and is discussed in most papers on chaos. For a nontechnical discussion of bifurcation, see Gleick (1987) and Stewart (1989). For a more analytical treatment of bifurcation, see May (1976) and Baumol and Benhabib (1989). A more rigorous discussion of the relationship between bifurcation and chaos is given in Li and Yorke (1975).

[16]Notice that not every initial condition gives rise to an aperiodic time path.

[17]This property is unlikely to be found in actual data, however, because of rounding. Although theoretically, aperiodicity is required for chaos, tests for chaos in actual data take a different approach, thus avoiding the problem.

[18]The time path can avoid having repeat values because the number of possible points between zero and one is infinite.

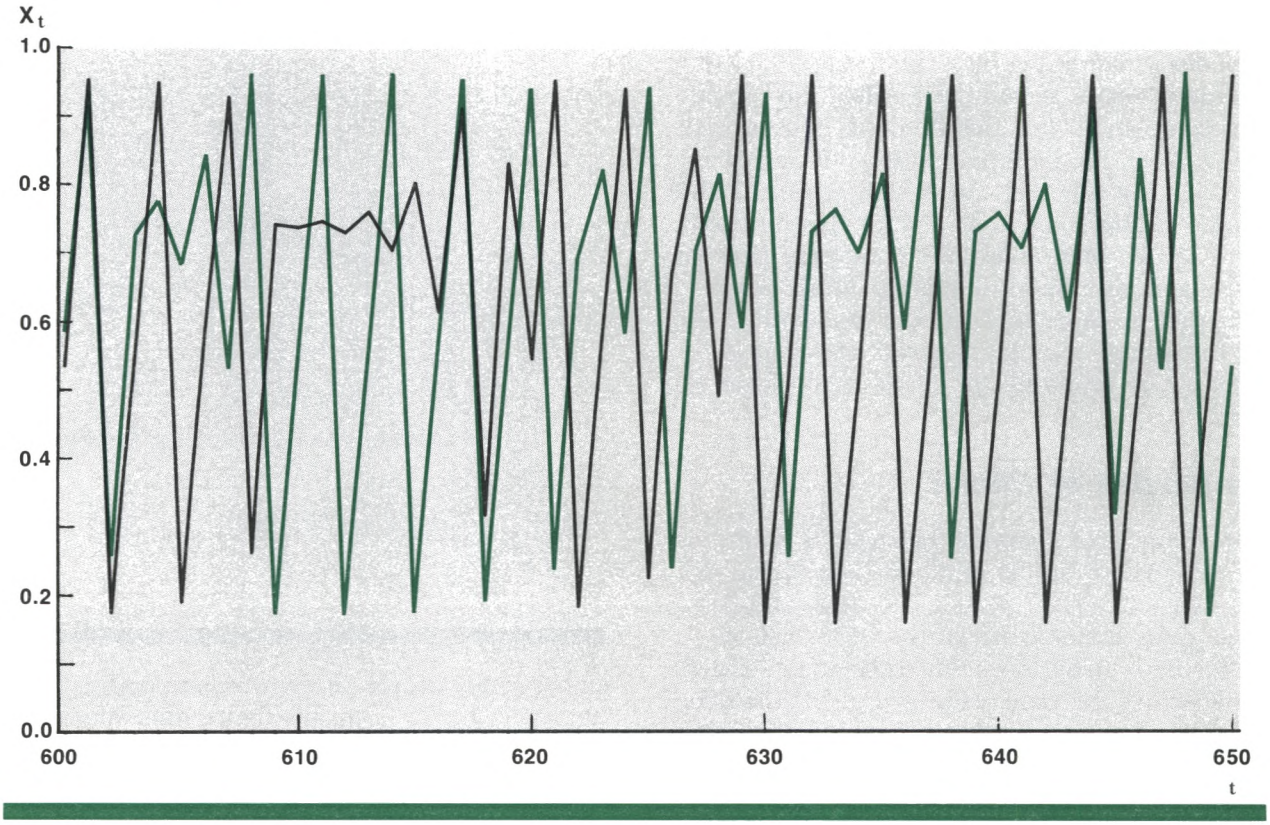
[19]Although it sometimes looks like the function is periodic, this appearance is a result of the lack of precision of the printer and the scale of the graph. In fact, there are no periodic points in this function.

Figure 6

A Segment of the Time Trend Showing Sensitivity to Initial Conditions

$X_{t+1} = 3.82840\ X_t(1 - X_t)$

$X_0 = .0101$ $X_0 = .0100$



seemingly trivial differences in the initial conditions, the time path produced by one initial value will not necessarily be similar to the time path generated by a marginally different initial value. In general, the two time paths that arise from the different initial values will have periods during which they are arbitrarily close together and periods during which they deviate substantially.

Chaotic functions also exhibit sensitivity to very small changes in the parameter values. A third- or fourth-order change in the value of a parameter can alter the time path from stable to chaotic or vice versa.

Sensitivity to changes in the parameter values is illustrated in figure 7. Here, a fifth-order change in the value of the tuning parameter (from 3.82840 to 3.82844) produces not only a substantially different time path from the one in figure 5, but also one that exhibits periodic rather than chaotic behavior.[20]

Are Attractors Strange?

Another feature often found in chaos, although neither necessary or sufficient for chaos, is a strange attractor.[21] The properties of attractors and strange attractors are best illus-

[20]Recall that when a function is in a chaotic region (that is, when the parameters are such that the function can exhibit chaos), there can be both periodic and aperiodic time paths.

[21]The only examples of chaos without the presence of a strange attractor are found in certain types of dissipative systems.

Figure 7
A Logistic Growth Curve With Periodic Points
$X_{t+1} = 3.82844\ X_t(1 - X_t)$
$X_0 = .0101 \quad t = 1 \text{ to } 500$

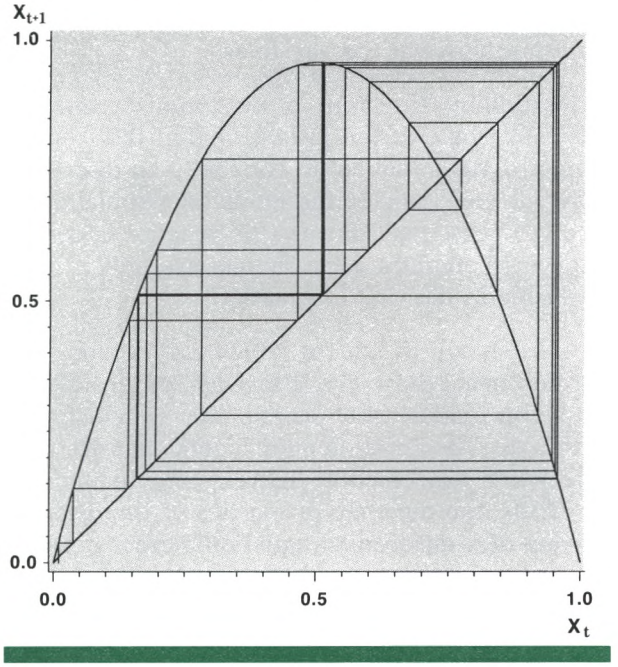
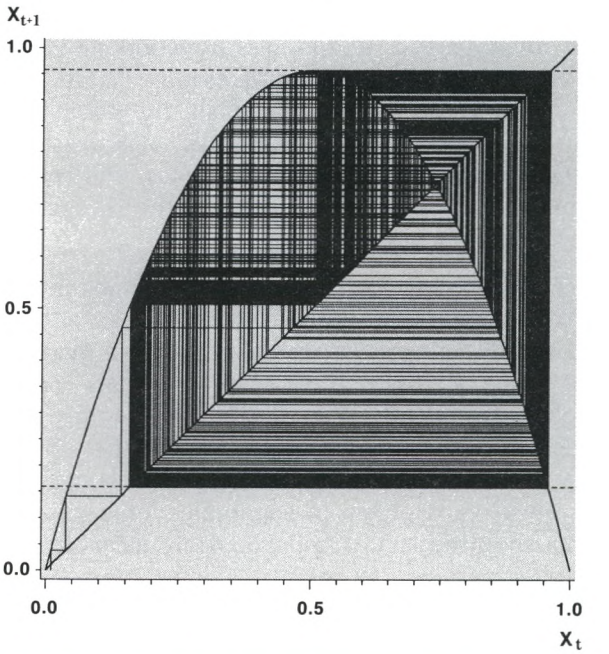


Figure 8
The Strange Attractor for a Chaotic Function
$X_{t+1} = 3.82840\ X_t(1 - X_t)$
$X_0 = .0101 \quad t = 1 \text{ to } 1500$



trated by example. In a stable system, the time path converges to an equilibrium point (for example, X^* in figure 4). The equilibrium point is also called the attractor, because the time path is "attracted" to the equilibrium point. Another possibility is that the time path has two attractors, and the system oscillates between them, never remaining at one equilibrium point. This is found in predator/prey population models, where the population grows until it is so large it begins to die off and then shrinks to a level so small it begins to grow again.

