Draft for comment

Do Inverted Yield Curves Subvert Economic Growth?

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This essay briefly summarizes the current state of evidence on the linkage between yield curve inversions and NBER business cycle peaks. Comments welcome.

Recently, the Treasury yield curve has become nearly horizontal and, at times, inverted (that is, negatively sloped) for yields less than 5 years to maturity. Consequently, some observers have expressed concern that the flattening portends a slowing of economic activity or, perhaps, a recession. There is good reason for such concern: Since 1964—when the long-term Treasury bond market became deep enough to allow meaningful analysis of maturity-related spreads among Treasury issues—every NBER business cycle peak has been preceded by an inversion of the yield curve. Yet, this empirical regularity should not be stretched too far because the relationship between yield curve inversions and subsequent downturns in economic activity, in fact, is tenuous.

What Causes The Yield-Curve Slope to Change?

Asset prices and related maturity-based yield spreads, including the slope of the yield curve, are determined by forward-looking investors in liquid, competitive financial markets. As such, they contain information of value for monetary policymakers and analysts. Selected yield curves during 2003-2006 from *National Economic Trends* are shown in Figure 1 (these curves show constant-maturity yields, as calculated by the U.S. Treasury and published by Federal Reserve Board on its H.15 statistical release). During this period, the 10-year yield increased approximately 100 basis points, from 3-3/4 percent in 2003 and 2004, to 4-1/2in 2005, to 4-3/4 in 2006. During the same period, the 3-month yield increased approximately 350 basis points, from 1 percent in 2003 and 2004, to 2-3/4 in 2005, to between 4-1/2 and 4-3/4 in 2006.

Historically, this pattern—rapidly increasing short-term yields combined with a narrowing of maturity-related spreads—has been a reliable predictor of slower future economic growth. Indeed, the *motivation* of the FOMC for increasing its federal funds target has been to moderate the pace of real economic growth and accompanying pressures on resource utilization that might tend to increase inflation. In this sense, both the Committee's actions and changes in maturity-related yield spreads have been consistent with the historical record. The "conundrum" that has puzzled some analysts, however, is the small, relative to increases in short yields, increase in longer-term yields. It is vacuous, of course, to observe that if long-term yields had increased more, than the yield curve would not be so flat. It is equally vacuous, albeit perhaps not so often spoken, to argue that the flattening of the yield curve is signally slower growth *because* long-term yields didn't increase: Would a more steeply upward sloped curve be a positive signal for growth if the cause of the steeper slope were larger increases in long-term yields? Nonsense.

Changes in one-year forward yields during the same period aide our understanding of the economic causes of changes in maturity-based spreads.[1] Selected forward-rate curves are shown

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in Figure 1.[2] During the past four years, the one-year forward rate two-to-three years ahead has increased from approximately 2-1/2 percent in 2003 and 2004, to 4 percent in 2005, to 5 percent in 2006. At the same time, the one-year forward rate nine to ten years ahead has changed little, from 5-1/2 percent in 2003 and 2004, to 4-1/2 percent in 2005, to between 5 and 5-1/2 percent in 2006.

Kozicki (1997) summarizes the most familiar explanations that, as of the mid-1990s, were invoked to link the yield curve's slope to macroeconomic activity. First, the slope reflects, in some part, the current and expected future stance of monetary policy. Often, a narrowing of maturity-based spreads (that is, a flattening of the yield curve) reflects sharp increases in short-term market rates due to Federal Reserve actions. Historically, long-term rates have tended to move less than short-term rates when monetary policy actions increased short-term rates, thereby flattening the curve. Equivalently stated, near-dated forward rates tend to increase more than later-dated forward rates. Potential reasons include investors anticipating that tight policy will be transitory, or that the central bank will effectively stabilize inflation over the long-term, or that slower economic activity will reduce future credit demand and real yields. The yield spread also reflects, in part, information on credit market conditions. Long yields, perhaps, are high relative to short yields at the time of policy tightenings due to strong credit demand. Finally, a small spread may reflect the direction of expected future inflation changes—a higher near-term inflation that triggers tighter monetary policy, and a subsequent lower inflation rate resulting for successful policy.

Modern models of maturity-related yield spreads separate longer-term yields into two components: the (algebraic) expected one-year forward rates (calculated via the naïve expectations hypothesis) and the term premium.[3] By construction, the term premium is the residual after the algebraic forward rates are subtracted from observed market yields. Next, the term premium is modeled as a function of (at least) three economic variables: a discount factor reflecting the relative value of consumption in the more distant future versus consumption in the near future (often referred to as the stochastic discount factor, or pricing kernel); expectations of short-term real yields expected to prevail at future dates; and the rate of inflation expected to prevail at future dates. Since the latter two variables are stochastic (with respect to the investor/household), their affect on yields also includes an appropriate risk premium. The most popular current explanations for the stability of far-dated forward rates cite decreases in the latter two risk premiums; see, for example, Bernanke (2006), Kozicki and Sellon (2005), Kim and Wright (2005). In turn, decreases in these risk premia likely reflect extrapolation of the "Great Moderation" of the last 20 years plus increased credibility of, and confidence in, the Federal Reserve's resolve to sustain a low, stable inflation rate.[4]

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[1] See for example Bernanke (2006), and Kozicki and Sellon (2005).

[2] These forward-rate curves, from *Monetary Trends*, are calculated in two steps. First, a Nelson-Siegel curve is fit to the set of all monthly average Treasury constant-maturity yields, to the longest reported maturity. Second, equations due to Robert Shiller are used to approximate the forward yields that would be obtained by using the theoretically correct zero-coupon bond yields rather than the Nelson-Siegel curve fitted to constant-maturity yields. For details, see the footnotes at the end of *Monetary Trends.* The use of this method is necessitated by data limitations in the production of *Monetary Trends.*.

[3] See Campbell, Lo and MacKinlay, chapter 10.

[4] Other analysts have explored the role of global capital flows. Investment in much of the developing world never fully recovered from the 1997 Asian financial crisis. Plus, a world "saving glut" has resulted from the the unprecedented simultaneous occurrence of two events during the last decade: the rapid growth of China and India, and sharp increases in prices for oil. Bernanke (2006) mentions these; for a broad international discussion with cross-region comparisons, see Lomax (2006).

