NBER WORKING PAPER SERIES

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Working Paper 10431
http://www.nber.org/papers/w10431

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2004

The views in this paper do not necessarily reflect the views of the Federal Reserve Bank of Cleveland or the Federal Reserve System. We thank James Stock and Mark Watson for kindly letting us use their computer programs and Luca Benati for letting us use his data. We also thank seminar participants at the Federal Reserve Bank of Cleveland Central Banking Institute, the NBER Monetary Economic meetings, the Western Economics Association, and especially James Stock and David Selover. The views expressed herein are those of the author(s) and not necessarily those of the National Bureau of Economic Research.

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NBER Working Paper No. 10431
April 2004
JEL No. E43, E42

ABSTRACT

This paper brings historical evidence to bear on the stylized fact that the yield curve predicts future growth. The spread between corporate bonds and commercial paper reliably predicts future growth over the period 1875-1997. This predictability varies over time, however, particularly across different monetary regimes. In accord with our proposed theory, regimes with low credibility (high persistence of inflation) tend to have better predictability.

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1. Introduction:

By now, the ability of the yield curve to predict recessions has reached the hallowed status of "stylized fact" among macroeconomists. Wesley Mitchell, as early as 1913, noted different patterns in long and short interest rates. Kessel (1965) more explicitly described how the term structure varied with the business cycle, and since then a variety of authors have looked at the ability of the term structure to predict future real activity. In the post -war U.S. economy, the term structure of interest rates has been a good predictor of future real activity. Inversions (short rates higher than long rates) predict recessions (Estrella and Hardouvelis, 1991) and more generally, a steep yield curve predicts fast growth and a flat curve, slow growth(Harvey, 1988,1991, Haubrich and Dombrosky, 1995). Dotsey (1998), Roma and Tourous (1997), Kozicki (1997), Stock and Watson (2001), and Hamilton and Kim (2002), among others, have further explored the predictive content of the yield curve.[1] The late 1990s appeared somewhat anomalous in that a relatively flat yield curve accompanied fast growth; however, an inversion did precede the recession that began in March of 2001.

The evidence that supports this stylized fact comes from the post World War II experience of the United States, though an increasing amount of work has looked at other countries (Harvey 1991, Stock and Watson 2003, Gonzalez, Spencer, and Walz 2000). The predictive content of the yield curve for longer historical periods, however, has been curiously neglected.[2] Whether the yield curve's ability to predict emerges as a general property of the American business cycle or depends sensitively on the structure of the economy, financial markets, and monetary policy seems an obvious question. Particularly since a subtext of the yield curve's predictive ability has been the instability of its relationship with output growth, looking at a long time series seems warranted. A broader historical perspective may also shed some light on the reasons behind the yield curve's ability to predict future output—for example, one simply cannot ascribe twists in the yield curve during the 1880s to an FOMC ratcheting up short-term rates.

[1] The literature is quite extensive, and Stock and Watson provide a useful survey, but some other papers we have found useful include Plosser and Rouwenhorst (1994), Chauvet and Potter (forthcoming), Dueker (1997), Friedman and Kuttner (1998), and Estrella and Mishkin (1998).
[2] Kessel (1965), of course, is a notable exception.

In this paper we attempt to answer this question by looking at the relationship between several measures of the term spread and movements in real economic activity. We focus on the United States for the period from 1875 to the present. We examine this relationship using a consistent long series on both interest rate spreads and real activity at quarterly frequency.

We then proceed to answer a second question which monetary theory suggests may be of importance: is there a systematic relationship between the monetary regime followed and the predictive ability of the spread? Does having a regime based on a credible nominal anchor, such as a gold standard or an inflation target, matter for how well the yield curve predicts future growth?

In section 2 we first analyze the pattern of spread and real GNP growth around reference cycle turning points. We then run predictive regressions to capture any systematic relationship. In section 3 we focus on the relationship between monetary regime and spreads by dividing the historical record into a number of episodes in which the price level and inflation rate follow behavior consistent with one of two regimes: a convertible or credible, low inflation regime and one of high inflation and lower credibility. We corroborate this division by looking at several measures of inflation persistence across those periods. We then ascertain the extent to which the relationship between GNP and the spread can be affected by persistence. Section 4 concludes.

2. Empirical Discussion on Spreads

Perhaps some reluctance in taking an historical perspective on the term structure lies with a concern about the data. Certainly it is not the case that the standard spread between 10-year Treasury bonds and three-month Treasury bills can just be extended back in time: T-bills were not authorized by Congress until 1929, and the three-month maturity became a standard only in 1938 (Cook 1986). Longer term government debt, because of its irregular issuance and its role as a backing for national banknotes, was not always representative of the debt markets (Homer 1977). Measuring real output is perhaps even more difficult: national accounts were not invented until after the First World War, and despite attempts to extend them backwards, the results are not always consistent.

In looking at such a long time period, data availability is the first concern, but consistency runs a close second. Fortunately, however, long-run series designed to be consistent already exist over a fairly extensive period. By updating the Balke and Gordon (1986) numbers we are able to construct quarterly series on output and interest rates from 1875 to 1997.

For real output, we use the quarterly real GNP numbers from Balke and Gordon (1986) for the years 1875-1983. Since the last years of this series are from the NIPA accounts, we continue the series until 1997Q2. For our measure of the term spread, we again go to Balke and Gordon, using the difference between the yield on corporate bonds and the commercial paper rate.[3] The corporate bond series is extended using numbers from Moody's (Balke and Gordon's source) and the six-month commercial paper rate from the Federal Reserve Bulletin, until 1997:Q2, when this series ends.

By building on the Balke and Gordon data we have a series at least designed to be consistent. Two differences with standard post Second World War data series need to be pointed out. First, the aggregate output series we use is gross *national* product, not gross *domestic* product. It includes the production by U.S. capital and labor overseas net of foreign capital and labor producing in the United States. Second, the yields are between two risky securities of imprecisely defined maturity, not between two riskless 10-year and three-month Treasuries. Our hope is that the differences in risk between the two securities do not dominate the term spread that arises from their maturities.

In table 1 we report the sample statistics for the data, and figure 1 plots the spread and GNP growth.

(figure 1 about here)

[3] Appendix B, Table 2.

	Real GNP	*Y/Y quarterly change,%*	*Commercial paper*	*Corporate bonds*	*Spread*	*Inflation persistence*
Dates	1875:Q2-1997:Q2	1876:Q2-1997:Q2	1875:Q2-1997:Q2	1875:Q2-1997:Q2	1875:Q2-1997:Q2	1875:Q2-1997:Q2
N	490	486	490	490	490	490
Mean	676.46	3.4	5.05	6.84	1.79	-18.12
Median	302.20	3.8	5.29	6.29	1.53	-19.20
Range	2644.65	41.0	15.71	14.15	11.90	74.15
S.D.		6.2	2.69	2.53	1.79	8.56

Table 1: *Summary statistics for the data used in predictive regression.*

One approach to the relationship between spreads and economic activity, based on work by Kessel (1965) and Dotsey (1998), is to look at the pattern of interest rates around business cycle peaks and troughs. Figure 2 plots the spread around business cycle peaks, splitting the period into three panels to make any pattern more transparent. Panel A plots cycles with peaks between 1875 and 1914, encompassing the pre-Federal Reserve days, panel B includes peaks between 1914 and 1953, and panel C includes the peaks after 1953. Kessel, who looked at business cycles between 1858 and 1961, finds a procyclical pattern, with short-term rates rising relative to long-term rates in expansions and falling in contractions; as the short rates often peak at the same time as the business cycle, this suggests predictability. Dotsey looks directly at the spread, and when he considers the period after 1953, finds that inversions generally precede the peak (and thus the contraction) by several quarters. We look at more business cycles (18 in all) and use a different spread, so the results differ somewhat. Though the spread is often negative at a business cycle peak, it remains positive in many cases.

For the post-Accord period, Dotsey finds his measure of the spread is negative at the business cycle peak in four of seven cases. Our definition of the spread is negative in three of seven cases (three positive and one at zero). For the period between the founding of the Fed and the Accord, of nine business cycles, our measure of the spread is negative only once. The situation is different pre-Fed, however. Of the nine cycles, the spread is negative at eight of the nine business cycle peaks.