A "strange attractor" is the name given to the case where there is a region, rather than a finite set of points, that attracts the time path of the variable. That is, after some number of iterations, which varies depending on the function, the time path of the variable is completely contained in this region (the strange attractor). Thus, even though the path is aperiodic and therefore never reaches an equilibrium in the standard sense, it also never leaves the strange attractor and therefore is not unstable (for example, never goes to positive or negative infinity). An example of this is shown in figure 8, which takes the same numerical example as in figure 5, but iterates it 1500 rather than 500 times. In this picture, the values of X are still contained in the same area as in figure 5, but the distribution of points is becoming denser. The bounded region (shown by the dotted line in figure 8) is the strange attractor for this function. If the function is iterated further, the area within the bounded region would appear to be a solid block, although the function would never have the same value twice. In fact, the existence of a strange attractor is an important way to distinguish between a random and chaotic time path.[22]

[22]Another definition of a strange attractor is an attractor with fractal dimension. In fact, if a strange attractor exists, the variable has fractal dimension. Random variables have infinite dimension, however. As a result, tests for dimension are one of the main ways data are tested to determine if they are chaotic. For the purpose of this paper, however, the issue of fractals and fractal dimension will be ignored. For a discussion of these topics, see Mandelbrot (1983) and Gleick (1987).

LESSONS FROM CHAOS

Although economists are beginning to incorporate chaos into their economic and econometric models, there has been little discussion of the ways in which chaotic dynamics are useful or realistic for economic models. Clearly, chaos holds considerable appeal for economists who are looking for a deterministic explanation of the apparent randomness in economic variables. Economists frequently assume randomness when they are unable to explain the behavior of an economic variable empirically. The presence of an alternative explanation, chaos, will require them to consider more carefully the rationale behind their assumptions.

One problem with incorporating chaos into economics is that, while economists can either postulate an equation and test it for the presence of chaos or, alternatively, see if the data themselves are chaotic, it is especially difficult to identify the correct functional form that characterizes the data. The choice of a functional form is always a problem in economics, but, as previously discussed, it is particularly difficult to model nonlinear dynamics. This problem is exacerbated because, as a result of the mathematics required, the study of nonlinear dynamics has, until recently, been relatively limited in general and largely ignored in economics.[23]

Even when it is possible to estimate nonlinear dynamic equations, the models themselves often cannot be solved analytically. Without explicit solutions to these models, their usefulness is extremely limited. Obviously, the difficulty of determining the "true" underlying model from a data series is a problem whether or not chaos exists. The "discovery" of chaos, however, has focused much more attention on this problem, especially if the data are nonlinear.

Economic Modeling and Chaos

The study of chaos emphasizes the importance of rigorously modeling the dynamics of a system rather than merely taking a static model (like equations 1 and 2) and adding time subscripts and an error term. Although these simpler models may be more likely to have solutions with explicit results that can be tested empirically, the dynamics that arise may not capture the behavior of the variable of interest. The richness of a model may be found in explaining the behavior of a variable over time as much as in the direct, time-independent (or time-constant) relationship between the variables.

In addition, the study of deterministic chaos illustrates some of the pitfalls of first differencing a dynamic model to convert it to discrete time, as was done in the model of population growth presented above. This practice is common in economics because data are only available in discrete intervals.

As is shown in Stutzer (1980) and demonstrated here, there are first-order differential equation models (such as equation 6) which converge to a steady-state equilibrium that are chaotic when expressed in discrete time (equation 9). Thus, the dynamic properties of the discrete analog of a differential equation cannot be assumed to be the same. In fact, it has been shown that, although chaos can arise in first-order *difference* equations, it can only arise in third-order or higher *differential* equations.[24] As a result, an economist must be careful about either converting a continuous time dynamic model into a discrete model (such as converting equation 6 into equation 7), or taking a static model and simply adding a time subscript, rather than postulating a model that is dynamic (in either discrete or continuous time) and estimating or solving it in that form. The choice of the appropriate type of model should depend on the economic variables being described rather than analytical convenience. This issue is particularly important if a continuous-time dynamic model is estimated in discrete time using the steady-state equilibrium properties of the continuous-time solution. The discrete-time equation that is being estimated may not reach a steady state at all, or the solution could differ qualitatively from that found in the continuous-time version of the model.

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[23]For recent work in nonlinear dynamics, see Grandmont (1987).

[24]The "order" of an equation refers, for a differential equation, to the highest power attained by the derivative and, for a difference equation, the highest degree of differencing. For a more complete discussion, see Chiang (1984).

Empirical Applications of Chaos in Economics

There are generally two approaches used in the empirical literature to test for the presence of deterministic chaos in economic and financial data. The first approach tests for the presence of nonlinearities in the data.[1] Since chaos only arises in nonlinear systems, finding nonlinearities in the data suggests that testing directly for the presence of chaos is appropriate. In addition, the presence of nonlinearities in the data provides information to theorists modeling these types of economic systems. Because testing for nonlinearities in the data is much simpler (and less controversial) than testing for chaos, these tests are often performed first.

Many macroeconomic time series have been found to behave in a nonlinear manner. Brock and Sayers (1988) find such evidence in data for quarterly employment (1950-83), quarterly unemployment (1949-82), monthly post-war industrial production and pig-iron production (1877-1937). Nonlinearities have also been found in the Divisia M1 monetary aggregates.[2] Other studies have found nonlinearities in financial data as well. For example, Hinich and Patterson (1985a, 1985b) find strong evidence of nonlinearity in daily stock returns.

The second approach is to test directly for the presence of chaos.[3] There are many problems with testing directly for chaos using economic data, however. The most obvious, and perhaps the most important, is the sensitivity of chaotic systems to small changes in the parameter values and initial conditions. For these tests to be accurate, the data need to be especially exact. This degree of precision presents a particular problem for economics, where controlled experiments are essentially impossible, especially on the macro level. Data collection is far from perfect, and the quality of the data declines as the degree of aggregation increases, introducing measurement error in the data. In addition, because of rounding, the data are not as precise as they should be. For this reason, tests for chaos are not simply tests for aperiodicity.

The quantity of high-quality data is also extremely important. Even if the results show aperiodicity for a sample of 100 observations, the system need not be aperiodic. The existing empirical tests for the presence of chaos require an extremely large number of highly accurate data. Rarely are both of these available to econometricians. As a result, any evidence from tests for chaos should be viewed with caution.

Given these caveats, some statistical tests, originating in the physical sciences, do look for the presence of chaos in economic data. These tests are run on variables that have long time series available, are not aggregate variables, and are thus more likely to provide accurate results. Tests have found evidence consistent with chaos in exchange rates (Ellis, 1990), daily gold and silver prices on the London market (Frank and Stengos, 1988) and in the Divisia monetary aggregates (Barnett and Chen, 1988).[4]

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[1]For a discussion of the tests used, see Brock and Sayers (1988), as well as the other papers cited above.

[2]For a definition and discussion of the Divisia monetary aggregates, see Barnett and Spindt (1982).

[3]A description of the actual empirical techniques used to test for chaos is beyond the scope of this paper. For a description of the tests available for chaos and their drawbacks, see Barnett and Hinich (forthcoming), Brock (1986) and Ramsey (1989).

[4]This is by no means a comprehensive survey of the empirical literature applying chaos to economic and financial data. For a more comprehensive discussion of the empirical work on chaos, see Barnett and Hinich (forthcoming) and Ramsey (1989).

Econometrics and Chaos

The study of deterministic chaos also offers several lessons for econometricians. If forecasting is a goal of economic modeling, inappropriate modeling techniques in the presence of chaos become more costly. If the data are chaotic, forecasting is close to impossible since a small error in the value of the initial condition can lead to highly inaccurate predictions (see, for example, figure 6). Similarly, an error in any parameter value can also produce incorrect forecasts (see figures 5 and 7). Thus, it is important

to realize the limitations of economic forecasts in the presence of chaotic variables.

Chaos does not have to be present in the data to find the sort of fluctuating behavior (although without any clearly defined periodicity) that is often found in economic data. Nonlinear nonchaotic models often can generate time paths that appear random, and testing for nonlinearities is the likely next step for future research in this area. In fact, empirical economists are beginning to test for both nonlinearities and chaos in economic data (see insert on page 47). As a result, more work needs to be done in understanding nonlinear estimation so that economic models can describe a greater variety of behavior and be more accurate as well. In addition, the existence of chaos suggests that economists might want to try nonlinear specifications of a variable before resorting to modeling it as a random variable. This in turn will help to improve the quality of economic forecasts in the presence of nonlinear variables.

