Evidence of Improved Inventory Control

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The advent of the computer and changes in business management techniques are commonly believed to have improved inventory control. As evidence of such improvement, most analysts cite the decline in the ratio of inventories to sales in manufacturing. But improved inventory control implies a faster adjustment of inventories to changes in sales as well as a decline in the average ratio of inventories to sales. Moreover, there are other goods-stocking sectors to consider besides manufacturing.

Most economists who relate inventory behavior to the business cycle seem to take for granted that because aggregate inventory-sales ratios have declined in the last decade, inventory cycles have become much smaller. For example, one economist noted that the recent recession "was remarkable for the almost total absence of a recognizable inventory cycle, *so far as one can judge from the behavior of aggregate inventory-sales ratios* [italics added]."[1] The effect of higher speeds of adjustment on inventory investment would, however, tend to offset that of lower inventory-sales ratios in evaluating changes in the size of inventory cycles. Thus, contrary to widely held opinion, improved inventory control can result in increased, rather than reduced, volatility in inventory investment.[2]

The question of whether inventory control has improved is an empirical one whose resolution is the primary purpose of this article. The resolution has important implications for the business cycle because recessions largely turn on the behavior of inventory adjustments.

In the following sections, we first review a popular model of investment that is often used in studies of inventory investment. We then use a basic form of this model to test the hypothesis of improved inventory control. Our objective is to focus on possible changes in parameters from one period of time to another, not to refine existing models or to add to the existing theory on inventory behavior.[3]

Our findings provide clear evidence of improved inventory control in manufacturing, both in finished goods stocks and in inventories of materials and supplies and work in progress. For retail and wholesale trade, our results are mixed.

Finally, we seek to determine empirically what effect these refinements have had on inventory investment volatility. Our findings show that, contrary to popular belief, investment volatility has increased in both the manufacturing and trade sectors.

A Model of Inventory Investment

In the following discussion, we use a standard partial stock-adjustment model, first presented in Lovell (1961), to test the hypothesis of improved inventory control. In this model, the amount of inventory investment that takes place in a given period, II_t, is the sum of desired, or planned, inventory investment and unanticipated inventory investment. Desired inventory investment during any period t is a fraction s of the difference between the actual stock of inventories KI at the end of the previous period and the desired stock KI^d at the end of the current period. In addition, if firms use inventories as a buffer against unexpected demand shocks, any deviation of sales from expected sales will result in unintended inventory investment.

$$(1)\quad II_t = s \cdot (KI_t^d - KI_{t-1}) - c \cdot (S_t - S_t^e)$$

where S_t is sales and S_t^e is expected sales. The variable s is commonly referred to as the "speed-of-adjustment" parameter because s determines how fast a given gap between actual and desired inventory

[1] William C. Melton, Chief Economist, IDS Financial Services, *Wall Street Journal*, September 9, 1991, p. A1.

[2] Bechter and Able (1979) explored the business cycle implications of improvements in inventory control. At the time, inventory data were less rich than desired for establishing clear evidence of improved inventory control, but the data did provide suggestive evidence which, used in simulations, implied smaller but quicker adjustments of inventories to reduced sales.

[3] Blinder and Maccini (1990) provide an excellent summary of recent econometric and theoretical work on inventories.

levels is closed.[4] The variable c measures the extent to which inventories serve as a "buffer stock" against unexpected changes in sales.

We assume that the expected level of sales S^e in period t+1 determines the desired stock of inventories for the end of period t (i.e., going into period t+1):

$$(2) \quad KI_t^d = a + i \cdot S_{t+1}^e.$$

The coefficient i measures the change in desired inventories accompanying a unit change in expected sales. Thus, i is the desired *marginal* inventory-sales ratio.[5]

Expected sales are not observed and must be modeled. Theory does not provide one specific method for modeling expected sales. Thus, to avoid introducing an unnecessary source of contention into the model, we represent expected sales as simply as possible by assuming that sales expected in the next period are equal to actual sales S in the current period:[6]

$$S_{t+1}^e = S_t.$$

Equation 2 becomes

$$(3) \quad KI_t^d = a + i \cdot S_t.$$

Substituting (3) into (1) and substituting for S_t^e yields:

$$II_t = s \cdot (a + i \cdot S_t - KI_{t-1}) - c \cdot (S_t - S_{t-1})$$

which simplifies to

$$(4) \quad II_t = a' + b \cdot S_t - s \cdot KI_{t-1} - c \cdot \Delta S_t$$

where

s = the speed-of-adjustment parameter;
i = the desired marginal inventory-sales ratio;
$a' = a \cdot s$;
$b = i \cdot s$; and

$$\Delta S_t = S_t - S_{t-1}.$$

The two parameters that we will employ to capture a firm's inventory management behavior are the speed-of-adjustment parameter, s, and the desired marginal inventory-sales ratio, i. Inventory investment, sales, the change in sales and the lagged inventory stock are all observable, so equation 4 may be used as a regression equation. The empirical results yield estimates of the two key parameters, i and s. These estimates are summarized in the following section.

ESTIMATION RESULTS OF THE INVENTORY INVESTMENT MODEL

We test the hypothesis of improved inventory control by considering the possible changes over time in the behavior of manufacturers, retailers and wholesalers. Moreover, we consider both manufacturers' finished goods inventories and their stocks of materials and supplies and work in progress. We disaggregate total business inventories to this extent because inventory behavior may have changed in different ways for different reasons in different sectors. Movements in aggregate inventory numbers might therefore give a misleading picture of the effects of the changes in inventory control.[7]

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[4] There are a number of different reasons why a firm would want to hold inventories. The most obvious is to avoid disruptions in sales. To avoid running out of stock, a firm tries to maintain some average desired inventory-sales ratio (which implies some desired marginal inventory-sales ratio). When actual sales differ from expected sales, the firm will miss its targeted average inventory-sales ratio. It then adjusts its desired marginal inventory-sales ratio in the next period to try to get its average ratio back to the original target. Given a production function, the average desired inventory-sales ratio for a firm is influenced by such things as the cost and probability of a disruption in its sales. See Blinder and Maccini (1990) for a brief discussion of this topic.

[5] Inflation and interest rates are among the other supposed determinants of desired inventories. Inflation encourages stockpiling of inventories by increasing the probability that firms can realize a capital gain by holding (investing in) inventories for some relatively short period of time. The real rate of interest might also affect investment decisions since it reflects either the cost of financing or the opportunity cost of holding inventories. Despite the theoretical plausibility of these effects, empirical efforts to establish their significance have been largely unsuccessful. Our effort abstracts from these other variables to focus on the relationship of inventories to sales. We return to interest rates briefly at the end of the paper.

[6] A number of papers have employed more complicated models of expected sales. See, for example, Irvine (1981) or Lovell (1961). Blinder (1986) points out that what is "unexpected" to the econometrician in that it cannot be forecast by some econometric model (e.g., an ARIMA model) may well be "expected" by the firm. Thus, the firm may be able to alter its production plans and its desired inventory level to what appear to be unanticipated shocks to the econometrician. Given this inherent difficulty in establishing a precise model of firms' sales expectations, we view the gains from our admittedly oversimplified model in terms of tractability as outweighing any potential losses in accuracy. Further, re-estimating the equations with several relatively simple alternatives resulted in models with less explanatory power.

[7] Blinder and Maccini (1990) note that most past studies of inventory behavior have been limited to manufacturers' finished goods stocks. They show (and we confirm below) that these inventories are the least variable among major categories. Thus, inventory studies limited to manufacturers' finished goods probably underpredict the volatility of inventory investment in the economy as a whole.

Equation 4 is estimated with quarterly data over two sample periods. The data are constant dollar inventory numbers supplied from the National Income and Product Accounts. The first period extends from 1967 through 1980 for the two manufacturing regressions, and from 1967 through the second quarter of 1979 for the two trade regressions. The second period begins in 1981 for manufacturing and in the third quarter of 1979 for retail and wholesale trade. All second period regressions end with the second quarter of 1991.[8] The estimated coefficients, with other selected results, appear in Tables 1 and 2.

The manufacturing regressions yield the most conclusive results. The estimate of the desired marginal inventory-sales ratio for materials and supplies and work in progress declines from 1.77 (= 0.209/0.118) to 0.52 from the first to the second period, while the estimate of the speed of adjustment rises from 11.8 percent to 48.4 percent.[9] For manufacturers' finished goods, i falls from 0.35 to 0.08 while s increases from 8.9 percent to 36.8 percent. Clearly, manufacturers controlled their inventories much more tightly after 1980 than before 1980.

The results for the trade sectors are inconclusive. In retail trade, the estimates for the desired marginal inventory-sales ratio actually increase from 1.62 to 1.84 from the earlier to the later period, just the opposite of what tighter inventory control would imply. On the other hand, the estimate of the speed-of-adjustment parameter increases significantly, from 28.4 percent to 47.4 percent, consistent with the hypothesis of tighter inventory control. In wholesale trade, the estimates move in the right directions, but the changes are small and insignificant: the desired marginal inventory-sales ratio decreases from 1.44 to 1.19 while the speed-of-adjustment parameter rises from 13.5 percent to 20.0 percent.[10] The results for the trade sectors thus neither confirm nor reject the hypotheses of improved inventory control in the trade sectors.

Behavior of the Parameters over Time

We turn now to the question of how the parameters changed over time. Intuitively, we felt the parameters were unlikely to display constancy in the earlier period, abrupt changes at the break point, and then constancy again. Instead, we thought a gradual transformation more likely.