Most of the recent work on the subject takes a more statistical approach, treating the spread as one variable in a regression designed to predict future output. The regressions all take the general form of

(1) $\Delta Y_{t+4} = \alpha + \beta \, Spread_t + \gamma(L)\Delta Y_t$.

Where ΔY_t is the annual growth rate of real GNP (at a quarterly frequency), *Spread* is the spread between long-term and short-term bonds, and $\gamma(L)$ is a lag polynomial, generally of length four (current and three lags).

We take several different approaches to estimating equation (1). The first two methods follow Stock and Watson (2001) and in fact use a slight modification of their computer code. The first method uses in-sample prediction. Equation (1) is estimated on the entire sample, and the parameters from that estimation are used in equation (1) to predict real GNP growth. The predictive content of the term spread is evaluated first by using a Granger causality test, specifically by calculating the heteroskedasticity-consistent F-test that $\beta = 0$. It is also evaluated by examining the ratio of the mean squared error of predictions using the spread and using the lags of ΔY_t alone. When we break the sample into sub-periods, we also test whether we have isolated a stable regime by using a QLR (or sup-Wald) stability test.

The Stock and Watson program reports these statistics for predictions two, four, and eight periods ahead. To avoid excessive data snooping (see Lo and MacKinlay 1990) we focus on the results for four quarters ahead, a traditional time frame for predictions involving the yield curve, although the results for the other prediction intervals are rarely materially different. Table 2 reports these results.[4]

[4] We use a different dating convention than do Stock and Watson. For them, the first quarter of a year is digitized as zero, while we use .25, so their 1925.00 translates into our 1925.25, and their 1925.75 becomes our 1926.00. Also note these dates are for the period run, so it includes the lags used and the extra quarter used to get growth rates. This means that the first period the regression can start in is1876:1, because the data start in 1875:1.

	Dates		Ratio MSE	Granger	QLR	Index1	Index2
	1876:1	1997:2	0.98	0.05	0.00	1910.4	1909:4
	1876:1	1913:4	0.92	0.00	0.00	1906:3	1906:3
	1914:1	1971:2	0.97	0.08	0.06	1946:2	1948:4
	1914:1	1945:2	0.95	0.06	0.00	1940:4	1940:2
	1946:1	1971:2	0.92	0.03	0.02	1965:3	1965:3
	1951:1	1964:4	0.77	0.00	0.00	1953.3	1961:4
	1971:3	1997:2	0.59	0.00	0.00	1991:4	1991:1
	1971:3	1984:4	0.44	0.00	0.00	1973.2	1980.4
	1985:1	1997.2	0.89	0.13	0.00	1994:4	1994:1

Table 2: *In-sample prediction results, using the spread, four quarters ahead, reporting the ratio of the Mean Squared Errors, the Granger causality test , the probability that the coefficient on Rspread is zero, QLR's Pvalue for the constant and spread, and the index of the maximum value of the QLR statistic.*

Notice several things in Table 2. First, the term structure adds predictive power: in every case, for every sub-period, the ratio of the MSE with the spread to the MSE without the spread is less than one, often by a large amount. The spread does particularly well for the two periods after the breakdown of Bretton Woods (1971). This is confirmed by the Granger causality test, which is significant at the 10 percent level in every case but the 1985-1997 period, and in many cases highly significant. Often, however, the QLR statistic is significant, suggesting coefficients are not fully stable over the sub-periods, though the exact form of the statistic picks out different break dates. Note also that despite several suggestions that the spread has become less accurate as a predictor since 1985, we find evidence that it still does well, although this sub-period has the least significant Granger causality statistic. Finally, though not reported in the table, small variations in the timing of the sub-samples do not matter materially for the results.

The next set of tests, termed "simulated out of sample" by Stock and Watson, estimates the regression with data only up to date *t*. Notice that we do not say "available at date *t*" because, strictly speaking, these GNP numbers were created well after the time they purportedly measure. The interest rate numbers would have been available, however. Also notice that the sample size grows over time.

As with the in-sample case, we use the spread and the contemporaneous value of RGNP growth (log difference real GNP) and three of its lags. We continue to concentrate on a forecast horizon of one year (four quarters). Predictive ability is measured by the mean squared error of the forecasts with and without the term spread.

Start	end	Univariate MSE	Spread MSE	Ratio MSE
1875:1	1997:2	0.004003	0.004159	1.038937
1875:1	1913:4	0.003769	0.003437	0.912104
1914:1	1971:2	0.005832	0.006629	1.136623
1914:1	1945:2	0.010547	0.011903	1.128518
1946:1	1971:2	0.000785	0.000879	1.11973
1951:1	1964:4	0.00103	0.000804	0.77958
1971:3	1997:2	0.000553	0.000415	0.75008
1971:3	1984:4	0.001111	0.000591	0.531985
1985:1	1997:2	0.000265	0.000275	1.035944

Table 3: *Out-of-Sample prediction results.*

In the out –of-sample results reported in table 3, the spread does a less impressive a job in improving on the predictive ability of the univariate regression. In only three of the nine sub-periods does the spread improve the MSE of the forecast. Significantly, those are the periods that did best in the in-sample tests of table 3: the sub-period before the Federal Reserve, and the two post-Bretton-Woods periods, particularly the first one.

Judging the ability of the yield spread to predict by looking at the ratio of the mean squared errors brings up a potential problem, however. Our extensive use of the mean squared error as a comparison statistic naturally brings up the distribution of that statistic. When does the difference between two mean squared errors really mean something? When is it due to something more than chance? While test statistics have been developed by West (1996) and Clark and McCracken (2001), the small-sample properties of nested hypotheses are not well understood at this point. For this reason, Stock and Watson do not report tests of forecast equality. While Monte Carlo simulation would not be practical for Stock and Watson given the number of countries and different time series they examine, in our case, the smaller number of series involved makes simulation more practical. Accordingly, we generate simulated distributions of the relative mean squared error under two conditions.

In the first case, we generate 2000 random samples of length 400 for real GNP and the spread. Real GNP is generated from equation (1) with only one lag of RGNP using the sample means and variances for real GNP and the spread, and using coefficients from the estimated version of equation (1). We then regress this artificial RGNP number against its lags and the artificial spread, and again against just its own lags. The ratio of the mean squared errors is computed and stored. Since the model assumes a role for the spread, this exercise provides a notion of "power"—how well the ratio of MSE can pick out a real difference when it is really there. The top panel of figure 3 plots a histogram of this distribution.

In the second case, we set $\beta = 0$ and again generate 2000 samples of length 400, again computing the ratio of MSE with and without the spread. Since this set of artificial data is constructed so that the spread does not matter, this exercise provides a measure of "size," or how often the ratio suggests that the spread matters when in fact it does not. The bottom panel of figure 3 plots the histogram of this distribution.[5]

In comparing the two distributions, notice that less than one percent of the false positives fall below 0.98—suggesting that a ratio of MSE at or below that number is unlikely to result from chance alone. In another case, checking the size for a series of length 150, scaled to match statistics of the 1875-1913 period, it is again the case that few MSE ratios by chance fall below 0.98, suggesting the significance of the MSE ratio for that time period.

Another approach, suggested by Cecchetti (1995), is to look at *rolling* regressions. This is an attempt to get around the problem that the longer out-of-sample regressions based on equation (1) assume constant coefficients. We compare the results for different prediction windows, using a base case of 24 quarters (six years). Table 4 reports the results.

[5] The simulations were run on a Dell Optiplex GX1 using the commands **rndn** (for the RGNP shock) and **rndu** (for the spread) in GAUSS for Windows NT/95 Version 3.2.32.

Window	MSE with spread	MSE, lags GNP	ratio
12	0.0005028	0.0006237	0.806
24	0.0006933	0.0008357	0.830
48	0.0008250	0.0008495	0.971
60	0.0008854	0.0008888	0.996
100	0.0010208	0.001029	0.9913

Table 4; *Mean squared errors for out-of-sample predictions using rolling regressions.*

For each case in table 4, using the spread allows for better prediction of future real GNP growth. The mean squared error is particularly lower for the shorter windows of three and six years.

