REEXAMINING THE TERM STRUCTURE OF INTEREST RATES AND THE INTERWAR DEMAND FOR MONEY[1]

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Abstract

This paper reexamines whether the term structure of interest rates, rather than merely a single interest rate, should be included in the demand for money of the interwar era. In contrast to earlier work, we use cointegration techniques to model the equilibrium/error correction process, and find that a sufficiently rich dynamic model using a single interest rate has considerable explanatory power. Nevertheless, we conclude that the inclusion of the term structure may help to explain the turbulent monetary dynamics of the Depression era.

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1 Introduction

In previous work, we have demonstrated that the entire term structure of interest rates, and not just its short end, is important to the demand for money during the period 1919-1939. We reexamine that conclusion in this paper, using the more appropriate equilibrium/error-correction setting, and find considerable support for that representation of the function.

The role of the term structure, as opposed to a single short-term rate taken to be "the" interest rate, is crucial to a resolution of the continuing controversy regarding the cause of the Great Depression. According to Temin (1976), since short-term rates were falling, money was easy; and the contraction of the money supply documented by Friedman and Schwartz (1963) must have represented an essentially passive adjustment to a decline in the demand for money. Bernanke (1983), on the other hand, argues that a tightening of non-price terms of credit transmitted difficulties in the financial sector to the real sector. Bernanke refers to this as a "nonmonetary effect" in order to distinguish it from the traditional "monetary" channel linking the monetary sector to the real sector. However the effect is characterized, we have shown that it is essentially arbitrary whether this effect is incorporated into the Hicksian IS or LM curves, as long as income is related to the appropriate interest rate(s).

In Bernanke's analysis, incorporating this effect into the IS curve implies that the IS and LM curves relate income to the expected return to lending. On the other hand, incorporating the effect into the LM curve implies that the IS and LM curves relate income to the expected cost of borrowing. The spread between borrowing and lending reflects the costs of financial intermediation. Although these costs are not directly observable, they include the transactions costs of loan approval, bonding, monitoring and foreclosure upon default and the ex ante distribution of default risk. While unobservable, these costs of financial intermediation might be proxied by observable non-price terms of credit, such as required loan-to-value ratios, and certain spreads in the structure of interest rates. The important point is that an increase in the cost of financial intermediation can explain the decline in the observed risk-free short-term rate, the increase in long-term rates and risky rates at all tenors, and the fall in income observed in the Great Depression. Such an investigation requires careful measurement of the term structure of interest rates of that era in order to capture the monetary dynamics inherent in the data.

The next section of the paper discusses the rationale for including the term structure of interest rates in the money demand function, and summarizes the methodology by which we have created term structure estimates for the 1919-1939 period. Section three contains the equilibrium/error-correction estimates, which take into account the cointegrated nature of money, income, and interest rates. The last section presents our conclusions.

2 The Role of Interest Rates in Money Demand

As Friedman (1977) has asserted, it is not sufficient to track the movements of any single interest rate, as a shortage of credit must manifest itself across tenors and risk classes. The representation of the behavior of interest rates–as opposed to that of a single rate–has occupied many researchers. The obvious solution of including several representative rates usually results in severe problems of collinearity. Although the spread, or term premium, between long and short rates may be a useful measure, it by itself is not likely to capture the degree of liquidity in credit markets. Heller and Khan (1979) defined one method of summarizing the term structure: fitting a quadratic trend to interest rates, and utilizing the resulting parameters as representations of the term structure. In the absence of a term premium, the intercept of such a relationship captures the level of rates. With significant curvature in the term structure, the linear and quadratic parameters will indicate the relation of longer-term rates to the instantaneous rate defined by the intercept.

While Heller and Khan studied the postwar era, Friedman and Schwartz (1982) fitted this quadratic to phase-averaged interest rates for the 1873-1975 period. For the interwar years, they made use of the term structure approximations generated by Durand (1942). Baum and Thies (1989) utilized a newer series of annual term structure estimates derived by Thies (1985) for the 1920-1939 period, and found that explanations based on the quadratic representation of the term structure meaningfully outperformed those based on a single short-term rate for this period. However, given structural shifts in the quadratic parameters between the 1920s and the 1930s, and the relatively few degrees of freedom available, it is obvious that a more careful investigation could be conducted using higher-frequency data. We now describe our estimated quarterly term structures for the 1919-1930 period, and their combination with Cecchetti's (1988) Treasury term structures for the 1930s.

