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The Corporate Spread Curve and Industrial Production in the United States

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The Corporate Spread Curve and Industrial Production in the United States

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Abstract

The term structure of domestic investment grade bond spreads – or corporate spread curve – contains useful information to predict future changes in industrial production, beyond the information already contained in interest rates, commercial paper-treasury bill spreads, and lagged values of industrial production. In fact, the corporate spread curve can explain the cumulative growth rate of industrial production over 3- to 48-month horizons, and the marginal growth rate over 6- to 18-month horizons. Unlike other financial variables, the corporate spread curve has been a stable predictor of real activity for the last fifteen years.

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I. INTRODUCTION

Financial instruments represent claims on the real economy, and therefore, financial asset prices should contain information about market's expectations about future economic developments. Because of their forward-looking nature and availability at high frequencies, financial variables have been extensively studied as potential predictors of real activity, and some of them have performed well in the past. In particular, the term structure of the U.S. government debt interest rates, or Treasury yield curve, predicted future output growth well until the mid-1980s. However, recent empirical studies found that the predictive power of the yield curve and other financial variables such as the paper-bill spread has declined substantially since 1985.[2] These developments point out the need for an alternative variable containing useful information about future real activity.

This paper proposes such a variable, the aggregate term structure of corporate bond spreads, or corporate spread curve. The corporate spread curve is defined as the difference between the spreads of long maturity and short maturity corporate bonds, where the spread is defined as the difference between the yields of a corporate bond and a default risk-free benchmark security with the same maturity. Thus, the corporate spread is a measure of the risk premium that compensates investors for holding risky corporate debt rather than default risk-free debt. This spread reflects a number of risks associated with corporate bonds, such as default risk, liquidity risk and tax risk among others. While it is safe to assume that liquidity and tax risks are not correlated with business cycles, default risk is clearly cyclical and tends to increase before recessions. In fact, the cyclicality of default risk is considered to be the main reason underlying the leading properties of the yield spread.[3]

The study of the predictive content of the corporate spread curve rather than corporate spreads themselves is motivated by a salient feature of the data: the corporate spread curve usually inverts prior to and during an economic expansion, and becomes upward sloping before an economic contraction (Figure 1).[4] Although there is no theory explaining the observed behavior of the corporate spread curve, we suggest that an analogy to the pure expectation hypothesis in the U.S. Treasury yield curve may be at work: before a recession,

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[2] Haubrich and Dombrosky (1986) and Dotsey (1998) documented a decline in the predictive power of the Treasury yield curve after 1985; Bernanke (1990) and Emery (1996) documented that the performance of the paper-bill spread deteriorated during the 1980s. See also Stock and Watson (2001) for an overview of the recent literature on the role of financial variables as leading indicators.

[3] See, for example, Friedman and Kuttner (1993), Gertler, Hubbard, and Kashyap (1991), Duca (2000) and Kwark (2000).

[4] Previous work by the authors (Chan-Lau and Ivaschenko, 2001) studies in detail how well corporate spreads and their systematic components explain changes in economic activity.

the long end of the corporate spread curve increases more than the short end because investors expect higher default rates, a characteristic associated with an economic slowdown.[5]

This paper assesses how well the corporate spread curve predicts changes in industrial production in the United States, which to our knowledge, has not been studied yet. It finds that the corporate bond spread curve to Treasury securities, or corporate-Treasury spread curve is useful to predict future changes in industrial production up to 48 months. The steepening of the corporate spread curve signals a future economic slowdown while its flattening precedes an economic recovery. In-sample and out-of-sample recursive estimations show that the predictive power of the corporate-Treasury spread curve has been very stable for the last twenty years. Furthermore, its predictive power, which has not deteriorated for the last fifteen years, has improved in the last five years.

There is a slight decline in the predictive power of the corporate spread curve when the spreads are calculated relative to agency bonds instead of Treasury securities. In this case, the corporate-agency spread curve explains future changes in industrial production up to 24 months horizons. One notably exception is the corporate-agency spread curve for AAA-rated bonds, possibly because agency bonds and AAA-rated bonds are close substitutes.[6] In general, though, corporate spread curves contain information beyond that already contained in default-risk free securities, namely Treasuries and agency bonds.

The rest of this paper is organized as follows. Section II reviews the related literature, describes current market developments affecting the predictive power of U.S. Treasury securities for future real activity, and argues why corporate bond yields may be a viable alternative to Treasuries as a forecasting variable. Section III describes the data and estimation methodology used. Section IV presents the results of in-sample estimations of the model using two different measures of industrial production growth as the dependent variable and two alternative default risk-free securities. Then, it assesses the robustness and stability of the model, its out-of-sample performance, and the quality of its predictions. Section V concludes.

[5] Merton (1974) and Duffie and Singleton (1999) have developed theories explaining the term structure of bond spreads for individual companies. However, these theories might not be directly applicable to an aggregate spread curve.

[6] In fact, agency bonds, although considered as different credit class by market practitioners, are mostly rated AAA.

II. Related Literature

Financial instruments, regardless of their complexity, ultimately represent claims on the real economy. Absent price bubbles and significant market frictions, financial prices convey useful information on market's expectations about future economic developments. Financial information is readily available at high frequencies and transmitted rapidly, as financial markets are relatively quick and efficient in recognizing and pricing new information. In contrast, economic information is usually gathered and reported with significant lags, and subject to further revisions and corrections, ruling them out as timely sources of information. Therefore, it is justified to use financial prices for forecasting purposes.

Several empirical studies have used theoretical relationships derived from theoretical asset pricing model, such as Lucas (1978) and Breeden(1979), to evaluate whether financial variables contain useful information about future economic activity. Most of these studies have focused on the information contained in U.S. Treasury securities for two reasons. First, Treasury securities contain valuable information about future monetary policy, which, in turn, affects real activity in the short- to medium-run. Second, they are less likely to be affected by liquidity and credit (or default) risk. Some of these studies are reviewed below.

Harvey (1988), using an empirical model derived from consumption-based asset pricing models, found that the Treasury yield curve predicted future real consumption growth better than its own lagged values and stock returns. Cochrane (1991), using a production-based asset pricing model, found that both the term structure of treasury securities and the corporate yield spread to treasuries had a common business cycle component that accurately forecasted investment returns.

Estrella and Hardouvelis (1991) documented that the Treasury yield curve explained more than 30 percent in real GNP growth variation 5 to 7 quarters ahead. The yield curve also predicted successfully all private sector components of real GNP and the probability of economic recessions. As a predictor of GNP growth, the yield curve outperformed other commonly used variables such as the index of leading indicators, real short-term interest rates, lagged growth of real activity, lagged rates of inflation, and survey forecasts. Also, the information in the term structure reflected factors independent from monetary policy.

Estrella and Mishkin (1998) found that the Treasury yield curve was the best out-of-sample predictor of recession at horizons of 2 quarters and beyond. Hamilton and Kim (2001) confirmed that the Treasury yield curve contained useful information about future GDP beyond that contained in measures of monetary policy and oil price changes. The usefulness of the yield curve of government securities as a predictor of economic activity has not been confined exclusively to the United States. Plosser and Rouwenhorst (1994) and Estrella and Mishkin (1997) extended some of the results described above to a number of European countries.

Despite these positive results, more recent studies have cast some doubt on the recent performance of the treasury yield curve as a predictor of economic growth in the United States, as documented by Haubrich and Dombrosky (1996), Dotsey (1998), and Stock and Watson (2001).[7] In particular, technical factors associated with demand and supply for U.S. Treasury securities have distorted the information contained in Treasury securities and may explain the poor predictive power of the Treasury yield curve recently.

On the demand side, the role of U.S. Treasury securities as "safe haven" has increased as a result of the turmoil experienced by financial markets during recent years, especially in the fall of 1998. This flight to quality, concentrated mostly on the ten-year Treasury note, introduced significant fluctuations to the Treasury yield curve that did not reflect future changes on real economic activity. On the supply side, the current strong fiscal position of the United States has reduced the government borrowing needs significantly. In consequence, the U.S. Treasury has been reducing the issuance of government securities since the mid-1990s, especially one-year bills. In January 2000, the Treasury launched a buy back program that reduced the stock of securities available to the public further. The shrinking supply of U.S. Treasury securities, and the corresponding loss of liquidity and market depth, may have influenced the informativeness of the Treasury yield curve. These factors may underlie the flattening and subsequent inversion of the curve during 2000.[8]

The decreased forecasting ability of financial variables that used to predict real activity well highlights the need for alternative variables that may contain useful information about future real activity. This paper proposes using the corporate spread curve of investment grade bonds to default-risk free securities. There are a number of reasons supporting this choice. First of all, the bond market is an important source of funding for corporations. Thus, corporate bond yields reflect credit markets tightness, which in turn affects investment decisions and future economic growth. In addition, increased reliance on bond rather than bank financing may also have changed the transmission channel of monetary policy, reducing the information content of the Treasury yield curve. Second, the term structure of corporate spreads may not be influenced as much as the Treasury yield curve by pressures arising from technical factors such as "flight to quality" or government debt reduction. Third, as described above, the corporate spread curve exhibits an apparent regular cyclical pattern: it tends to invert before and during an economic expansion and becomes upward sloping before an economic contraction.

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[7] The forecasting power of another financial variable used to predict real economic growth well, the paper-bill spread was also found to weaken during the 1980s. See Bernanke (1990) and Emery (1996), and Stock and Watson (2001) and references herein for a detailed discussion of instability of the relationship between financial variables and real activity.

[8] See Fleming (2000a, 2000b) and Schinasi, Kramer and Smith (2001) for recent analyses of the U.S. Treasury market.

The literature on corporate spreads as predictors of real activity is very recent and relatively limited. Saito and Takeda (2000) studied how well the term structure of AAA-rated bonds, defined as the difference between the yields of 10-year AAA-rated bonds and a 3-month corporate commercial paper, predicted real GDP growth, compared to the equivalent Treasury note term structure. They found that the corporate term structure outperformed the Treasury term structure in both in-sample and out-of-sample forecasting. They also concluded that the AAA corporate yield curve had valuable information about the probability of recession.

Our approach differs from the paper cited above in many ways. First and foremost, we consider the term structure of spreads rather than the term structure of yields, allowing us to disentangle the information contained in corporate bonds from that contained in Treasury securities. Moreover, this allows us to focus on the informational content of corporate risk. Second, the analysis in this paper is more comprehensive. It analyzes the predictive power of the corporate spread curve for a wider range of investment-grade corporate bonds, and considers spreads to another default-free benchmark, agency bonds, in addition to Treasury securities. Finally, this study also performs a comprehensive analysis of the robustness and stability of the model.

III. Data and Empirical Methodology

This study uses the Industrial Production Index provided by the Office for National Statistics as a measure of economic activity. Spreads are computed using redemption yields from the Lehman Brothers Investment Grade Corporate Bond Indexes for long maturities and intermediate maturities. The Lehman Brother Indexes include the four investment grade credit tiers defined by Moodys: AAA, AA, A, and Baa. Monthly data for the period February 1973 to September 2001 is used.

The dependent variable in our analysis is the future growth rate of industrial production measured in two different ways. The first measure is the annualized *cumulative* percentage change in the industrial production index:

$$Y_{t,t+k} = (1200/k)log[I_{t+k}/I_t], \tag{1}$$

where k denotes the forecasting horizon in months, I_{t+k} denotes the level of the index during month $t+k$, and $Y_i(k)$ denotes the percentage change in the production index. The second measure used in the analysis is the *marginal*, year-to-year percentage change in the index of industrial production k months ahead,

$$Y_{t+k,t+k+12} = 100\ log[I_{t+k+12}/I_{t+k}]. \tag{2}$$

For simplicity, dependent variables (1) and (2) are referred to as cumulative and marginal growth rate of industrial production respectively. Predicting the marginal growth rate is a better measure of how far in the future the model predicts.

The main explanatory variable in this study is the term structure of corporate spreads. The term structure of corporate spreads (or slope of the corporate spread curve), $TERM^C$, is defined as the difference between the spreads of long-term ($SPREAD^{C,L}$) and intermediate-term ($SPREAD^{C,I}$) corporate bonds to Treasury securities:

$$TERM^C{}_t = SPREAD^{C,L}{}_t - SPREAD^{C,I}{}_t. \quad (3)$$

The corporate spread over Treasury securities of a corporate bond rated C, $SPREAD^C$, is defined as the difference between the redemption yield on the corporate bond index corresponding to the same credit rating, R^C, and the redemption yield on the government bond index of the same maturity, R^T :

$$SPREAD^C{}_t = R^C{}_t - R^T{}_t, \quad (4)$$

Yield and spread variables all have conventional dating: variables dated t are aggregates for month t. Table 1 presents sample statistics of the variables used in the analysis. Table 2 presents the correlation between the term structure of corporate spreads and the marginal cumulative growth rate of industrial production for different credit tiers and different lags.