To observe this process, we ran rolling regressions to obtain a time series of coefficients.[11] Each regression covered 40 calendar quarters of data. In each successive regression, a new quarter was added to the end of the sample period and an old quarter was deleted from the beginning. These rolling regressions produced a time series for each of the regression coefficients from 1977:2 through 1991:2.[12]

The results of the rolling regressions are presented in Charts 1-8. Two parameter charts are displayed for each sector: the desired marginal inventory-sales ratio and the speed of adjustment.[13]

For manufacturers' inventories of materials and supplies and work in progress, Charts 1 and 2 show generally steady improvement in the two key parameters. The speed-of-adjustment parameter moves steadily up while the desired marginal inventory-sales ratio trends downward. The most noteworthy movements in the parameters occur over

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[8] The justification for the timing of the breaks is discussed in the appendix. Data for these series (seasonally adjusted quarterly data in 1982 dollars) are not available for years before 1967.

[9] An acknowledged flaw in the partial stock-adjustment model is that it tends to produce implausibly low speed-of-adjustment estimates [see Blinder and Maccini (1990) for a brief discussion of this issue]. Thus, it follows that our results may be biased downward also. We maintain, however, that the changes in the regression coefficients from the earlier period to the later period are made no less meaningful by such bias. There seems to be little reason why the results of one period would be more biased than the results of the other. Further, the measures of goodness of fit are relatively stable across periods, indicating that the model is no more or less misspecified from one period to the next.

[10] The change-in-sales variable was left out of the final form of the wholesale trade regressions because it was insignificant. Results including the variable were virtually the same as the reported results.

[11] We first tried forming a time series of coefficients by repeatedly regressing equation 4, adding one quarter to the sample period each time. This "updating formulae" method generally provided disappointing results because the marginal influence of one quarter of data was negligible once the number of observations became relatively large. Technical treatments of both the updating formulae method and a version of the rolling regression technique are available in Brown, Durbin and Evans (1975).

[12] Rolling regressions of shorter lengths (e.g., 30 quarters) were too noisy. As a result, we have no reliable measure of how the key parameters behaved during the first oil crisis in 1973 and 1974. Our intuition is that desired marginal inventory-sales ratios and speed-of-adjustment parameters fluctuated dramatically during this period, perhaps imposing a significant effect on the aggregate results in Tables 1 and 2. In fact, the data from tests using the updating formulae method show sharp movements over this period, but a combination of low degrees of freedom and often insignificant coefficients in the regressions imply that the results are totally unreliable.

[13] Each observation is assigned to the endpoint of the 40-quarter sample period over which that regression is run (e.g., the coefficients obtained from the regression over the period 1979:1 through 1988:4 are assigned to 1988:4).

Table 1

Regression Results

1967:2 through 1980:4 for manufacturing sectors

1967:2 through 1979:2 for trade sectors

	REGRESSION COEFFICIENTS			OTHER SUMMARY STATISTICS				
SECTOR	SALES	CHANGE IN SALES	LAGGED STOCK	DESIRED MARGINAL I-S RATIO	$\bar{R}$ SQ	SEE	D.W.	AR1
MANUFACTURING: MATERIALS AND WORK IN PROGRESS	0.209 (6.6)	−0.115 (−2.2)	−0.118 (−5.6)	1.77	0.62	1.20	2.18	YES
MANUFACTURING: FINISHED GOODS	0.031 (1.8)	−0.094 (−2.9)	−0.089 (−2.2)	0.35	0.21	0.81	1.95	YES
RETAIL TRADE	0.461 (5.8)	−0.289 (−1.7)	−0.284 (−5.7)	1.62	0.40	1.23	1.94	YES
WHOLESALE TRADE	0.194 (2.4)		−0.135 (−2.2)	1.44	0.16	1.19	2.00	YES

Table 2

Regression Results

1981:1 through 1991:2 for manufacturing sectors

1979:3 through 1991:2 for trade sectors

	REGRESSION COEFFICIENTS			OTHER SUMMARY STATISTICS				
SECTOR	SALES	CHANGE IN SALES	LAGGED STOCK	DESIRED MARGINAL I-S RATIO	$\bar{R}$ SQ	SEE	D.W.	AR1
MANUFACTURING: MATERIALS AND WORK IN PROGRESS	0.253 (3.4)	−0.163 (−2.2)	−0.484 (−4.1)	0.52	0.59	1.41	2.11	YES
MANUFACTURING: FINISHED GOODS	0.029 (1.9)	−0.075 (−1.2)	−0.368 (−3.1)	0.08	0.22	1.16	2.13	YES
RETAIL TRADE	0.874 (5.0)	−0.725 (−3.2)	−0.474 (−5.0)	1.84	0.38	2.22	1.92	YES
WHOLESALE TRADE	0.239 (3.8)		−0.200 (3.8)	1.19	0.21	1.53	1.79	NO

NOTE: t-statistics are in parentheses. AR1 indicates whether the regression corrects for first-order serially correlated errors using the Cochrane-Orcutt method. AR1 was employed when the Durbin-Watson statistic was outside of the 5 percent confidence range. D.W. refers to the Durbin-Watson statistic of the reported regression.

MANUFACTURING: MATERIALS AND SUPPLIES AND WORK-IN-PROGRESS SECTORS

Chart 1

DESIRED MARGINAL INVENTORY-SALES RATIO

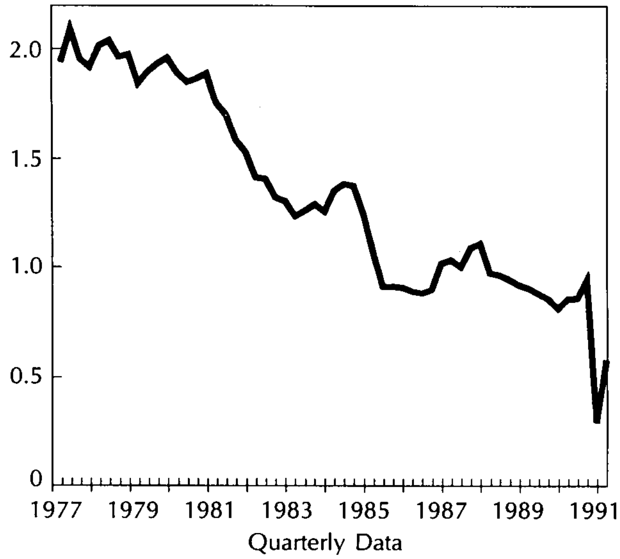
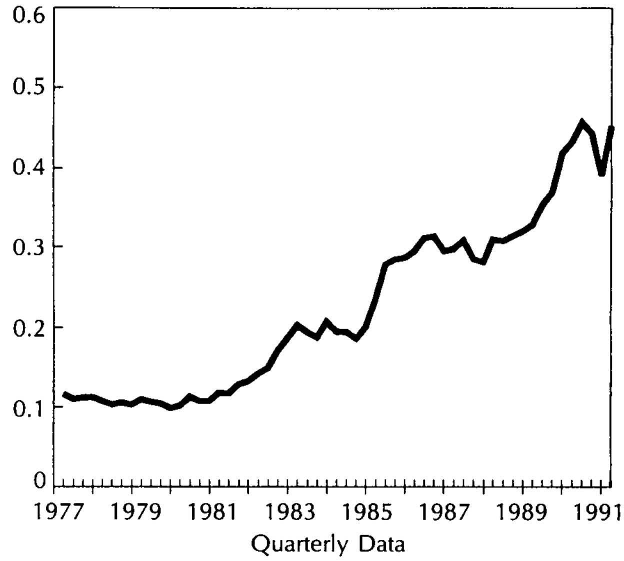


Chart 2

SPEED OF ADJUSTMENT



the most recent business cycle. The desired marginal inventory-sales ratio and the speed of adjustment temporarily plummet as firms evidently are caught with unusually high stocks of unintended inventories. This behavior contradicts the conventional view, held before the latest recession, that lower inventory-sales ratios would reduce the size of cyclical inventory adjustments.

Manufacturers' finished goods (Charts 3 and 4) show what appears to be a one-time shift in the parameters. The speed of adjustment increases and

MANUFACTURING: FINISHED GOODS SECTOR

Chart 3

DESIRED MARGINAL INVENTORY-SALES RATIO

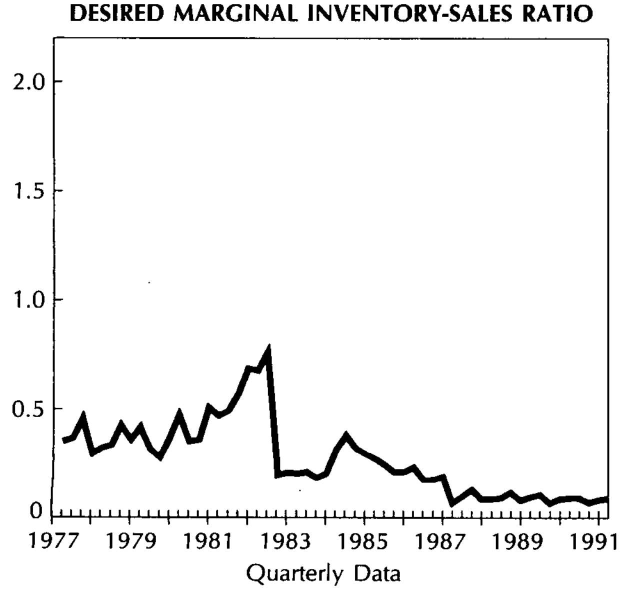
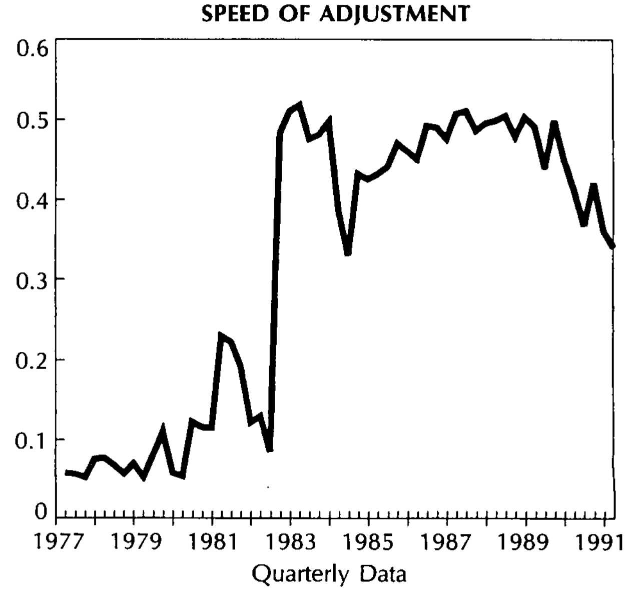