The MSE using a rolling regression can handle the problem of shifting coefficients, but it does not tell us how those coefficients change over time or regimes. Figures 4 and 5 plot the coefficient of the spread in the regressions and also the *t*-statistic on the spread for the window of 24 quarters. The effect of the spread shifts dramatically over time, reaching both positive and negative values. The shift is particularly abrupt in the years near the end of the Second World War**.** The *t*-statistic generally shows significance, particularly in later years.

Table 5 takes another approach. It shows the mean squared error of the predictions across different regimes. A comparison with table 3 is quite interesting. Overall, the spread appears to better advantage in the rolling regressions. For all but one subperiod, using the spread helps, although with a six-year window, the results for the shorter subperiods should be treated with caution. The pre-Fed period no longer stands out as a good time for the spread. The post-Accord period looks good, as does the post-Bretton Woods period. Once again, however, the years after 1985—the so-called “maestro” years--show the spread is less able to predict.

Start	end	Univariate MSE	Spread MSE	Ratio
1875:1	1997:2	0.000836	0.000693	0.830
1875:1	1913:4	0.000892	0.000843	0.945
1914:1	1971:2	0.001300	0.001039	0.800
1914:1	1945:2	0.001945	0.001659	0.853
1946:1	1971:2	0.000347	0.000323	0.933
1951:1	1964:4	0.000529	0.000461	0.871
1971:3	1997:2	0.000220	0.000170	0.772
1971:3	1984:4	0.000692	0.000536	0.775
1985:1	1997:2	0.000328	0.000333	1.012

Table 5: *Rolling regression* (o*ut-of-sample) prediction results, 24-period (6-year) window.*

One concern already alluded to earlier potentially makes these results less compelling: questions about the data. Chief among these are the interpolation of the GNP numbers, anomalies at the end of World War II, and the quality of the commercial paper yields. Adjusting our work to address these concerns actually highlights the robustness of the yield curve's predictive content.

Using the original annual data (again from Balke and Gordon), the predictive ability of the yield curve increases noticeably, at least as measured by the ratio of the mean squared error. For example, over the entire 1875-1996 period, the ratio of MSE (for rolling regressions with a six year lag) is 0.32 for annual data, compared with 0.80 for quarterly data. The ratio of MSE is uniformly lower using annual data, and except for the 1951-1962 period, much better.

Reapportioning the high growth years at the end of the Second World War between the war and post-war regimes creates a modest difference. Starting the post-war period in 1947 instead of 1946 shifts the ratio of MSE from 0.933 to 0.939, and a 1948 start gives a ratio of 0.924. There is a somewhat larger effect on the war years (a shorter sample), as extending them to the end of 1947 reduces the ratio of MSE from 0.853 to

0.749, and extending them through 1947 yields 0.752. Note in all cases that the yield curve continues to show predictive power.

One may also be concerned about using commercial paper yields as a measure of short-term interest rates, particularly because of the low volumes in this market between the Great Depression and the end of the Second World War. We feel this concern is exaggerated, not only because the commercial rate has been a workhorse for historical interest rate studies (see, for example, Zarnowitz 1992), but also because the strong positive results we obtain strongly argue against excessive noise in the data. As a further check, however, we replaced the commercial paper rate with the call money rate (from MacAulay 1938) for the available years, 1875-1936. The results remained quite similar. The ratio of MSE for rolling regressions falls from .830 (using commercial paper) to .817 for the entire sample period, increases from 0.945 to 0.958 for the pre-Fed period, and falls from 0.800 to 0.795 in the 1914-1971 period. Notice the yield curve continues to help predict output, and that the relative ranking of the predictability across time periods remains the same.

Overall, then, the term spread we use has predictive power for future real GNP growth, and often does better than using just the lags of GNP itself. Although there is good evidence that the yield spread "works" in some sense over the entire sample, there are two periods when it does particularly well. The first is in the pre-Fed gold standard days, 1875-1913, and the second is in post-Bretton Woods period, especially between 1971 and 1984. Note that these results may not match up exactly with the literature, which uses a different yield spread (Treasuries), an option not available to us because we want a consistent series. Previous work has, however, suggested that the predictive ability of the term structure may have broken down in the more recent period (Haubrich and Dombrosky 1996; Stock and Watson 2001).

This then establishes the first part of the hypothesis: The yield curve has significant predictive power for future economic growth, and this relationship seems to have prevailed for the past 125 years. Furthermore, our use of regressions suggests that this predictive power is not only about direction; a steeper yield curve not only signals an expansion, but it also heralds stronger growth.

3. Monetary Regimes and Predictability

The yield curve's ability to predict, robust as it is, does not appear to be constant over time. This leads to the second area we explore in this paper: the extent to which that predictive ability relates to the monetary regime in place. In this section we sketch out the attributes of some key idealized regimes, discuss the salient features of different regimes since 1875, and examine the evidence for the effect of the regime on the yield curve.

A succinct way to define a monetary regime is "as a set of monetary arrangements and institutions accompanied by a set of expectations—expectations by the public with respect to policymakers' actions and expectations by policymakers about the public's reaction" (Bordo and Schwartz 1999, p. 152). It's perhaps most useful to consider some idealized regimes first.

Consider a gold standard regime and a fiat regime with a stable price level. In both regimes, either because of the commitment to gold or the commitment to a stable price level, long-run expectations of inflation are zero: The price level in 20 years is expected to be the same as it is today. Two sorts of shocks might hit these economies: real or inflationary.

Inflation, when it occurs, will be temporary. Under a gold standard regime, a big gold discovery might flood the country with gold, increasing its money supply and thus prices, until the specie-flow mechanism distributed the gold to the rest of the world. (In the longer run, the shift in the relative price of gold will shift the gold to non-monetary uses and eventually reduce even the world's monetary gold stock. See Barro (1979) Because the inflation is known to be temporary, it will have different impacts on short-term and long-term interest rates.[6]

Short term rates will rise. They will rise because inflation expectations rise above zero, as the inflation, though temporary, persists for a few periods (e.g., at least several quarters). One caveat is important here. The initial reaction of short-term rates may well be negative, as the liquidity effect drives rates down (for example, if the central bank lowers its policy rate). The liquidity effect will die out, however, leaving the expected

[6] This abstracts from wars and other shocks which lead to suspension of convertibility.

inflation effect to dominate. Under a credible fiat regime, an inflation shock may occur for any number or reasons, such as a response to unemployment or an imperfect forecast of money demand.

A temporary bout of inflation will have no effect on long-term rates; without a real effect, it will not shift real rates, and being temporary, it will have minimal impact on inflation expectations for the long haul. The absence of a long-term effect holds true in either regime. Implicitly this result relies on treating the nominal term structure as determined by the simple expectations hypothesis plus the Fisher equation.

Putting these together for the term structure, under a gold standard or a credible fiat regime, an inflationary shock will leave long rates alone but increase short rates, flattening the yield curve, potentially leading to an inversion. Thus, while the liquidity effect might lead to a steeper yield curve on occasion, an inflationary shock will eventually lead to a flatter curve.

A real shock also has a differential impact on short and long rates. If the real shock is temporary, say a harvest failure, railroad strike, or oil crisis, short rates will rise, as people attempt to smooth consumption by borrowing from the future. Because the shock is temporary, short rates will soon return to normal. As a consequence, the impact on long-term rates will be small, again as implied by the expectations hypothesis. The net result is that a real shock will flatten the yield curve, potentially leading to inversion.

The two idealized regimes thus share another feature. Both real and inflationary shocks tend to move the term structure in the same way; increasing short rates while leaving long rates unchanged. Looking just at the term structure, then, it would be difficult to predict future real activity, as an inversion could be caused by either real or inflationary shocks. The yield curve would be a rather noisy signal.

Now consider a third idealized regime, a fiat money standard without credibility, where inflation is a random walk (that is, very persistent). Far from expecting price level increases to be reversed, the public expects the higher inflation rate to continue forever (see Evans and Wachtel 1993). Again consider what happens to the term structure under both a real and an inflationary shock.