In addition, the use of a random component in estimation does not necessarily imply that the variable itself is random, but rather that other relevant variables might be excluded from the regression. Although each of these other variables could have a small influence on the system by itself, the total effect of these excluded variables could be substantial. Given both the difficulty in detecting what these missing variables might be and data limitations, such a complex system might best be approximated by a random variable, even if there is no true randomness in the variable being estimated. In fact, some argue (see, for example, Kelsey, 1988) that, since economic models do not include such (chaotic) phenomena as weather and other biological factors which can influence economic variables, it "seems inevitable that we will have random terms in our equations."[25]

CONCLUSION

The study of deterministic chaos and its subsequent application to economics has opened a new realm of possibilities for economists trying to explain cyclical or erratic behavior in economic variables. As discussed above, chaos has implications for both theoretical modeling and empirical applications in economics. By illustrating explicitly how restrictive the assumption of linearity can be, the study of chaos emphasizes the importance of allowing for the possibility of nonlinear behavior. The use of chaos in economics also has offered new explanations for behavior that, until recently, has been able to be explained only by random forces.

The techniques that have arisen from the study of chaos in the physical and biological sciences are in their infancy. As these techniques become more refined, and economists become better trained in working with these types of models, their ability to explain the behavior of variables such as exchange rates, business cycles and stock prices is likely to improve. That possibility alone is sufficient reason for economists to take a closer look at deterministic chaos in particular and nonlinear dynamics in general.

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[25]Kelsey (1988), p. 12.

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David Laidler

David Laidler is a professor of economics at the University of Western Ontario and is affiliated with the C.D. Howe Institute.
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The Legacy Of The Monetarist Controversy

INTRODUCTION

It is not quite true, as one (hostile) commentary has asserted, that Monetarism was developed by "Milton Friedman at the Federal Reserve Board (sic) of St. Louis," but it is nevertheless the case that the intellectual environment created at this Bank by Homer Jones ensured that the doctrine took root and flourished here when it was very much a minority taste elsewhere.[1] And indeed, at least two early and seminal contributions to the Monetarist controversy, Andersen and Jordan (1968) and of course Brunner (1968), which gave the controversy its label, first appeared in the Bank's *Review*. The Monetarist controversy, therefore, is surely a suitable topic for this lecture. Now Monetarism has been much defined and debated over the years, to the point at which one may find authority for applying the term to almost any economic and/or political doctrine one likes, or more probably dislikes. However, it is not so much my purpose here to define that doctrine in detail yet again, as it is to discuss the consequences for the development of monetary economics, both in theory and practice, of the debates to which it gave rise during the 1960s and 1970s.

In this lecture, I shall first of all describe the issues that were at stake at the outset of those debates. I shall show that although the Monetarist policy agenda was very different from that of what we might call "Keynesian" orthodoxy, the positive differences in economic analysis which underlay the policy debate were at first empirical in nature, raising no fundamental questions of economic theory. I shall also show, however, that, whether it was logically necessary or not, theoretical considerations of profound importance did get introduced into the Monetarist controversy as it progressed. Although these at first seemed to strengthen the Monetarist position, I shall go on to argue that these very considerations in the longer run undermined it, leaving Monetarism without distinct theoretical foundations, and incapable of coping with the empirical difficulties which it began to encounter from the mid-1970s onward. Furthermore, I shall suggest that most, though not all, of those empirical problems stemmed from an attempt by "Keynesian" orthodoxy to adapt Monetarist ideas to its own use. Finally, I shall argue that though the Monetarist controversy was to all intents and purposes over by the early 1980s, the problems which it bequeathed to monetary economics continued to affect theoretical, empirical- and policy-oriented aspects of the sub-discipline into the 1980s, with results which

[1]See Gould, Mills and Stewart (1981), p. 26.

I cannot help but view with considerable discomfort.

THE MONETARIST CONTROVERSY IN THE 1960s

The Monetarist controversy concerned the role played by monetary variables in general, and the quantity of money in particular, in the macroeconomy. Different exponents of Monetarism stressed different propositions, but it would be fair to say that, from the point of view of the non-academic observer whose main concern was the conduct of economic policy, Monetarism involved first a theory of inflation, second a theory of the cycle, and third, as a corollary of these, a recommendation for the conduct of monetary policy. Specifically, inflation was said to be explicable in terms of the rate of growth of the money supply, and the cycle, or more precisely its turning points, in terms of changes in that rate of growth. From these propositions, it immediately seemed to follow that both inflation and cycles could be avoided by choosing an appropriate rate of growth for the money supply, and binding the monetary authorities to deliver it year in and year out by imposing upon them some quasi-constitutional rule of conduct. The central item on the Monetarist policy agenda was thus to eliminate inflation and stabilize the real economy by taking discretionary power away from the central bank.[2]

Whatever position may be taken about its validity, this Monetarist agenda is nowadays treated as having been (and perhaps as still being) worthy of serious discussion. It was not so 25 or 30 years ago. Then, though the Phillips curve, about which I shall have more to say below, was coming onto the scene, the predominant view treated inflation as largely a matter of "cost-push" forces. The cycle was regarded as having its roots in investment fluctuations, and some mixture of wage-price guidelines and fiscal measures was thought best able to cope with the policy problems the two phenomena presented. Monetary tools had at best a minor role to play in the conduct of macro policy, and the relevant variables were, in any event, thought to be not the quantity of money, but the level and structure of nominal interest rates. In 1960, say, that as yet un-named body of doctrine which we now know as Monetarism was hardly debated for the simple reason that it was regarded as quite outlandish. This was strange indeed, because at that time no fundamental questions of economic theory separated proponents of the conventional macroeconomic wisdom of the early 1960s from their Monetarist critics. Each side in the debate that was to follow could, and did, derive their views from specific quantitative hypotheses about relationships embodied in what was, nevertheless, qualitatively speaking, essentially the same macroeconomic model, that staple of the contemporary textbooks, the Hicks-Hansen IS-LM framework.[3]

The first stage of the Monetarist controversy was about the empirical nature and stability of the demand for money function, or, as it was then thought equivalently, the relationship determining money's velocity of circulation. As early as 1956, Friedman had advanced the hypothesis that the demand for money was a stable function of a few arguments, and by 1959 had produced empirical evidence which seemed to show that, as far as real money balances were concerned, "few" meant "one": namely, permanent real income. The implications of this result were startling, because, once fed into the IS-LM framework, they suggested that if the quantity of money was held to an appropriate constant growth rate, there would be essentially no scope for shocks originating on the real side of the economy, for example, in the investment component of aggregate demand, to bring about any significant fluctuations in nominal income. Nor would there be any role for fiscal measures to play in influencing that variable. Furthermore, a slightly later, but essentially complementary, study by Friedman and Meiselman (1963)

[2]In an earlier essay, Laidler (1982), Ch. 1., I analyzed the essential characteristics of Monetarism from an academic perspective, concentrating there on the role of a stable demand for money function and the expectations-augmented Phillips curve in defining the doctrine. As the reader will see, these relationships play a large part in the following discussion, and I regard this essay as supplementing rather than in any way contradicting this earlier piece.

[3]Thus Laidler (1969) used this framework to motivate its discussion of the significance of the demand for money function, while Friedman (1971) also used it as an expository device. Note, however, that Brunner and Meltzer (e.g., 1976), because of their insistence on the importance of credit market effects in the generation of the money supply, were led to extend this framework to a point at which it became sufficiently different in its characteristics to make it misleading to treat it as simply one more variant on IS-LM.

seemed to confirm directly the irrelevance of variations in autonomous expenditure, while at the same time attributing a considerable influence on money income's behavior to the growth rate of the money supply.

The appealing simplicity of these results did not long survive further empirical investigation. A number of studies soon found a role for interest rates to play in influencing velocity, hence re-opening the theoretical possibility of variables other than money affecting the time path of money income, and the Friedman-Meiselman results were not robust in the face of small changes in the way in which the Keynesian concepts of autonomous and induced expenditure were measured.[4] Nevertheless, from a practical point of view, the modifications to the basic Monetarist position required by these results were rather minor. The quantity of money did seem to be an economic variable of potentially strategic importance; and real shocks originating in the private sector, not to mention impulses coming from fiscal policy, did seem to play a potentially less important role in determining money income's time path than the conventional wisdom of about 1960 would have had it. By 1967 results such as these were sufficiently well established and widely accepted that it was possible for the present writer to begin work on a supplementary textbook (Laidler, 1969) which summarized the empirical evidence on the demand for money function, and explicitly interpreted it in terms of the above-mentioned IS-LM model along just such lines as these.