Chart 4

SPEED OF ADJUSTMENT



the desired marginal inventory-sales ratio decreases from 1982:3 to 1982:4 by relatively large amounts.[14] By 1991, the desired marginal inventory-sales ratio is down to about 0.10, implying that a firm expecting its sales to increase by 10 percent would only want to increase its finished goods inventories by 1 percent. In other words, manufacturing firms appear to be holding extremely small finished goods inventories. Thus, a study of inventory control which focuses only on manufacturers' finished goods will poorly explain the behavior of inventory investment over the last decade or so.

In retail trade, Charts 5 and 6 show no clear trends in the parameters. The hypothesis of improved inventory control is supported by our findings of decreasing desired marginal inventory-sales ratios and increasing speeds of adjustment until about 1984. After then, however, the two parameters move in the opposite directions.

Finally, Charts 7 and 8 provide further evidence that, in wholesale trade, the magnitude of change has been the least of the four sectors. The speed-of-adjustment parameter increases over the period 1982 to 1984, but the amount of the change is relatively small. The desired marginal inventory-sales ratio does appear to trend downward, but does not exhibit the kind of dramatic movements characteristic of the other three sectors.

In sum, the results of the rolling regressions for the manufacturing sector suggest a fairly sharp change in the inventory control parameters for finished goods and a steady but larger change in those for materials and supplies and work in progress. Our hypotheses concerning the parameters that determine inventory control behavior are supported by strong evidence for the manufacturing sectors. In the trade sectors, however, the key parameters wander over time.

Implications for Inventory Investment Volatility

Contrary to popular belief, inventory investment is **not** less volatile today. Leaner inventories are not a sufficient condition for less variability in inventory investment because increasing speeds of adjustment can more than offset decreases in inventory-sales ratios. Since the regression results show that these two parameters have indeed been moving in opposite directions, the effect on variability becomes an empirical question.

To answer this question, we divide the inventory investment series into two time periods for each

[14] Because these series are 40-quarter moving averages, a large change in the speed-of-inventory-adjustment estimate from the 1982:3-ending regression to the 1982:4-ending regression implies a dramatic, sudden modification in the behavior of inventory investment.

RETAIL TRADE SECTOR

Chart 5

DESIRED MARGINAL INVENTORY-SALES RATIO

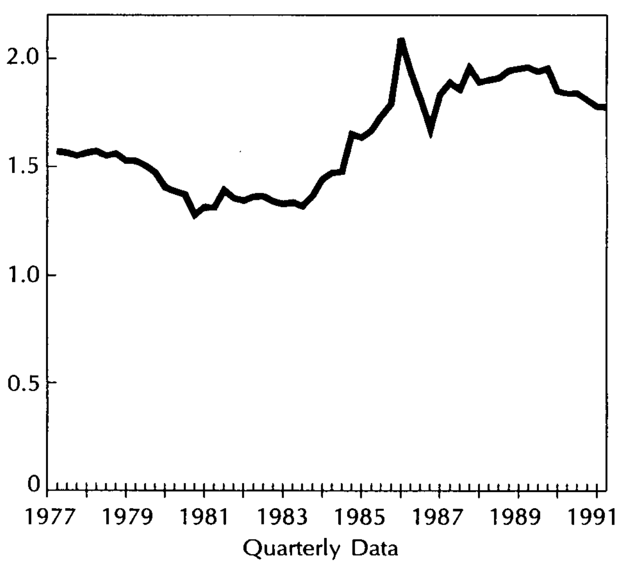


Chart 6

SPEED OF ADJUSTMENT

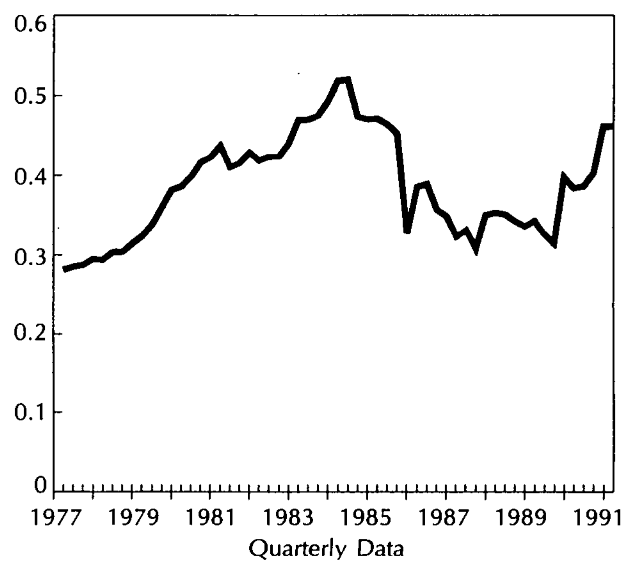


Chart 7

DESIRED MARGINAL INVENTORY-SALES RATIO

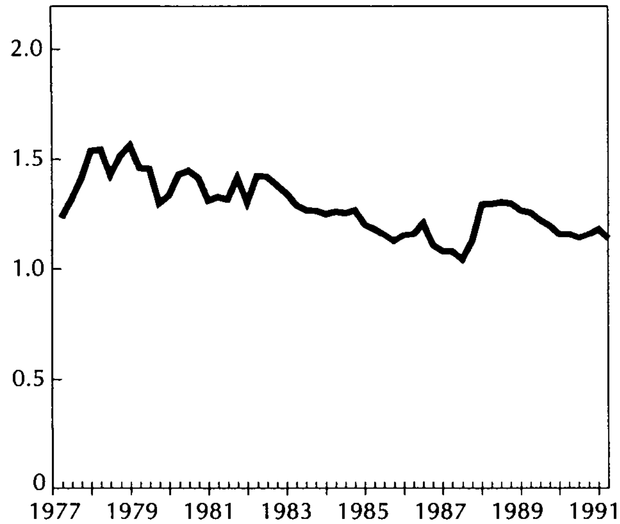
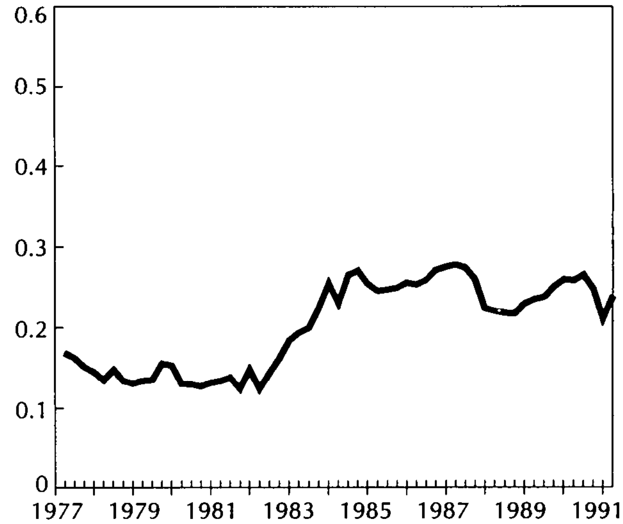


Chart 8

SPEED OF ADJUSTMENT



sector according to the break points given in Tables 1 and 2. We then calculate the variance for each of the periods. The results are summarized in Table 3. The investment variances for all four sectors are actually **larger** in the second period. Further, the increase in the variance is statistically significant at the 5 percent level.[15,16] Finally, these statistics confirm that inventory investment by manufacturers in finished goods is the least variable of the four types of inventory investment.

WHY HAS INVENTORY BEHAVIOR CHANGED?

We offer here some tentative explanations of our results. Tests of these hypotheses should provide the basis for further research.

The most obvious explanation for improved inventory control at earlier stages of processing in manufacturing is the advent of just-in-time techniques in the early 1980s. These procedures imply lower inventory-sales ratios as well as faster speeds of adjustment.

The decline in the ratio of inventories to sales for manufacturers' finished goods suggests that many producers may have switched to selling on a custom-order basis as opposed to selling from stocks as a supermarket does. Producing for orders is consistent with just-in-time arrivals of materials for production lines.

The behavior of real interest rates may have influenced inventory investment. High real rates increase the costs of maintaining high levels of inventories. A sudden increase in real rates corresponds closely with our break points: real rates rose sharply from historically low (in fact, predominantly negative) levels during the late 1970s to historically high levels in the early 1980s. Although attempts to incorporate real interest rates into regression equations like equation 4 have generally been unsuccessful, it is still plausible that real rates have exerted an indirect effect by encouraging cost-saving innovations such as just-in-time.