Analysts are correct to be concerned regarding inversions in the yield curve's slope. Every recession since 1950 has been preceded by the yield curve's slope falling considerably below its historical average, if not becoming negative. Figures 3 and 4 summarize the time-series evidence. The yield curve slope falls sharply prior to each NBER cycle peak (Figure 3 shows the familiar national income accounts GDP data, while Figure 4 uses Macroeconomic Advisers' monthly GDP series which starts in 1993. NBER recession periods are shaded light gray.). Estrella (2005) notes that models based on the same measure of the yield curve's slope displayed in the tables below have been able to predict every U.S. recession since 1950 (whether the curve inverted or not) with only one false signal: 1966-1967. Yet, significant economic slowdowns have not always followed a flattening or inversion of the curve. Kozicki (1997) notes that these patterns are not unique to the United States; she finds similar patterns among 9 other developed countries.

Inversion Episodes

Tables A and B summarize the historical evidence since 1950. The first table is based on Treasury constant-maturity yields, as published on the Federal Reserve Board's H.15 data release. The second table is based on synthetic zero-coupon Treasury yields, calculated by Mark Fisher at the Federal Reserve Bank of Atlanta and obtained from the BIS's *DataBank*.[5] The yield curve's slope is measured by the spread between the Treasury yield at 10-year and 3-month maturities, a measure which past studies have labeled as the most reliable for predicting changes in economic activity.[6]

In the left panels of the tables, each row corresponds to a month in which the yield curve became inverted, having been positively sloped during the previous month. In the right panels, each row corresponds to an NBER business cycle peak. The left panels make clear that yield curve inversions tend to predict approximately twice as many recessions as actually occur: there are 6 post-1964 NBER cycle peaks but 12 inversions of constant-maturity yields and 14 of zero-coupon yields.

Figure 5 compares the characteristics of yield curve inversions shown in the left panels of the tables. Generally, for similar inversion episodes, the maximum spread (slope of the yield curve) is (algebraically) smaller for the zero-coupon yields than for the constant-maturity yields. The upper panels of the figure compare the durations between the zero-coupon and constant-maturity yields, the lower panels compare the maximum negative slopes of the yield curve. Because there are few observations, statistical inferences are not appropriate. Visual inspection of the figure suggests, however, that the characteristics of inversions differ across the two datasets and that perhaps some care should be exercised, in analytical discussions, regarding which data are used.

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[5] Although the maturities of the securities in these two tables is the same, the durations of the securities differs (the duration of a zero-coupon security equals its maturity, while the duration for a coupon issue is less than its maturity). Further, the synthetic zero-coupon securities that correspond to the zero-coupon yields are pure discount bonds and, hence, would sell at a significant discount from par value, while the synthetic coupon securities that correspond to the constant-maturity yields would, presumably, sell close to par with potentially differing tax implicatioins. Published constant-maturity 10-year rate data begin April 1953, and published constant-maturity 3-month rate data begin September 1981. Long-term bond yields beginning 1950 are from *Banking and Monetary Statistics, 1941-1970*, pages 722 and 723. Three-month Treasury yields for dates prior to September 1981 are bond-equivalent yields calculated from published secondary market discount yields on 3-month Treasury securities. Conclusions for dates prior to 1964 must be treated with caution due to the thinness of the long-term bond market.

[6] See Estrella and Mishkin (1998) and Kozicki (1997).

Broadly speaking, duration and maximum yield spread appear bimodal. For the 12 constant-maturity inversions, half lasted 3 months or less and 3 lasted 1 year or more. The maximum negative slope also appears bimodal, with half having slopes greater than -28 basis points and half less than -49 points (3 less than -150 basis points). The number of elapsed months from the onset of inversion to the cycle peak also is bimodal, with 6 episodes lasting 9 months or less, and 6 lasting 1 year or more. The 14 zero-coupon inversions seem less bimodal, with 5 lasting 3 months or less and only 2 lasting more than 1 year. Five of the inversions have a maximum negative slope of greater than -20 basis points, and only 2 have a maximum slope less than -160 basis points. The duration of inversions to similar to the constant-maturity inversions.

Despite some statistical differences, conclusions regarding correlation between inversions and NBER business cycle peaks largely are invariant across the two datasets. For example, in the right-hand side panel of table B, for both the NBER recessions beginning July 1990 and March 2001, the yield curve inversions ended well before the cycle peak; the "lead" for the zero-coupon based indicator was longer, however.

1966

One date, 1966, deserves special discussion for something that it lacks: designation as an NBER business cycle peak. By both the constant-maturity and zero-coupon measures, the yield curve was significantly inverted during 1966. The zero-coupon curve became inverted in April and remained inverted for 11 months with a maximum yield spread of -.56 basis points; the constant-maturity curve became inverted in January for one month and in September for 6 months, with a similar yield spread. Yet, the NBER's Business Cycle Dating Committee did not designate a business cycle peak during 1966 or 1967. Filardo (1999), in his comparison of five special-purpose business-cycle forecasting models (most of which include the yield curve as an explanatory variable), notes that the models interpret 1966-1967 as containing a strong signal of a forthcoming recession that does not occur. Filardo writes that the models' errors are understandable since the 1966 experience was sufficiently deep that the NBER's business cycle dating committee "almost" designated a peak in 1966. Robert Hall, chair of the NBER business cycle dating committee, writing in the *NBER Reporter*, Summer 1991, is more circumspect: "A number of previous episodes have challenged the Bureau's dating process. In 1967, the economy paused dramatically during a period of otherwise strong growth. Many economists considered the period a recession. But the Bureau concluded that the depth of the decline of the economy was considerably less than its standard for a recession."

Yet, the issue is not clear-cut. Friedman and Schwartz (1982, p.74), for example, citing work by Fabricant (1972), assert a cycle peak in 1966 and a trough in 1967 and add these dates to their cycle chronology.[7] But, others do not concur. In a 1992 article on growth cycles, Zarnowitz (1992) notes that real growth slowed sharply in 1966-1967 but did not decrease. Further, examination of both contemporary and vintage data regarding real output and employment supports Hall's position.[8] Real GNP (then measured in 1958 dollars) did not decrease during the period and employment fluctuated month-to-month, increasing in some, decreasing in others, around an essentially unchanging average level.