Prior to 1929, there is insufficient information in U.S. Treasury securities' prices to construct meaningful term structures of interest rates. Thus, Cecchetti (1988) began his series of monthly Treasury term structure estimates in January 1929, after the Treasury's first issuance of medium-term notes. While Treasury securities cannot be relied upon for term structure estimation prior to 1929, there is an obvious source of information: high-grade conventional railroad bonds. Macaulay (1938) relied on railroad bonds to construct an index of long-term interest rates for the period from 1857 to 1936. Homer (1963, p.314) indicated that, by the 1890s, yields on high-grade railroad bonds were comparable to those of the best municipal issues.

During the period of interest, the locus of market activity and pricing information was the New York Stock Exchange (NYSE) bond market. During the 1920's, six to seven hundred of the bond issues listed on the New York Stock Exchange were railroad bonds–in the aggregate, about $10 billion of market value. These constituted about one-half of all listed issues by number and about one-quarter by value. The financial stability of railroad corporations–the preeminent examples of the large corporate form since the turn of the century–is evident given that over half of the outstanding railroad bonds (by number as well as value) were Aaa-rated during the 1920's (Hickman, 1960, pp. 6-7). This implies that these bonds were traded on an income basis, with little concern for risk of default.

During this time period, the *Commercial and Financial Chronicle* published, each January, an annual review of the major financial markets which provided the monthly high and low sales prices for all bonds traded on the New York Stock Exchange. We have collected the majority of those price quotations, which effectively constitutes the universe of actively traded, high grade (Moody's rating of Baa or better) conventional railroad bonds with 25 years or less remaining term. We exclude income bonds and convertible bonds. For each bond, we have constructed annual series of the issue's Moody's rating and the amounts outstanding, as well as the price at which the bond may be called (if applicable) and the series of monthly high and low sales prices, with gaps for months with no trades.

As we have described in detail elsewhere (1992), we infer monthly term structures of interest rates for AAA-rated railroad bond from these data via a two-step process. In step one, we derive smoothed, free-form term structures using a variant of McCulloch's (1971) term structure model. In step two, we treat these free-form estimates as data, and with them estimate the parameters of the Nelson-Siegel (1987) form of the term structure. Their form of the term structure is pleasing not only because it efficiently reduces the term structure to a small number of parameters, but also because these parameters are easily interpreted as the instantaneous rate, the asymptotic long-term rate, and an intermediate rate. (A fourth parameter, not utilized in this study and never well-identified, is interpreted as an adjustment rate). The statistical significance of the parameter representing the intermediate-term rate argues against the imposition of monotonicity on the term structure, such as was performed by Durand (1942) in generating the "basic yield" data for the interwar period. The Nelson-Siegel parameters are then used to produce estimates of spot rates at any tenor.

The collapse of the corporate bond market in the early 1930s precludes expansion of our railroad-bond term structures through that decade. However, the concomitant growth in Federal debt–and the associated maturation of the Treasury market–permitted Cecchetti (1988) to construct Treasury term structures for 1929 onward. We estimate a quadratic in tenor for each quarter of the 1929-1939 period from his estimates, and then adjust the resulting a0, a1, a2 for the risky vs. risk-free spread[2] in the overlapping period: the eight quarters 1929:1-1930:4. This gives us a comparable set of quadratic term structure parameters for the entire 1919-1939 period.

3 An Error-Correction Representation of the Interwar Demand for Money

In our previous work, we presented estimates of a static demand-for-money equation of the form

$$\log \frac{M2}{P} = \beta_0 + \beta_1 \log RGNP + \beta_2 CPRT + \epsilon \qquad (1)$$

where M2 and real GNP are measured in levels[3] and CPRT is the 4-6 month commercial paper rate. The alternative model replaced the single interest rate with a set of three parameters summarizing the term structure of interest rates. However, if the variables in this relation are nonstationary (for instance, integrated of order one), a "levels" regression may be spurious. We first examine the time-series properties of the variables in our model, and then present estimates based on an alternative modelling strategy: the error-correction representation of the demand for money, which should allow us to better capture the dynamics of the underlying process.

[2] The a0 estimate for 1930-1939 was adjusted upward by the average spread between the corporate and Treasury rates for the eight overlap quarters of 1929-1930. The a0, a1 and a2 series for this overlap period were then smoothed by arithmetic weights blending the corporate and Treasury values.

[3] The same specification was tested in per capita terms; the results were similar and generally inferior.