An inflation shock will increase short rates, just as before. Long rates will also increase, as expectations of inflation are permanently higher, and so expectations of all future short rates are moved up by this amount. An inflation shock thus has minimal effect on the term structure, as both long and short rates move up by the amount of the permanently higher inflation rate. In other words, the inflation shock is neutral with respect to the slope of the term structure. This result rests on two additional assumptions that need to be made clear. First, inflation is not expected to be so high and variable as to destroy the long-term bond market; inflation remains somewhat moderate. Secondly, an inflation shock does not itself signal a shift in the process for inflation that materially changes either the variance or the persistence of inflation. For example, the shock will not be neutral with respect to the slope if it indicates a shift to increasing inflation.

A real shock, by contrast, will increase short rates (think of the central bank contracting the money supply), but, as it is temporary, long rates will not increase. In this case, the term structure gets flatter, tending to inversion. Consequently, in a regime with persistent inflation, yield curve inversions signal downturns. Since inflationary shocks do not create inversions, they do not add noise.

Put another way, albeit still somewhat informally, using the Fisher equation, which explains nominal rates as the sum of real rates and expected inflation, we find that for periods $i = 1,2$ we have

(2) $R_i = r_i + \pi_i^e$

where R_i is the nominal interest rate in period i, r_i is the real rate, and π_i^e is the expected inflation rate in period i. The simple expectations theory of the term structure then implies that the long rate is

(3) $R_L = (R_1 + R_2)/2$.

Substituting (2) into (3) implies that the long-short spread, R_L-R_1 is just

(4) $R_L - R_1 = \dfrac{r_2 - r_1}{2} + \dfrac{\pi_2^e - \pi_1^e}{2}$.

Now a more sophisticated asset-pricing approach would lead to

$$(5)\ \ R_L - R_1 = \frac{\mathrm{E}[\frac{u'(c_{t+1})}{u'(c_t)}]}{\sqrt{\mathrm{E}[\frac{u'(c_{t+2})}{u'(c_t)}]}} \bullet \frac{\mathrm{E}(\frac{1}{\Pi_{t+1}})}{\sqrt{\mathrm{E}[\frac{1}{\Pi_{t+1}} \cdot \frac{1}{\Pi_{t+2}}]}} ,$$

where $u'(c_s)$ is the marginal utility in period *s,* E is the expectations operator, and Π_{t+s} is the gross inflation rate from *t* to *t+s.*

In either case, however, the effect of regime credibility on the yield curve is substantially the same. Thus, in a very credible regime of price level targeting, high inflation today means that expected inflation should be negative, as prices must drop to keep the price level at its target. After the target is reached, no more inflation is expected; a natural way to interpret this result is that high π_0 implies $\pi_1^e < 0,\ \pi_2^e = 0$. High inflation today would steepen the yield curve by dropping short rates.

In a credible regime with a zero inflation target, rather than a price level target, the price increase is not taken back, so inflation is always expected to be zero. Thus, whatever inflation is today, $\pi_1^e = \pi_2^e = 0$, and today's inflation has no impact on the yield curve. We suspect, however, that few regimes have such a strong response to inflation at the time horizon of short maturities, e.g., three months. Consequently, it makes more sense to assume some additional short-term persistence in inflation, so that high inflation today implies high inflation in the near term, but no expected inflation in the long term. This results in $\pi_1^e > 0$ and $\pi_2^e = 0$, implying that inflation today flattens the yield curve.

For a non-credible regime, where inflation is a random walk, today's inflation rate is the best guess of future inflation rates, so $\pi_1^e = \pi_2^e = \pi_0$. Inflation shifts the yield curve up in a parallel fashion, keeping the spread unchanged.

3.1. Historical Regimes

As the reader might have guessed, the regimes discussed so far, though idealized, are not purely hypothetical. The gold standard regime corresponds to the United States from 1879 to 1897, a time of generally declining prices. The random-walk inflation regime corresponds to the United States in 1963-1990, a time of generally high and persistent inflation. The 1920s are an example of a somewhat impure gold standard regime, with the Federal Reserve operating. The 1950s (post-Accord), a time of low inflation, are perhaps the closest example to a fiat regime with a stable price level, a regime perhaps once again entered in the late 1990s.

The analysis of section 2 provides some broad predictions about how well the yield curve should predict real activity in each of these periods. It ought to do well in the post-war period, but relatively poorly in the 1800s, 1920s, and 1950s.

One possible problem in comparing regimes lies with the advent of the Federal Reserve in 1914. Federal Reserve smoothing of short-term interest rates at a seasonal frequency (Mankiw, Miron, and Weil 1987), means that some real and inflationary shocks will not show up directly in short-term rates. This will most directly affect comparisons between the 1800s and later periods, because the 1920s, 1950s and 1960-1970s all fall into the post-Fed period. To the extent that the Fed was offsetting shocks, however, the smoothing may change the frequency of shocks observed, but some whould still be observable. Inflationary shocks caused by the financing of crop movements may disappear after 1914, but shocks from gold discoveries would still remain. What the difference would mean, economically and econometrically, remains an open question.

Looking at specific periods also holds the promise of being able to disentangle real and inflationary shocks—looking at specific episodes of oil shocks, harvest failures, gold discoveries, and the like. While this paper does not pursue it, such an approach might allow further confirmation or rejection of the story in Section 2, if inflationary noise or real shocks can be identified and correlated with the term structure.

Table 6 provides the dates of the different regimes and data on inflation, real GNP growth, term spread and inflation persistence.

Regime	Dates	Inflation	RGNP growth	Spread	Inflation persistence
TOTAL	1875:1-1997:2	2.27%	3.44%	1.79%	-18.12
Commodity	**1875:1-1913:4**	**-0.07**	**4.04**	**0.35**	**-20.82**
Transition	**1914:1-1971:2**	**2.76**	**3.21**	**2.26**	**-17.95**
New Fed	1914:1-1920:4	11.23	0.047	1.65	-19.85
Roaring 20s	1921:1-1929:2	-1.31	6.48	1.81	-19.12
Depression	1929:3-1941:4	-0.45	2.28	4.68	-18.28
World Wars	1914:1-1945:2	2.11	3.51	2.98	-18.79
Bretton Woods	**1946:1-1971:2**	**3.33**	**3.71**	**1.36**	**-16.94**
Post-Accord	1951:1-1964:4	1.72	3.60	1.35	-19.59
Vietnam	1965:1-1971:2	4.79	4.48	1.23	-18.06
Fiat	**1971:3-1997:2**	**5.82**	**3.94**	**2.53**	**-15.26**
Great inflation	1971:3-1984:4	8.77	4.82	1.95	-13.24
Maestro	1985:1-1997:2	2.75	3.01	3.44	-18.46

Table 6: *Dates, inflation, real growth, spread, and inflation persistence for difference regimes. RGNP growth and spread are from our updates of Gordon and Balke. Inflation is from Benati, his update of Gordon and Balke. Inflation persistence is calculated by Benati, one-sided log spectral density at zero. Persistence data begins in 1876:Q2.*

The Gold Standard 1879-1914

The United States was on a specie standard from 1879 to 1914. It was *de jure* bimetallic but *de facto* gold. After the Civil War, the U.S. was still on the greenback paper money standard (greenbacks were inconvertible paper dollars issued to help finance the war), but by 1879 convertibility had been reestablished. The standard that was restored, however, was gold because silver, the undervalued currency under the bimetallic standard established by the Constitution in 1789, had been driven out of the U.S. by the mid-1850s and the Coinage Act of 1873 (“the Crime of ‘73”) had demonetized the standard silver coin. The U.S., like other countries on the gold standard, followed the key rule of maintaining a fixed price of domestic currency in terms of gold (Bordo and Kydland 1995). The U.S. Treasury acted as the monetary authority, freely buying and selling gold on demand, since the country did not have a formal central bank. By fixing the price of gold in terms of dollars, gold served as the nominal anchor for the price level.

Under the gold standard price level movements would tend to be mean reverting; price level movements would eventually be reversed. This property derived from the fact that gold was a form of commodity money, and under a commodity money standard, market forces in the long run determined the price level. According to the classical theory of the gold standard (Barro 1979; Bordo 1984), while the monetary authority sets the nominal price of gold, the real price is determined by the demand and supply of monetary gold. Shocks to the demand or supply of gold would affect the relative price of gold and hence given the nominal price, the price level. These shocks are offset by two sets of forces: changes in production arising in response to the real price shock, and substitution between monetary and non-monetary uses of gold. The operation of these forces causes the price level to revert to some long-run mean level. Indeed, the pattern of wholesale prices in the U.S., as well as the U.K. displays a wavelike motion reflecting alternate phases of rising and declining price levels in accord with this theory (Bordo 1981).