Finally, the abrupt reversals of the parameters for retail trade reported by the rolling regressions could be due to the change in the structure of the industry in the mid-1980s. In recent years, the market

[15] The F-statistic is $F(n_2, n_1) = [s_2^2 / (n_2 - 1)] / [s_1^2 / (n_1 - 1)]$ where s^2 represents variance of the sample, n represents number of observations in the sample and the subscripts denote the first and second sample periods.

[16] It could be argued that the variances in the second period are higher simply because the economy grew. Thus, we repeated the F-tests in Table 3 substituting coefficients of variation (standard deviation divided by the mean) for the standard deviations in the F-statistic formula. As it turns out, the means of inventory investment in all four sectors **decreased** from the first regime to the second so the coefficients of variation provide even stronger evidence of increased inventory volatility.

share of big warehouse discount and specialty stores increased at the expense of traditional department stores. These newer stores have eliminated wholesalers by keeping large amounts of stock on the shelves and, therefore, may maintain higher inventory-sales ratios and adjust their inventory levels less rapidly to changes in retail sales.

Table 3

Variance Results for Inventory Investment

SECTOR	VARIANCE IN SUB-PERIOD 1	VARIANCE IN SUB-PERIOD 2	F-STATISTIC	SIGNIFICANCE LEVEL
MANUFACTURING: MATERIALS AND WORK IN PROGRESS	3.759	4.848	1.698	0.0328
MANUFACTURING: FINISHED GOODS	0.831	1.813	2.874	0.000136
RETAIL TRADE	2.519	8.149	3.303	0.0000275
WHOLESALE TRADE	1.690	2.979	1.763	0.0253

APPENDIX

TIMING OF THE PERIOD SHIFT

Selecting the best place to "break" the data into earlier and later periods proved difficult. Lacking one predominant theory, we used purely statistical tests and criteria to select the break point.

The break points that we ultimately chose maximized the adjusted coefficients of determination (R-Bar Squared) and minimized the standard errors of the estimators for both periods. Our tests indicated, however, that, within a span of about four years, the precise timing of the period shift did not alter the basic results. That is, moving the break point forward or backward by several quarters led to only marginal changes in standard errors and the values of the key parameters (see Tables A1 and A2).

Our statistical criteria led us to choose a different break point for manufacturers' inventories than for trade inventories. Besides being justified statistically, different break points seemed logical because even though manufacturing and trade were probably influenced by common economy-wide developments, they might have had different forces driving the timing of their period shifts.

We tested our choices of break points by adding dummy variables to the basic equation and using a Chow test to determine whether and where there was a structural shift:

$$(5)\quad II_t = a' + b \cdot S_t - s \cdot KI_{t-1} - c \cdot \Delta S_t + d \cdot D_t + e \cdot (D_t \cdot S_t) + f \cdot (D_t \cdot KI_{t-1}) + g \cdot (D_t \cdot \Delta S_t)$$

where D_t = the dummy variable = 0 before the break point; = 1 after the break point. We ran the equation 5 regression repeatedly for each of the four categories of inventories, using a different break point each time from 1973 through 1987.

At the break points chosen, the F-statistics for equation 5 regressions were significant (indicating a structural shift) at the 1 percent level for both manufacturing sectors and retail trade. The F-statistic for wholesale trade, however, was not significant at the 5 percent level.[17]

[17] The F-statistic for the wholesale trade sector has a significance level of 0.32. A discussion of why we picked this break point given these results follows later in the section.

Table A1

Selected Estimation Results for Equations with Break Point at 1979:1

SECTOR	MARGINAL DESIRED INVENTORY-SALES RATIO		SPEED OF ADJUSTMENT		R-BAR SQUARED	
	1967:2-1978:4	1979:1-1991:2	1967:2-1978:4	1979:1-1991:2	1967:2-1978:4	1979:1-1991:2
MANUFACTURING: MATERIALS AND WORK IN PROGRESS	1.74	0.66	0.121	0.369	0.60	0.57
MANUFACTURING: FINISHED GOODS	0.43	0.09	0.056	0.554	0.15	0.23
RETAIL TRADE	1.63	1.84	0.305	0.481	0.42	0.39
WHOLESALE TRADE	1.51	1.19	0.133	0.198	0.18	0.20

Table A2

Selected Estimation Results for Equations with Break Point at 1983:1

SECTOR	MARGINAL DESIRED INVENTORY-SALES RATIO		SPEED OF ADJUSTMENT		R-BAR SQUARED	
	1967:2-1982:4	1983:1-1991:2	1967:2-1982:4	1983:1-1991:2	1967:2-1982:4	1983:1-1991:2
MANUFACTURING: MATERIALS AND WORK IN PROGRESS	1.63	0.10	0.148	0.358	0.69	0.53
MANUFACTURING: FINISHED GOODS	0.47	0.12	0.098	0.356	0.21	0.13
RETAIL TRADE	1.51	1.82	0.330	0.464	0.34	0.35
WHOLESALE TRADE	1.32	1.17	0.149	0.240	0.17	0.21

For each of the two categories of manufacturers' inventories, the chosen break point yielded a local maximum of the F-statistic, but not a global maximum. However, none of the break points yielding higher F-statistics produced estimates with smaller standard errors **and** larger adjusted coefficients of determination for **both** periods when used to re-estimate equation 4. Further, the estimates of the key parameters were only marginally changed.

A third-quarter 1979 break point maximizes the F-statistic for retail trade. For wholesale trade, no break point within the period 1978 through 1982 yields a significant F-statistic at the 5 percent level. This confirms our analysis from text Tables 1 and 2 that the changes in the key parameters for the wholesale sector, while in the right direction, are not large enough to indicate any structural change.[18] In sum, the techniques that we used to select break points indicated that our choices were at least as good as any of the alternatives.

[18] The F-statistic for wholesale trade *is* significant for a range of values of the break points from 1975:4 through 1977:2. The regression results for the equations with the break point at the global maximum (1976:2) do yield substantially lower standard errors and higher adjusted coefficients of determination. However, they also confirm the lack of economically significant structural change (the marginal desired inventory-sales ratio decreases from 1.134 to 1.130 and the speed of adjustment increases from 18.7 percent to 21.4 percent).

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Indexed Bonds as an Aid to Monetary Policy

Robert L. Hetzel

A principal long-term goal of Federal Reserve monetary policy is to restore price stability to the United States economy. In this article, the author suggests that a measure of the public's inflation expectations would assist the Fed in attaining its goal and proposes that, to provide such a measure, the U.S. Treasury issue bonds indexed to eliminate losses resulting from inflation. The article, which originally appeared without the appendix in this Bank's 1991 Annual Report, *is reprinted here to stimulate further discussion of issues related to the effort to eliminate inflation. The views expressed are the author's and not necessarily those of the Bank or the Federal Reserve System.*

Contracts requiring payment of dollars in the future for future delivery of goods and services are a regular part of economic life. Workers enter into contracts, formal and informal, for a dollar wage for the next year. Colleges set tuition payments once a year. Rents for apartments are set annually and homeowners contract for mortgage payments in dollars. The purchasing power represented by these dollar payments, however, depends upon the rate of inflation realized after the contracts are signed. People must forecast inflation in order to estimate the purchasing power of future dollar payments.

This article argues that it would be helpful to the Federal Reserve System to have a measure of the public's inflation forecast. The Fed, through its control of the money stock, controls the long-run rate of inflation. There is, however, always considerable short-run uncertainty regarding the way in which changes in its policy instrument (reserves or the federal funds rate) will ultimately affect money growth and inflation. A measure of the inflation forecast by the public would offer the Fed a useful "outside" assessment of the inflationary consequences thought likely to follow from its policy actions. This inflation forecast could be inferred from the yield gap between the interest rates paid on conventional bonds and on bonds indexed to the price level.[1] Unfortunately, indexed bonds are not now traded in the United States. This paper proposes that the U.S. Treasury issue indexed bonds to create a measure of the public's inflation forecast.

THE PROPOSAL

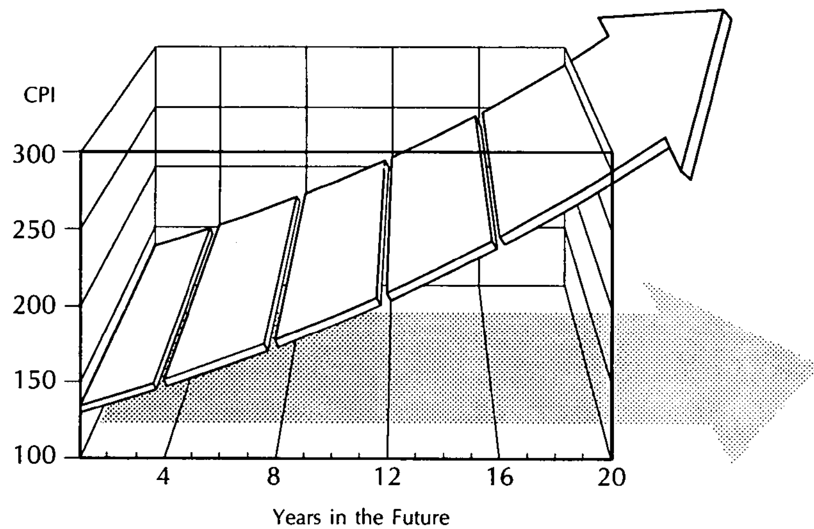
A measure of the inflation expected by the public could be created by legislation requiring the Treasury to issue zero-coupon bonds with maturities of one year, two years, and so on out to twenty years. A zero-coupon bond is a promise to make a future one-time payment. Zero-coupon bonds sell at a discount and yield a return through capital appreciation. Under the proposal, half the bonds issued would be conventional (nonindexed) zero-coupon bonds that would offer a principal payment of a given dollar amount. The other half would offer a principal payment in dollars of constant purchasing power achieved by indexing the principal payment to the price level. For example, if the principal payment of the conventional zero-coupon bond were $100 and the price level were to rise by 5 percent in the year after the sale of the bonds, an indexed bond with a maturity of one year would pay $105.[2]