We first consider, via augmented Dickey-Fuller and Phillips-Perron test statistics on the above variables, whether the variables may be considered to be integrated of order one. All data (except the term structure parameters, described above) are taken from Balke and Gordon (1986). Table 1 presents those test statistics; each of the variables fails to reject the null hypothesis of $I(1)$ at reasonable significance levels, while tests on their differences indicate that their differences are stationary. The static regressions used to calculate residuals for cointegration tests are:

$$\begin{aligned}
\left(\log \frac{M}{P}\right) &= -3.987 + 0.842 \log RGNP - 0.045 CPRT + e \\
R^2 &= 0.823 \; DW = 0.222 \; ADF = -3.403 \; PP = -.2.687 \\
\left(\log \frac{M}{P}\right) &= -4.030 + 0.879 \log RGNP - 0.0762 a_0 - 0.0137 a_1 - 0.0042 a_2 + e \\
R^2 &= 0.858 \; DW = 0.370 \; ADF = -3.944 \; PP = -.3.560
\end{aligned}$$

which indicate that cointegrating relationships exist for both the single-interest-rate and the term-structure form of the model. Many researchers have modelled these relationships via the Engle-Granger "two-step" methodology (1987), in which residuals from the static ("equilibrium") regressions above are entered in a second regression equation containing the differences of the variables. Recently, Phillips and Loretan (1991) have demonstrated that a single-equation approach to estimation, utilising nonlinear least squares (NLS), can yield significant benefits. They conclude that

> "In SEECM (single-equation error-correction models) modelling there is an asymptotic advantage to the use of lagged equilibrium relationships in the regression and thereby the use of nonlinear least squares (NLS)... Asymptotic theory favours the use of NLS on non-linear-in-parameters SEECM's rather than simply OLS on linear SEECM models formulated with lags (and possibly leads) of differences of all variables in the system...the requisite information set for valid conditioning is better modelled by employing lagged equilibria than it is by the use of lagged differences in the dependent variable." (1991, p.426)

Unlike the Engle-Granger two-step procedure, in which the parameters of the equilibrium error equation are estimated separately from the parameters of the error-correction mechanism, this formulation jointly estimates the nonlinear relation which captures both the equilibrium and error-correction characteristics of the cointegrated system.

In our context, the application of the Phillips-Loretan (PL) methodology leads to the following equation for the single-interest-rate formulation:

$$\begin{aligned}\left(\log \frac{M}{P}\right)_t &= \alpha + \beta \log RGNP_t + \gamma CPRT_t \\ &+\delta_{11}\left[\left(\log \frac{M}{P}\right)_{t-1} - \alpha - \beta \log RGNP_{t-1} - \gamma CPRT_{t-1}\right] \\ &+\delta_{12}\left[\left(\log \frac{M}{P}\right)_{t-2} - \alpha - \beta \log RGNP_{t-2} - \gamma CPRT_{t-12}\right] \\ &+\delta_{20}\Delta \log RGNP_t + \delta_{21}\Delta CPRT_t + \varphi_{20}\Delta \log RGNP_{t-1} + \varphi_{21}\Delta CPRT_{t-1} + \epsilon_t\end{aligned} \tag{2}$$

where the equation in levels of the variables is augmented with two lags of the equilibrium error as well as the current and lagged differences of the explanatory variables. Following Phillips-Loretan, we initially included first-order leads of the differences of the explanatory variables, but did not find them significant.

When the single interest rate is replaced with the three parameters summarizing the term structure, the Phillips-Loretan methodology led us to the specification in [3], again containing two lags of the equilibrium error, current and lagged differences of the regressors, and no leads. Our estimates of the single-interest-rate and term-structure forms of the model are presented in the first and second columns of Table 2.

$$\begin{aligned}\left(\log \frac{M}{P}\right)_t &= \alpha + \beta \log RGNP_t + \gamma_0 A_{0t} + \gamma_1 A_{1t} + \gamma_2 A_{2t} \\ &+\delta_{11}\left[\left(\log \frac{M}{P}\right)_{t-1} - \alpha - \beta \log RGNP_{t-1} - \gamma_0 A_{0t-1} - \gamma_1 A_{1t-1} - \gamma_2 A_{2t-1}\right] \\ &+\delta_{12}\left[\left(\log \frac{M}{P}\right)_{t-2} - \alpha - \beta \log RGNP_{t-2} - \gamma_0 A_{0t-2} - \gamma_1 A_{1t-2} - \gamma_2 A_{2t-2}\right] \\ &+\delta_{20}\Delta \log RGNP_t + \theta_{21}\Delta A_{0t} + \theta_{22}\Delta A_{1t} + \theta_{23}\Delta A_{2t} \\ &+\phi_{20}\Delta \log RGNP_{t-1} + \phi_{21}\Delta A_{0t-1} + \theta_{22}\Delta A_{1t-1} + \theta_{23}\Delta A_{2t-1} + \epsilon_t\end{aligned} \tag{3}$$