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[7] Fabricant did not call, in his paper, for 1966-67 to be a cycle peak. Rather, based on preliminary data as published in 1971, he noted that the 1966-67 slowdown seemed at least as severe as 1969-70, which the NBER committee had designated a recession period.

[8] Vintage data are available on the Federal Reserve Bank of St. Louis FRASER web site in several publications, including *Business Conditions Digest* and *Economic Indicators.*

NBER Cycle Peaks

The right-hand panels of both tables A and B examine NBER business cycle peaks since 1950. The first three cycle peaks—in 1953, 1957 and 1960—were not preceded by inversions.[9] The next two cycle peaks are the "classic" cases. In these cases, the inversions began 5 to 8 months prior to the cycle peaks and continued until after the peak. The next two cycle peaks, 1980 and 1981, reflect the Federal Reserve's aggressive disinflationary policy that began in late 1978 and intensified after October 1979. The extreme size and duration of the inversions—as much as 400 basis points and 20 months for the zero-coupon yields—perhaps makes treacherous generalizations from these cycle peaks.

The final two cases correspond to the two most-recent mild recessions. Many analysts have noted the anomalous behavior of macroeconomic variables during and after these recessions. The yield curve's inversions surely are candidates for inclusion in this group: the inversions, relative to previous cycle peaks, are of short duration, modest size, and *reversed* prior to the cycle peak (that is, the yield curve slope becomes positive prior to the NBER cycle peak). In part, this behavior likely reflects changes in the conduct of monetary policy, including an increased willingness by the FOMC to aggressively move its federal funds rate target in response to anticipated future inflation. These events likely are too recent to determine whether they presage a changed future relationship between the yield curve's slope and business cycle peaks.

Probit Models

The use of simple probit models to link maturity-based spreads (the yield curve slope) to business cycles was introduced by Estrella and Mishkin (1998). Dueker (1997) extended the Estrella-Mishkin model by introducing Markov switching between two regimes. In one regime, the yield curve slope, even if inverted, has little or no predictive power; in the other regime, the yield curve have power as a predictive variable. In light of the patterns shown in the tables included here, these results seem very reasonable. Chauvet and Potter (2002) extend the Estrella-Mishkin model to consider regime switching. The estimates, however, are highly uncertain regarding the existence of more than one regime. Filardo (1999) provides a summary of several statistical methods used to link the yield curve slope to future economic activity, including probit models.

Wright (2006) extends and updates the probit models as predictors of business cycle peaks, emphasizing that asset prices (and yields), business cycles, and the rate of real growth, for example, are endogenous variables, simultaneously determined. Noting that maturity-based yield spreads such as the 10-year less 3-month spread on Treasuries have had a "positive statistical relationship" with real GDP growth over subsequent quarters, he concludes that at least two factors from the yield curve should be included in predictive regressions: the short-term rate and the spread between the short and long-maturity rates. Overall, he finds that recent flatness of the yield curve likely is due to a decrease in investors' required term premiums, although he does not provide an explanation for the decrease (see Bernanke, 2006).

[9] At least, not preceded by inversions when the yield spread is calculated from data published in *Banking and Monetary Statistics.* These data are an average rate of long-term government bonds, not restricted to a 10-year maturity.

Dueker (2005) has extended the yield curve-probit regression framework by embedding the yield curve slope, the effective federal funds rate (similar to Wright's suggestion that a short rate be included in probit models), and NBER business cycle dates in a VAR forecasting model that predicts the probability of being near an NBER business cycle turning point. The VAR—by including qualitative variables for cycle peaks and extending the analysis to a dynamic probit forecasting framework—tracks business cycle turning points well. Consistent with the short duration of the inversions for 1969-1970 and 1990-1991, for example, the latent recession-tracking variable in the VAR predicts a shallow recession in both periods.

The track record of econometric studies that have attempted to predict real output *growth*, rather than business cycle dates, with the yield curve's slope is mixed. Early studies generally were unsuccessful. A recent analysis in the same spirit—simultaneous modeling of the level of yields, maturity-based spreads, and the growth rate of real GDP—is provided by Ang, Piazzesi and Wei (2006), who, via an arbitrage-free two-factor term structure framework, include in their model the entire slope of the yield curve.

It is worthwhile to note that recent studies—including Wright (2006), Kim and Wright (2005), Dueker (2005), and Ang, Piazzesi and Wei (2006)—conclude that models must include at least two variables—the yield curve's slope and the level of the short-term rate (or factors resembling these)—to accurately track real growth or business cycle dates. By itself, the yield curve's slope is a weak indicator of future economic activity, at best.

Summary

In short, maturity-based yield spreads—the slope of the yield curve—reflect relative asset prices (valuations) as determined by the actions of forward-looking investors in liquid, competitive financial markets. As such, they contain valuable information for monetary policymakers and analysts. Inversions of the yield curve generate significant concern among analysts; the historical record suggests such concern is reasonable. A large number of econometric studies have shown that the yield curve's slope is a valuable indicator of the future pace of economic activity. Yet, relative to other economic data, there have been relatively few yield curve inversions during the last half-century. The number of false signals and the bimodal nature of the data suggests caution when interpreting inversions as leading indicators of future economic activity.

Yield Curves and NBER Business Cycle Peaks

A. (Synthetic) Constant-Maturity Treasury Yields

Yield Curve Inversions and Cycle Peaks					NBER Business Cycle Peaks *				
Beginning Month	Duration	Max Spread	Next Peak	Month to Peak***	Peak	Previous Inversion*	Duration (months)	Max Spread	Lead (months)***
Jan 1966	1	-.10	Dec 1969	47	Jul 1953	----			
Sep 1966	6	-.49	Dec 1969	39	Aug 1957	----			
Dec 1968	3	-.28	Dec 1969	12	Apr 1960	----			
Apr 1969	1	-.17	Dec 1969	8	Dec 1969	Jun 1969	9	-.51	6 months
Jun 1969	9	-.51	Dec 1969	6	Nov 1973	Jun 1973	16	-1.6	5 months
Jun 1973	16	-1.6	Nov 1973	5	Jan 1980	Nov 1978	18	-3.3	14 months
Nov 1974	1	-.04	Jan 1980	62	Jul 1981	Oct 1980	12	-3.5	9 months
Nov 1978	18	-3.3	Jan 1980	14	Jul 1990	Nov 1989	2	-.16	8 months
Oct 1980	12	-3.5	Jul 1981	9	Mar 2001	Jul 2000	7	-.70	8 months
Jun 1989	2	-.16	Jul 1990	13					
Nov 1989	2	-.08	Jul 1990	8					
Jul 2000	7	-.70	Mar 2001	8					

* Monthly data. NBER business cycle peaks prior to 1969 (July 1953, Aug 1957, and April 1960) were not preceded by inversions.
** Measured by 10 year minus 3 month constant maturity yield beginning Sept 1981; minus bond-equivalent 3-month bill yield earlier.
*** Number of months between initial inversion and cycle peak.