The automatic price stabilizing property of the gold standard determined the price level for the entire gold standard world; it could be treated as a closed system. The gold standard also had an automatic international adjustment mechanism, called the price specie flow mechanism, which harmonized price levels across countries. The mechanism, in theory, allowed gold flows and international capital flows to finance current account imbalances without involving monetary authorities directly. In practice, however, central banks often violated the "rules of the game," which prescribed that monetary policy should only speed up the automatic adjustment mechanism, by engaging in sterilization policies as well as limited countercyclical demand management (Bordo and MacDonald 1997).

The 1879-1914 period is neatly split into two episodes of declining and then rising prices of approximately 16 years. The first, from 1879 to 1897, exhibited fairly mild deflation of 1.2 percent (annual rate GNP deflator figures, Q4 over Q4 price level change). This deflation was a worldwide phenomenon which resulted from excess demand for monetary gold that had arisen from two sources. First, a number of important countries left bimetallic and silver standards and joined the gold standard. Second, real incomes worldwide had grown. The episode was punctuated by several recessions of increasing severity.

The subsequent episode, 1897-1914, was one of mild inflation with price levels rising by 0.9 percent on average and rapid growth of 3.5 percent. It was punctuated by several recessions, the most notable in 1907-08. The inflation reflected the consequences of massive gold discoveries in South Africa and Alaska which doubled the world's monetary gold stock. Many argue that these discoveries were no accident, that the rising real price of gold in the previous two decades had stimulated an intensive search for new sources of gold and new technologies to improve the output of existing mines.

<u>The Interwar Period, 1919-1941</u>

World War I was a period of high inflation in the U.S. (25 percent per year from 1914 to 1919) but the U.S. did not leave the gold standard (except for an embargo on gold exports in 1917-1919) as did the other countries fighting the war. The inflation reflected massive gold imports from the European belligerents buying war materiel as well as inflationary finance once the United States entered the war. The war was followed by a further bout of commodity inflation, which ended with a severe deflation and depression from 1919 to 1921. This episode is attributed to tight central bank policies around the world as policymakers attempted to restore the prewar gold standard.

The 1920s were a decade of near price stability (prices declined by less than 1 percent per annum), accompanied by very rapid growth with two mild cycles. The U.S. in this period still adhered to the gold standard but its automatic international adjustment mechanism was greatly tempered by Federal Reserve countercyclical policies and gold sterilization. The decade ended with the stock market crash of 1929 and the Great

Contraction of 1929-1933. The consensus view attributes its severity to the Federal Reserve's failure to offset the monetary collapse triggered by several waves of banking panics (Friedman and Schwartz 1963). It also was transmitted abroad by many countries continued adherence to the gold standard.

The contraction ended in the spring of 1933 following the banking holiday in March, a cutting of the link with the gold standard in April and a reflationary Treasury gold and silver purchase program. The U.S. went back to the gold standard at a devalued parity in 1935 but the gold standard after this point was even more managed than in the 1920s.

Post-World War II: Bretton Woods

World War II, like World War I, was a period of high inflation, although a smaller fraction of war expenditure was money financed. After the war, the U.S. and many other countries joined a new international monetary system, the Bretton Woods system. It involved a much less direct link to gold as a nominal anchor than had existed during either the interwar or prewar gold standards. Under Bretton Woods, the U.S. served as the center country, pegging the dollar at the 1934 parity of $35.00, with the Treasury committed to buying and selling gold freely. Other countries would peg their currencies to gold and then intervene to maintain the peg. The system was an adjustable peg. Members could alter their parities in the face of a fundamental disequilbrium which systematically over- or undervalued their real exchange rates (Bordo 1993).[7]

The Bretton Woods system, once current account convertibility was restored by 1959, operated fairly successfully in fostering world trade for less than a decade. It also was associated with relatively low inflation from the early 1950s to the mid 1960s in the U.S. as well as other countries. It is highly possible that the golden nominal anchor served to restrain US policy-makers, in part echoing the earlier gold-based regimes.

[7] Other aspects of the Bretton Woods system included current account convertibility with capital controls encouraged, the use of domestic monetary and fiscal policies to offset domestic aggregate demand shocks independent of the balance of payments, and the use of IMF credits to finance short term balance of payments disequilibria.

But the Bretton Woods regime was short lived. It began collapsing in 1968 as a result of underlying flaws in its design (Bordo 1993, Garber 1993), inappropriate policies followed by its members, evasion of capital controls, and, above all, the abandonment by the center country of its responsibility to maintain price stability. The United States began following expansionary monetary and fiscal policies to finance social programs and the Vietnam War. The link with gold was severed in 1971 when President Nixon closed the gold window. Thus the golden anchor, which had been stretched since 1914, was finally abandoned in 1971 (Redish 1996).

The Fiat Money Regime

The breakdown of Bretton Woods was followed by more than a decade of high inflation. The advanced countries shifted to a regime of managed floating and fiat money. Inflation and rapid money growth in the 1970s reflected attempts to play the Phillips curve tradeoff, the accommodation of oil price shocks, and the use of inappropriate policy models and indicators (Bordo and Schwartz 1997; Calomiris and Wheelock 1998). Evidence of a regime shift after Bretton Woods is observed in increasing inflation persistence and other attributes of the time series properties of inflation (see table 8 below and Bordo and Schwartz 1997).

In reaction to the distortions associated with high inflation, major policy reversals occurred in the U.S. and other countries in 1979. In the U.S., the Volcker shock of 1979 involved a shift in Federal Reserve operating procedures away from a focus on interest rates and towards aggregates. The shift led to a massive monetary contraction, a spike in interest rates of all maturities, and a severe recession from 1979 to 1982. The policy reversal succeeded after a few years in reducing the core rate of inflation to under 5 percent. Since then, the continued pursuit of low inflation in the U.S. and other advanced countries, the announcement of explicit inflation targets in the UK, Canada and Sweden, (although not the U.S.), and the adoption of independent central banks by many countries, all point in the direction of another regime change. This latest regime change, back towards a commitment to low inflation, in many ways echoes the convertibility principle of the old gold standard.

3.2 Inflation Persistence

The above discussion suggests a way to measure the performance and credibility of regimes. Since under the gold standard inflation was temporary, and quickly brought under control by the price-specie flow mechanism, while the post-Bretton Woods era saw inflation stay high for extended periods, the persistence of inflation appears as a key factor in regimes. Are high levels of inflation followed by more high levels, or does the rate quickly revert to lower levels? In credible regimes, such as the gold standard, inflation shows little persistence. Less credible regimes, such as the post-Bretton Woods years show more persistence. Persistence can provide a quantitative way to distinguish policy regimes and assess how the predictive content of the yield differs across them.

However, the level of persistence and how it has changed over time and over regimes, has been the subject of much dispute. Cogley and Sargent (2001), applying Bayesian techniques to a vector autoregression with random coefficient find that persistence changes over time, with low persistence before the 1960s, high persistence in the 1970s and early 1980s, and reduced persistence in recent years. This is consistent with their finding that high persistence correlates positively with the level of inflation.

Stock (2001) has disagreed with these results, arguing that inflation persistence has been effectively constant over the post-war period, showing no correlation between levels and persistence. Stock uses a different estimation approach, looking at the largest root of an autoregressive representation of inflation. He further aruges that the Cogley and Sargent techniques confuse changes in persistence and changes in variance. Their measure of persistence is related to the height of the spectrum at zero frequency. Consequently, a process with a low spectrum overall (low variance) may look less persistent than a process with a high spectrum.

Benati (forthcoming) directly addresses Stock's concerns: Using a random coefficients autoregressive process for inflation, Benati adjusts for the variance of inflation and thus is able to disentangle persistence and variance. Of equal value to us, he uses inflation from the Balke-Gordon source, giving us a measure of persistence that accords nicely with our other data. Cogley and Sargent (2003) also account for variance, by using the normalized spectrum, and like Benati find that persistence does change over time.