Both forms of the equation appear to be reasonable. Neither form appears to possess autocorrelated errors, given the results of the Ljung-Box Q test for the first 24 sample autocorrelations. The term-structure form of the equation has a slightly lower standard error of regression. As in our earlier work, all three term structure coefficients enter negatively. We are able to reject first- through eighth-order ARCH processes in the residuals for both equations–much more decisively for the term-structure form of the equation. However, the Jarque-Bera test for normality of the term-structure equation's errors rejects normality, perhaps reflecting the presence of outliers during this turbulent period of banking failure and concomitant contraction of the banking industry.[4]

To further analyse the adequacy of these alternative explanations of the demand for money, we present in-sample dynamic forecasts of $\log(\frac{M}{P})$ derived from the two forms of the model presented in Table 2 in Figure 1. Both forms of the equation do quite well in tracking the demand for money in the early 1920s. In 1928, the term-structure form begins to overpredict substantially, while the single-interest rate form tends to underpredict. In the depression year of 1929, both equations predict poorly, but the term structure form, capable of capturing the interplay of short and long rates present in this period of turmoil, appears to do a better job. Through the stagnant times of the mid 1930s, both equations underpredict, but from early 1938 the single-interest-rate form of the equation exhibits wide swings.

This figure is instructive in terms of the equations' ability to cope with both the 1920s and 1930s experience. In earlier work, based on a much smaller, annual data set and stationary time series specifications, we concluded that there had been a significant shift in the demand for money between those two decades. Other researchers, such as Hafer (1985), have also reported such a break. That conclusion is not borne out in the current application of more appropriate dynamic modelling techniques to quarterly data. The cointegrating relationships presented in Table 2 tend to perform well throughout the

[4] The Jarque-Bera test combines sample estimates of the third and fourth moments (skewness and kurtosis) of the residual series.

entire sample period. We also note that the findings of our earlier work on the superiority of the term structure formulation are affirmed (if only weakly) in the cointegration/error-correction framework, in the sense that there is no clear dominance of a demand-for-money equation containing term structure parameters over an equation utilizing a single interest rate.

4 Conclusions

We demonstrate how monthly estimates of the term structure of interest rates may be used to improve the performance of U.S. demand-for-money functions for the interwar period. The traditional specification of those functions, when applied to quarterly data, does not appear to have attractive stochastic properties. As an alternative, we generate models in the equilibrium/error-correction setting which are capable of capturing both the long-run relationships and the transitional dynamics of the demand for money. The cointegrating relationships appear to fit well throughout both the 1920s and the 1930s, and do not suggest structural instability during the period. There is weak support for the hypothesis that the entire term structure, and not just a single interest rate, should be included in the demand for money function.

In contrast to earlier static modelling, the term structure representation of interest rates does not appear to contribute significantly to the equilibrium/error-correction dynamic model. This suggests that much of the effects of the substantial changes in the shape of the term structure during this period are adequately represented by the changes in short-term interest rates, which would be consistent with the forward interest rates implicit in these term structures being determined by the information revealed by changes in short-term rates.

With the earlier, static form of the model, it was clear that low short-term interest rates did not necessarily indicate that money was easy; the spread between short- and long-term interest rates had to be taken into account. In the present dynamic form of the model, it is again clear that low short-term interest rates do not necessarily indicate that money is easy. Recent changes in short-term rates and the persistence of monetary disequilibria (as measured by the lagged equilibrium errors) would also have to be considered.

Beginning in 1929, when the Fed dramatically raised the discount rate, and continuing through the mid 1930's, in spite of a series of reductions of the discount rate, both specifications of the dynamic model underpredict the real money supply. This is mainly due to the persistent effects of the initial disequilibrium. Accordingly, it could be argued that money remained tight throughout the Great Depression. In any case, the level of short-term interest rates is again shown to be a inadequate indicator of monetary conditions.

References

[1] Balke, Nathan and Robert J. Gordon, 1986. Appendix B: Historical Data, in Robert J. Gordon, ed., *The American business cycle: continuity and change.* Chicago: University of Chicago Press.