Now the reader will be well aware that our earlier confidence in the empirical stability of the demand for money function has not been entirely justified by subsequent experience. I will take up this matter below. For the moment it is more important to concentrate upon another anomaly in this aspect of the Monetarist controversy, namely that empirical evidence on the stability of the demand for money function, though relevant to Monetarist propositions about the causative role of money *vis à vis* both inflation and the cycle, and hence also to proposals to tie down monetary policy by way of a growth rate rule, stops far short of establishing them. Thus, if monetary elements in the generation of inflation on the one hand, and the cycle on the other, are to be discussed coherently, one requires more than a link between the time path of money and money income. One also needs a theory of how fluctuations in money income are divided up between its price level and real income components. Moreover, a stable demand for money function is quite compatible with the existence of cost-push inflation and a cycle whose origins lie in the private sector of the economy, provided only that institutional arrangements are such as to render the supply of money as an essentially passive variable.

Empirical evidence about the stability of the demand for money function, that is to say, got Monetarist analysis taken seriously enough for it to become controversial, but it could not in and of itself guarantee its victory in a debate which rather centered on the two issues raised above. The first issue became known as the problem of Friedman's "missing equation," and debate about it overlapped heavily with discussions of the "Phillips curve," otherwise known as the "inflation-unemployment trade off." As to the second, it was addressed by such workers as Philip Cagan (1965), and Brunner and Meltzer (e.g., 1964, 1976) who opposed their findings to the then "new view" of money propounded by James Tobin (eg., 1969) and his associates. It will be helpful to discuss these two aspects of what we might term the second stage of the Monetarist controversy in turn.

The problem of decomposing variations in money income into their real and price level components was a longstanding one in macroeconomics, dating back at least to Hicks' original (1937) formulation of the IS-LM framework as a model of the determination of money income. Though subsequent developments of this system reinterpreted it as dealing with real income, that still left prices unexplained. Here, the usual solution was to have them determined by the behavior of the money wage, and as I have already noted, to treat the latter variable as being driven by exogenous "cost-push" factors. However, this is not the whole story, for "demand-pull" explanations of inflation also had their adherents, and the Phillips (1958) curve relating the rate of money wage inflation inversely to

[4]Among early papers finding a significant interest elasticity of demand for money were Meltzer (1963) and Laidler (1966). Both Ando and Modigliani (1965) and De Prano and Mayer (1965) showed that fairly small changes in the definition of "autonomous" expenditure led to rather large effects on the assessment of its influence on aggregate demand. Strangely enough, at this stage of the Monetarist controversy, questions about vagueness in the definition of money were not raised.

the level of unemployment soon came to be seen as a device for synthesizing these two points of view. Wage inflation, according to the Phillips curve was proximately caused by an excess demand for labor, for which variable the unemployment rate was a proxy. Such excess demand could either result from "pull" forces shifting the labor demand curve, or "push" influences shifting the supply curve. In either case, however, price inflation would be determined by the difference between wage inflation and labor productivity growth. Hence there seemed to exist a structural inverse trade-off between inflation and unemployment, or equivalently a positive relationship between the level of real output and inflation.[5]

From the point of view of microeconomics, the above analysis was fatally flawed, being based on a theory which had the supply and demand for labor determine the *money*, rather than the *real*, wage, and it was not long before Phelps (1967) and Friedman (1968) independently pointed this out. The latter, moreover, brought his critique into the center of the Monetarist controversy, by noting, first that the orthodox Phillips curve predicted that an inflationary monetary policy could generate permanent gains in real income, and second, that when its underpinnings were corrected to take account of the money wage-real wage distinction, the inflation-unemployment trade-off was reduced to a temporary phenomenon at most. Hence, a key ingredient of the theory which yielded the characteristic Monetarist propositions about money growth affecting only prices in the long run but quantities too, in the short run, was created *after* the empirical observations upon which those propositions were based had been published, and turned out to be a theory not of money, but of labor market behavior. It seemed to be, moreover, in its original form, a modification of a device borrowed from one branch of the orthodoxy to which Monetarism was opposed. As a practical matter, rather than replace it with some alternative equation, the Phelps-Friedman critique of the Phillips curve simply added the expected inflation rate to the relationship's right-hand side, with a coefficient of unity.

As with Monetarist propositions about the demand for money function, then, questions raised by the Monetarist "correction" to the Phillips curve seemed to be inherently empirical. Either the labor force was immune to money illusion in the long run, so that there was no permanent inflation-unemployment trade-off, or it was not, in which case such a permanent trade-off existed. This question generated much empirical work in the late 1960s and early 1970s, and it is a fair generalization that as more and more evidence was added by the passage of time, the more the work in question came to support the Monetarist position. Evidence from the 1950s and early 1960s was compatible with the existence of an inflation-unemployment trade-off, but the experience of higher inflation rates from the mid-1960s onward made this hypothesis harder and harder to support.[6] Once again, though, there was no reason why this result could not be incorporated into the framework of a suitably extended IS-LM model. However, two factors militated against so simple and harmonious an outcome to this stage of the Monetarist controversy.

To begin with, the original Phelps-Friedman critique of the Phillips curve had been advanced on theoretical grounds, and before empirical evidence seemed to require economists to change their notions about labor market behavior. When confronted with a choice between what empirical evidence seemed to show, and what elementary economic theory required to be the case, Phelps and Friedman had chosen the latter. *Ex-post*, they were vindicated by empirical evidence, and this vindication served notice on macroeconomists that they would be wise to pay more attention to the microeconomic foundations of their empirical generalizations than had typically been the case up until then. Second, Friedman's version of the critique had been accompanied by a brief account of labor market behavior, part of which was quite incompatible with the then conventional interpretation of real income and employment fluctuations as manifestations of variations in excess demand in the economy.

[5]Phillips' original analysis was much elaborated by Lipsey (1960), but responsibility for explicitly treating the Phillips curve as a structural relationship constraining policy choice probably rests with Samuelson and Solow (1960).

[6]The relevant empirical literature was voluminous, but is surveyed by Laidler and Parkin (1975).

Conventionally enough by the standards of the 1960s Friedman described the early stages of the economy's response to a monetary expansion in the following terms.[7]

> ...much or most of the rise in income will take the form of an increase in output and employment rather than in prices. People have been expecting prices to be stable, and *prices and wages have been set for some time in the future* on that basis. It takes time for people to adjust to a new state of demand. Producers will tend to react to the intitial expansion in aggregate demand by increasing output, employees by working longer hours, and the unemployed by taking jobs now offered at former nominal wages. This much is pretty standard doctrine. (p. 103, my italics)

However, Friedman immediately went on to elaborate this account of the mechanisms that brought about short-term fluctuations in income and employment:

> Because the selling prices of products typically respond to an unanticipated increase in nominal demand faster than prices of factors of production, real wages received have gone down—though real wages anticipated by employees went up, since employees implicitly evaluated the wages offered at the earlier price level. Indeed, the simultaneous fall *ex-post* in real wages to employers and rise *ex-ante* in real wages to employees is what enabled employment to increase. (pp. 103-04)

Unemployment fluctuations in the conventional view of the Phillips curve had been treated as manifestations of variations in the pressure exerted by excess demand in goods and labor markets characterized by less-than-perfect price flexibility, and hence likely to be operating out of equilibrium in the wake of any shock to aggregate demand. The first passage quoted above is quite compatible with this view. In the second passage quoted, however, employment fluctuations are explicitly pictured as arising from voluntary decisions taken in response to price changes and, in the case of the suppliers of labor, on the basis of faulty expectations which would in due course be corrected.

Thus Friedman's critique of the Phillips curve potentially involved much more than the addition of an extra variable to the right-hand side of an equation. It also pointed toward a fundamental reinterpretation of the labor market behavior underlying it. Viewed with hindsight, it provides as an unmistakable sketch of the microfoundations of the short-run aggregate supply curve which was to become the central analytic device of New-classical economics. As we shall see below, this device would in due course, and quite paradoxically, not strengthen but thoroughly undermine the very Monetarist explanation of the business cycle to which Friedman's analysis of inflation-unemployment interaction was particularly addressed.

The analysis of inflation-unemployment interaction was by no means the only area in which, during the 1950s and 1960s, macroeconomists were seeking to strengthen the microeconomic foundations of their analysis. A whole set of questions concerning the determination of the money supply, and the mechanisms whereby monetary changes might interact with aggregate demand in the economy, were also addressed in such terms, both by adherents of the conventional Keynesian macroeconomic wisdom of the time, and by Monetarists. Here as elsewhere, the contentious issues were more empirical than theoretical. As Harry Johnson noted as early as 1962, there was no debate in principle between, say, Brunner and Meltzer on the one hand and James Tobin on the other about the basic nature of the linkages between the monetary and real sectors of the economy. Both saw these as involving disturbances to the structure of the portfolios of the banking system and the non-bank public generating changes in the relative rates of return on various assets, financial and real, which would in turn provoke attempts on the part of agents to restore equilibrium by way of sales and purchases of various assets. Both sides also agreed that financial institutions and the non-bank public alike should be analyzed as maximizing agents.