The paper evaluates the following linear relationship between industrial production growth and the corporate spread curve:

$$Y_t(k) = X_t'\beta + u_t, \quad (5)$$

where $Y_t(k)$ is either the cumulative or marginal future growth rate of industrial production, X_t is a (2 x 1) vector consisting of 1 and an explanatory variable $TERM_t$, defined by equations (3) and (4) and u_t is the error term. The forecasting horizon k varies from 3 to 48 months. This equation cannot be estimated by simple OLS, since the error term, u_t, is not independently distributed as the dependent variable is affected by temporal aggregation and, by construction, includes overlapping observations. The overlapping observations induce a moving average process of order $k-1$ and order 11 when the cumulative growth rate and marginal growth rate are used as dependent variables respectively. In addition, the error term may have an autoregressive nature owing to the AR(1) process in the growth rate of industrial production. These estimation problems can be addressed by the Generalized Method of Moments (GMM), developed by Hansen (1982), which imposes no restrictions on the distribution of the error term, u_t. Autocorrelation and heteroskedasticity problems can be addressed by using the Newey and West (1987) technique.

The moment conditions stipulate that prediction errors are orthogonal to the information set Ω_t :

$$E[(Y_t(k) - X_t'\beta)|\Omega_t] = \mathbf{0}. \quad (6)$$

For estimation purposes, conditional moments are transformed into unconditional ones using a set of instruments, $Z_t \subset \Omega_t$. When the cumulative rate of growth is used as the dependent variable, the vector of instruments includes a constant, first and second lags of the regressor, and $(k+1)^{th}$ and $(k+2)^{th}$ lagged values of the dependent variable. When the marginal forward rate of growth is used as the dependent variable, the vector of instruments consists of a constant, first and second lagged values of both the regressor and the dependent variable.[9] Using instruments we also alleviate problems arising from the endogeneity of the explanatory variables and obtain consistent estimates of parameters even if residuals follow a moving average process.[10] So, the following set of moment conditions is estimated:

$$\mathrm{E}\,[(Y_t - X_t'\beta) \otimes Z_t] = \mathbf{0}_{5\times1}, \tag{7}$$

The goodness-of-fit of the model is tested using the overidentifying restrictions test by Hansen (1982).

IV. EMPIRICAL RESULTS

This section presents the results corresponding to the in-sample estimation of the basic model, which considers both cumulative and marginal growth rates of industrial production as the dependent variable and the slope of the corporate spread curve to Treasury securities as the explanatory variable. In order to assess whether the corporate spread curve contains additional information not captured by other variables, the results are compared to those obtained using as explanatory variable the slope of the yield curve of other debt instrument. Also, the marginal contribution of the corporate spread curve to explain future growth is evaluated by including additional regressors. The model is also evaluated using an alternative default-risk free security to Treasury securities, agency bonds. Finally, the robustness and stability of the model, as well as its out-of-sample forecasting performance are evaluated.

A. The Basic Model and Alternative Specifications

The Basic Model

Equation (5) was estimated repeatedly using as explanatory variable the slope of the corporate spread curve to Treasuries for different investment-grade credit tiers (AAA, AA, A, and Baa). Forecasting horizons of 3, 6, 9, 12, 18, 24, 36, and 48 months were included.

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[9] Nelson and Starz (1990) argue that in linear models, a valid instrument should be uncorrelated with u_t and strongly correlated with X_t. See also Gallant and Tauchen (1992) for the discussion on instrument selection.

[10] This endogeneity may stem from the fact that the corporate bond yields include the risk premium that is, in turn, believed to be related to the business cycle variables.

Tables 3 and 4 presents the results corresponding to the use of cumulative growth rate and marginal growth rate of industrial production as the dependent variable respectively. Tables 3 and 4 also present estimation results corresponding to equation (5) when the explanatory variable is replaced by the slope of the term structure of *yields* of three different debt instruments (corporate bonds, U.S. Treasury securities, and Agency bonds) for comparison purposes. The coefficients presented in these tables should be interpreted with an opposite sign, as the GMM estimation was performed on the moment conditions written as $E[(Y_t + X_t'\beta) \otimes Z_t] = \mathbf{0}_{5x1}$ rather than $E[(Y_t - X_t'\beta) \otimes Z_t] = \mathbf{0}_{5x1}$. The results are discussed next.

The corporate spread curve is significant in explaining future cumulative growth of industrial production at the 5 percent level, for all credit tiers and forecasting horizons. The only exception is the corporate spread curve of A-rated bonds, which explain cumulative growth significantly up to 18 months horizon. With respect to future marginal growth rate, which is harder to predict,[11] the corporate spread curve to Treasuries is significant across all credit tiers over 6 to 18 months horizons. The results also show that future declines in industrial production growth are preceded by the steepening of the corporate spread curve, a fact consistent with the "risk expectation" hypothesis. This hypothesis states that if long-term corporate spreads reflect market expectations about future short-term credit risk, then the upward-sloping term structure of corporate spreads should signal future deterioration of credit quality and an increase in corporate defaults, both salient characteristics of recessions.

For comparison purposes, model (5) was also estimated using the slope of the term structures of yields on corporate, agency, and treasury bonds as the explanatory variable. For the cumulative growth rate, coefficients for all three explanatory variables are significant over 3 to 48 months forecasting horizons. However, the unconditional mean of industrial production growth, as measured by the constant term, is underestimated across all explanatory variables. For marginal growth rate, the coefficients associated to the different yield curves were significant over 3, 6, 12 and 18 months horizons for Treasuries, 9 to 18 months horizons for agencies, and 3 to 24 months horizons for AAA-rated corporate bonds.

In case of yields, a steepening of the slope of the yield curve predicts a future increase of industrial production growth, which is consistent with the results from previous studies. The fact that the slopes of the corporate, agency, and treasury yield curves exhibit a similar cyclical behavior suggests that the term structure of corporate yields conveys little information beyond what is already contained in the U.S. Treasury term structure. Hence, studying corporate spreads is useful for this insolates information specific to corporate bonds.

Alternative default-risk free benchmark

Equation (5) was also tested using agency bonds as alternative default risk-free securities. Agency bonds, which are considered almost default-risk free by the market, are

[11] This fact is documented in Estrella and Hardouvelis (1991).

not likely to be affected by the recent developments in the market for U.S. government securities. The results, presented in Table 5, indicate that the slope of the corporate spread curve to agencies can predict cumulative growth rate of industrial production at 3 to 18 months horizons regardless of credit rating, with the exception of the AAA-rated corporate spread curve. This is a reassuring finding, since it suggests that corporate spread curves do contain useful information about future real activity beyond what is contained in the Treasury yield curve. The poor performance of the AAA-rated corporate spread curve to agencies may be explained by the fact that agency bonds are also AAA-rated instruments.

Inclusion of Additional Regressors

Equation (5) was also estimated including lagged values of the dependent variable or the paper bill spread as an additional explanatory variable in order to assess whether the slope of the corporate spread curve to Treasuries contributed additional information about future growth of industrial production.[12] Because corporate spreads contain a liquidity risk premium which is affected by the stance of monetary policy, the federal funds rate was not included among the additional explanatory variables to avoid multicollinearity problems.[13] The results, not reported here but available from the authors upon request, show that the coefficients on the paper-bill spread are not significant at all forecasting horizons. Table 6 reports the results corresponding to the inclusion of lagged values of the dependent variable. The results show that the coefficients associated with the slope of the corporate spread curve to Treasuries preserve their signs, magnitude and significance across all forecasting horizons and credit classes. Hence, the corporate spread curve contains useful additional information about future changes in industrial production.

B. Robustness Check and Analysis of Coefficient Stability

The results are very similar when the number of lags in the Newey-West estimator is increased from 12 to 36.[14] However, the coefficients became slightly less significant when 12 lags were used. robust to changes in the number of lags in the Newey-West estimator.

The results are also robust to the expansion of the instrument set. When an augmented instrument set $Z_{1t}' = (Y(k)_{t-4}, Y(k)_{t-3}, Y(k)_{t-2}, Y(k)_{t-1}, X_{t-4}, X_{t-3}, X_{t-2}, X_{t-1})$ is used –where Y is the

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[12] Stock and Watson (1989) and Friedman and Kuttner (1992) found that the spreads between commercial paper and U.S. Treasury bill could predict output growth.

[13] Bernanke and Blinder (1992) suggested that the Federal Funds rate was an appropriate measure of the monetary policy.

[14] The choice of 36 lags follows from an analysis of the correlogram of changes in the industrial production index. See Newey (1994) for a comprehensive explanation of the technique.

independent variable and X is the explanatory variable– the sign and the magnitude of the coefficients are not affected. However, including too many restrictions affects the goodness-of-fit of the model negatively, especially at longer forecasting horizons, as indicated by a deteriorating J-statistics. This deterioration in the goodness-of-fit demonstrates how important it is to choose the instrumental variables carefully. Though the third and the fourth lags of the independent and dependent variables are uncorrelated with the contemporaneous residuals, they are much less correlated with the explanatory variable than the first and the second lags. Therefore, these additional instruments increase the model's restrictions without adding too much new information and adversely affect the model's goodness-of-fit. When we modify Z_{1t}' by eliminating either lagged values of Y or lagged values of X, the model still performs well for forecasting horizons of 3 to 48 months for cumulative growth, and for forecasting horizons of 6 to 18 months for marginal growth.

The stability of the model was assessed by estimating the model for the initial period from January 1973 to December 1980, and re-estimating it recursively up to September 2001. For cumulative growth rate, the recursive coefficients are significant and stable for 3 to 12 months forecasting horizons for all credit classes for the January1989-September 2001 period (Figure 2). Over a 24 months forecasting horizon, coefficients are below 5 percent for all but Baa-rated bonds. Over longer horizons, 36 and 48 months, recursive coefficients for AAA and AA-rated corporate spread curves are significant only after 1994, and are insignificant for A and Baa-rated bonds. Most of the significant coefficients appear to be stable after 1985 as their changes are less than one standard deviation over the entire period (Figure 3). There are two exceptions, though. Coefficients for AAA bonds over a 3 months horizon and for AA bonds over 3 to 9 months horizons changed by almost two standard deviations from 1985 to 2001. Moreover, the precision of estimates over short (3 and 6 months) horizons has decreased slightly for A- and Baa-rated bonds since early 1996 as indicated by increasing standard errors.

For the marginal rate of growth, recursive coefficients for the corporate spread curve over 3 to 12 months forecasting horizons are significant over the whole period for all credit tiers but the Baa-rated spread curve (Figure 4). All significant coefficients have become stable after 1992 (see Figure 5). In general, coefficients are much more volatile with respect to the magnitude of their standard deviations for the marginal growth rate than the cumulative growth rate of industrial production. This is not surprising since the marginal growth rate is much more volatile and more difficult to predict.

There are two features worth noting. First, regardless of what growth rate measure is used, significant coefficients exhibit higher volatility during periods surrounding the last two recessions – from 1980 to 1982 and from 1990 to 1991 – especially for short forecasting horizons. However, coefficients have been stable since the early 1980s because changes in coefficients during 1990-1992 are negligible with respect to their respective standard deviations. Nevertheless, it is premature to conclude that the relationship between the term structure of spreads and real activity has become more stable even during recession periods. Second, the trajectories of all significant coefficients point towards a structural break in the relationship between the term structure of corporate spreads and real activity in 1985, followed by a period of instability across all credit classes which came to a close by early 1987.

For comparison purposes, the model was estimated recursively using the slope of the Treasury yield curve as the explanatory variable. The results, presented in Figure 6, suggest the existence of a structural break in 1984 followed by a two year period characterized by coefficient instability. Another structural break occurred in 1990, followed again by an unstable period that lasted two years.[15] It should be noted that in each structural break, the coefficients of the slope of the Treasury yield curve adjusted downwards suggesting a decline in its predictive power since 1985. In contrast, the coefficients of the corporate spread curve trended upwards. The next section analyzes the robustness of the predictive power of the corporate spread curve in more detail, and also evaluates its out-of-sample forecasting ability.

C. Evaluating the Quality of Predictions

The predictive performance of the corporate spread curve was assessed relative to the performance of several alternative models, including the random walk model, and models using the corporate bond yield curve, the term structure of agency bond yields and Treasury bond yields.[16] Rolling out-of-sample forecasts and Root Mean Squared Errors (RMSE) for the period from January 1981 to March 2001 were estimated for these models. The results, reported in Table 7, show that the corporate spread curve for all credit tiers outperforms the random walk model, the Treasury yield curve, and the agency bond yield curve in forecasting the future cumulative growth rate of industrial production over all forecasting horizons, with AA being the only exception.

Compared to the term structure of corporate bond yields, the evidence is mixed. Point estimates of RMSE for the AAA-corporate spread curve are smaller than those for the yield term structure over horizons beyond 12 months, for the A-rated corporate spread curve over 3 to 9 months horizons, and for the Baa-rated corporate over 3 and 6 months horizons only. However, some of these estimates are statistically indistinguishable from each other.

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[15] The same analysis was also performed for the term structure of corporate yields and agency bonds. It yielded results similar to the analysis of the U.S. Treasury term structure and is not reported here.

[16] The choice of the random walk model is guided by the documented empirical behavior of real GDP growth rate (Cochrane, 1988) and the authors' analysis of the time series properties of the growth rate of industrial production. The choice of the Treasury term structure is justified by a vast literature outlined in the introduction that uses this variable to predict real activity. The term structure of corporate yields is used for comparison purposes with the paper by Saito and Takeda (2000), who used the term structure of AAA-rated bonds to predict real GDP growth in the United States.