Benati reports four measures of persistence: one- and two-sided estimates of the log spectral density at zero, and one- and two-sided sums of autorgressive coefficients. While Benati appears to somewhat prefer the two-sided spectral measure, we prefer the one-sided, as it does not bring in future information that may contaminate predictions. Empirically, however, it makes little difference.

3.3 Effect of Persistence on Predictability

As discussed above, our examination of regimes leads us to predict that the yield curve will predict better in less credible regimes. There, nominal shocks increase both short and long interest rates, leaving the spread between them relatively unaffected. In the more credible regimes, nominal shocks move short rates but not long rates, adding noise to the signal coming from the real yield spread. Thus a key factor in the predictive content of the yield curve should be the persistence of inflation.

First, though, it makes sense to take a closer look at the relationship between persistence and the yield spread itself. The high serial correlation (at a quarterly frequency) in both the spread and persistence measures makes a simple correlation unreliable. To correct for this we run regressions of the spread against all four of Benati's measures of persistence, using Newey-West standard errors to correct for heteroskedasticity and autocorrelation. Table 7 reports these results.

Variable	*Constant*	*Spec 1*	*Spec2*	*Sumau1*	*Sumau2*	*Sqec*
Coefficient	-1.35	0.29				
	(-1.07)	(2.37)				
	14.75		0.69			
	(5.73)		(5.21)			
	0.52			2.83		
	(3.58)			(7.03)		
	-0.53				4.06	
	(-2.12)				(7.27)	

Table 7: *Regression of spread against Benati persistence measures, t-stats in parenthesis based on Newey-West corrected standard errors with four lags.*

An increase in persistence goes along with a steeper yield curve, on average. For positive inflation rates (which predominate in the sample) this accords with the theory of section 3; with little persistence, a high inflation shock increases the nominal interest rate today but leaves long rates unchanged, leading to an inversion. With higher persistence, both long and short nominal rates increase.

A first approach to understanding the effect of inflation persistence on the predictive ability of the yield curve is to make a comparison across regimes. Using the ratios of MSE in table 5 and the inflation persistence estimates in table 6, we compute a simple correlation between a regime's inflation persistence and the term structure's predictive ability. This yields a correlation of –0.60, which has a *t*-value of 1.97, for a probability of 0.089. A Spearman rank correlation yields –0.68, with a *t* of 2.48 and probability value of 0.04, though the *t* is not a good approximation for the 7 degrees of freedom in our sample. There are similar (somewhat stronger) results if we use the predictive content measures of table 3 (out of sample, not rolling). This seems mainly, but not exclusively, driven by the post-Bretton Woods and great inflation regimes, which have both very persistent inflation and very good predictive content. Thus, there is at least marginal evidence that more persistent inflation (higher values of the measure) correlate with better predictive ability (lower MSE ratio).

Start	End	Persistence	MSE ratio, rolling	MSE Ratio, out of sample	MSE ratio, in-sample
1875:1	1997:2	-18.12	0.830	1.038937	0.98
1875:1	1913:4	-20.82	0.945	0.912104	0.92
1914:1	1971:2	-17.95	0.800	1.136623	0.97
1914:1	1945:2	-18.79	0.853	1.128518	0.95
1946:1	1971:2	-19.59	0.933	1.11973	0.92
1951:1	1964:4	-16.94	0.871	0.77958	0.77
1971:3	1997:2	-15.26	0.772	0.75008	0.59
1971:3	1984:4	-13.24	0.775	0.531985	0.44
1985:1	1997:2	-18.46	1.012	1.035944	0.89
Correlation with persistence			-0.59755 (1.97)	-0.55251 (1.75)	-0.77627 (3.26)

Table 8: *Correlation of predictive ratios with persistence. t values in parenthesis.*

This correlation is robust to the concerns voiced in section 2 about the uniformity of the data series (annual versus quarterly data, anomalies the end of the World War II, and commercial paper versus call money yields). Thus, using annual data, the correlation of the predictive ratio with persistence for the rolling regressions remains negative, at –0.44, though the *t*-statistic is lower, at 1.3. Shifting the endpoint of World War II actually improves the results, as those years also show very high inflation persistence, and so the correlation both gets more negative (to –0.66) and the *t*-statistic increases (to 2.38). Using call money rates, the correlation comes in at –0.62, with a *t*-statistic of 2.65. The general relationship thus appears to hold even in these alternative empirical specifications.

A somewhat different approach to uncovering the effect of persistence on predictability would be to correlate the two at a quarterly frequency. At least initially, this gives a more continuous variable than shifts in regime, and does not require assuming particular dates for regime changes. The difficulty is that there is no natural measure for predictability quarter-by-quarter. Figure 6 shows one attempt, plotting the difference in the absolute value of the prediction errors between a regression that uses only lagged values of RGDP and one that uses the yield spread, against persistence. The relation is quite noisy, and though it consistently shows a negative relationship between persistence and predictability, the coefficient is never statistically significant.

4. Conclusions: Lessons from History for Policy.

This paper has shown that the stylized fact that the yield curve predicts future growth holds for the past 125 years, and robustly across several specifications. The monetary regime seems important, and in accord with our theory, regimes with low credibility (high persistence) tend to have better predictability.

This finding provides important reinforcement for the notion that the monetary regime is critical in interpreting the yield curve, and that the term structure of interest rates is heavily conditioned on the monetary regime. In particular, it may be quite misleading to draw general conclusions from data generated in one inflation regime.

For policymakers, our results suggest that credibility is not always an unmixed blessing. While a more credible regime will usually mean monetary policy is less a source of instability for the economy, that very credibility may make policymaking more difficult, as information sources such as the yield curve become less informative.

It is also possible to turn the results around. Notions such as credibility are often hard to pin down and measure, and our results suggest an additional metric: the predictive content of the yield. This can provide an additional piece of evidence about the credibility of the regime in question.

The ability of the yield curve to predict the future course of the economy is by now well known. An historical perspective not only confirms the robustness of that result, but also sheds insight into the real and financial effects of differing monetary regimes.

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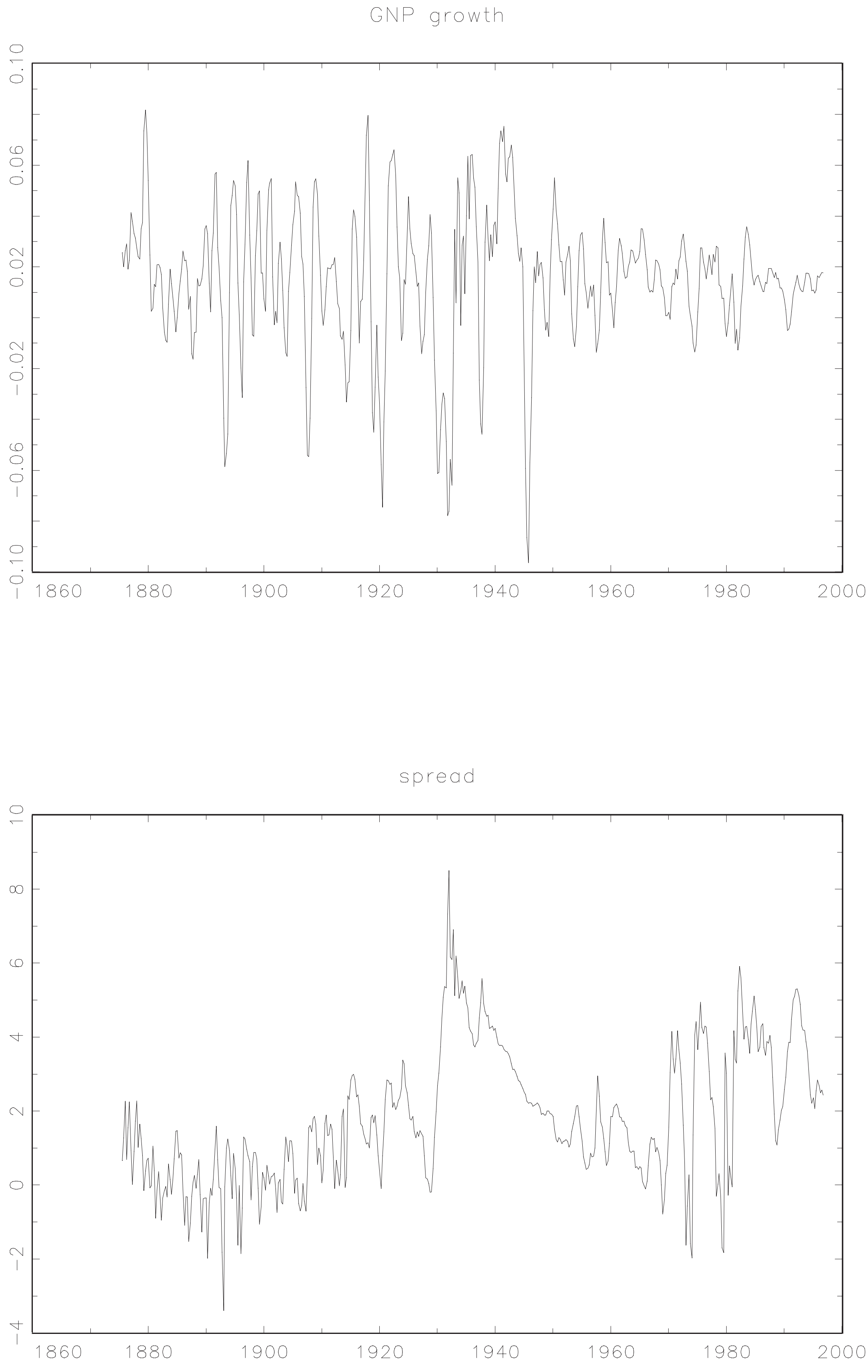