What defined the Monetarist position here was not its general approach, but rather a set of specific hypotheses about the quantitative nature of the responses in question. First, as far as the non-bank public was concerned, Monetarists took a broad view of the array of assets whose rates of return were relevant to what we might term the transmission mechanism of monetary policy. Specifically, they argued that monetary policy would have effects not just on rates of return borne by financial assets, but also on the implicit rates of return yielded by producer and consumer durables. Hence they saw its effects as being both more pervasive, and quanti-

[7]Friedman's (1969) *Optimum Quantity of Money* reprints many of his seminal contributions, and the page references here and elsewhere to quotations from his work are to this source unless otherwise noted.

tatively more significant too, than did proponents of the Tobinesque "new view." Furthermore, while not denying that disturbances originating in the private sector of the economy would impinge upon the behavior of financial institutions, so that the quantity of money was undoubtedly in this sense an endogenously determined variable, they nevertheless strongly resisted the idea that the endogeneity in question also involved that variable being passively demand-determined, even when the monetary authorities used short-term interest rates as their policy instrument.

Such an outcome was logically possible, to be sure. If interest rate changes disturbed only the margin between financial assets (let us call them bonds) and money, then a reduction, say, in interest rates would lead to the public simply offering bonds to the banks in exchange for money with no further consequences. However, consistent with their broad view of the range of assets relevant to the transmission mechanism, Brunner and Meltzer argued that the principal margin likely to be disturbed by a change in interest rates was that between bonds and physical capital, including consumer durables. The public would sell bonds to the banks, of course, but as part of a process of replacing those bonds with physical capital. Furthermore, and crucially, this would be only a first-round effect, for the sale of bonds to the banks would be in exchange for newly created money which would have to be accommodated in the portfolios of the non-bank public. Since the banks had presumably changed interest rates for a reason in the first instance, the possibility of their simply acquiescing in the destruction of newly created cash by the public discharging debts to them could be discounted. Hence, further substitution effects, changes in aggregate demand, and ultimately in the price level, would be set in motion.

Monetarists' theoretical position *vis-á-vis* the behavior of the quantity of money in circulation, then, may be described succinctly as follows. Rather than being a passive demand-determined variable, money also had a separate supply function which was derivable from analysis of the interaction of banks and the public in the market for bank credit. In turn, the quantity of credit which banks were willing to grant, as well as the terms on which they would make it available, were both subject to a strong (though not unique) influence flowing from the quantity of reserves which the central bank made available to them. The quantity of money was an endogenous variable, certainly, arising from a complex set of interacting portfolio choices, but it was nevertheless controllable by the monetary authorities. This theoretical position, moreover, was supported by a good deal of empirical evidence, some yielded by formal econometric studies, and some by less-formal historical work to the effect that the behavior of bank reserves, or more precisely of the quantity of high-powered money, was the principal determinant of the quantity of money in circulation and that variations in the ratio of high-powered money to the money supply proper could be modeled as the outcome of systematic maximizing portfolio choices.[8]

THE SUBVERSION OF MONETARISM BY NEW-CLASSICAL ECONOMICS

In the previous section of this essay, I have described the main elements of Monetarist doctrine, and have tried to show that they were all reasonably well-developed in the academic literature by the end of the 1960s. However, it took the inflationary experience of the early 1970s, particularly in the United States and Britain, to draw popular attention to that doctrine by providing, during its early stages, something as close to a controlled experiment as one ever gets in economics. In both countries, monetary expansion preceded an inflation which the authorities attributed to cost-push forces and attempted to control with wage-price control programs, and in both countries those programs failed. Though the OPEC-led energy price increases of 1973 contaminated the later stages of the experiment by introducing an extraneous cost-side impetus to the upward progress of prices, the early 1970s was nevertheless the last time that wage-price controls were deployed as an *alternative* to monetary restraint in an anti-inflation policy. Moreover, the fact that the high

[8]Perhaps the best known of early econometric studies of the money supply function is Brunner and Meltzer (1964). The standard historical study is that of Cagan (1965). Brunner's (1968) St. Louis *Review* piece contains perhaps his single best exposition of the Monetarist position on the generation of the money supply, and of the characteristics distinguishing it from the Tobinesque "new view."

inflation of the 1970s was combined with an obvious deterioration in real economic performance, rather than an improvement, ensured that Monetarist ideas about the absence of a long-run inflation-unemployment trade-off quickly became conventional wisdom.

At the very time at which Monetarist ideas were gaining popular acceptance, however, their academic foundations began to shift dangerously as New-classical economics was developed. I have suggested elsewhere that the work of Robert E. Lucas, Thomas Sargent, Neil Wallace and Robert Barro is more usefully treated as separate and distinct from Monetarism, and for what I still regard as good reasons.[9] However, this was and remains, something of a minority viewpoint; and the fact remains that the two central characteristics of New-classical economics, namely the interpretation of the Phillips curve as a reflection of an aggregate supply relationship, and the rational expectations hypothesis, were quickly adopted by leading Monetarists. This was unfortunate, because as the Monetarist controversy moved into the 1970s and 1980s, it increasingly became, as a matter of fact, a controversy about New-classical economics. The majority of economists failed to distinguish between Monetarism and New-classical economics, and accepted James Tobin's characterization of New-classical economics as Monetarism Mark II.[10] When New-classical economics was academically discredited, so too was Monetarism in general, leading to what, as I shall argue in the final section of this paper, is a dangerous gap in the structure of contemporary monetary economics.

I have already noted that Friedman's 1968 analysis of the inflation-unemployment trade-off relied on two incompatible theories of labor market behavior. In the passages quoted earlier, we had quantities moving *instead of* wages and prices, which had already been set and hence were unable immediately to change; and we also had quantities moving *in response to* asymmetrically perceived money-price changes. We had, in short, both an informal account of the effects of wage and price stickiness which was, as Friedman said, "pretty standard doctrine" in the macroeconomics of the 1960s; but we also had an unmistakable sketch of an aggregate supply curve interpretation of the short-run Phillips curve in which money-wage and price flexibility was of the essence.

There is little point in speculating about the extent to which Friedman was aware of the tensions inherent in his analysis in 1968; but it is interesting to note that, at that time, he characterized Phillips' work as "...containing a basic defect—the failure to distinguish between *nominal* wages and *real* wages..." (p. 102, Friedman's italics) whereas in 1975 he referred not only to this point, but also attributed to Phillips an error in having "...taken the level of *employment* [instead of the rate of change of prices] as the independent variable..." in the relationship. By 1975 Friedman clearly was aware that there was a choice to be made concerning the microeconomic underpinnings of the Phillips curve and had explicitly rejected that which hinged on interpreting the unemployment rate as a proxy variable for some excess demand for labor concept. Brunner and Meltzer made a similar choice concerning the modeling of the linkages between output and price-level variations in designing the basic framework which they and their associates used to analyze the inflationary process in a number of countries in the mid- 1970s. Like Friedman too, they chose to model expectations as being formed not adaptively but, following Lucas and Sargent and Wallace, rationally, as the inflation forecast of the "true model" of the economy under analysis.[11]

These developments seemed at the time to be in no sense revolutionary. I have already remarked that the Phelps-Friedman critique of the Phillips curve initially involved using simple microeconomic analysis to mount a theoretical attack on what at the time seemed like an hypothesis well-supported by empirical evidence; and in the event, microeconomic principles proved a sounder guide than what turned out to be some misleadingly special observations. To show that price-output interaction could be derived from a supply and demand apparatus without resort to purely empirical generalizations about price stickiness, and to show that the analysis in ques-

[9]This argument is developed in some detail in Laidler (1982), Ch. 1.

[10]This characterization of Tobin's is developed and defended by him in Tobin (1981), in a paper prepared for the same conference as the above mentioned Laidler (1982), Ch. 1.

[11]The relevant work here is contained in Brunner and Meltzer, eds. (1978). Note that the details of their formulation of the aggregate supply curve, with output's rate of change rather than level playing a major role, set it apart from the standard Lucas (e.g., 1973) formulation. These matters, discussed by McCallum (1978), are not central to the matter under discussion here.

tion was compatible with agents making use of "all available" information in a utility maximizing fashion, simply seemed to be making even more secure the microeconomic foundations of a particular piece of macroeconomics, and hence to be rendering it less prone to excessive dependence on theoretically unsupported empirical observations of a type that had proved so misleading in the recent past.

Also, and crucially, New-classical macroeconomics still seemed to yield Monetarist implications, namely that inflation in the long run was a monetary phenomenon, and that, in the short run, so was the cycle. To be sure, it broadened the menu of monetary rules that would enable the cycle to be avoided to any that the general public could understand and therefore use as a basis for expectations formation, but a constant growth rate rule was still a particularly simple, and therefore viable, item on the menu in question, and it was of course a particularly appropriate choice if price stability in the long run was added to the elimination of the cycle as a proper goal for monetary policy.