Regarding the ability to predict the future marginal growth rate of industrial production, our model does better than the random walk at all forecasting horizons except 3 months (see Table 8). This result holds for all credit classes. The term structure of spreads does better that the Treasury term structure for two lower credit tiers, A and Baa, and slightly worse for two other credit classes. Spreads do better than yields over shorter forecasting horizons, 3 and 6 moths, for A and Baa bonds only. The term structure of agencies was not significant for most of the forecasting period, and, therefore, is not presented in the table.

The analysis described above, which spans the post-1990 period, shows that our model performed better than the random walk. Nevertheless, we consider necessary to assess whether the forecasting power of the corporate spread curve has deteriorated after the structural break in 1985. To this end, we estimated the out-of-sample forecasting of the corporate spread curve for different periods, including the structural break of 1985, and compared the RMSE to the random walk model. The results, presented in Table 9, show that the structural break of 1985 did not affect negatively the forecasting power of the corporate spread curve. Moreover, the corporate spread curve outperforms the random walk model in predicting cumulative growth of industrial production after 1985 over 3 to 48 months forecasting horizons across all credit classes.

The model also outperforms the random walk for all credit classes below AAA even before 1985 but these results shall be interpreted with caution due to the relatively small number of observations used in the forecast estimation. The AAA-rated corporate spread curve outperforms the random walk in the pre-1985 period for 18 to 48 months forecasting horizons, and after 1985 over all forecasting horizons except 3 months.

To assess whether the remarkably long economic expansion in the United States has influenced the predictive power of the term structure of spreads, we also estimate RMSEs for two periods – before and after 1995. This cut-off point, although somewhat arbitrary, roughly coincides with a significant compression of corporate spreads in the U.S. bond markets.[17] The results show a significant improvement in the precision of forecasts produced by the term structure of corporate spreads after 1995 compared to the previous period (see Table 9). Compared to the random walk, our model does slightly better in the first period and significantly better in the second period.

D. Directional Accuracy of Predictions

The directional accuracy of the model's predictions can be evaluated in different ways. One of them is to assess whether the model can predict cyclical turning points of the dependent variable. However, there is no clear definition of what a cyclical turning point of industrial production is, making it difficult to draw meaningful conclusions about the accuracy of the model. Therefore, the analysis is limited to documenting how many times the

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[17] See Chan-Lau and Ivaschenko (2000).

model correctly predicts whether industrial production growth changes are positive or negative in period $t + 1$ conditional on the information available in period t. Table 10 shows that the corporate spread curve correctly predicts the sign of changes in the growth rate of industrial production in more than fifty percent of all cases. The model is more successful in predicting positive changes in the dependent variable, being correct in more than 60 percent of cases, while the probability of being correct in predicting negative changes never exceeds 51 percent. For comparison purposes, the probability of being correct by forecasting flipping a fair coin would be only 25 percent.[18] Nevertheless, the model performs well taking into account that monthly changes of industrial production are very volatile.

V. Conclusions

An empirical regularity of the US data, the countercyclical behavior of the slope of the term structure of corporate spreads to Treasuries, or corporate spread curve, suggests that it may be a useful predictor of real economic activity. The empirical results reported here corroborate this conjecture: the corporate spread curve can explain future cumulative changes in industrial production over three to 48 months forecasting horizons. Moreover, it predicts the marginal rate of growth of industrial production, a variable much more difficult to predict, 6 to 18 months into the future.

The results also confirm that the steepening of the spread curve signals a future economic slowdown, a fact which could reflect market expectations about increasing default risk in the future, a conspicuous feature of an economic downturn. The analysis also confirms that the corporate spread curve has additional information about real activity beyond that contained in the Treasury yield curve and other variables commonly used to predict economic activity including lagged values of industrial production growth and the paper-bill spread.

The relationship between the corporate spread curve and future growth of industrial production uncovered in this study has been relatively stable, and has not experienced significant structural breaks since early 1980. Unlike the Treasury yield curve, the corporate spread curve has been relatively stable predictor of real activity during the last recession. Moreover, contrary to other financial variables, the corporate spread curve has not lost its forecasting power after 1985 and the quality of its predictions has improved significantly after 1995. It should be kept in mind, though, that conclusions about the stability of the relationship between the corporate spread curve and real activity should be taken cautiously given the limited amount of data available since the last recession.

[18] It is not possible to perform a formal chi-square test of directional accuracy in this case because of overlapping observations. See Conover (1998) for details.

Table 1. Correlations between the Corporate Spread Curve and the Marginal Growth Rate of Industrial Production

The slope of the term structure is defined as a difference between long- and intermediate- maturity corporate spreads to Treasury securities. The slope of the term structure is lagged ***k*** months.

	AAA	AA	A	Baa
***k* =0**	-0.055	-0.031	-0.001	-0.003
***k* =3**	-0.175	-0.164	-0.118	-0.116
***k* =6**	-0.223	-0.221	-0.175	-0.171
***k* =9**	-0.293	-0.321	-0.280	-0.282
***k* =12**	-0.392	-0.448	-0.419	-0.401
***k* =18**	-0.343	-0.414	-0.437	-0.416
***k* =24**	-0.226	-0.250	-0.313	-0.273

Table 2. Sample Statistics

	Mean	Variance
Growth Rate of Industrial Production		
Marginal	2.828	21.203
Cumulative for the next k months		
k = 3	2.633	50.936
k = 6	2.656	35.008
k = 9	2.668	25.850
k = 12	2.686	20.876
k = 18	2.692	10.841
k = 24	2.748	5.575
k = 36	2.870	3.700
k = 48	2.901	
Term Structure of Corporate Spreads		
AAA	-0.044	0.168
AA	-0.001	0.181
A	-0.026	0.174
Baa	-0.065	0.237

Table 3. GMM Estimation of the Relationship Between the Corporate Spread Curve, Different Yield Curves and the Future Cumulative Growth Rate of Industrial Production

The moment conditions estimated are as follows $E_t[(Y_t(k) + X_t`\beta) \otimes Z_t] = 0_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and X_t is $TERM_t$ defined as a difference between long- and intermediate-maturity corporate spreads to Treasury securities. $Y_t(k)$ is calculated as a marginal percentage change in the Index, k periods ahead. $Z_t' = (Constant, X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are standard deviations for coefficients, corrected for autocorrelation and heteroskedasticity.

	k = 3	*k = 6*	*k = 9*	*k = 12*	*k = 18*	*k = 24*	*k = 36*	*k = 48*
Corporate Spreads								
AAA								
α	-2.695*	-2.341*	-2.360*	-2.409*	-2.596*	-2.646*	-2.730*	-2.718*
	(0.800)	(0.792)	(0.750)	(0.708)	(0.624)	(0.670)	(0.593)	(0.552)
β	6.501*	6.256*	5.693*	5.227*	3.745*	2.921*	2.110*	1.880*
	(2.518)	(2.372)	(2.355)	(2.111)	(1.442)	(1.322)	(1.088)	(0.918)
AA								
α	-3.011*	-2.604*	-2.587*	-2.612*	02.736*	-2.757*	-2.775*	-2.876*
	(0.821)	(0.817)	(0.775)	(0.717)	(0.606)	(0.620)	(0.530)	(0.460)
β	7.593*	7.180*	7.057*	6.602*	4.928*	3.948*	2.553*	2.020*
	(2.632)	(2.044)	(1.918)	(1.719)	(1.226)	(0.072)	(0.930)	(0.851)
A								
α	-2.887*	-2.260*	-2.544*	-2.562*	-2.678*	-2.734*	-2.874*	-2.971*
	(0.777)	(0.789)	(0.750)	(0.708)	(0.640)	(0.661)	(0.538)	(0.474)
β	7.242*	6.539*	6.084*	5.711*	4.637*	3.791	1.698	1.015
	(2.4140	(1.839)	(1.688)	(1.564)	(1.273)	(0.108)	(0.971)	(0.941)
Baa								
α	-2.718*	-2.433*	-2.463*	-2.528*	-2.675*	-2.758*	-2.940*	-3.037*
	(0.723)	(0.748)	(0.714)	(0.678)	(0.637)	(0.671)	(0.516)	(0.437)
β	5.983*	5.188*	4.992*	4.605*	3.768*	3.113*	1.231*	0.687
	(2.012)	(1.458)	(1.194)	(1.065)	(0.891)	(0.762)	(0.533)	(0.554)

Table 3. GMM Estimation of the Relationship between the Corporate Spread Curve or different Yield Curves and the Future Cumulative Growth Rate of Industrial Production (concluded)

Corporate Yields								
AAA								
α	1.033	1.522	0.911	0.287	-0.219	-0.688	-1.230*	-1.836*
	(1.272)	(1.519)	(1.067)	(0.753)	(0.543)	(0.520)	(0.559)	(0.405)
β	-7.442*	-7891*	-6.823*	-5.777*	-5.049*	-4.202*	-2.977*	-2.091*
	(2.075)	(2.306)	(1.618)	(1.110)	(0.835)	(0.590)	(0.573)	(0.444)
AA								
α	1.434	1.951	0.953	0.250	-0.212	-0.485	-0.913	-1.510*
	(1.271)	(1.737)	(1.253)	(0.840)	(0.575)	(0.638)	(0.745)	(0.611)
β	-7.429*	-7.917*	-6.331*	-5.225*	-4.558*	-4.030*	-3.146*	-2.275*
	(2.304)	(2.742)	(1.968)	(1.324)	(0.927)	(0.774)	(0.738)	(0.555)
A								
α	1.182	1.368	0.513	-0.077	-0.691	-0.843	-1.030	-1.431*
	(1.293)	(1.473)	(1.110)	(0.860)	(0.688)	(0.671)	(0.700)	(0.583)
β	-7.169*	-7.221*	-5.852*	-4.879*	-3.951*	-3.535*	-3.033*	-2.444*
	(2.624)	(2.685)	(1.946)	(1.396)	(1.043)	(0.834)	(0.750)	(0.497)
Baa								
α	1.165	1.193	0.373	-0.213	-0.915	-0.876	-0.639	-1.234
	(1.417)	(1.622)	(1.286)	(0.960)	(0.661)	(0.656)	(0.596)	(0.838)
β	-7.592*	-7.345*	-5.895*	-4.864*	-3.705*	-3.561*	-3.645*	-3.204*
	(2.659)	(2.764)	(1.968)	(1.309)	(0.831)	(0.840)	(0.733)	(1.234)
Agency Yields								
α	-1.234*	-1.560*	-1.566	-1.511	-1.576*	-1.691*	-2.011*	-2.243*
	(0.838)	(0.795)	(.0823)	-0.0791	(0.719)	(0.754)	(0.720)	(0.576)
β	-3.204*	-2.690*	-2.556*	-2.483*	-2.166*	-1.858*	-1.311*	-1.055*
	(1.234)	(1.201)	(0.928)	(0.809)	(0.608)	(0.488)	(0.475)	(0.352)
Treasury Yields								
α	-0.535	-0.045	-0.303	-0.692	-1.224*	-1.494*	-1.785*	-2.148*
	(0.770)	(1.029)	(0.958)	(0.744)	(0.560)	(0.645)	(0.666)	(0.536)
β	-4.158*	-4.372*	-3.937*	-3.390*	-2.671*	-2.206*	-1.603*	-1.190*
	(1.261)	(1.359)	(1.196)	(0.875)	(0.570)	(0.446)	(0.435)	(0.341)

* indicates estimator significant at 5 percent level.

The weighting matrix is estimated using the Newey-West procedure to ensure it is a positive-semidefinite. We use 36 lags in the Newey-West estimator.