Holders of indexed bonds do not have to worry about the depreciation of the dollars in which they are paid. For a zero-coupon bond sold in, say, 1992, both the amount bid and the purchasing power afforded by the principal payment are measured in 1992 dollars. The discount on the bond, therefore, is a measure of the real yield (real capital appreciation) offered by the bond over its life. The yield on indexed bonds would offer a direct measure of the real (inflation-adjusted) rate of interest. Furthermore, the existence of indexed bonds of different maturities would provide a measure of the term structure of real rates of interest.[3]

Because holders of the indexed bonds are guaranteed payment representing a known amount of purchasing power, they do not have to forecast inflation. In contrast, holders of the nonindexed bonds *would* have to forecast future changes in the value of the dollar. Consequently, the yield on the nonindexed bonds would incorporate an inflation premium to compensate for the expected depreciation in the purchasing power of the dollar, and the difference in yields between the nonindexed and indexed bonds, therefore, would measure the inflation expected by investors over the life of the bond. The existence of bonds of different maturities would offer a term structure of expected future inflation. Given the current price level, this term structure would yield a time profile of the future price level expected by the public.

Figure 1

TIME PROFILE OF EXPECTED FUTURE PRICE LEVEL



Note: Hypothetical observations are based on assumed 4 percent rate of inflation.

Figure 1 illustrates a hypothetical example in which the public expects future inflation to remain steady at 4 percent a year. (The contemporaneous price level is also taken to be 138, the current value of the CPI.) If nonindexed and indexed zero-coupon bonds are issued at maturities ranging from one year to twenty years, the yield gap on successive issues would permit inference of a term structure of future inflation. These yearly expected inflation rates, when applied to the current price level, would allow construction of the time profile of the future price level expected by the public shown in Figure 1.

Consider an indexed one-year-maturity zero-coupon bond that is a promise to pay \$100 in one year, with the \$100 indexed to the consumer price index. If the real rate of interest were 3 percent, the bond would sell for \$97. If the public believed that the one-year inflation rate would be 4 percent, a comparable nonindexed bond would sell for \$93, returning 4 percent in compensation for the expected inflation and a 3 percent expected real yield. The interest rate on the nonindexed bond would then be 7 percent, with a 3 percent real interest rate on the indexed bond. The "yield gap" between these two rates is the 4 percent inflation rate expected by the market.

THE YIELD GAP AS AN INDICATOR OF MONETARY POLICY

In order to achieve its inflation objective, the Fed could, in principle, change its policy instrument in response to discrepancies between the actual price level and a target path for the price level. Because individual policy actions affect prices only with long lags, however, such a straightforward strategy could be destabilizing. In practice, the Fed monitors indicator variables to determine whether the changes in its policy instrument are consistent with the inflation rate it considers acceptable.

Some economists have suggested that the Fed change its policy instrument in response to movements in the prices of actively traded commodities. These prices *do* move freely in response to changes in expenditure produced by monetary policy actions; however, they often move in response to market-specific disturbances. At such times, commodity prices might give misleading signals about the thrust of monetary policy.

Milton Friedman has long advocated a low, stable rate of growth of M2 as the guide to monetary policy. M2 has maintained a reliable relationship to the public's dollar expenditure over long periods of time. In fact, the ratio of dollar GNP to M2, known as M2 velocity, is currently about 1.63, little changed from its value in 1914 when the Federal Reserve was founded. Over periods of time as long as several years, however, M2 velocity fluctuates significantly. Many economists also fear that future financial innovation could alter the long-run relationship between M2 and GNP. It is possible that a consensus will never emerge that a particular monetary aggregate is a reliable indicator of the stance of monetary policy.

In contrast to these alternatives, the yield gap between nonindexed and indexed bonds would offer a direct measure of expected inflation. This measure would offer useful information to monetary policymakers because it would be formed by market participants who have a direct financial interest in forecasting inflation.

AVOIDING INFLATION AND DISINFLATION

The lag between changes in the Federal Reserve's policy instrument and changes in prices means that it is difficult to associate particular policy actions with inflation. This difficulty lowers the cost of exerting political pressure for an inflationary policy; moreover, the quicker impact of stimulative monetary policy on output than on prices generates political pressure to trade off immediate output gains against a delayed rise in inflation. Indexed bonds of the sort proposed here would balance these pressures by threatening an immediate rise in the yield gap between indexed and nonindexed bonds. The Fed would have a clear and more immediate justification for resisting inflationary pressures.

Further, with indexed bonds, public pressure for an inflationary monetary policy that was associated with a rise in the yield gap in itself would produce countervailing pressure. Holders of nonindexed bonds would suffer a capital loss when the yield gap rose. All creditors receiving payment in nonindexed dollars in the future would feel worse off. The yield gap would restrain pressure for inflationary policy by offering an immediate and continuous market assessment of the potential impact of such a policy.

Surprise inflation acts like a capital levy imposed on money and government securities. The essentially fiscal transfer that arises from surprise inflation does not have to be legislated explicitly. Federal Reserve independence is designed to prevent monetary policy from becoming the handmaiden of fiscal policy. Institutional arrangements, like the federal structure of the Fed with its regional bank presidents and long terms for members of the Board of Governors, give substance to central bank independence. The continuous market assessment of the level of future inflation offered by the yield gap between nonindexed and indexed bonds would constitute an additional safeguard against surprise inflation.

POSSIBLE DISTORTIONS IN THE YIELD GAP

The information on expected inflation offered by the yield gap between nonindexed and indexed bonds of equal maturities would be diminished if the gap fluctuated in response to tax and/or risk premium factors. These possibilities are considered in turn.

Tax Distortions

Ideally, for both the nonindexed bond and the indexed bond, income subject to taxation would be indexed for inflation. That is, holders of both types of bonds would pay taxes only on the increase in purchasing power gained from holding the bonds, rather than on any increase in the dollar value of the bond that only compensates for inflation.

In order to illustrate this point, consider the following hypothetical example. Suppose that, for both the indexed and nonindexed bonds, only the return that represents a gain in purchasing power is taxed. As before, if the real rate of return is 3 percent, an indexed bond that promises to pay $100 of constant purchasing power next year would sell for $97 in the current year. If, subsequently, inflation turns out to be 4 percent, the holder of the indexed bond will receive $104. In this case, taxable income would be calculated as the $7 in total income minus the $4 inflation adjustment, which is a capital depreciation allowance to maintain the purchasing power of the investor's capital. The holder of the *nonindexed* bond also would be taxed only on the real portion of the bond's yield.[4]

If, alternatively, taxable income were not indexed for inflation, an increase in the inflation rate would increase the taxes paid by the holders of indexed bonds, which would reduce the real after-tax yield on the bonds even if there had been no reduction in the real before-tax yield. Unless the tax code were indexed, the yield on the indexed bond would rise as inflation rose to compensate for the increase in taxes imposed by higher inflation. The yield on the indexed bond would then offer a distorted measure of the economy-wide real rate of interest. With the relatively moderate levels of inflation experienced in the 1980s, however, the distortions caused by the present absence of inflation indexing in the tax code would not greatly impair the usefulness of the indexed bond as a measure of the real rate of interest. Moreover, if the tax treatment for the nonindexed and indexed bond were the same, information about expected inflation contained in the yield gap between the nonindexed and indexed bond would not be distorted by changes in the rate of inflation.

Possible Risk Premium Distortion

Because the public might be willing to pay something to hold an asset whose value is not arbitrarily affected by unanticipated inflation, it is possible that a risk premium might bias the yield gap upward. The yield gap would then overstate expected inflation. Also, the risk premium could vary so that the yield gap would change even with no change in expected inflation. (Note that if the yield gap incorporated a risk premium, the Treasury would have to compensate investors for the inflation risk entailed by holding its nonindexed bonds. Indexed bonds would not carry this cost.)

Whether a risk premium would, in fact, be incorporated in the yield gap is of course an empirical question. Woodward (1990) examined the behavior of the yield gap between nonindexed and indexed British bonds and concluded that any risk premium must have been very small.[5] If the risk premium had been significant, the yield gap between conventional and indexed bonds would have implied implausibly low estimates of expected inflation for Britain for the 1980s. Furthermore, Woodward's measure of real yields (adjusted for preferential tax treatment of indexed bonds) produces surprisingly high values. Because real yields averaged around 5.5 percent, it is implausible that holders of indexed bonds were foregoing much yield as protection against surprise inflation. (See Figure 2.)

The magnitude of a possible risk premium also would depend upon monetary policy. Suppose that the central bank had made a credible commitment to price stability. With such a policy, random shocks would still cause the central bank to miss its price level target, but these misses subsequently would be offset. Consequently, the price level would fluctuate around a fixed value, and the magnitude of any discrepancy between yields of nonindexed and indexed bonds due to a risk premium would decline as maturities lengthened.

Alternatively, suppose that the central bank allowed contemporaneous price level shocks to be incorporated permanently in the future price level target. Consequently, the price level would wander randomly over time. (The central bank could allow this kind of price-level drift even if it did not introduce a systematic bias in favor of inflation.) The difficulty in predicting the real purchasing power of a promise to pay a fixed dollar amount in the future would increase as the time horizon lengthened. With this policy, the magnitude of any discrepancy between yields of nonindexed and indexed bonds due to a risk premium would not decline as maturities lengthened.