Even in the mid-1970s, it should have been apparent that the attempt to underpin the Monetarist position with New-classical foundations was dangerous. As early as 1958, Friedman had suggested that monetary policy affected the economy with a "long and variable" time lag. The evidence with which he supported this suggestion identified a change in monetary policy as a change in the rate of growth of the quantity of money in the economy; and it showed that downturns in that rate of growth occurred on average 16 months before the corresponding upper turning point of the cycle, while upturns in money growth led cyclical troughs by about twelve months. Furthermore, as Friedman (1987) was later to note more explicitly, the effect of changed money growth on nominal income[12]

> ...typically shows up first in output and hardly at all in prices. If the rate of monetary growth increases or decreases, the rate of growth of nominal income and also of physical output tends to increase or decrease about six to nine months later, but the rate of price rise is affected very little...the effect on prices comes some 12 to 18 months later...(p. 17)

In 1963, Friedman and Schwartz had presented a more elaborate analysis of money's role in generating the cycle, in the course of which they explained the length of the time lags involved in terms that amounted to an informal sketch of a dynamic version of the Monetarist version of the transmission mechanism which Brunner and Meltzer were also expounding at the time.

> The central element in the transmission mechanism...is the concept of cyclical fluctuations as the outcome of balance sheet adjustments, as the effects on flows of adjustments between desired and actual stocks. It is this interconnection of stocks and flows that stretches the effects of shocks out in time, produces a diffusion over different economic categories, and gives rise to cyclical reaction mechanisms. The stocks serve as buffers or shock absorbers of initial changes in rates of flow, by expanding or contracting from their "normal" or "natural" or "desired" state, and then slowly alter other flows as holders try to regain that state. (p.234)

The empirical evidence referred to here, and particularly that part of it dealing with the timing of output responses relative to those in prices, and an explanation of that evidence in terms of a transmission mechanism involving portfolio disequilibria working themselves slowly out over real historical time are quite incompatible with New-classical analysis. Since both the evidence in question and the above explanation of it were available and well established before the development of New-classical ideas, the incompatibility in question ought to have prevented those ideas from being adopted as a basis for Monetarist propositions, but it did not. Whether this was because the problem was not fully appreciated at the time, or because that shift in methodological priorities away from empirical evidence and toward "sound" theoretical foundations upon which I have already commented caused those who were aware of it to opt for the latter is hard to say. I suspect that a strong element of the latter consideration must have been at work, though, since the inconsistency in question is hardly subtle.[13]

To begin with, the price flexibility postulate of New-classical economics creates problems for the

[12]The reader's attention is drawn to the recent (1987) vintage of this statement. I have not been able to find so clearcut and concise an exposition of the point in Friedman's earlier work, though I believe that the basic message contained in the passage quoted here can be distilled from the evidence presented in Friedman (1969), Chs. 10-12.

[13]Though I do not claim to have understood this matter fully from the outset, I did discuss it in some detail as early as 1978 in an essay reprinted as Chapter 4 of Laidler (1982).

Monetarist account of the transmission mechanism. Slow adjustment of portfolios in the wake of a monetary disturbance is of the very essence here, and it is usual to explain the slowness in question in terms of transactions costs. But if the price level moves freely and instantaneously to keep markets cleared it also, in the process, eliminates portfolio disequilibria quite costlessly for agents. According to Friedman and Schwartz, excessive money holdings develop because, when money growth increases, the rate of inflation does not respond immediately. But according to New-classical economics it does, and so increased money growth cannot cause a temporary rise in buffer-stocks of money as a preliminary to increased expenditure flows. The conflict here between traditional Monetarism and New-classical analysis concerns rival theoretical constructions. Much more serious is the conflict between theory and evidence which arises when the New-classical aggregate supply curve is confronted with the empirical evidence concerning the interaction of money, output and prices over the course of the cycle, evidence upon which traditional Monetarism laid considerable stress.

As is well known, the New-classical aggregate supply curve explanation of the decomposition of nominal income changes into their real and price-level components hinges upon the distinction between demand side shocks whose price level effects can be anticipated by agents, and those that cannot. The word "anticipated" normally means "expected *and acted upon*," but since the New-classical model is one in which flexible prices always move costlessly and instantly to equate supply and demand in all markets, the second phrase is redundant in its context. If a price level change is anticipated by agents, there will be no quantity changes associated with it; but if it is not, then the specific money-price changes in particular markets that are associated with it will be misinterpreted as reflecting relative price changes and voluntary responses in quantities of goods and services supplied will occur. Cyclical fluctuations in real variables may therefore be interpreted as the consequence of unanticipated price level changes. The trouble here is that it is hard to see how output and employment fluctuations can be responses to price level fluctuations *if they precede those price level fluctuations*; but the empirical evidence tells us that they do just that.

This inconsistency of the timing of data with the basic structure of New-classical theory, which should have led monetarists to reject that theory from the outset, did eventually undermine it. So long as empirical work was confined to testing the proposition that output and employment fluctuations could be modeled as responses to "unanticipated" money, all seemed well. However, Robert J. Barro (1978) noted that the theory in question made specific predictions about the relationship between monetary shocks and price level changes as well. When he came to test the latter predictions, he found that, in order to reconcile them with his data, the price level's response to unanticipated monetary shocks had to be characterized by a rather slow-moving distributed lag process, in an economy in which, however, prices could respond with no lag to anticipated money. Furthermore, his results also seemed to require that the aggregate demand for money display a greater sensitivity to transitory than to permanent changes in income, the very opposite result to that implied by a wide variety of other studies. New-classical analysis could be forced to fit the data generated by the U. S. economy, that is to say, only by way of some extremely implausible subsidiary assumptions.

Nor did the results of subsequent empirical work enhance New-classical economics' claim to be taken seriously. Mishkin (1982) repeated Barro's tests of the irrelevance of anticipated monetary shocks for output using more sophisticated econometric techniques, and found that this resulted in a reversal of the initial results—apparently anticipated monetary changes did have real effects. Boschen and Grossman (1982) noted that money supply estimates are published weekly, and that only the errors in these estimates properly can be regarded as constituting the unanticipated component of the money supply. They further noted that the latter were implausibly small to form the basis of a monetary explanation of the cycle, and that output changes were in fact correlated with monetary changes about which information had previously been published.

In addition to these problems raised by academic work, of course, there was the experience of the early 1980s recession, which played the same role in publicly discrediting New-classical economics, as did the inflation of the 1970s in undermining "Keynesian" theory. New-classical economics discounted the importance of real world wage and price rigidities, and placed considerable faith, therefore, in the public's willingness to react immediately to a well-publicized

anti-inflation policy based on monetary contraction in such a way as to reduce inflation without serious real income and employment consequences. The policies in question certainly did reduce inflation, but the recession which accompanied that reduction was, in some respects, the worst since the 1930s. Moreover, the United Kingdom and Canada carried out similar experiments at about the same time with similar results. By the mid-1980s, the New-classical development of the Monetarist account of the role of money generating the business cycle was thus widely recognized to have failed in its encounter with empirical evidence. This could have led to a revival of interest in more traditional Monetarist analysis; but it did not, because the very postulate that had established the respectability of that analysis in the first place, namely a stable aggregate demand for money function, had also run into difficulties.

THE KEYNESIAN ADOPTION OF THE STABLE DEMAND FOR MONEY FUNCTION

The early studies of the aggregate demand for money function, which established Monetarism's respectability, were carried out using long runs of U.S. data, some stretching back into the 19th century. Moreover, the data themselves were highly time aggregated. Thus Friedman's (1959) seminal study covered the years 1869-1956, and used cycle averages of variables in estimating its basic equation. One business cycle, that is to say, lasting on average about four years, provided one observation. Later studies, such as those of Meltzer (1963) or Laidler (1966) dealt with essentially the same time period, but used annual observations. It was an obvious enough extension of such work to test the hypotheses at stake in it against data drawn from other countries and also against more time disaggregated data too, and such extension proceeded apace in the 1960s mainly at the hands of people far more interested in exploiting new data and computing techniques than furthering any particular policy agenda.

At first the hypotheses in question—that the demand for money varied with some real income or wealth measure, some measure of the opportunity cost of holding money, and in proportion to the general price level—displayed remarkable robustness; so much so that, by the early 1970s, the demand for money function was a prime candidate to become the centerpiece of stabilization policy, much as had the Keynesian consumption function or the Phillips curve at earlier times. For the demand for money function's full potential for such a use to be exploited by policy makers, detailed knowledge of the function's contemporary form was obviously needed, and in the early 1970s a remarkably simple version of the equation seemed to be able to deal with quarterly U. S. data with a high degree of precision. This relationship, nowadays known as the "Goldfeld equation" after its most careful exponent (Goldfeld, 1973), had the long-run average value of money holdings determined by real income and interest rates, but involved the hypothesis that when some disturbance took money holdings away from this long-run average, they would move back toward it slowly over time, with the speed of adjustment in question being proportional to the size of the gap to be closed.[14] The Goldfeld equation fitted U. S. data well, appeared to be stable over time, and crucial for policy purposes, dealt with data at a relatively low degree of time aggregation. It did indeed appear to be so policy relevant that, in his Presidential address to the American Economic Association, Franco Modigliani (1977) argued that it could, and should be used as the basis of an activist monetary stabilization policy in the Keynesian mold.