Source: Author's calculations.

B. (Synthetic) Zero-Coupon Treasury Yields

Yield Curve Inversions and Cycle Peaks					NBER Business Cycle Peaks *				
Beginning Month	Duration	Max Spread	Next Peak	Month to Peak***	Peak	Previous Inversion*	Duration (months)	Max Spread	Lead (months)***
					Jul 1953	----			
Dec 1965	3	-.23	Dec 1969	49	Aug 1957	----			
Apr 1966	11	-.56	Dec 1969	45	Apr 1960	----			
Sep 1967	1	-.02	Dec 1969	27	Dec 1969	Apr 1969	11	-1.1	8 months
Dec 1968	3	-.08	Dec 1969	12	Nov 1973	Apr 1973	10	-1.6	7 months
Apr 1969	11	-1.1	Dec 1969	8	Jan 1980	Sep 1978	20	-4.0	16 months
Apr 1973	10	-1.6	Nov 1973	7	Jul 1981	Sep 1980	14	-3.1	10 months
Mar 1974	9	-1.6	Jan 1980	71	Jul 1990	Jan 1989	10	-.50	18 months
Sep 1978	20	-4.0	Jan 1980	16	Mar 2001	Apr 2000	9	-.60	11 months
Sep 1980	14	-3.1	Jul 1981	10					
Feb 1982	5	-.67	Jul 1990	102					
Jan 1989	10	-.50	Jul 1990	18					
Sep 1998	1	-.17	Mar 2001	30					
Dec 1998	1	-.14	Mar 2001	27					
Apr 2000	9	-.60	Mar 2001	11					

* Monthly data. NBER business cycle peaks prior to 1969 (July 1953, Aug 1957, and April 1960) were not preceded by inversions.
** Measured by 10 year minus 3 month constant maturity yield beginning Sept 1981; minus bond-equivalent 3-month bill yield earlier.
*** Number of months between initial inversion and cycle peak.

Source: Author's calculations using data obtained by BIS *DataBank*.

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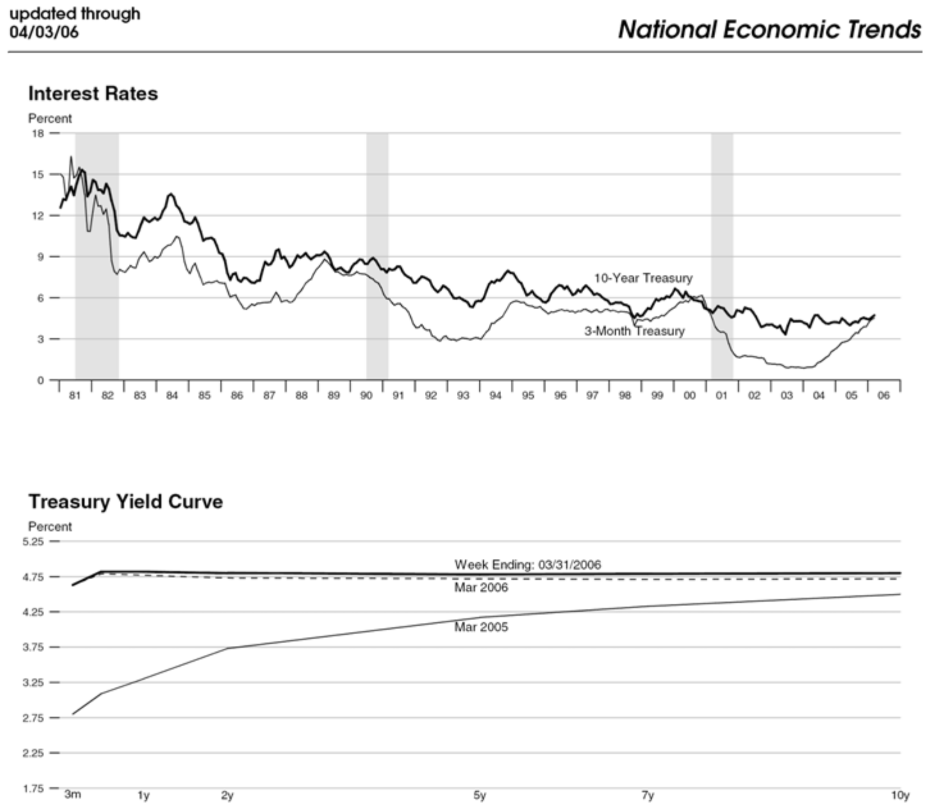
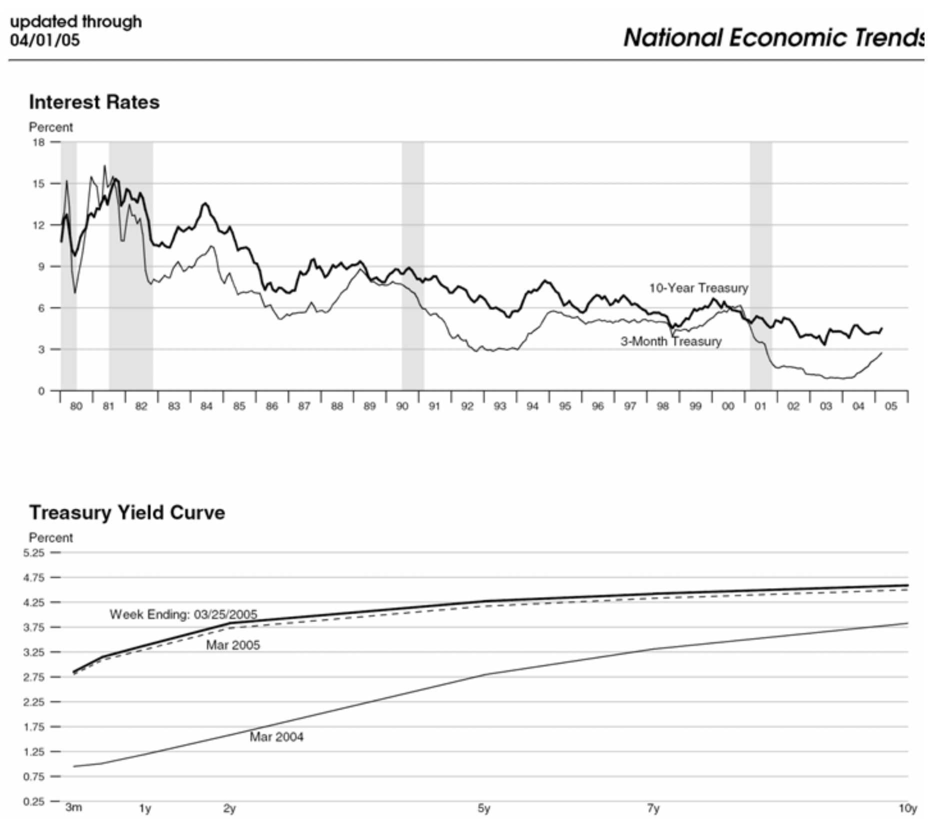
Figure 1