Table 4. GMM Estimation of the Relationship between the Corporate Spread Curve or Different Yield Curves and the Future Marginal Growth Rate of Industrial Production

The moment conditions estimated are as follows $E_t[(Y_t(k) + X_t`\beta) \otimes Z_t] = 0_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and X_t is $TERM_t$ defined as a difference between long- and intermediate-maturity corporate spreads to Treasury securities. $Y_t(k)$ is calculated as a marginal percentage change in the Index, k periods ahead. $Z_t' = (Constant, X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are standard deviations for coefficients, corrected for autocorrelation and heteroskedasticity.

	k =3	*k =6*	*k =9*	*k =12*	*k =18*	*k =24*	*k = 36*	*k = 48*
Corporate Spreads								
AAA								
α	-3.453*	-3.270*	-2.903*	-2.554*	-2.719*	-3.155*	-3.167*	-3.112*
	(0.730)	(0.720)	(0.725)	(0.732)	(0.659)	(0.785)	(0.769)	(0.629)
β	2.679	3.323	4.425*	5.151*	3.615*	0.753	0.839	0.894
	(2.164)	(2.004)	(2.060)	(2.164)	(6.668)	(1.795)	(1.501)	-1.283
J-statistic (p-value)	0.001	0.000	0.003	0.049	0.012	0.069	0.000	0.000
AA								
α	-3.644*	-3.483	-3.104	-2.731*	-2.788*	-3.153*	-3.206*	-3.184*
	(0.718)	(0.707)	(0.724)	(0.732)	(0.642)	(0.737)	(0.740)	(0.622)
β	3.531	4.620*	6.049*	6.664*	4.866*	1.241	0.342	0.005
	(1.935)	(1.910)	(1.846)	(1.755)	(1.565)	(1.719)	(0.206)	(1.638)
J-statistic (p-value)	0.000	0.000	0.000	0.068	0.010	0.057	0.000	0.000
A								
α	-3.568*	-3.402*	-3.044*	-2.685*	-2.701*	-3.054*	-3.261*	-3.259*
	(0.708)	(0.695)	(0.706)	(0.728)	(0.687)	(0.752)	(0.772)	(0.593)
β	3.671	4.537*	5.364*	5.754*	4.936*	1.903	-0.644	-1.177
	(0.012)	(1.846)	(1.643)	(1.614)	(1.581)	(1.533)	(1.631)	(1.474)
J-statistic (p-value)	0.000	0.000	0.000	0.023	0.005	0.059	0.000	0.000
Baa								
α	-3.536*	-3.372*	-3.019*	-2.683*	-2.705*	-3.044*	-3.260*	-3.216*
	(0.674)	(0.651)	(0.664)	(0.696)	(0.694)	(0.767)	(0.758)	(0.594)
β	2.632	3.540*	4.342*	4.628*	4.072*	1.907	-0.653	-0.577
	(1.648)	(1.565)	(1.325)	(1.088)	(1.144)	(1.256)	(1.190)	(1.172)
J-statistic (p-value)	0.000	0.000	0.000	0.028	0.009	0.065	0.000	0.000

Table 4. GMM Estimation of the Relationship between the Corporate Spread Curve or Different Yield Curves and the Future Marginal Growth Rate of Industrial Production (concluded)

Corporate Yields								
AAA								
α	-1.532*	-0.725	0.112	0.179	-0.813	-1.653	-3.069*	-3.838*
	(0.773)	(0.829)	(0.895)	(0.744)	(0.777)	(0.944)	(1.259)	(0.758)
β	-4.010*	-5.109*	-6.072*	-5.826*	-4.0612*	-2.820*	-0.416	1.054
	(1.012)	(.1.207)	(1.347)	(1.121)	(0.950)	(0.909)	(1.698)	(1.403)
AA								
α	-1.465	-0.625	0.139	0.100	-0.996	-1.549	-2.870*	-3.429*
	(0.921)	(1.046)	(1.0800	(0.826)	(0.965)	(1.190)	(1.367)	(0.904)
β	-3.563*	-4.666*	-5.552*	-5.202*	-3.464*	-2.772*	-0.814	0.283
	(1.303)	(1.584)	(1.715)	(1.327)	(1.181)	(1.159)	(1.652)	(1.374)
A								
α	-1.791	-0.896	-0.010	-0.220	-1.433	-2.034	-2.542*	-2.972*
	(0.992)	(1.109)	(1.079)	(0.859)	(1.000)	(1.190)	(1.244)	(0.987)
β	-2.977*	-4.258*	-5.440*	-4.868*	-2.865*	-2.065	-1.392	-0.564
	(1.398)	(1.788)	(1.896)	(1.402)	(1.160)	(1.143)	(1.381)	(1.301)
Baa								
α	-1.429	-0.701	-0.083	-0.368	-1.942	-2.342	-2.341	-3.122*
	(1.112)	(1.260)	(1.234)	(0.955)	(1.147)	(1.340)	(1.408)	(0.981)
β	-3.734*	-4.681*	-5.519*	-4.829	-2.089	-1.543	-1.858	-0.388
	(1.443)	(1.807)	(1.857)	(1.306)	(1.476)	(1.617)	(1.803)	(1.358)
Agency Yields								
α	-3.087*	-2.622*	-2.003*	-1.625*	-1.637*	-2.226*	-2.502*	-2.915*
	(0.940)	(0.843)	(0.794)	(0.798)	(0.754)	(0.967)	(1.002)	(0.759)
β	-0.854	-1.615	-2.362*	-2.488*	-2.034*	-1.116	-0.493	-0.225
	(0.837)	(0.910)	(0.913)	(0.814)	(0.499)	(0.753)	(0.916)	(0.740)
Treasury Yields								
α	-2.405*	-1.921*	-1.203	-0.829	-1.477*	-2.390*	-3.062*	-3.286*
	(0.743)	(0.745)	(0.791)	(0.730)	(0.627)	(0.962)	(1.018)	(0.664)
β	-2.019*	-2.538*	-3.196	-3.389*	-2.387*	-1.224	-0.356	0.085
	(0.840)	(0.890)	(0.966)	(0.974)	(0.493)	(0.700)	(0.923)	(0.798)

* indicates estimator significant at 5 percent level.
The weighting matrix is estimated using the Newey-West procedure to ensure it is a positive-semidefinite. We use 36 lags in the Newey-West estimator.

Table 5. GMM Estimation of the Relationship Between the Corporate Spread Curve (Spreads to Agencies) and the Future Cumulative Growth Rate of Industrial Production

The moment conditions estimated are as follows $E_t[(Y_t(k) + X_t`\beta) \otimes Z_t] = 0_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and X_t is $TERM_t$ defined as a difference between long- and intermediate-maturity corporate spreads to agency securities. $Y_t(k)$ is calculated as a marginal percentage change in the Index, k periods ahead. $Z_t' = (Constant, X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are standard deviations for coefficients, corrected for autocorrelation and heteroskedasticity.

	k =3	*k =6*	*k =9*	*k =12*	*k =18*	*k =24*	*k =36*	*k =48*
AAA								
α	-2.964*	-2.973*	-2.879*	-2.879*	-2.799*	-2.738*	-2.930*	-2.854*
β	4.001**	2.648	2.390	2.390	1.638**	1.431	0.961	1.104
	(2.113)	(1.705)	(1.628)	(1.627)	(0.906)	(0.984)	(1.089)	(0.782)
AA								
α	-3.230*	-3.147*	-3.024*	-2.955*	-2.865*	-2.790*	-2.916*	-2.940*
β	5.303*	4.603*	4.510*	4.152*	3.028*	2.379*	1.368	1.279
	(2.332)	(1.834)	(1.643)	(1.478)	(1.009)	(1.005)	(0.862)	(0.826)
A								
α	-3.117*	-3.051*	-2.943*	-2.877*	-2.803*	-2.752*	-2.972*	02.985*
β	5.184*	4.311*	3.987*	3.736*	2.962*	2.376*	0.771	0.504
	(2.172)	(1.698)	(1.534)	(1.451)	(1.168)	(1.087)	(0.865)	(0.820)
Baa								
α	-2.984*	-2.943*	-2.849*	-2.808*	-2.745*	-2.728*	-2.992*	-3.026*
β	4.849*	4.226*	3.980*	3.621*	2.893*	2.246*	0.663	0.385
	(1.897)	(1.534)	(1.328)	(1.1139)	(0.936)	(0.817)	(0.507)	(0.534)

* estimator is significant at 5 percent level;** estimator is significant at 10 percent level
The weighting matrix is estimated using the Newey-West procedure to ensure it is a positive-semidefinite. We use 36 lags in the Newey-West estimator.

Table 6. GMM Estimation of the Relationship Between the Corporate Spreads Curve and the Future Cumulative Growth Rate of Industrial Production Including the Lagged Dependent Variable as a Regressor

The moment conditions estimated are as follows $E_t[(Y_t(k) + X_t`\beta_1 + Y`_{t-1}\beta_2) \otimes Z_t] = 0_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and X_t is $TERM_t$ defined as a difference between long- and intermediate-maturity corporate spreads to Treasury securities. $Y_t(k)$ is calculated as a marginal percentage change in the Index, k periods ahead. $Z_t' = (Constant, X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are standard deviations for coefficients, corrected for autocorrelation and heteroskedasticity.

	k = 3	*k = 6*	*k = 9*	*k = 12*	*k = 18*	*k = 24*	*k = 36*	*k = 48*
Corporate Spreads								
AAA								
α	-1.391*	-1.760*	-2.018*	-2.536*	-3.160*	-3.582*	-3.541*	-3.653*
	(0.641)	(0.624)	(0.765)	(0.765)	(0.916)	(0.880)	(0.400)	(0.307)
β_1	5.70*	6.158*	5.184*	5.168*	3.487*	2.678*	1.893*	1.659*
	(1.965)	(2.223)	(2.247)	(2.065)	(1.489)	(1.147)	(0.633)	(0.474)
β_2	-0.295*	-0.146*	-0.077	0.028	0.136	0.245	0.306	0.412*
	(0.075)	(0.074)	(-0.784)	(0.124)	(0.138)	(0.150)	(0.174)	(0.189)
AA								
α	-1.670*	-2.007*	-2.247*	-2.745*	-3.254*	-3.549*	-3.412*	-3.611*
	(0.667)	(0.614)	(0.700)	(0.750)	(0.754)	(0.776)	-0.345	(0.223)
β_1	6.038*	6.879*	6.975*	6.616*	4.888*	3.810*	2.216*	1.630*
	(1.903)	(1.853)	(1.870)	(1.764)	(1.335)	(1.086)	(0.681)	(0.621)
β_2	-0.294*	-0.152*	-0.076	0.029	0.127	0.208	0.246	0.370
	(0.077)	(0.067)	(0.088)	(0.105)	(0.123)	(0.150)	(0.173)	(0.207)
A								
α	-1.4848*	-1.841*	-2.041*	-2.618*	-3.177*	-3.502*	-3.501*	-3.795*
	(0.657)	(0.609)	(0.704)	(0.751)	(0.738)	(0.740)	(0.290)	(0.267)
β_1	5.514*	6.254*	6/065*	5.714*	4.605*	3.737*	1.712*	0.928
	(2.680)	(1.604)	(1.592)	(1.577)	(1.382)	(1.171)	(0.760)	(0.569)
β_2	-0.310*	-0.174*	-0.109	0.012	0.124	0.213	0.277	0.430*
	(0.078)	(0.062)	(0.083)	(0.104)	(0.119)	(0.146)	(0.166)	(0.198)
Baa								
α	-1.358*	-1.772*	-1.971*	-2.561*	-3.162*	-3.547*	-3.509*	-3.811*
	(0.27)	(0.574)	(0.686)	(0.726)	(0.735)	(0.750)	(0.301)	(0.300)
β_1	4.410*	4.943*	4.882*	4.611*	3.824*	3.063*	1.244*	0.565
	(1.453)	(1.196)	(1.084)	(1.142)	(1.055)	(0.897)	(0.474)	(0.342)
β_2	-0.309*	-0.166*	-0.107	0.007	0.124	0.226	0.272	0.428
	(0.084)	(0.068)	(0.089)	(0.103)	(0.117)	(0.151)	(0.173)	(0.195)

* indicates estimator significant at 5 percent level.
The weighting matrix is estimated using the Newey-West procedure to ensure it is a positive-semidefinite. We use 36 lags in the Newey-West estimator.

Table 7. Out-of-Sample Forecasting Performance of Different Models in Predicting the Future Cumulative Growth Rate of Industrial Production

Figures in the table are the Root Mean Squared Errors (RMSE) for out-of-sample forecasts of the cumulative growth rate of industrial production produced by different models. Out-of-sample forecasts are produced for the pariod from 1990:1 to 2002:6 - k, where k is a forecasting horizon. First model is a random walk model of the growth rate of industrial production, second model uses the term structure of Treasury securities as explanatory variable, third model uses the term structure of Agency bonds, and the last model uses term structures of different corporate spreads as explanatory variables. Term structure is defined as a difference between long and intermediate maturity bond yields or bonds spreads.

	$k = 3$	$k = 6$	$k = 9$	$k = 12$	$k = 18$	$k = 24$	$k = 36$	$k = 48$
Random Walk	4.701	4.238	3.939	3.904	3.556	3.292	2.511	2.600
Treasury Term Structure	4.565	3.554	2.941	2.506	2.017	2.006	2.018	2.186
Agency Term Structure	4.647	3.452	2.771	2.409	2.078	2.050	1.902	2.144
Corporate Spread Term Structure:								
AAA	4.369	3.508	2.901	2.482	1.941	1.759	1.669	2.077
AA	5.150	3.895	3.745	3.483	2.694	2.401	2.184	2.311
A	4.268	3.482	3.022	2.781	2.389	2.360	2.127	2.216
Baa	4.332	3.498	3.062	2.804	2.448	2.311	2.038	2.165
Corporate Yield Term Structure:								
AAA	4.207	3.358	2.814	2.482	2.126	2.200	2.290	2.183
AA	5.055	4.394	3.226	2.549	2.098	2.103	2.037	2.192
A	5.427	4.172	3.090	2.378	1.729	1.735	1.911	2.183
Baa	5.021	3.823	2.926	2.309	1.619	1.698	1.894	2.218

Table 8. Out-of-Sample Forecasting Performance of Different Models in Predicting the Future Marginal Growth Rate of Industrial Production

Figures in the table are the Root Mean Squared Errors (RMSE) for out-of-sample forecasts of the future marginal growth rate of industrial production produced by different models. The forecasting period is from 1990:1 to 2001:6 - k, where k is the forecasting horizon. First model is a random walk model of the growth rate of industrial production, second model uses the term structure of Treasury securities as explanatory variable, third model uses the term structure of Agency bonds, and the last model uses term structures of different corporate spreads as explanatory variables. Term structure is defined as a difference between long and intermediate maturity bond yields or bonds spreads.