Figure 1. *The time series of spreads (yield on corporate bonds minus commercial paper rate) and growth rate of real gross national product.*

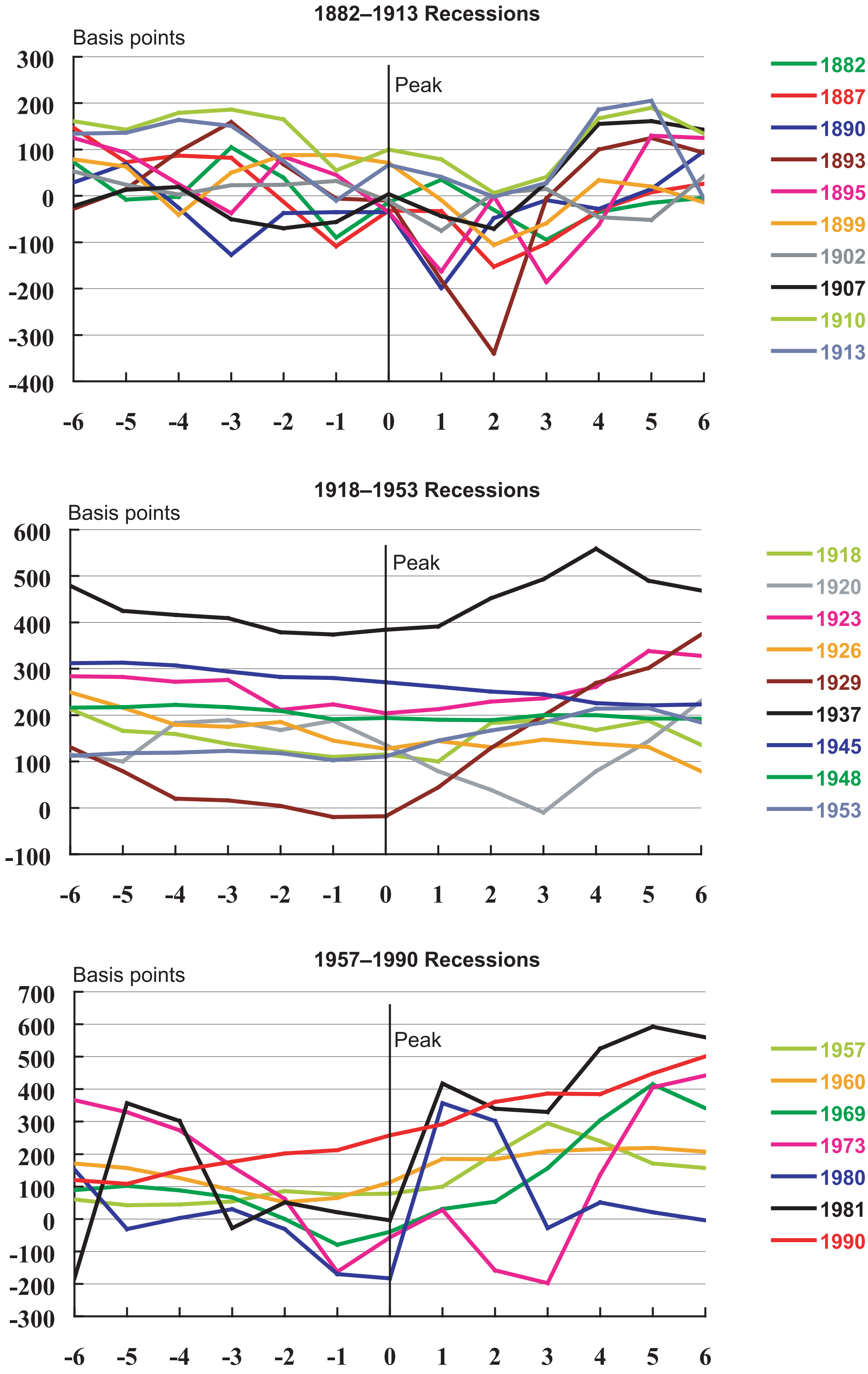
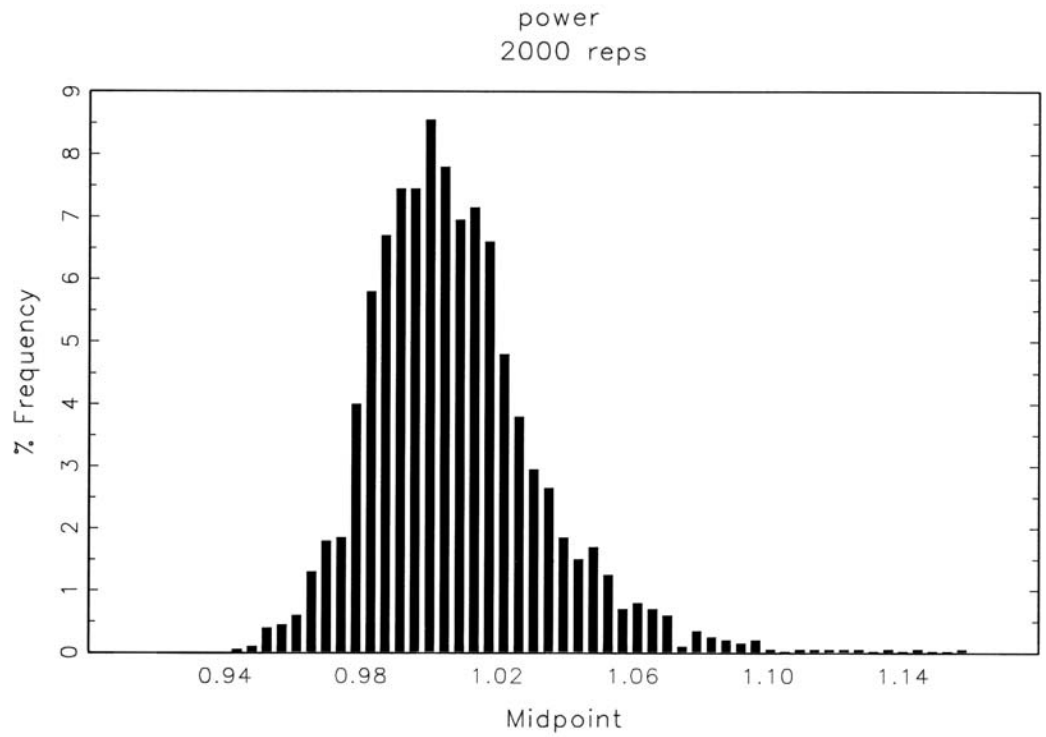


Figure 2. Yield spreads around business cycle turning points.