Selected Treasury Yield Curves from *National Economic Trends*, 2003-2006



2006

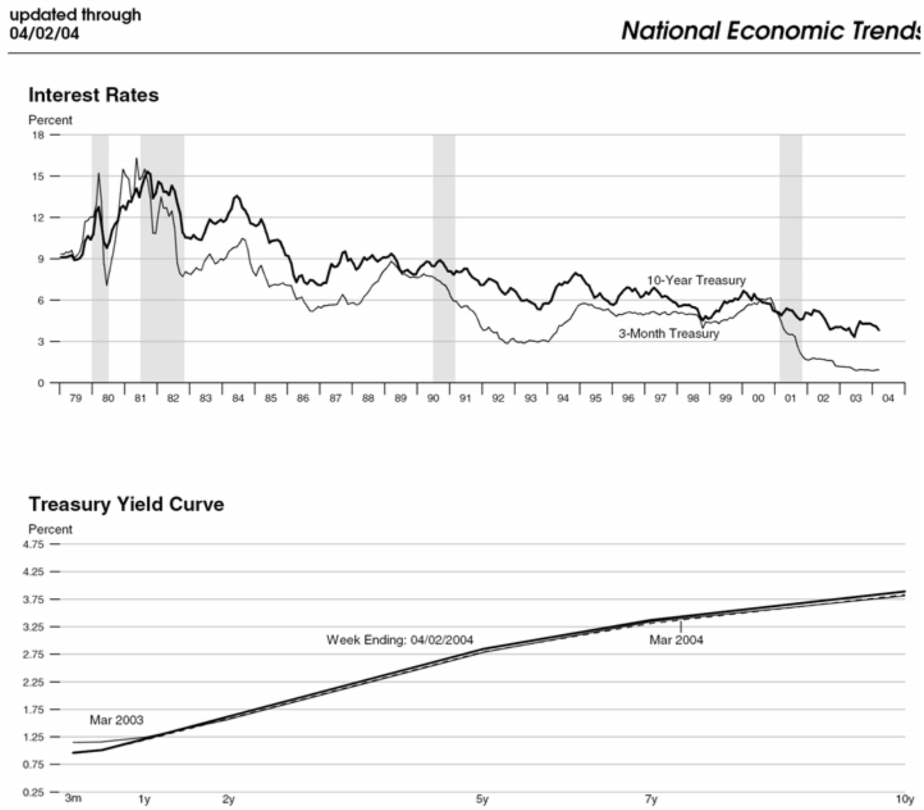
Source: *National Economic Trends*, April 2006



2005

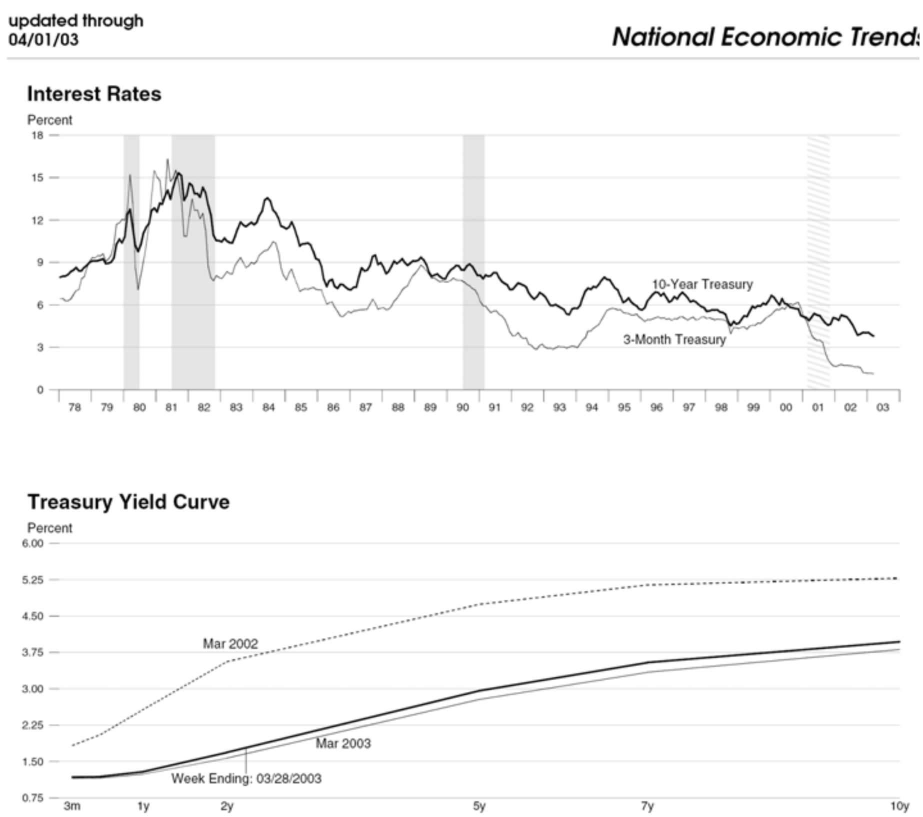
Source: *National Economic Trends,* April 2005