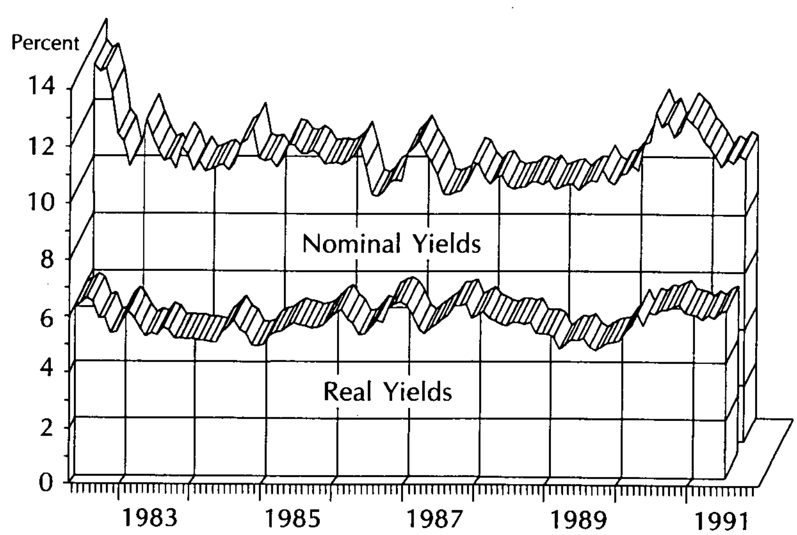
Even if the yield gap between nonindexed and indexed bonds were to incorporate a risk premium, changes in the yield gap would still convey important information to the central bank. Increases in the yield gap would be of concern to the central bank even if they were caused by an increase in the risk premium, rather than by an increase in expected inflation. A central bank must assure markets that its independence is a safeguard against surprise inflation. An increase in the size of the risk premium caused by increased concern for surprise future inflation would indicate to the central bank a need to reinforce the credibility of its commitment to monetary stability.

ISSUES FOR DEBT MANAGEMENT

The idea of indexed bonds has been advanced numerous times in the past. The Treasury possesses the authority to issue indexed bonds, but has always resisted doing so. In congressional hearings on

Figure 2

YIELDS ON INDEXED AND NONINDEXED BONDS



Note: Monthly observations of yields on indexed bonds issued in April 1982 and maturing in August 2011 and of yields on conventional bonds maturing in August 2011. Data were furnished by G. Thomas Woodward.

indexed bonds (U.S. Congress, 1985), Francis Cavanaugh, the Director of the Office of Government Finance and Market Analysis of the Treasury, detailed the reasons.

Mr. Cavanaugh argued that the Treasury did not know whether anyone would buy indexed bonds.[6] If there were no demand for them, their issuance would increase the Treasury's cost of funding the government's debt.

> . . . we have yet to see any strong evidence of potential demand for such an indexed bond in this country. . . . An indexed bond, because of its novel features, would not realize the full benefits of the liquidity of the conventional Treasury market, and its relative lack of liquidity would be reflected in the bid price received by the Treasury in an indexed bond auction. . . . Thus a requirement that the U.S. Treasury issue indexed bonds, especially fixed amounts each year, could lead to significant increases in the cost of financing the public debt (U.S. Congress, pp. 17 and 20).[7]

According to this argument, there is uncertainty over whether anyone would value the inflation protection offered by indexing. Because inaccurate inflation forecasts are costly, however, it seems implausible that no savers would be interested in protecting against such risk. Consider, for example, the experience of someone who bought and held a 30-year government bond 30 years ago. In 1961, the long-term government bond yield was 3.9 percent. On average, over the three years 1959, 1960, and 1961, CPI inflation averaged 1.1 percent. Assuming, given this experience, that in 1961 investors believed that the long-term rate of inflation would be 1.1 percent, a purchaser of a 30-year bond would have anticipated a yearly gain in real terms of 2.8 percent (3.9 percent minus 1.1 percent). In fact, over the 30-year period from 1961 to 1991, CPI inflation averaged 5.2 percent. The investor lost 1.3 percent of his capital each year (3.9 percent minus 5.2 percent) because of inflation (not counting taxes paid on coupon payments). Instead of a 30 percent gain in capital from holding the bond for 30 years, the investor lost 30 percent of his capital. Munnell and Grolnic (1986) make a persuasive case that, at a minimum, pension funds and holders of IRAs would be interested in indexed bonds.[8]

BRITISH EXPERIENCE

British Indexed Gilts

Britain has issued indexed bonds (gilts) since 1981. Unfortunately, indexing in Britain is poorly designed for measuring expected inflation. British bonds are indexed to the retail price index (RPI), which is a poor measure of inflation because it includes the cost of mortgage interest payments. Also, coupon and principal payments are indexed with an eight-month lag.[9] This eight-month lag makes real yields on indexed bonds with a maturity even as long as five years sensitive to variations in inflation. The difference between yields on nonindexed and indexed bonds, therefore, cannot reliably be used to measure expected inflation over periods as short as a few years.

The practice of issuing only long-term indexed bonds compounds the difficulty of measuring the public's expected inflation over periods as short as a few years. In order to observe a yield gap on bonds of short maturity, it is necessary to wait until the passage of time reduces the maturity of the long-term bonds. Even though indexed bonds were first issued in 1981, there is still a paucity of indexed bonds with a short period to maturity. As of the end of 1990, the average maturity of indexed bonds outstanding was 18.9 years. There were only £1.05 billion of indexed securities outstanding with maturities of five years or less. Also, for short-term maturities, the absence of nonindexed bonds with exactly the same maturity as indexed bonds becomes more of a problem.

In a personal communication with the author, Alan Walters noted that in Britain the Exchequer varied the relative supplies of nonindexed short-term debt and long-term indexed bonds in response to changes in the yield gap between the two kinds of debt. In order to ensure that the yield gap reflects expectations of inflation, rather than relative supplies, he recommended that in the future indexed and nonindexed debt be issued in fixed proportions.[10]

British Monetary Policy

The usefulness of a yield gap between nonindexed and indexed bonds as a measure of expected inflation has been questioned on the basis of the British experience. In an article in the *Financial Times* (April 29, 1991), Anthony Harris stated that the "gap has tracked current inflation faithfully, but has no forecasting value at all. . . . The market forecasts the way a picnicker does—by looking out of the window." Therefore, he concludes, the nonindexed-indexed bond gap cannot "give a valuable steer on monetary policy." Presumably, Mr. Harris has in mind the failure of the yield gap to predict the increase in inflation that occurred in 1988. A brief review of British monetary policy in the latter 1980s proves to be helpful in understanding Mr. Harris' contention that bond markets are not forward-looking.

In Britain, inflation fell from 20 percent in 1980 to an average of about 3.5 percent in 1986 and 1987. (Figures for inflation are for the RPI excluding mortgage interest payments.) Until 1988, actual inflation moved fairly closely with long-term expected inflation, inferred from the yield gap between the indexed bond issued in 1982 and maturing in 2006 and a conventional bond with approximately the same maturity.[11] (See Figure 3.) Over 1986 and 1987, in particular, the yield gap averaged about 3.5 percent. Actual inflation began to rise in early 1988 and peaked in 1990 somewhat above 9 percent. The yield-gap measure of expected inflation did rise steadily with actual inflation in early 1988, but reached a peak of only about 6 percent in early 1990.

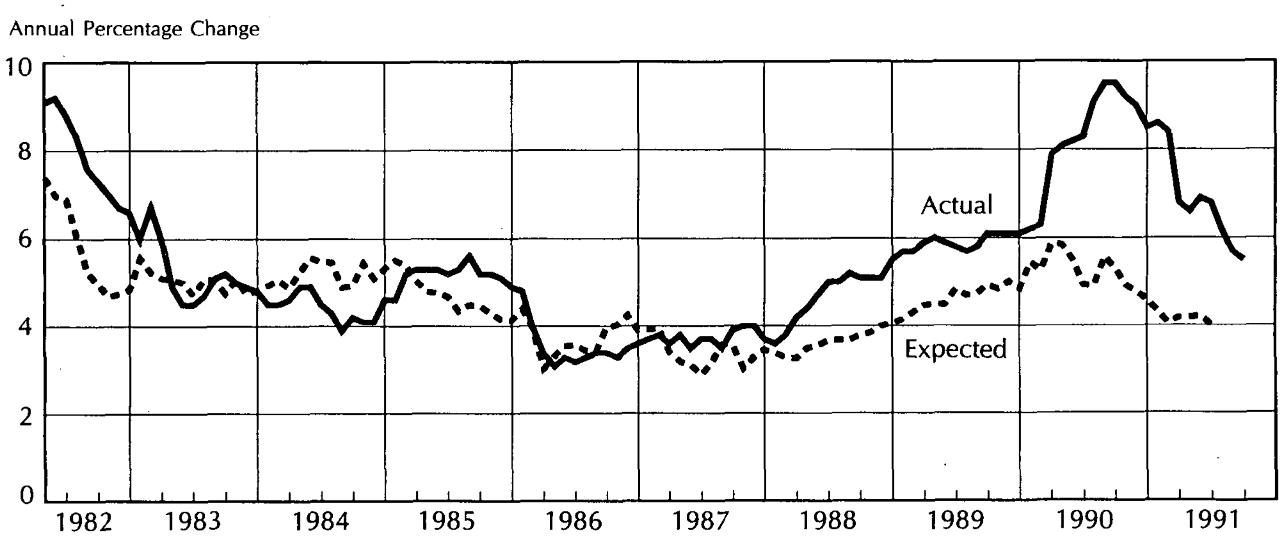
What caused the sharp rise in inflation, which was understated by the yield gap? After the Louvre Accord on February 3, 1987, Nigel Lawson, Chancellor of the Exchequer, began to peg the DM/£ exchange rate informally at 3 to 1. At the same time, the real terms of trade began to appreciate steadily in Britain's favor. That is, British physical assets and commodities became more attractive. This appreciation was prompted by three factors. First, the Conservative electoral victory in 1987 made Britain appear to be a safe haven for foreign capital. Second, the rise in the price of oil after its 1986 trough and a large oil discovery announced on March 8, 1988, raised the value of British exports. Finally, the reduction in marginal tax rates, announced March 15, 1988, increased the attractiveness of investment in Britain and reduced capital outflows.