	$k = 3$	$k = 6$	$k = 9$	$k = 12$	$k = 18$	$k = 24$	$k = 36$	$k = 48$
Random Walk	1.819	3.128	4.139	4.945	5.604	5.481	5.176	5.359
Treasury Term Structure	3.126	2.987	2.816	2.534	2.310	2.390	2.302	2.343
Agency Term Structure	2.963	2.961	2.868	2.617	2.447	2.451	2.421	2.156
Corporate Spread Term Structure:								
AAA	3.155	2.987	2.891	2.733	2.484	2.514	2.315	2.331
AA	3.494	3.481	3.504	3.314	2.661	2.498	2.336	2.308
A	3.018	2.890	2.792	2.731	2.558	2.533	2.394	2.498
Baa	3.019	2.952	2.877	2.766	2.570	2.483	2.458	2.447
Corporate Yield Term Structure:								
AAA	2.843	2.655	2.466	2.242	2.225	2.331	2.394	2.429
AA	3.246	3.161	3.016	2.689	2.443	2.377	2.326	2.440
A	3.300	3.224	3.074	2.523	2.273	2.328	2.273	2.286
Baa	3.022	2.885	2.757	2.368	2.326	2.371	2.217	2.331

Table 9. Out-of-Sample Forecasting Performance of the Corporate Spreads Curve Across Three Different Periods

Figures in the table are the Root Mean Squared Errors (RMSE) for out-of-sample forecasts of the future marginal growth rate of industrial production produced by different models. First model is a random walk model of the growth rate of industrial production, second model uses the term structure of Treasury securities as explanatory variable, third model uses the term structure of Agency bonds, and the last model uses term structures of different corporate spreads as explanatory variables. Term structure is defined as a difference between long and intermediate maturity bond yields or bonds spreads. k is a forecasting horizon.

	$k=3$	$k=6$	$k=9$	$k=12$	$k=18$	$k=24$	$k=36$	$k=48$
Random Walk								
1980:1 - 1985:12	10.216	8.453	8.303	8.452	6.825	5.362	3.792	3.059
1986:1 - 2001:6 - k	4.547	3.871	3.218	2.900	2.623	2.716	2.511	2.537
1980:1 - 1995:12	7.300	6.057	5.700	5.674	4.733	4.057	3.170	2.815
1996:1 - 2001:6 - k	6.652	5.576	5.221	5.179	4.333	3.734	2.987	2.721
1980:1 - 2001:6 - k	6.976	5.817	5.461	5.427	4.533	3.896	3.079	2.768
Corporate Spread Term Structure:								
AAA								
1980:1 - 1985:12	10.210	9.465	9.394	8.885	5.786	3.590	2.396	1.739
1986:1 - 2001:6 - k	4.724	3.667	3.000	2.631	2.282	2.069	1.724	1.777
1980:1 - 1995:12	7.412	6.500	6.164	5.737	3.948	2.766	2.070	1.814
1996:1 - 2001:6 - k	3.944	3.431	3.260	3.127	2.396	1.866	1.023	0.996
1980:1 - 2001:6 - k	6.738	5.929	5.646	5.288	3.698	2.632	1.967	1.764
AA								
1980:1 - 1985:12	8.490	7.691	8.081	7.854	5.771	4.058	3.108	1.800
1986:1 - 2001:6 - k	5.051	3.786	3.621	3.411	3.001	2.775	2.100	1.962
1980:1 - 1995:12	6.661	5.474	5.626	5.443	4.307	3.448	2.635	1.961
1996:1 - 2001:6 - k	4.546	4.212	4.011	3.724	2.617	1.802	0.659	1.087
1980:1 - 2001:6 - k	6.215	5.207	5.308	5.124	4.035	3.224	2.472	1.908
A								
1980:1 - 1985:12	8.910	7.515	7.293	7.012	5.714	4.227	2.967	1.758
1986:1 - 2001:6 - k	4.375	3.477	3.078	2.876	2.817	2.774	2.075	1.880
1980:1 - 1995:12	6.424	5.199	4.890	4.686	4.139	3.475	2.510	1.861
1996:1 - 2001:6 - k	4.467	4.151	3.970	3.718	2.812	2.200	1.398	1.560
1980:1 - 2001:6 - k	6.009	4.975	4.700	4.497	3.917	3.290	2.397	1.839
Baa								
1980:1 - 1985:12	8.651	6.956	6.711	6.556	5.639	4.443	2.380	1.760
1986:1 - 2001:6 - k	4.148	3.331	2.975	2.709	2.708	2.715	2.011	1.839
1980:1 - 1995:12	6.197	4.837	4.516	4.322	3.990	3.504	2.227	1.837
1996:1 - 2001:6 - k	4.228	4.028	3.939	3.788	3.044	2.430	1.385	1.487
1980:1 - 2001:6 - k	5.782	4.661	4.393	4.213	3.825	3.343	2.138	1.812

Table 10. Out-of-Sample Directional Accuracy of the Corporate Spread Curve and Corporate Yield Curve in Predicting the Future Cumulative Growth Rate of Industrial Production

DOUT indicates the difference in the cumulative growth rate of industrial production from time t to time $t + 1$, DF indicates the difference in the forecasted cumulative growth rate of industrial production over the same period. Numbers in the table are simple number of observations falling into each category, unless indicated otherwise.

	k = 3	*k = 6*	*k = 9*	*k = 12*	*k = 18*	*k = 24*	*k = 36*	*k = 48*
Corporate Spread Term Structure:								
Number of obs., total	**130**	**127**	**124**	**121**	**115**	**109**	**97**	**85**
AAA								
DOUT > 0, DF > 0	32	34	33	38	35	30	27	30
DOUT <= 0, DF <= 0	32	35	25	25	27	22	17	14
DOUT > 0, DF <= 0	31	25	31	27	24	27	26	17
DOUT <=0, DF > 0	35	33	35	31	29	30	27	24
Percentage correct, total	0.49	0.54	0.48	0.52	0.54	0.48	0.45	0.52
Percentage correct, positive changes	0.51	0.58	0.53	0.58	0.59	0.53	0.151	0.64
Percentage correct, negative changes	0.48	0.51	0.42	0.45	0.48	0.42	0.39	0.38
AA								
DOUT > 0, DF > 0	29	29	33	31	29	29	28	30
DOUT <= 0, DF <= 0	36	36	31	25	26	26	23	12
DOUT > 0, DF <= 0	34	30	31	34	30	28	25	17
DOUT <=0, DF > 0	31	32	29	31	30	26	21	26
Percentage correct, total	0.50	0.52	0.52	0.46	0.48	0.50	0.53	0.49
Percentage correct, positive changes	0.46	0.49	0.52	0.48	0.49	0.51	0.53	0.64
Percentage correct, negative changes	0.54	0.53	0.52	0.45	0.46	0.50	0.52	0.32
A								
DOUT > 0, DF > 0	33	29	27	36	30	25	27	30
DOUT <= 0, DF <= 0	34	31	21	29	29	23	24	11
DOUT > 0, DF <= 0	30	30	37	29	29	32	26	17
DOUT <=0, DF > 0	33	37	39	27	27	29	20	27
Percentage correct, total	0.52	0.48	0.39	0.54	0.51	0.44	0.53	0.48
Percentage correct, positive changes	0.52	0.49	0.42	0.56	0.51	0.44	0.51	0.64
Percentage correct, negative changes	0.51	0.46	0.35	0.52	0.52	0.44	0.55	0.29
Baa								
DOUT > 0, DF > 0	33	32	26	33	31	22	24	29
DOUT <= 0, DF <= 0	36	33	21	24	29	20	24	9
DOUT > 0, DF <= 0	30	27	38	32	28	35	29	18
DOUT <=0, DF > 0	31	35	39	32	27	32	20	29
Percentage correct, total	0.53	0.51	0.38	0.47	0.52	0.39	0.49	0.45
Percentage correct, positive changes	0.52	0.54	0.41	0.51	0.53	0.39	0.45	0.62
Percentage correct, negative changes	0.54	0.49	0.35	0.43	0.52	0.38	0.55	0.24

Table 10. Out-of-Sample Directional Accuracy of the Corporate Spread Curve and Corporate Yield Curve in Predicting the Future Cumulative Growth Rate of Industrial Production (concluded)

Corporate Yield Term Structure:								
AAA								
DOUT > 0, DF > 0	25	27	29	25	26	28	30	30
DOUT <= 0, DF <= 0	31	34	28	23	27	24	25	18
DOUT > 0, DF <= 0	38	32	35	40	33	29	23	17
DOUT <=0, DF > 0	36	34	32	33	29	28	19	20
Percent correct, total	0.43	0.48	0.46	0.40	0.46	0.48	0.57	0.56
Percent correct, positive changes	0.40	0.46	0.45	0.38	0.44	0.49	0.56	0.64
Percent correct, negative changes	0.46	0.50	0.47	0.41	0.48	0.46	0.57	0.48
AA								
DOUT > 0, DF > 0	28	27	30	32	31	25	30	30
DOUT <= 0, DF <= 0	33	33	27	25	28	18	22	16
DOUT > 0, DF <= 0	25	32	34	33	28	32	23	17
DOUT <=0, DF > 0	34	35	33	31	28	34	22	22
Percent correct, total	0.47	0.47	0.46	0.47	0.51	0.39	0.54	0.54
Percent correct, positive changes	0.44	0.46	0.47	0.49	0.52	0.43	0.57	0.64
Percent correct, negative changes	0.49	0.49	0.45	0.45	0.50	0.35	0.50	0.42
A								
DOUT > 0, DF > 0	27	29	32	31	31	30	29	30
DOUT <= 0, DF <= 0	28	32	30	21	25	22	21	16
DOUT > 0, DF <= 0	36	30	32	34	28	27	24	17
DOUT <=0, DF > 0	39	36	30	35	31	30	23	22
Percent correct, total	0.42	0.48	0.50	0.43	0.49	0.48	0.52	0.54
Percent correct, positive changes	0.43	0.49	0.50	0.47	0.53	0.53	0.55	0.64
Percent correct, negative changes	0.42	0.47	0.50	0.38	0.45	0.42	0.48	0.42
Baa								
DOUT > 0, DF > 0	27	29	30	30	29	27	29	27
DOUT <= 0, DF <= 0	31	36	28	26	27	23	24	17
DOUT > 0, DF <= 0	36	30	34	35	30	30	24	20
DOUT <=0, DF > 0	36	32	32	30	29	29	20	21
Percent correct, total	0.45	0.51	0.47	0.46	0.49	0.46	0.55	0.52
Percent correct, positive changes	0.43	0.49	0.47	0.46	0.49	0.47	0.55	0.57
Percent correct, negative changes	0.46	0.53	0.47	0.46	0.48	0.44	0.55	0.45

Figure 1.