Figure 1
(con't)



2004

Source: *National Economic Trends*, April 2004

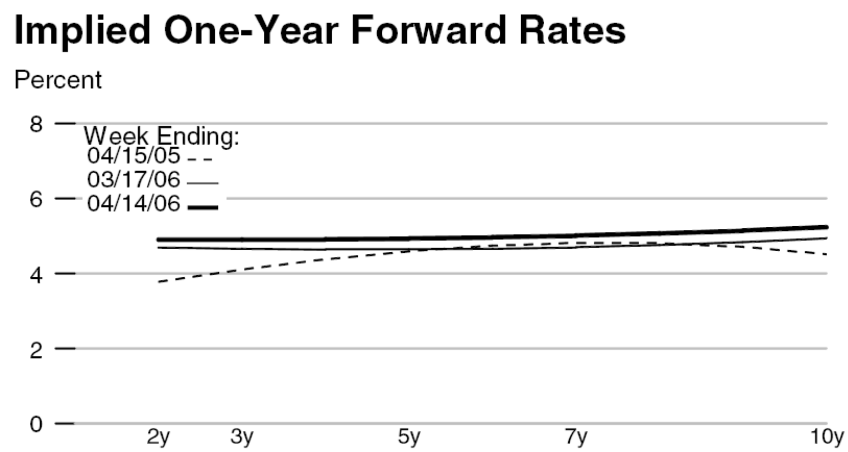


2003

Source: *National Economic Trends*, April 2003

Selected Forward-Rate Curves from *Monetary Trends*, 2003-2006

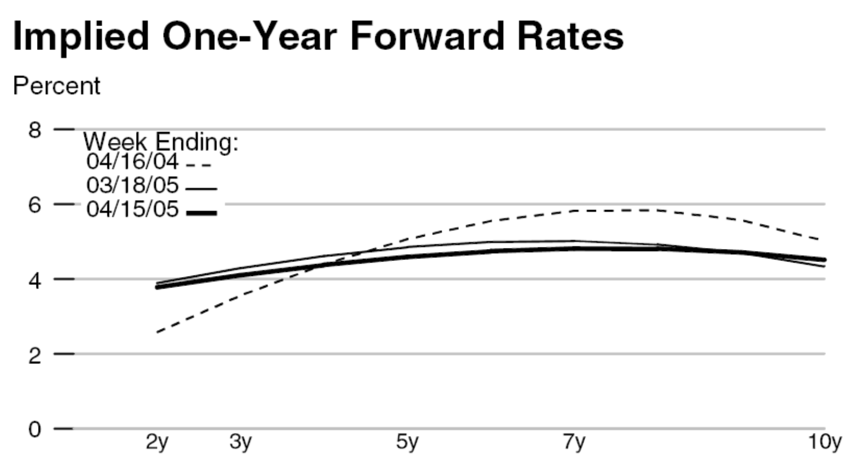
updated through
04/18/06



2006

Source: *Monetary Trends*, April 2006

updated through
04/19/05

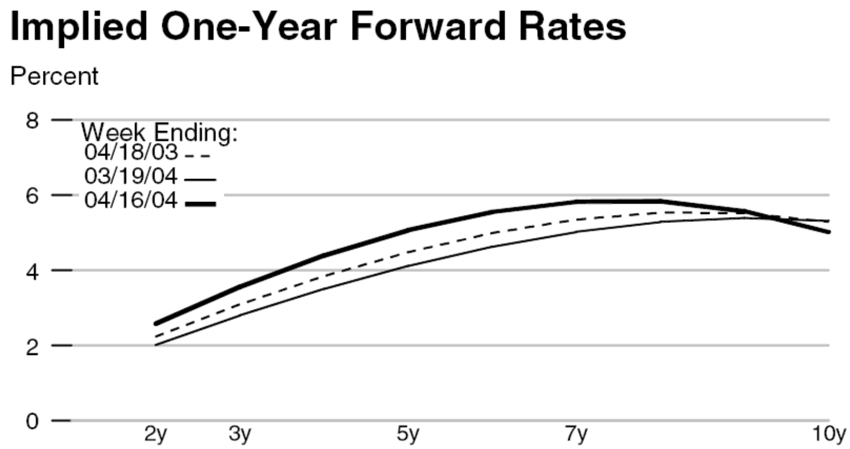


2005

Source: *Monetary Trends*, April 2005

Figure 2
(con't)