Modigliani's address in fact appeared after the first signs of trouble with the relationship had appeared. Before dealing with that, however, it is worth reiterating that the progress of the demand for money function so briefly dealt with above was by no means synonymous with the progress of Monetarism, but rather it involved a component of Monetarism being taken over by the Keynesian opposition. Just as the association of Monetarist ideas about the cycle with those of New-classical economics was to prove destructive, so too was this association, and once more this could have been, but was not, discerned at the time in the light of evidence then available. That the association in question was indeed being formed was, of course, obvious enough once Modigliani made the existence of a

[14]Though the relationship in question is now irrevocably known as the "Goldfeld Equation," it was in fact used before him in studies of the demand for money by, among others, Teigen (1964) and Chow (1966). Goldfeld, be it explicitly noted, did not claim originality for the relationship in question.

stable demand for money function an important part of the basis of his case for monetary fine-tuning, a policy stance to which Monetarism was root and branch opposed; and I am not here claiming otherwise. However, I am also claiming that the equation fitted by Goldfeld, and the interpretation he put upon it, were quite antithetical to earlier Monetarist ideas about the demand for money function in particular, and the role of money in the economy in general.

To begin with, the demand for money function for which Friedman had initially claimed stability was the "long run" relationship. In 1959 he had tested it against cycle average data, among other reasons, in order to abstract from the complex interactions among money, output, prices and interest rates that characterized the cycle, and which would tend to obscure the underlying stability of the relationship in question. Nor was such a procedure a quirk of one particular paper: the empirical work of Friedman and Schwartz's *Monetary Trends...*, though not published until 1982, was largely completed in the late 1960s and was based upon cycle phase average data. The apparent stability of demand for money functions such as Goldfeld's, which used quarterly data and hence were dominated by within-cycle interactions among variables, should have been a source of puzzlement to Monetarists, therefore, not of satisfaction.

Monetarists should also have seen that Goldfeld's interpretation of his equation ran quite counter to their ideas about the transmission mechanism.[15] He used the money supply as the dependent variable of his relationship, and treated it as responding passively, albeit with a distributed lag, to variations in the arguments of his demand for money function. It is of the very essence of the Monetarist view that there exists a supply function of money that is independent of the demand function, and that the interaction over time of the money supply, income, interest rates and the price level involves causation running predominantly, though not uniquely, from money to the other variables. Goldfeld's work on the demand for money, and many other studies in the same vein, were thus based implicitly on the "new view" of the money supply process discussed above, of which Brunner (1968) had been so critical. And indeed, in the 1970s, as central banks became interested in controlling the time path of monetary aggregates, their procedures involved measuring or forecasting the values of all the right-hand-side variables of a Goldfeld-style equation except the interest rate, and then setting the latter in order to achieve a value of the quantity of money demanded equal to the money supply target. Clearly such a procedure left no room for taking account of the subtle interactions among markets for money, credit and equity that lay at the heart of the Monetarist view of the matter.

Be that as it may, the stability of the Goldfeld short-run demand for money function that ought to have puzzled Monetarists did not last long. By 1976 he was inviting his readers to solve "The Case of the Missing Money," while by the early 1980s, a number of commentators were contemplating an unexplained decline in money's velocity of circulation.[16] Nor were problems with the demand for money function a uniquely American phenomenon; Canada and the United Kingdom too had problems with badly behaved demand for money functions in the same years; so did Australia and New Zealand a little later; and this list is far from exhaustive. There is little point here in attempting a survey of the voluminous literature generated by these events. Suffice it to say that a wide variety of *ad hoc* explanations, often relying upon particular institutional changes were proposed, and often (not always) proved fragile. The upshot was that in the eyes of the majority of commentators the postulate of a stable aggregate demand for money function was discredited, and along with it the very foundation of Monetarism.

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[15]The first sign of discomfort about this matter that I can find in my own writings appears on pp. 143-44 of the second (1977) edition of my *Demand for Money*, where I refer to there being a fallacy of composition involved in proceeding from the individual to the market experiment when analyzing adjustment processes in the demand for money function. Chapter 2 of Laidler (1982) developed my doubts about all this in much more detail.

[16]And this decline in velocity was associated with rapid money growth failing to produce renewed inflation in the recovery from the 1982 recession. Monetarists should not have predicted renewed inflation then, because actual and expected inflation fell dramatically in the preceding downswing, and hence should have led to an increase in the demand for real balances which could be met only by a *falling* price level or a *growing* nominal money supply. What ought to have been done, and what was done, however, are different matters, and careless Monetarist predictions at this time did help to discredit the doctrine.

Of course this upshot was preposterous. The stability that Monetarism had from the outset attributed to the demand for money function was long run in nature, and the relationships that collapsed were short-run formulations, espoused by Keynesian economists intent on establishing a basis for a policy of monetary fine-tuning. Moreover, those relationships were based on a view of the money supply process which Monetarists had vigorously opposed from the earliest stages of the controversy. An alternative inference to be made from the collapse of the empirical stability of short-run demand for money functions from the mid-1970s onward was that this was the result of their failure to model the dynamic relations among the quantity of money, interest rates, real income and prices as the outcome of the interaction of an independent supply of money function with the arguments of the demand function; that the problem stemmed not from instability of the latter relationship at all, but from the inability of simple single equation distributed lag techniques to come to grips with the dynamic complexities involved in the transmission mechanism of monetary policy.

Those of us who advanced the latter explanation, however, did not find much of a sympathetic audience, even among Monetarists. No doubt this was partly because we did not make our case as clearly as we might have done. But it was mainly because the case in question had as a key component the notion that markets failed to clear instantaneously in the manner demanded by New-classical economics. Rather, it was argued that the transmission mechanism worked along the portfolio disequilibrium lines sketched by Friedman and Schwartz (1963) in the passage quoted on page 56. In the wake of the success of the Phelps-Friedman critique of the Phillips curve, Monetarism had come to attach great importance to adhering to "sound" microeconomic foundations, so much so that it had, as we have seen, become intertwined with New-classical economics; and New-classical economics was unable to tolerate such "disequilibrium" analysis.[17] As has already been noted, the failure of New-classical business cycle theory in the early 1980s was widely regarded as a failure of the Monetarist view of the phenomenon; and what I am now arguing is that this same association with New-classical ideas prevented Monetarism from deploying its own earlier analysis of the transmission mechanism as a defense against an attack on another of its key components. Empirical evidence about the instability of the *short-run* demand for money function ought not to have been interpreted as undermining Monetarist propositions about the stability of the long-run relationship, but it was. By the early 1980s, the Monetarist controversy was over, with Monetarism discredited in the eyes of most observers.

THE LEGACY OF THE CONTROVERSY

The Monetarist controversy was concerned with policy, but the issues involved in it did, at the time, pose questions which defined a frontier of academic research in monetary theory. Furthermore, and again at the time, the latest in econometric techniques were applied to the investigation of the empirical questions which the controversy raised. There was nothing special about all this. The Keynesian revolution too had been simultaneously about theory, empirical evidence and policy, and so had virtually every previous debate in the history of monetary economics. The end of the Monetarist controversy, however, ushered in a period during which monetary economics began to disintegrate into relatively self-contained bodies of theoretical work on the one hand and empirical policy-related work on the other. Whether this disintegration is a temporary or permanent phenomenon, only time will tell.

New-classical economics was underpinned by a strong methodological preference on the part of its exponents for grounding macroeconomic theorizing on explicit microeconomic foundations. Such foundations, however, are capable of yielding a wider variety of macro models than the monetary explanations of the business cycle that lay at the heart of the work of Lucas and Sargent and Wallace. Thus the empirical failure of those models did not lead to the aban-

[17]Some of the problem here stemmed from semantics. If "disequilibrium" behavior is read as synonymous with "unplanned" behavior, then it is understandable that an economist would not wish to rely on it in constructing an economic model. If it means merely behavior incompatible with the existence of continuous competitive equilibrium in all markets, then it is surely more acceptable. The fact remains that those of us who used it in the latter sense were read as using it in the former, and were not sufficiently careful to explain ourselves. The result was a considerable amount of unconstructive debate and confusion among Monetarists.

donment of the methodological agenda which had produced them, but merely to an attempt to replace them with an alternative explanation of the cycle with equally well, or even better, defined micro premises. I refer here to that body of research known as "real business cycle theory" which is based on a stochastic version of the New-classical growth model of Meade, Swan and Solow, and attributes cyclical fluctuations to exogenous shocks to the aggregate production function, in much the same way as, over a century ago, Jevons attributed the cycle to fluctuations in agricultural productivity associated with sunspot activity.