With a pegged exchange rate, the appreciation in the real terms of trade appeared as a rise in British prices, which was accommodated by high money growth. Growth in the monetary base went from about 4 percent in the middle of 1987 to more than 10 percent toward the end of 1988. In the spring of 1988, Mr. Lawson allowed the DM/£ exchange rate to rise, but only grudgingly. To retard the pound's appreciation, he lowered the UK bank base lending rate to a low of 7.5 percent in May 1988, from a high of 11 percent in early 1987. In June 1988, in response to the sustained rise in inflation that began in early 1988, Mr. Lawson reversed course and began to raise the base rate, which reached 15 percent in October 1989.

In light of this experience, were the holders of British bonds making forward-looking predictions of inflation? In 1987, the holders of bonds maturing in 2006 were predicting inflation of somewhat less than

Figure 3

ACTUAL AND EXPECTED INFLATION IN THE UNITED KINGDOM



Note: Actual inflation is the annual percentage change in the RPI excluding mortgage interest payments over the preceding 12-month period. Expected inflation is inferred from the yield gap between an indexed bond maturing in 2006 and a conventional bond with approximately the same maturity. The yield gap was adjusted for different tax treatment in the two bonds. The expected inflation series was supplied by G. Thomas Woodward.

4 percent over the next 19 years. Can this prediction be defended as forward-looking in light of the increase in British inflation from somewhat less than 4 percent in 1988 to almost 10 percent in 1990? With the pound pegged to the mark, British inflation must equal German inflation plus whatever appreciation (or minus whatever depreciation) occurs in the terms of trade. Historically, German inflation has varied around 3 to 4 percent. If changes in the terms of trade are inherently unpredictable, then a prediction of inflation of 3 to 4 percent was a reasonable estimate.[12]

Ex post, predicted inflation in the 3- to 4-percent range now appears to have been reasonable. Since Britain's formal entry into the EMS in the autumn of 1990, the DM/£ exchange rate has stayed very close to 3 to 1. With the cessation in the appreciation in the British terms of trade, British inflation had to fall to the German level. By autumn 1991, it had been brought roughly into line with German inflation of about 4 percent.[13] In short, there is nothing in the British experience to indicate that bondholders are not forward-looking.

Can Bond Markets Predict Inflation?

On the basis of an examination of the British experience, Gabriel de Kock (1991) concludes that using a yield gap to measure expected inflation as proposed here would not be useful to the Fed. Based on the British experience, he makes two assertions. First, he asserts that the yield on the indexed bond does not offer a measure of the economy's real yield. Second, he claims that the yield gap between nonindexed and indexed bonds possesses no predictive power for future inflation beyond what is furnished by recent, actual inflation. The empirical tests De Kock conducts, however, are not capable of proving or disproving these assertions.[14]

De Kock tests whether the yield gap predicts subsequent inflation rates over 12-, 24-, and 36-month periods, respectively. Apparently, he chooses these rates because they are of "primary concern to policymakers." They were not, however, what bondholders were trying to predict. The author derives his measure of expected inflation from comparing the yield on nonindexed bonds with the yield of indexed bonds of roughly the same maturity issued in March 1982 and maturing in July 1996. For example, the first observation used by the author is dated March 1982. The yield gap between nonindexed and indexed bonds then reflects the market's expectation of inflation from March 1982 to July 1996. The author compares this expectation of inflation with actual inflation over the much shorter periods beginning in March 1982 and ending in March 1983, March 1984, and March 1985. In order to perform the kind of ex post test of predictive power the author wishes to conduct, it will be necessary to wait until 1996 (or close to that date).[15]

Despite the inability of De Kock's tests to bring evidence to bear on the ex post predictive accuracy of the yield gap as a measure of expected inflation, his work does raise the interesting question of how to interpret evidence on ex post predictive accuracy. Would evidence that investors predict inflation poorly affect the value to the central bank of a yield-gap measure of expected inflation? The answer would appear to be no. What matters in determining the real rate of interest is what inflation rate financial markets expect, not whether ex post they predicted inflation accurately. Moreover, evidence from a yield-gap measure of expected inflation demonstrating that the public in practice predicts inflation poorly would provide an incentive to the central bank to alter monetary policy to ensure that at least in the long term the price level would be easy to predict.

Summary and Concluding Comments

The yield-gap proposal advanced here differs from earlier proposals for indexed bonds in its recommendation that (1) equal amounts of nonindexed and indexed bonds of the same maturity be issued and (2) the resulting yield gap be used as an indicator of whether particular monetary policy actions are consistent with the Federal Reserve's inflation objective.[16]

The Federal Reserve determines the long-term rate of inflation. The measure of expected inflation proposed here would allow the Fed to observe whether there was a discrepancy between the rate of inflation expected by the public and the rate of inflation it seeks to achieve. Monetary policymakers would then be in a better position to make policy in a way that avoids discrepancies between expected and subsequently realized inflation. The yield-gap measure of expected inflation would allow monetary policy to be evaluated on whether or not it provides a stable monetary environment characterized by moderate fluctuations in expected inflation and the absence of inflationary and disinflationary surprises.

APPENDIX

Using Indexed Bonds in Making Monetary Policy: An Illustration

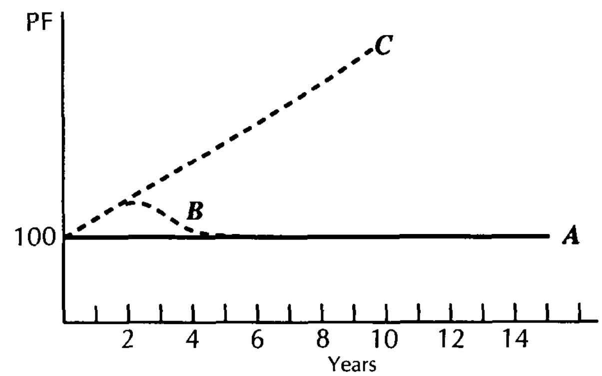
At present, the Fed must infer how its actions affect the public's perception of the inflation rate that it, the Fed, considers acceptable. The Fed becomes concerned when financial markets appear to interpret a policy action as signaling a willingness on its part to tolerate a higher inflation rate. A yield gap indicator would allow the Fed to observe directly how it is influencing the public's expectation of inflation. The example below illustrates this point.

Figure 1 displays hypothetical time profiles of the public's expectation of the future price level as inferred from the yield gap between nonindexed and indexed bonds of successively longer maturity. To simplify the discussion, I assume initially that the public believes the Fed will maintain the rate of inflation at 0 percent on average. Line A in Figure 1 (the solid line) reflects the assumption of expected long-term price stability. (The yield gap between nonindexed and indexed bonds is zero. The current value of the price index is taken to be 100.) Figure 2 displays the term structure of real yields inferred from indexed bond yields of successively longer maturity. Initially, I assume that the yields on indexed bonds indicate that the public believes real yields will remain at 3 percent. Line 1 in Figure 2 (the solid line) reflects this assumption.

Finally, I assume that the rate of growth of real GNP has declined relative to what the Fed considers a sustainable rate. In response, the Fed has over time gradually worked the funds rate down (by lowering its borrowed reserves target or by reducing the discount rate). At some point, a rise in long-term bond rates follows a reduction in the funds rate. The Fed then must decide whether this rise should deter future funds rate reductions. The Fed will be concerned that the rise in bond rates signals the market's belief that it is willing to tolerate a higher inflation rate. In this situation, a yield gap indicator would help the Fed understand the cause of the rise in bond rates. Consider the following possibilities.

I. The measure of the public's expectation of inflation remains unchanged. That is, line A in Figure 1 continues to measure the future profile of the price level expected by the public. Bond yields have risen because real yields have risen.

Figure 1

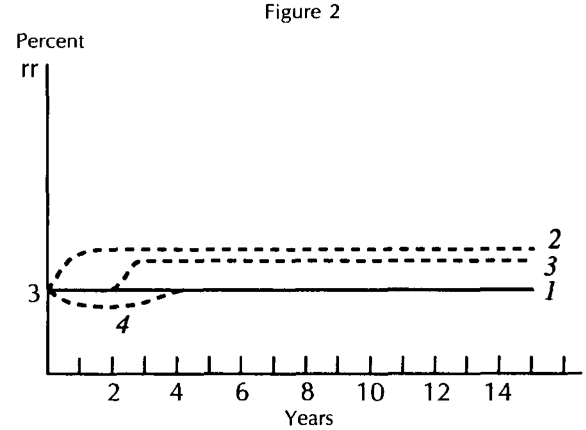


Note: Time profile of the future price level expected by the public (PF) inferred from the yield gap between nonindexed and indexed bonds of successively longer maturities.

A. Line 2 in Figure 2 shows a first possible case. It shows real yields rising at all but the very shortest maturities. (Yields on the shortest maturities are tied down by the current value of the funds rate.) This evidence suggests that the economy has begun to strengthen. It favors prompt action to reverse the recent reduction in the funds rate.