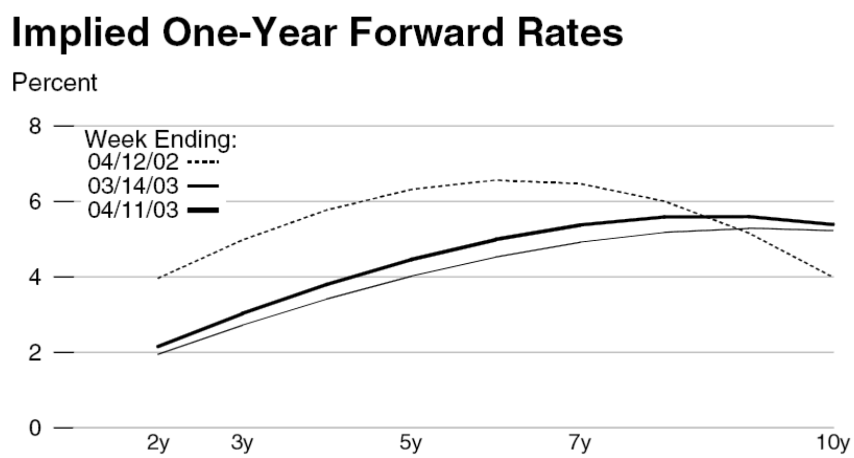
**updated through
04/20/04**



2004

Source: *Monetary Trends*, April 2004

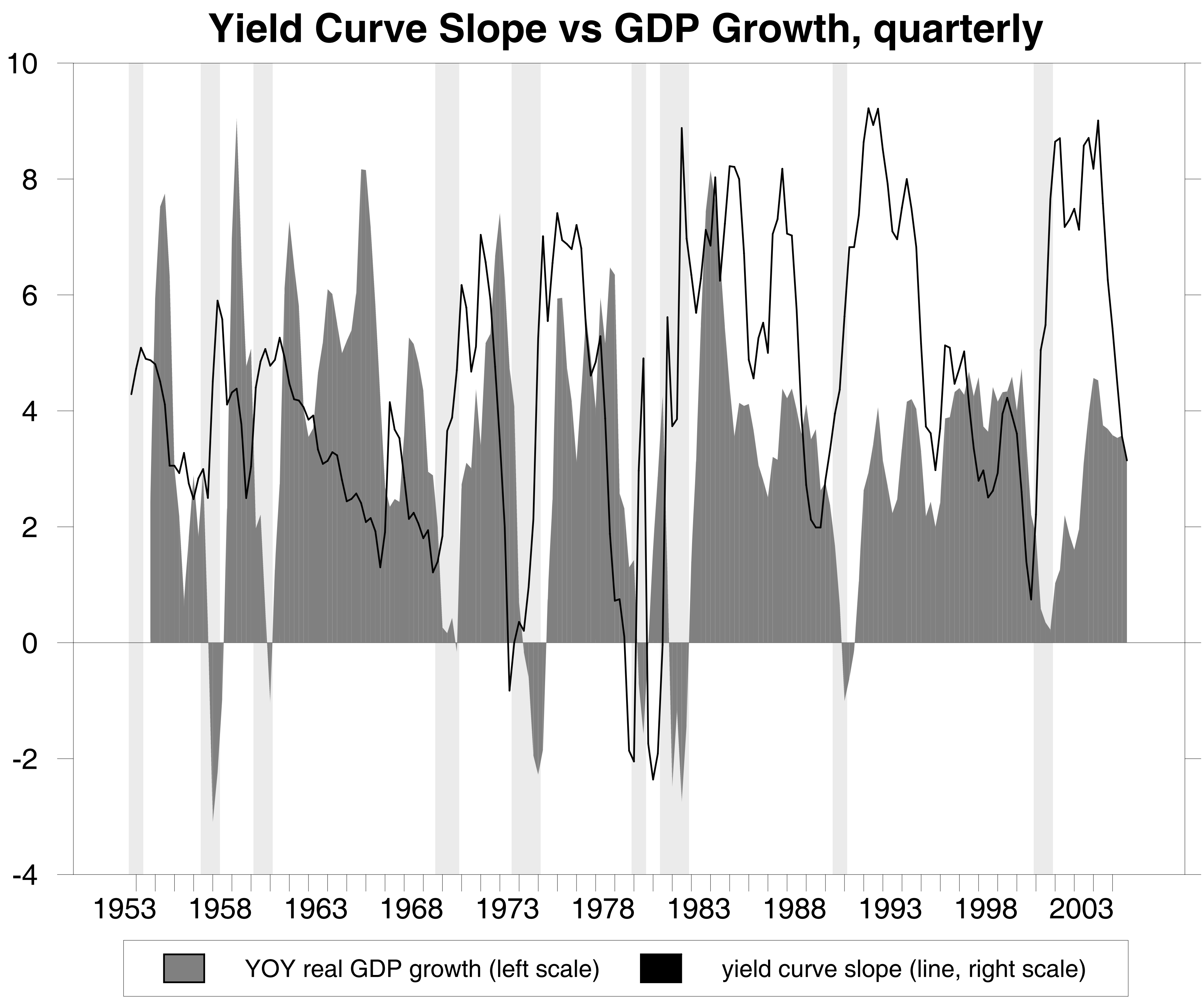
**updated through
04/14/03**



2003

Source: *Monetary Trends*, May 2003

Figure 4


Yield Curve Slope vs GDP Growth, quarterly
10
8
6
4
2
0
-2
-4
4
3
2
1
0
-1
-2
-3
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
YOY real GDP growth (left scale)
yield curve slope (line, right scale)