[2] Baum, C.F. and C.F. Thies, 1989. The term structure of interest rates and the demand for money during the great depression. *Southern Economic Journal* 56:2, 490-498.

[3] Baum, C.F. and C.F. Thies, 1992. On the Construction of Monthly Term Structures of U.S. Interest Rates, 1919-1930. *Computer Science in Economics and Management*, 5:221-246.

[4] Bernanke, Ben, 1983. Nonmonetary effects of the financial crisis in the propagation of the Great Depression. *American Economic Review* 73:257-276.

[5] Cecchetti, Stephen, 1988. The case of negative nominal interest rates: new estimates of the term structure of interest rates during the great depression. *Journal of Political Economy* 96:6, 1111-1141.

[6] Durand, David, 1942. Basic yields on corporate bonds, 1900-1942. Technical paper no. 3, National Bureau of Economic Research.

[7] Engle, R.W. and C.W.J. Granger, 1987. Cointegration and error correction: representation, estimation, and testing. *Econometrica* 55, 251-276.

[8] Friedman, Milton, 1977. Time perspective in demand for money. *Scandinavian Journal of Economics*, 397-416.

[9] Friedman, Milton and Anna J. Schwartz, 1963. *A monetary history of the United States*, 1867-1960. Princeton: Princeton University Press.

[10] Friedman, Milton and Anna J. Schwartz, 1982. The effect of the term structure of interest rates on the demand for money in the United States. *Journal of Political Economy*, 90:1, 201-212.

[11] Hafer, R.W., 1985. The stability of the short-run money demand function, 1920-1939. *Explorations in Economic History*, 271-295.

[12] Heller, H. Robert and Mohsin S. Khan, 1979. The demand for money and the term structure of interest rates. *Journal of Political Economy*, 109-130.

[13] Hickman, W. B., 1960. *Statistical measures of corporate bond financing since 1900.* Princeton: Princeton University Press.

[14] Homer, S., 1963. *A history of interest rates.* Rutgers University Press.

[15] Macaulay, Frederick, 1938. *The movements of interest rates, bond yields and stock prices in the United States since 1856.* National Bureau of Economic Research.

[16] McCulloch, J. Huston, Measuring the term structure of interest rates. *Journal of Business* 44, 19-31.

[17] Nelson, C. and A. Siegel, 1987. Parsimonious modeling of yield curves. *Journal of Business* 60:4, 473-489.

[18] Phillips, P.C.B. and M. Loretan, 1991. Estimating long-run economic equilibria. *Review of Economic Studies* 58, 407-436.

[19] Temin, Peter, 1976. *Did Monetary Forces Cause the Great Depression?* New York: W.W. Norton.

[20] Thies, Clifford, 1985. New estimates of the term structure of interest rates, 1920-1939. *Journal of Financial Research* 8, 297-306.