B. Line 3 in Figure 2 shows a second case. It shows real yields rising only in the future.

Figure 2



Note: Term structure of the real rate of interest (rr) inferred from yields on indexed bonds of successively longer maturities.

This evidence suggests that market participants expect a rise in real rates in the future, perhaps because of an optimistic assessment of prospects for a future revival of economic activity. This evidence suggests ceasing actions that lower the funds rate, but delaying actions to raise it. In this latter case, the delayed rise in the real rate could also reflect the market's belief that the Fed will be reluctant initially to let short-term market rates rise in response to stronger economic activity. Such a belief, however, would appear unlikely because of the assumption of an unchanged expectation of inflation (an absence of movement in line A in Figure 1).

II. A second possibility is that bond yields have risen because the public now expects positive inflation to replace price stability.

A. In the first case considered, line A changes to line B in Figure 1. As depicted by line B, the public now believes that the Fed will maintain an unchanged price level in the long term, but that the near-term inflation rate will be positive. If real yields have remained unchanged (line 1 is unchanged in Figure 2), then it is likely that market participants expect some transitory increase in inflation unrelated to monetary policy. In this case, the Fed is likely to postpone further policy actions that would reduce the funds rate.

B. In the second case, the rise in bonds rates is accompanied by a change in the expected future price profile from line A to line C in Figure 1. If, at the same time, real yields rise (line 1 in Figure 2 changes to line 2), it is likely that the market believes that Fed easing has gone too far. It believes that the cumulative reduction in the funds rate will not only stimulate economic activity, but also will create inflation. This information is likely to induce the Fed to reverse its most recent action reducing the funds rate.

C. A third case is illustrated by the combination of movement to line C in Figure 1 and line 4 in Figure 2. This combination suggests that market participants have become concerned that monetary policy will become inflationary in the future, but real rates are falling in the climate of weakness in economic activity. This information suggests that the Fed should continue to reduce the funds rate, but reaffirm its commitment to maintaining price stability. For example, the Fed could communicate to the public the level of future inflation it considers acceptable by specifying an explicit target path for the future price level.

ENDNOTES

[1] See Hetzel (1990 and 1991) and *Bondweek* (1991). The idea of indexed bonds is an old one. In his *Review* article, "The Concept of Indexation in the History of Economic Thought," Humphrey (1974) lists a number of early economists who advocated indexed bonds: John Maynard Keynes in 1924; George Bach and Richard Musgrave in 1941; and Milton Friedman in 1951. Humphrey also notes two early examples of indexed bonds. During the American Revolution, the Massachusetts legislature issued bonds with interest and principal tied to an index of the prices of staple commodities. In 1925 the Rand Kardex Co., at the urging of Irving Fisher, issued a 30-year bond indexed to the wholesale price index. In 1985, Senators Quayle and Trible introduced a bill to index government bonds (S. 1088, the "Price Indexed Bonds Act of 1985") and Representative Lungren introduced a similar bill in the House (H.R. 1773, "The Price Indexed Bonds Act of 1985"). See the U.S. Congress (1985) Hearings, "Inflation Indexing of Government Securities."

[2] The bonds would be issued and retired just after the middle of the month, when the CPI is announced for the preceding month. The dollar principal payment on an indexed bond would then be increased by the percentage increase in the CPI from the month preceding its issue to the month preceding its redemption. Zero-coupon bonds avoid problems of how to index partially accrued coupon payments when a bond is traded before maturity.

[3] Forward rates for individual years would be inferred under the assumption that the yield over the life of the bond is a geometric average of the yields over the successive individual years.

[4] The issue of how to tax capital gains is perennially contentious. There is a consensus among economists, however, that taxing capital gains representing only paper gains that compensate for inflation distorts investment and savings decisions undesirably.

[5] Woodward has published a series on the real yield on indexed bonds and on the implied expected inflation rate. A key feature of his series is an adjustment for different tax treatment of nonindexed and indexed gilts. In Britain, holders of indexed bonds do not pay taxes on that part of the income due to capital appreciation, while holders of nonindexed bonds pay taxes on the inflation premium built into interest payments. This difference in tax treatment increases the size of the yield gap between the two kinds of bonds beyond bondholders' expectation of inflation. Woodward reduces the gap by the estimated amount due to this tax effect. Subtracting this reduced difference from

the yield on nonindexed bonds gives a tax-adjusted real yield series. That is, it provides a measure of the real yield that holders of indexed bonds would receive in the absence of favorable tax treatment.

[6] Treasury opposition to the issue of indexed bonds also appears to reflect a general hesitation to innovate in debt management techniques. "A poorly received Treasury issue, because of faulty design or a misreading of a new potential market, could adversely affect Treasury's credibility in the market. So we approach innovation with great care" (U.S. Congress, 1985, p. 20).

[7] Mr. Cavanaugh actually expressed both the concern that there would be no demand for indexed bonds and that there would be too much demand. In the latter case, their issue would be a problem because they would compete with S&Ls for funds (U.S. Congress, p. 23). It is hard to know what to make of the assertion that the market for indexed bonds would be illiquid. If dealers in government securities find it profitable to sell conventional debt, why would they not find it profitable also to sell indexed debt?

[8] Munnell and Grolnic (1986, pp. 4,5) note, "Anyone saving for a specific goal, such as purchasing a house or sending children to college, should welcome the opportunity to ensure that such savings will not be eroded by inflation. . . . Moreover, in the United States there may well be a niche for index bonds that has not been adequately explored—namely, the financing of fully indexed annuities for retirees. These annuities could play an important role in protecting elderly people against the erosion of their pension income during their retirement years." Munnell and Grolnic then document that pension plans have not historically adjusted payments to beneficiaries to compensate fully for inflation.

They also note that there are no financial instruments that can satisfactorily protect purchasing power against inflation. "Common stocks . . . seem to be a particularly unsuitable investment for producing a stable real income. While over the past 30 years stocks have provided a high average real return, this return has been so volatile that investors have experienced significant periods of negative real earnings. Long-term bonds have fared even less well: their average real return has been near zero and in recent years the variability has been almost as great as that for common stocks. Treasury bills do appear to offer a stable real positive return, but this return is very low and these instruments are a less than perfect hedge against inflation" (Munnell and Grolnic, 1986, p. 18).

[9] An eight-month lag was adopted to simplify calculation of accrued interest on bonds with semi-annual coupon payments. With the eight-month lag, immediately after a coupon payment, assuming the most recently available price index is for two months in the past, one can calculate the indexed value of the coupon payment six months in the future.

[10] The Bank of England supplied the author with data on outstanding debt by maturity for both nonindexed and indexed debt. The yield gap between nonindexed and indexed debt did indeed influence relative supplies of the two kinds of debt. Relative supplies, however, did not appear to influence the subsequent yield gap.

[11] Data for expected inflation were supplied by Thomas Woodward. They are derived from the yield gap between conventional and indexed bonds after an adjustment for the favorable tax treatment of indexed bonds. See endnote 5 and Woodward (1990).

[12] In 1990, expected inflation measured by the yield gap rose to about 6 percent, which was higher than the trend rate of German inflation. Investors in British bonds may have believed that Britain would abandon the 3-to-1 DM/£ exchange rate to avoid the costs of a severe disinflation. They may also have believed that the trend rate of German inflation would rise because of fiscal pressures from German reunification.

[13] The DM/£ exchange rate began to fall in 1989. This fall indicated that the terms of trade were no longer appreciating in Britain's favor. A pegged exchange rate then required a convergence of British and German rates of inflation. This convergence in inflation rates required a drastic monetary deceleration in Britain. In 1989 and the first part of 1990, growth in the broad monetary aggregate M4 was around 20 percent, while growth in the monetary base M0 was around 8 percent. By autumn 1991, M4 growth had fallen to around 8 percent and M0 growth had fallen to around 2 percent.

[14] See De Kock (1991). De Kock supports the first assertion by pointing to the absence of a negative relationship between the yield on indexed bonds and future changes in economic activity. Economic theory, however, does not predict a negative (or any predictable) relationship between these two variables. In fact, in any macroeconomic model, the sign of the correlation between the real rate of interest and future economic activity depends upon the kind of shock impinging upon the economy. In a standard IS-LM model, for example, a positive real sector shock (rightward shift in the IS schedule) will lead to a *higher* real rate of interest and a *higher* level of real GNP.

The author's rationale for his test appears to rely on the assumption that a rise in interest rates necessarily reflects a tightening of monetary policy, and conversely. For example, he argues that the yield gap could not have been an adequate measure of inflation expectations in Britain in the period from early 1988 through mid-1990. Over this period, long-term market rates rose (monetary policy was tightened according to De Kock) and expected inflation (measured by the yield gap) rose, rather than fell. Measured by growth of the monetary aggregates, however, monetary policy was expansionary. Growth in the monetary aggregates M0 and M4 was quite rapid. Monetary deceleration did not begin until mid-1990. Market rates could have risen because expected inflation rose.

[15] The favorable tax treatment accorded indexed bonds widens the size of the yield gap. Because the author fails to correct for this tax effect, he concludes that the yield gap is a biased measure of inflation. That is, he finds that the yield gap, which includes a tax effect, consistently overpredicts inflation. Also, the author uses a theoretically unsatisfactory measure of inflation. He uses the retail price index that includes mortgage interest payments. It would have been better to use the retail price index that excludes these payments.

[16] In a personal communication to the author, Milton Friedman argued for using the yield gap as a *target*. He would instruct the Federal Reserve to eliminate the gap over time.

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