AAA Spread Term Structure and Growth Rate of Industrial Production

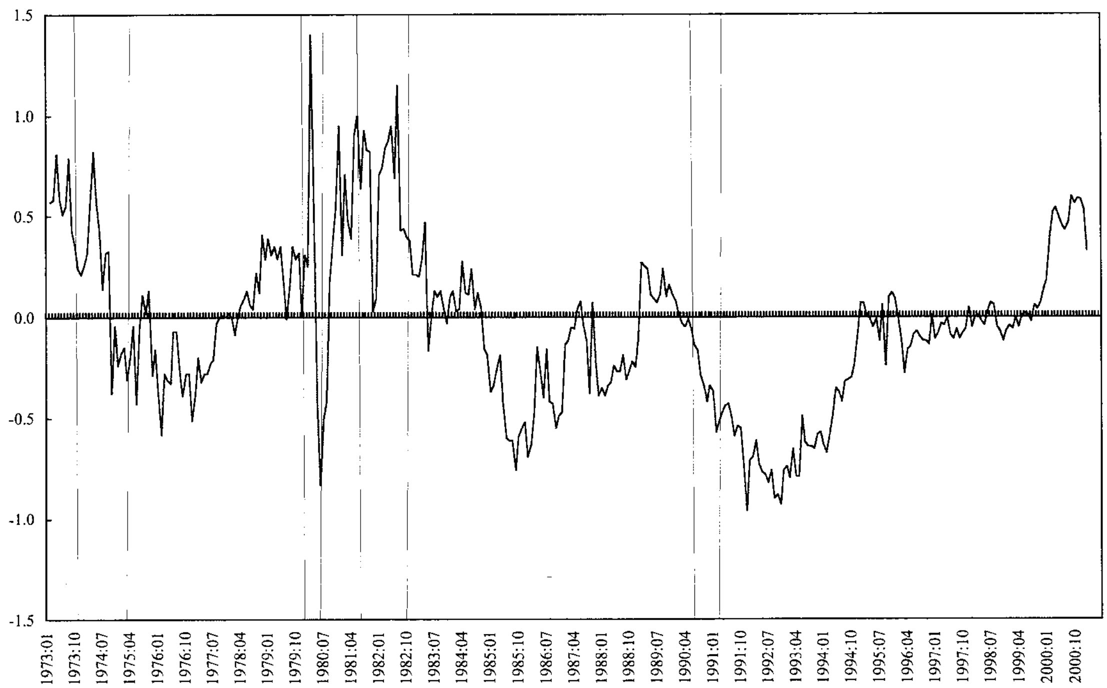


Figure 2. P-values of corporate spread curve coefficients

Cumulative Growth

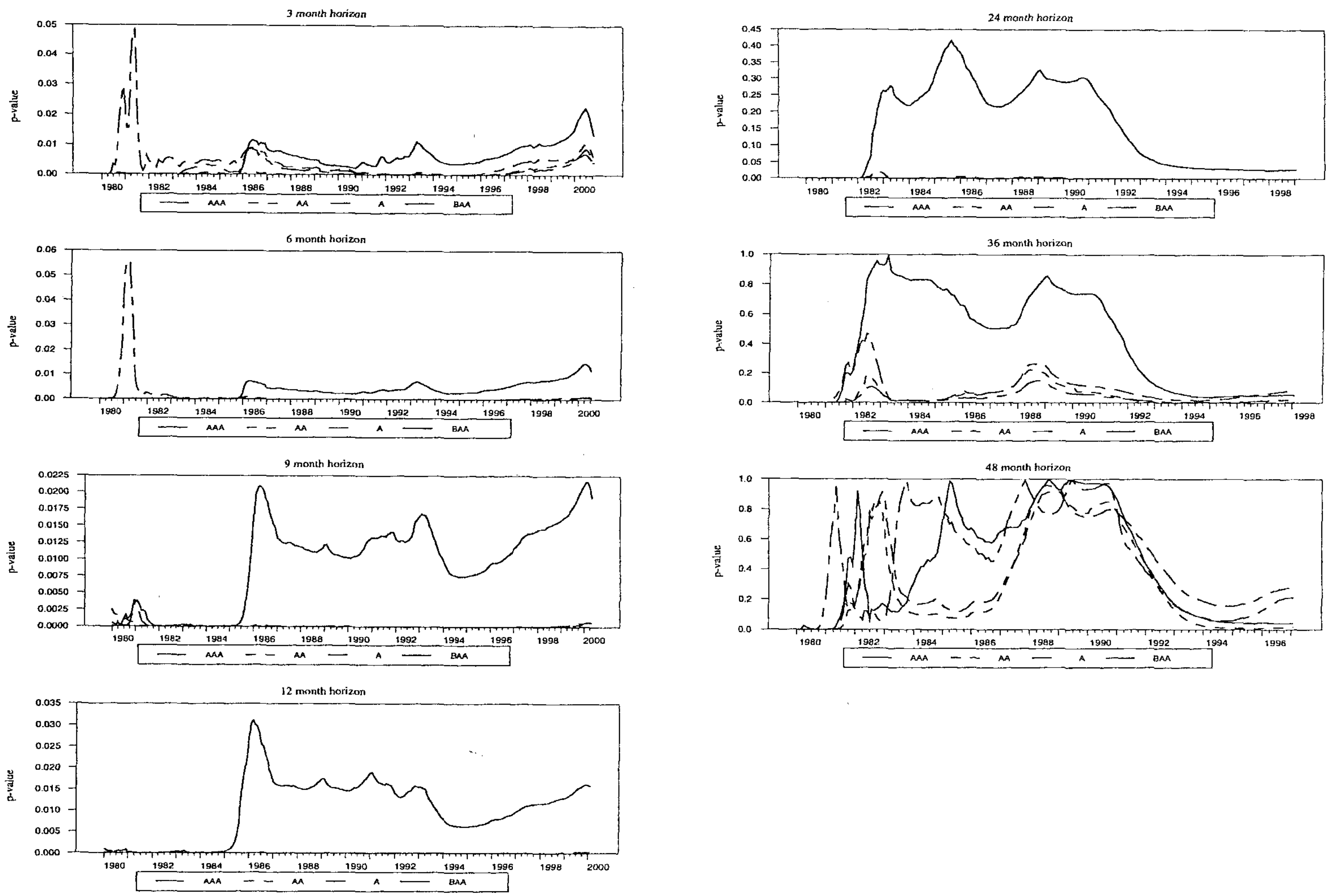


Figure 3. Corporate Spread Curve Coefficients: Estimates and Standard Errors - AAA
Cumulative Growth

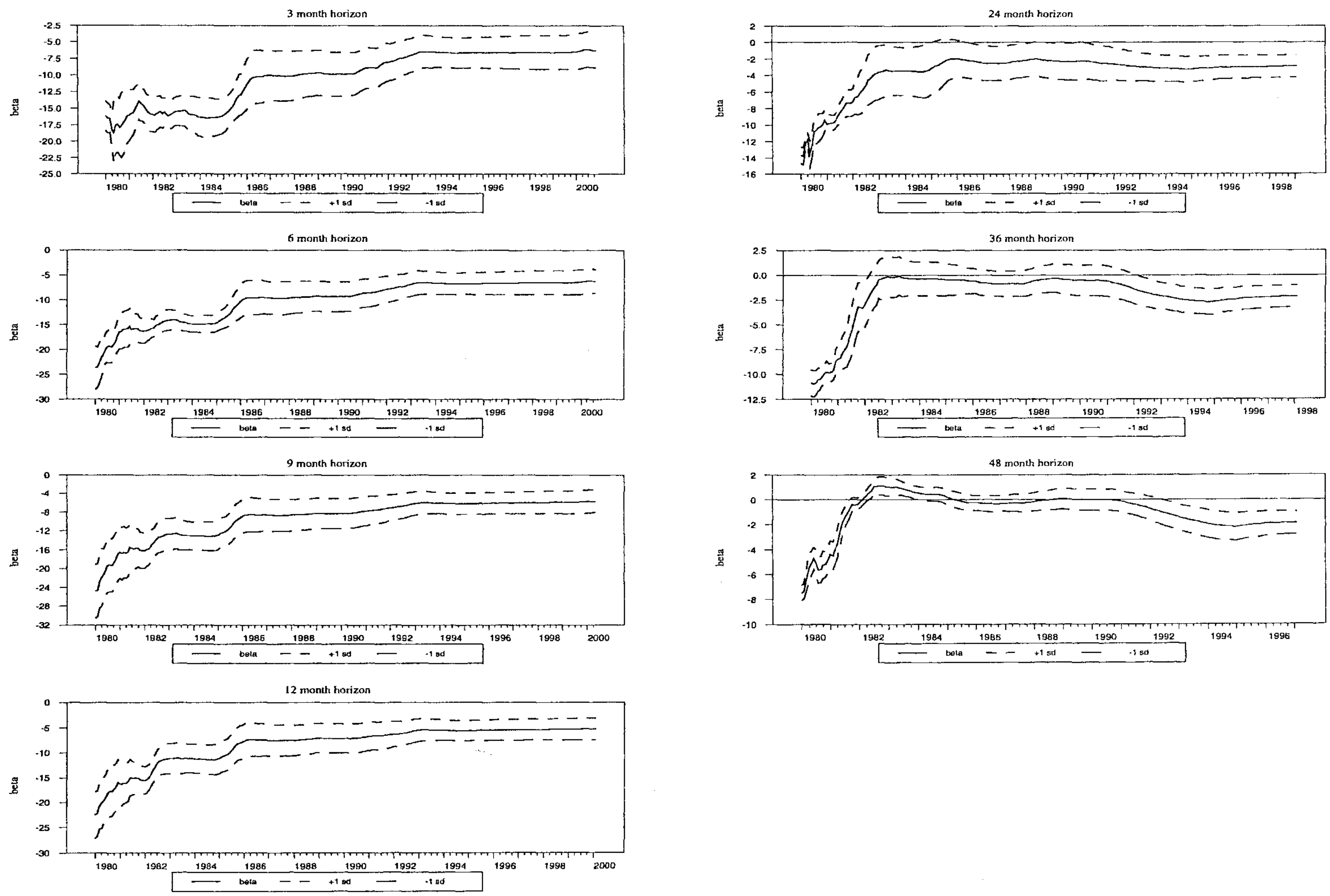


Figure 3 (cont.). Corporate Spread Curve Coefficients: Estimates and Standard Errors - AA

Cumulative Growth

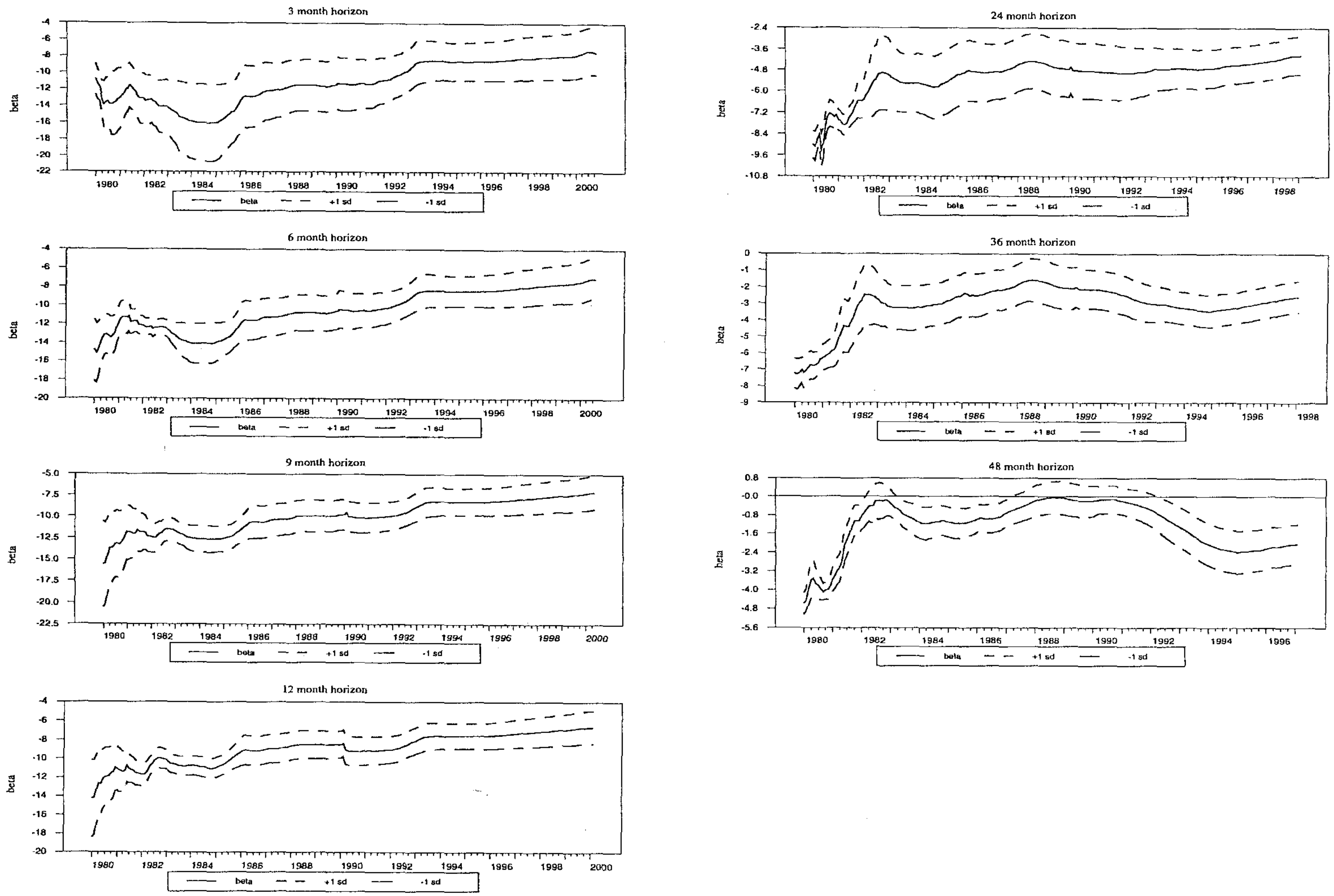


Figure 3 (cont.). Corporate Spread Curve Coefficients: Estimates and Standard Errors - A Cumulative Growth