The exponents of real-business cycle theory, though hostile to econometric testing, nevertheless do not ignore empirical evidence, and have begun to address the question why, if it is not a causative factor in cyclical fluctuations, there are nevertheless systematic relations among the quantity of money and other variables. The very manner in which the question is posed virtually dictates the answer offered, namely that the relations in question are the result of reverse causation running from the cycle to money, rather than vice versa. Thus, in what is surely one of the greater ironies in the recent history of economics, a research agenda which is widely regarded as a direct descendant of the Monetarism of the 1960s has ended up adopting a view of the role of money in the economy directly opposed to that of its intellectual antecedent, and virtually identical to that of the most extreme form of "post-Keynesian" economics.[18] This is no accident, for a view of the world which has markets functioning perfectly and without friction leaves no more room for money to play an important role than does a view in which markets do not function at all.

Though one important group among the academic heirs of Monetarism has thus systematically adopted hypotheses that downgrade the importance of monetary phenomena, and has also abandoned traditional econometric methods as a basis for empirical research, this does not mean that econometric work on monetary economics ceased in the early 1980s. On the contrary, a diverse body of contributors, including unrepentantly old-fashioned Monetarists, econometricians in search of an area in which to try out new techniques, not to mention economists associated with central banks in various countries which do, after all, still have to carry out monetary policy regardless of the state of academic opinion concerning its importance, have generated an extensive empirical literature on the demand for money function during the 1980s. The literature in question has been lively and, as I shall now argue, productive in two lines of inquiry.

First, questions arising from the fact of institutional change in the monetary sector have been examined using both historical and contemporary data. In both cases, this phenomenon has been found to be sometimes important. Thus Bordo and Jonung (1987), using data going back to the 19th century for five countries, have shown that the slow decline in velocity which occurred largely before the first world war seems to have been associated with the increasing degree of monetization of the economies involved, and its later rise with the increasing efficiency of monetary exchange. Closer to our own time, the sharp increase in the velocity of M1 balances in Canada that occurred at the turn of the 1980s has been shown, beyond reasonable doubt, to have been associated with the simultaneous spread of daily interest checking accounts. As to the United States, the work of Barnett (e.g., 1990) using Divisia aggregates, provides evidence that various instances of financial deregulation have produced shifts in the demand for more conventionally measured aggregates; while the very fact that it proved necessary not so long ago to redefine those aggregates is itself testimony to the importance of institutional developments.

The other line of inquiry to which I refer above has involved the application of far more sophisticated techniques than were previously available, both to the explicit modeling of the so-called short-run demand for money function, and closely related, to the task of extracting information about the underlying long-run relationship from data with a high degree of time disaggregation. Here the results have been quite startling. Short-run dynamics dominate quarterly data and have to be modeled with a great deal more care than exponents of, say, the Goldfeld equation brought to bear or, given the state of econometric technique, could have been expected to bring to bear, on the task. Never-

[18] I refer here to King and Plosser (1984) which uses a form of the old "money-income-causes-money" hypothesis to reconcile monetary phenomena with a productivity-shock theory of fluctuations in real variables.

theless, once this is done, stable long-run relationships, very much like those which were first estimated by Friedman (1959), Meltzer (1963) or Laidler (1966), are after all to be found buried in those data. This same result emerges with powerful simplicity from a recent "low-tech" study by Robert E. Lucas (1988), who shows that data for the last 25 years or so of United States history are still scattered (albeit widely, and with complex serial correlation) around a velocity function directly derived from Meltzer's (1963) estimates of the long-run demand for money. Nor are results of this sort confined to the United States. Similar conclusions arise when British, Canadian or Japanese data are analyzed.

As yet, this empirical evidence has not attracted the academic attention it deserves, largely, I suspect, because the treatment of the short-run dynamics in the studies which generate it has been based more on econometric technique than economic theory. Exponents of the so-called "buffer-stock" approach to modeling the demand for money, who have of course followed up the analysis of the transmission mechanism of Brunner and Meltzer as well as Friedman and Schwartz, have tried to bridge this gap. They have tended to ground their explicit analysis on rather simple special cases, however, which have not proved empirically robust; and this in turn has led to an identification of the general approach with those special cases and a tendency to dismiss prematurely the broad insight which it yields: namely that the dynamics of what we have learned to call the *short-run demand for money function* are not the property of a structural relationship at all, but rather reflect that complex interaction of the quantity of money with other variables to which the Monetarists of the 1950s and 1960s used to refer as a *transmission mechanism subject to long and variable lags*.[19]

The Monetarist controversy was about theory and empirical evidence, to be sure, but it was also about monetary policy; and here it has left its strongest mark. To begin with, the idea that inflation is fundamentally a monetary phenomenon, so outlandish in the 1950s, has by now become something close to conventional wisdom. We nowadays hear very little about cost-push forces and the need to control them with wage and price guidelines, controls and so on. Closely related, central banks routinely pay attention to the behavior of monetary aggregates in designing their anti-inflation policies. Though even such hard-core Monetarists as Brunner and Meltzer (1987) no longer argue that the dominant impulse driving the business cycle is always the quantity of money, neither they, nor the practitioners of monetary policy, have shown the slightest sign of taking the productivity shock hypothesis of the real business cycle theorists seriously.[20] Rather, the exclusively monetary interpretation of the cycle has been replaced by an eclectic approach in which monetary factors have an always potentially important, and sometimes an actually important, role to play. That is why the pursuit of price stability by monetary means is tempered by caution concerning the short-term costs that could be incurred if the pursuit in question was to become too vigorous. And eclecticism about the causes of cyclical instability has not been accompanied by a revival of interest in the use of fiscal policy for stabilization purposes—though this probably has as much to do with the fiscal deficits that are the legacy of supply-side economics as with any lessons learned during the Monetarist controversy itself.

A superficial reading of the above record might suggest that, whatever its academic standing, Monetarism is alive and well in policy circles. That it has left a lasting mark in those circles is beyond doubt, but its success on the policy front has been far from complete. Indeed, on one interpretation of the evidence, Monetarism's partial success here may have been worse than failure. The Monetarist agenda, after all, involved establishing the importance of the quantity of money as a policy variable *as a preliminary step to removing from the monetary authorities their discretionary control over it*; and the record

[19]For an informal but more complete exposition of the arguments involved here, see Laidler (1987). One of the better known pioneering special case empirical formulations of the approach is that of Carr and Darby (1981), who refer to it as a "shock-absorber" approach.

[20]Let it be clear, however, that I do not regard "real business cycle theory" as a total waste of time, and that I do think it merits policymakers' attention. Though I find it hard to believe that shocks to technology will turn out to be the sole or even main source of real world cyclical fluctuations, it is nevertheless the case that, from a theoretical point of view, such shocks as do originate in such phenomena are likely to be welfare improving. The valuable message of real business cycle theory, then, is that we should not take it for granted that stabilizing the cycle is always and everywhere desirable. It might not be in particular instances. That reminder is surely worth having.

shows that only this preliminary step was completed. Monetary policy plays a far more important role in macroeconomic affairs now than it did 30 years ago, but those in control of it have, as a result, much more power than previously, not less, as the Monetarist agenda intended. This cannot really be helped, because part of the academic legacy of the Monetarist controversy has been a greater appreciation of the role of institutional change in influencing velocity's long-run behavior; but once that role is admitted, the case for tying down monetary policy with rules becomes far more difficult, perhaps impossible, to make.

All this, though, poses a challenge. If monetary policy cannot be tied down by rules, then the next-best solution is to subject it to the discipline of constant public scrutiny and criticism. Academic economics has a large role to play here, in providing the intellectual basis for such activity, but at the moment it is not in good condition to do so. We do have, as I have noted above, a large and growing body of empirical work which points to the long-run stability (not constancy, note) of money's velocity, institutional change notwithstanding. That same body of work, however, tells us that the short-run dynamics of that function are at least as complex as anyone thought they were 30 years ago; and we are no further forward now than we were then in understanding just why this is the case.

At the same time, the gap between theoretical work on the role of money in the economy, and our empirical knowledge in the area, which was opened up when the Monetarist controversy became a debate about New-classical economics and began to pay more attention to microfoundations than to data, still remains. Intellectual vacuums of this sort rarely remain unfilled for long, but until this one attracts more attention than it has to date, the Monetarist controversy's legacy must be judged to be a distinctly uncomfortable one. The controversy weakened the links between academic research and contemporary policy which in the past made such research a natural source of constraining criticism of the conduct of policy, while simultaneously enhancing the discretionary powers of policy makers. That is hardly what its participants intended.

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Federal Reserve Bank of St. Louis
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