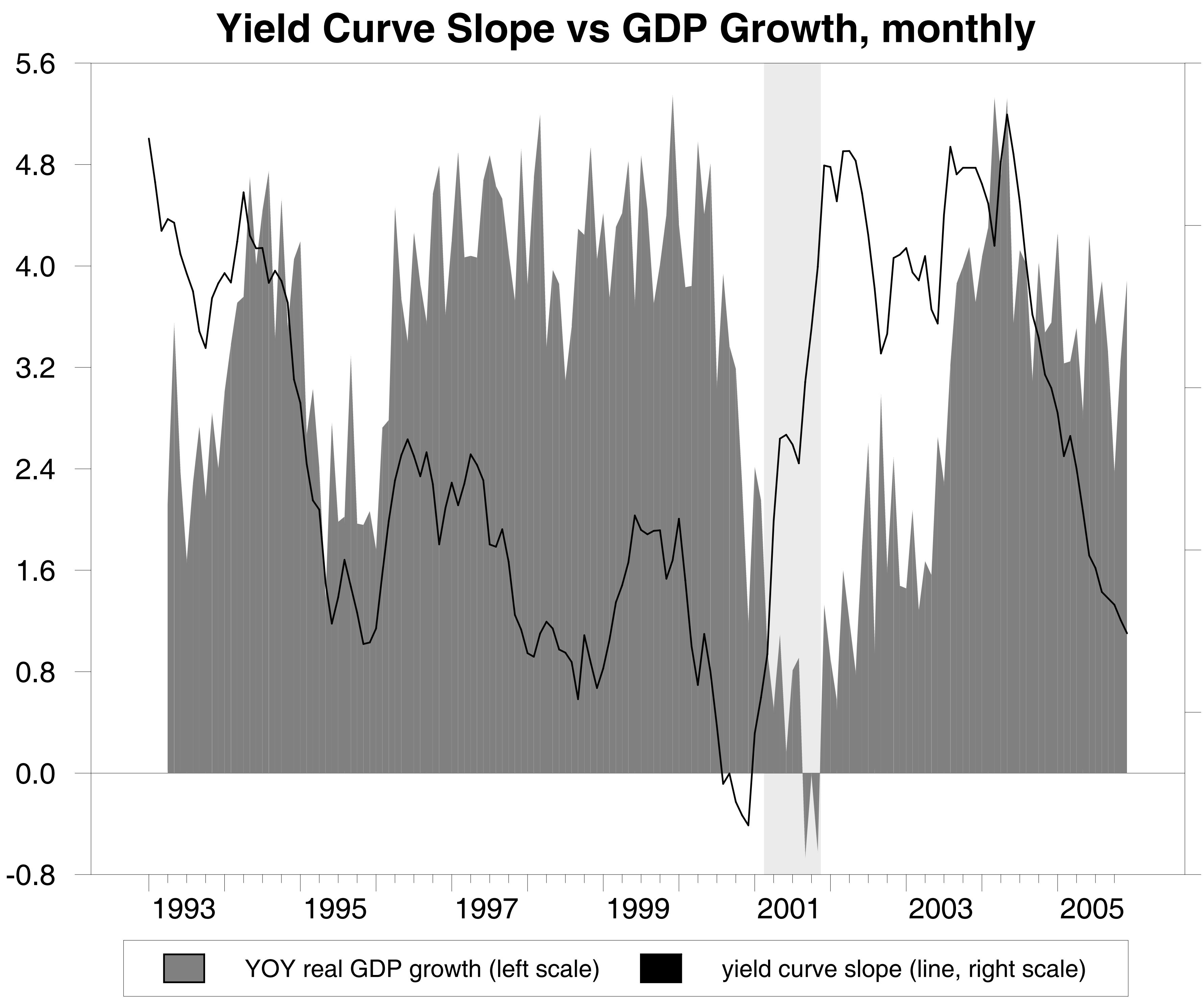

Yield Curve Slope vs GDP Growth, monthly
5.6
4.8
4.0
3.2
2.4
1.6
0.8
0.0
-0.8
4
3
2
1
0
-1
1993
1995
1997
1999
2001
2003
2005
YOY real GDP growth (left scale)
yield curve slope (line, right scale)

Figure 4

Duration and Maximum Yield Spread

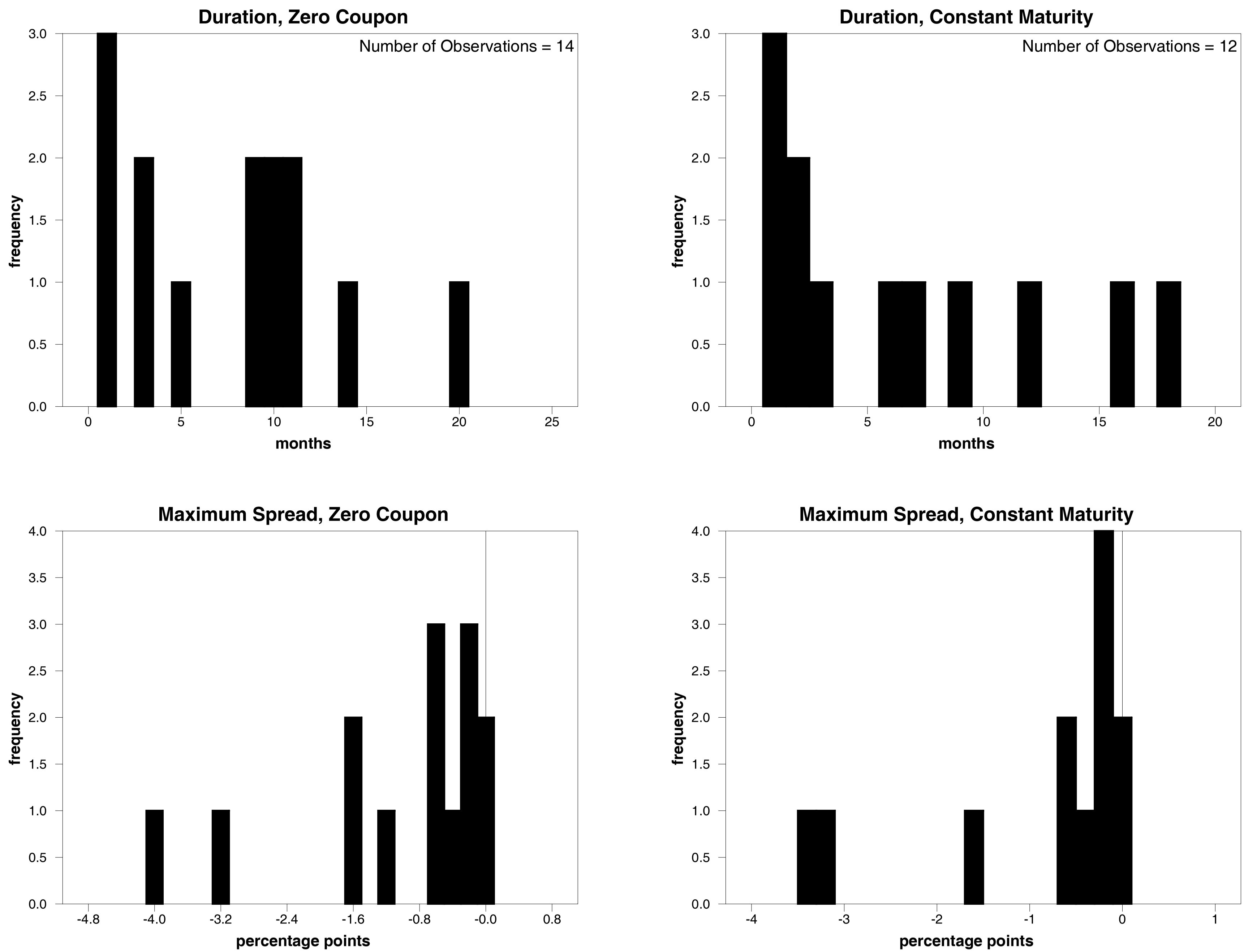


Figure 5