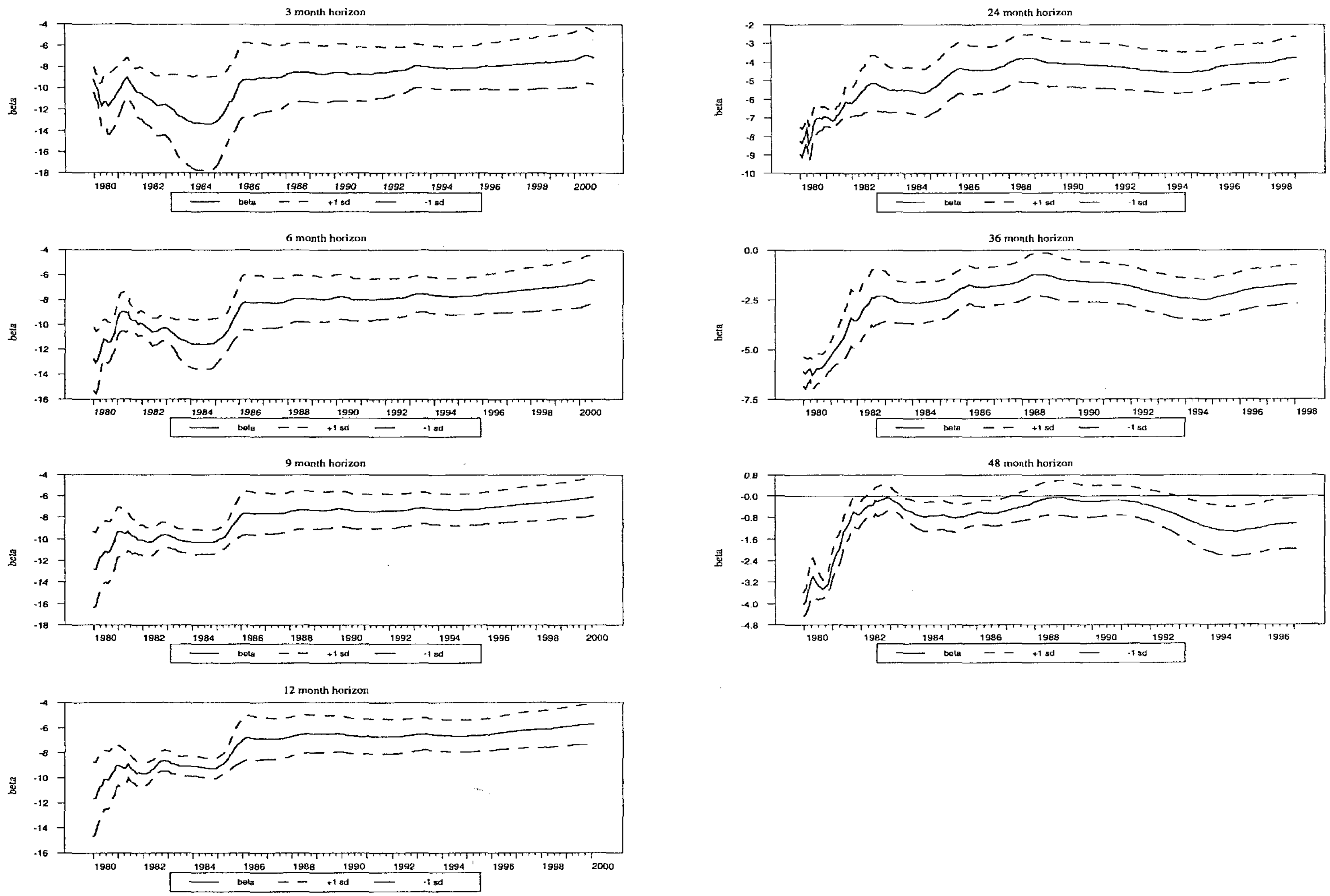


Figure 3 (cont.). Corporate Spread Curve Coefficients: Estimates and Standard Errors - BAA

Cumulative Growth

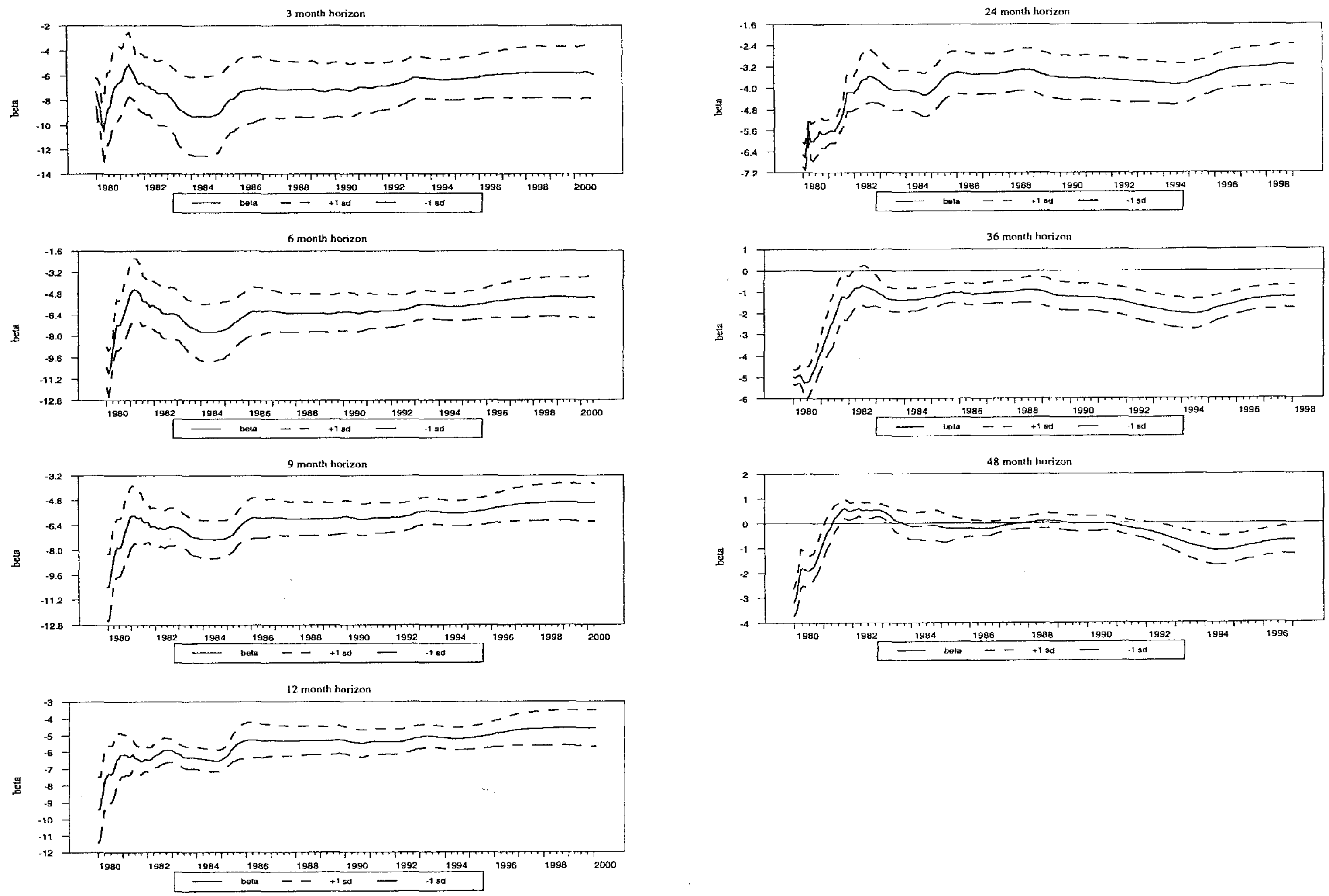


Figure 4. P-values of corporate spread curve coefficients

Marginal Growth

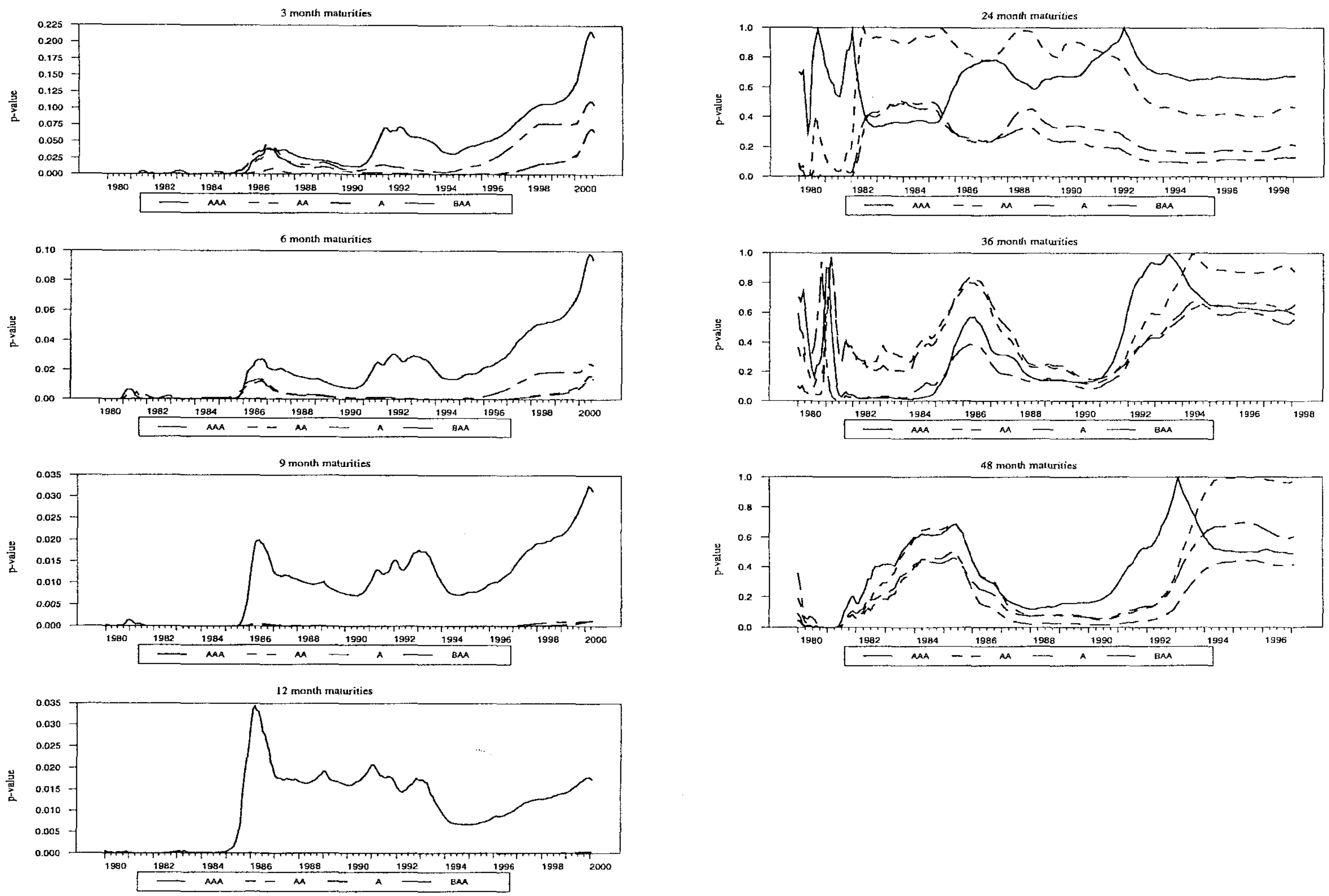


Figure 5. Corporate Spread Curve Coefficients Estimates and Standard Errors - AAA

Marginal Growth

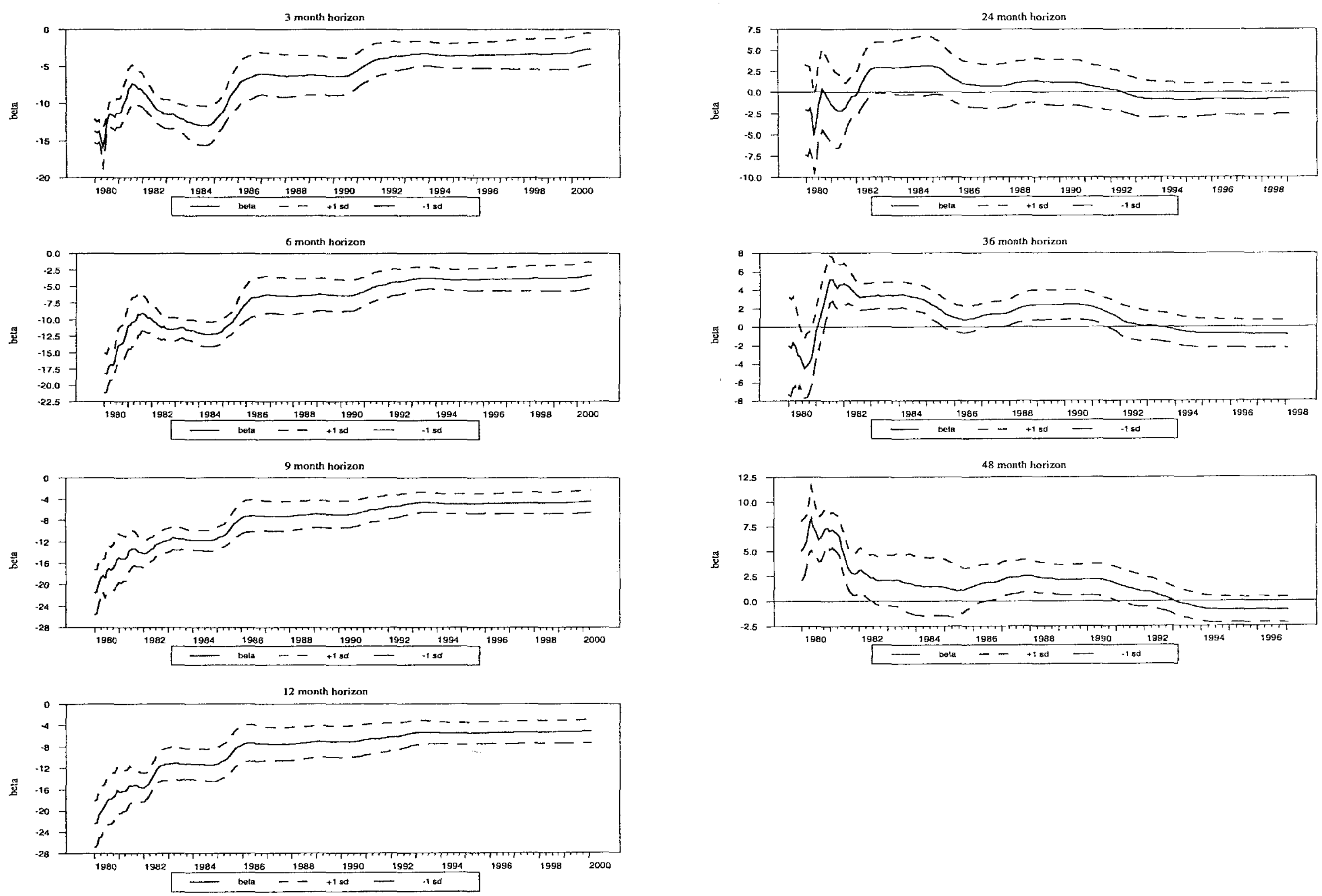


Figure 5 (cont.). Corporate Spread Curve Coefficients Estimates and Standard Errors - AA