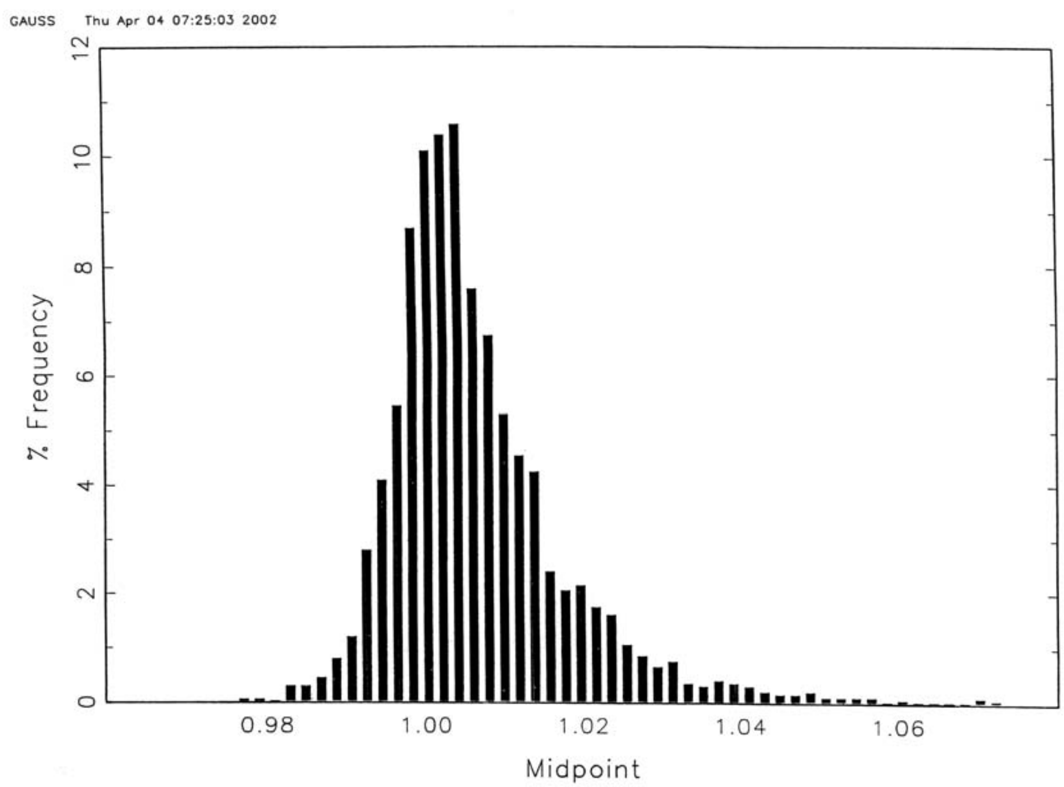


Figure 3. Histograms of mean squared error ratios, based on simulations for power and size.

Figure 4. Coefficient of spread in rolling regression.

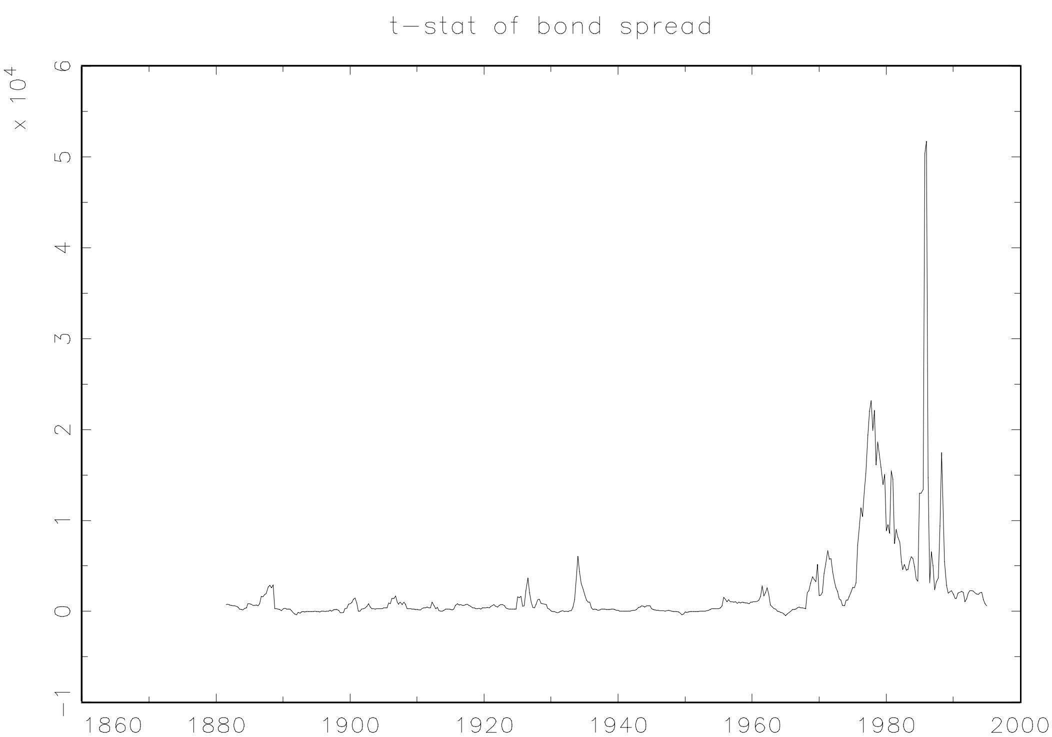


Figure 5. t-statistic of spread in rolling regression.

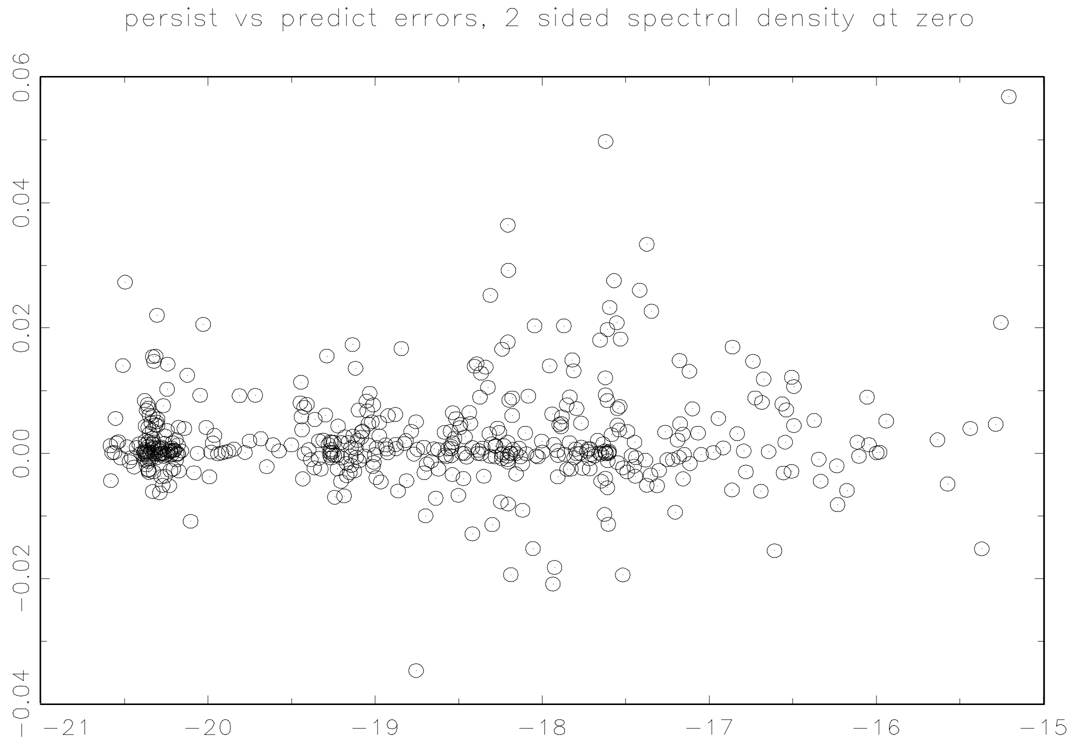


Figure 6. Scatterplot of prediction error against inflation persistence, quarterly.