Table 1. Integration Test Statistics

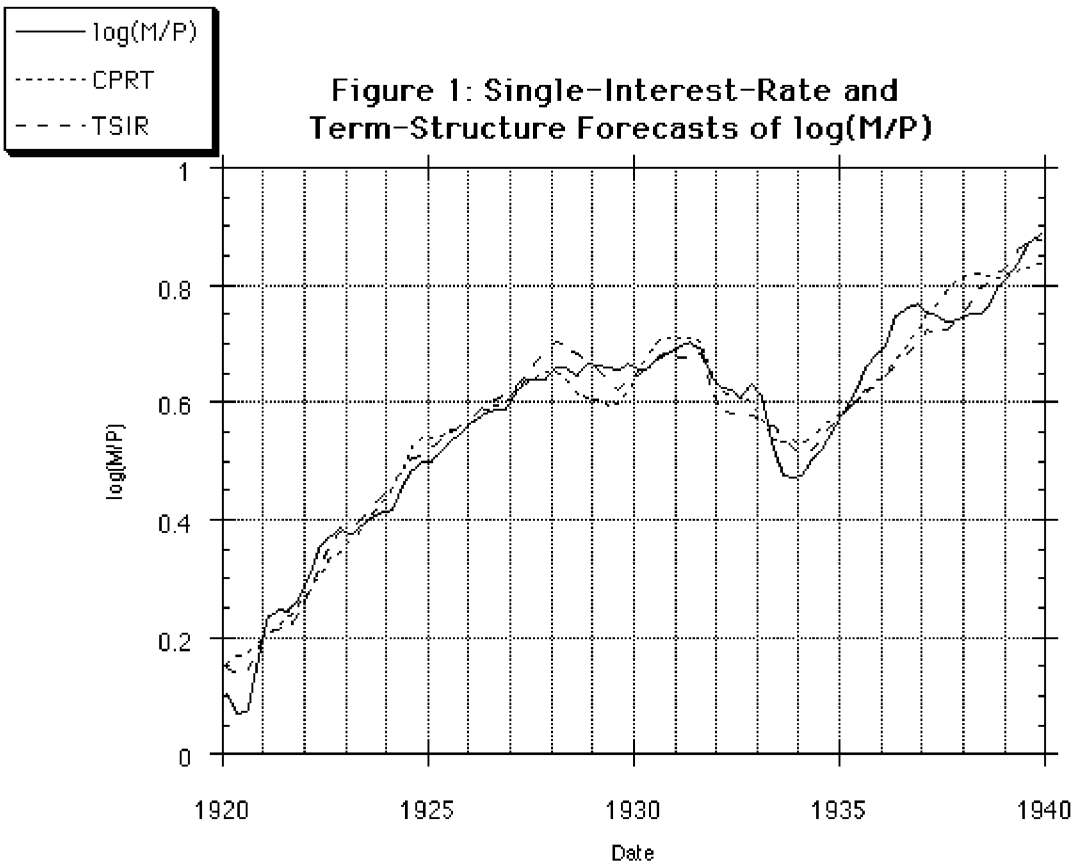
Variable	Augmented Dickey-Fuller[a]	Phillips-Perron[a]
$\log\left(\frac{M}{P}\right)$	-1.184	-0.404
log RGNP	-1.496	-0.690
CPRT	-0.877	-1.018
log price deflator	-2.135	-0.821
a_0	-1.225	-1.050
a_1	-1.431	-1.447
a_2	-1.498	-1.635
$\Delta \log\left(\frac{M}{P}\right)$	-3.308	-5.354
Δ log real GNP	-3.066	-6.450
Δ CPRT	-5.148	-5.548
Δ log price deflator	-5.731	-3.916
Δa_0	-5.311	-8.035
Δa_1	-4.090	-9.174
Δa_2	-3.704	-9.213

[a] Calculated with four lags of the variable.

Table 2. Estimates of the Error-Correction Model of the Demand for Money, 1920:1-1939:4

Explanatory Variable	1	2
constant	-4.087	-0.5725
	(0.7973)	(2.6794)
log $RGNP_t$	0.8650	0.3815
	(0.1407)	(0.3832)
$CPRT_t$	-0.0425	
	(0.0094)	
Error $correction_{t-1}$	1.3878	1.2495
	(0.1017)	(0.1148)
Error $correction_{t-2}$	-0.5074	-0.3657
	(0.0923)	(0.1074)
Δ log $RGNP_t$	-0.8659	-0.5057
	(0.1421)	(0.3410)
Δ $CPRT_t$	0.0158	
	(0.0101)	
Δ log $RGNP_{t-1}$	0.4204	0.1113
	(0.1196)	(0.1709)
Δ $CPRT_{t-1}$	-0.0111	
	(0.0067)	
a_{0t}		-0.1961
		(0.1268)
a_{1t}		-0.0263
		(0.0300)
a_{2t}		-0.0041
		(0.0069)
Δ a_{0t-1}		0.1288
		(0.1230)
Δ a_{1t-1}		0.0131
		(0.0291)
Δ a_{2t-1}		0.0010
		(0.0067)
Δ a_{0t-2}		-0.0732
		(0.0387)
Δ a_{1t-2}		-0.0083
		(0.0100)
Δ a_{2t-2}		-0.0009
		(0.0024)
R^2	0.9906	0.9920
S.E.R.	0.0186	0.0180
Ljung-Box Q(24)	27.6 (0.28)	22.0 (0.58)
ARCH(8)	8.44 (0.39)	2.17 (0.98)
Jarque-Bera	3.01 (0.22)	8.58 (0.01)

Notes: Estimated standard errors are given in parentheses. Ljung-Box Q(n) is the portmanteau test for autocorrelation up to order n. ARCH(8) is the autoregressive conditional heteroskedasticity test. Jarque-Bera is their test (1980) for normality of the residuals. Tail probabilities of the χ^2 test statistics are given in parentheses.


log(M/P)
CPRT
TSIR
Figure 1: Single-Interest-Rate and
Term-Structure Forecasts of log(M/P)
log(M/P)
1
0.8
0.6
0.4
0.2
0
1920
1925
1930
1935
1940
Date