Marginal Growth

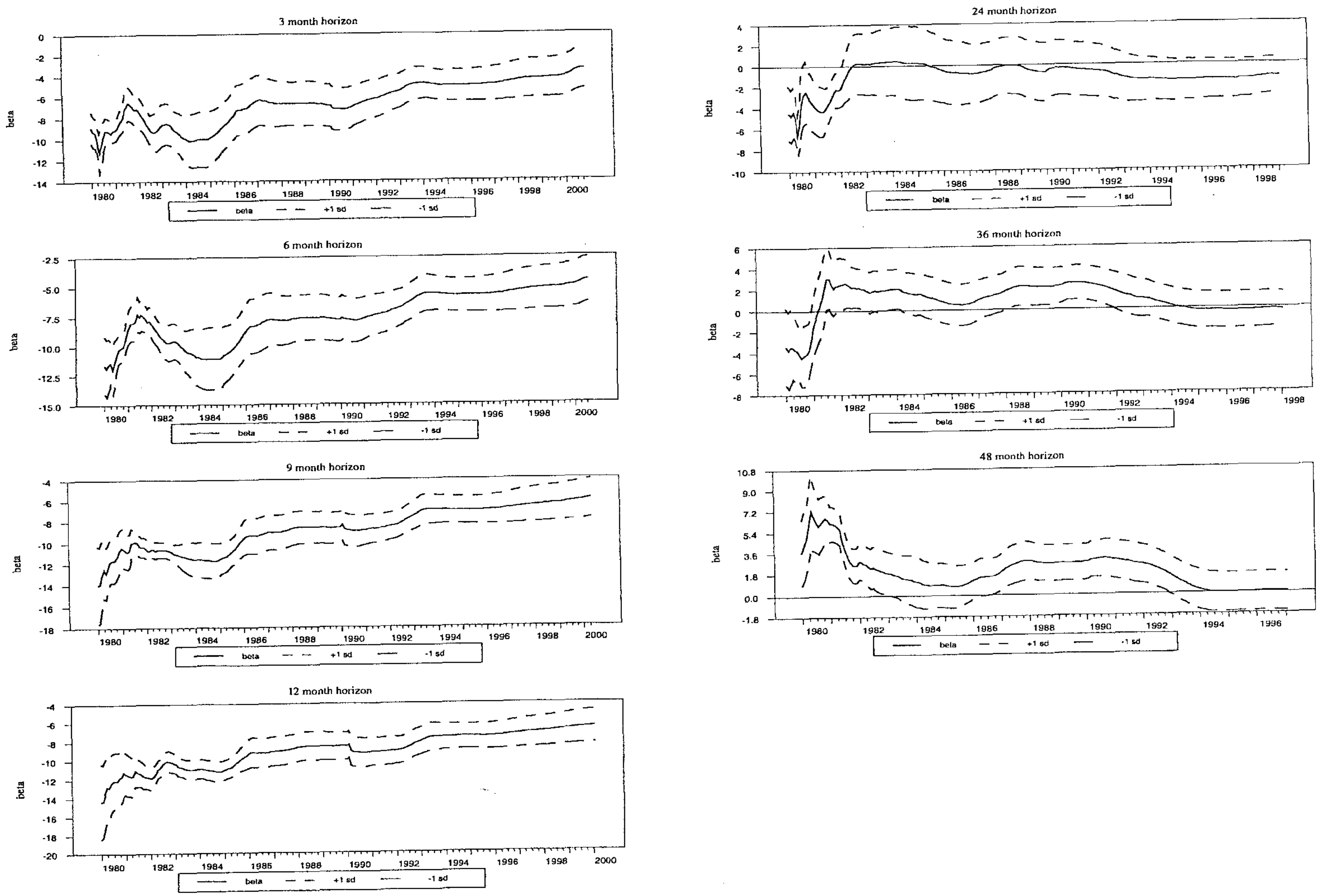


Figure 5 (cont.). Corporate Spread Curve Coefficients Estimates and Standard Errors - A Marginal Growth

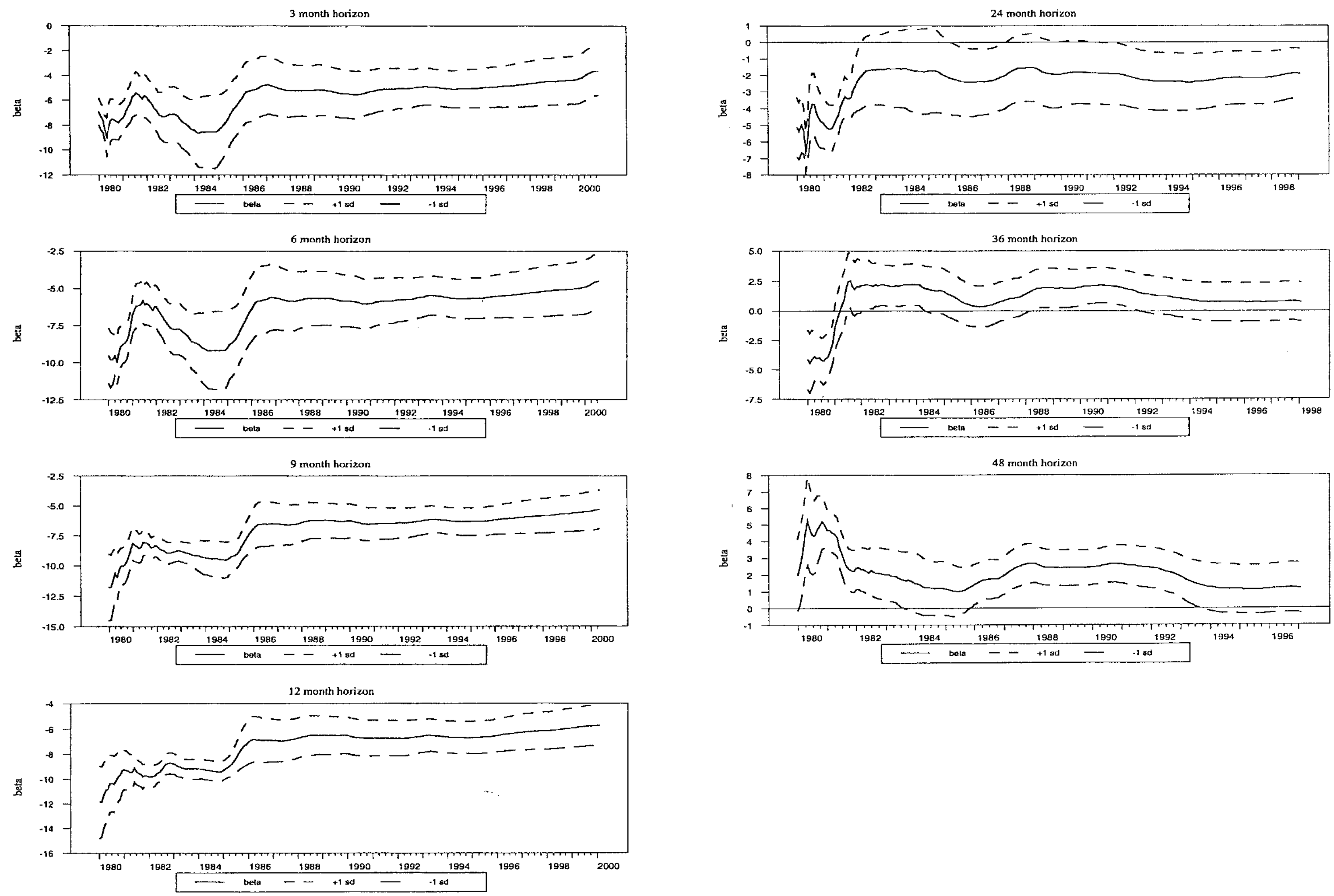


Figure 5 (cont.). Corporate Spread Curve Coefficients Estimates and Standard Errors - BAA

Marginal Growth

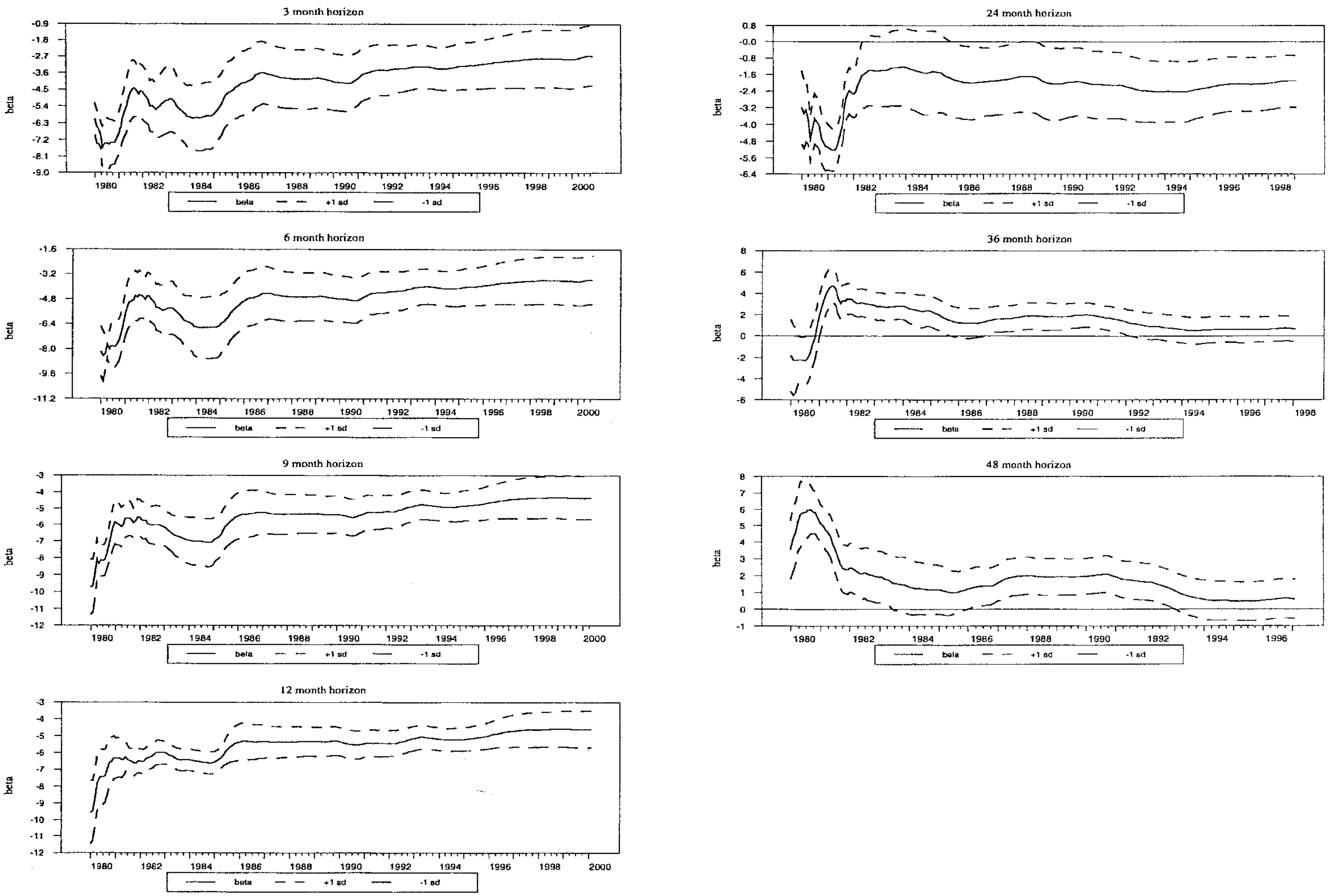
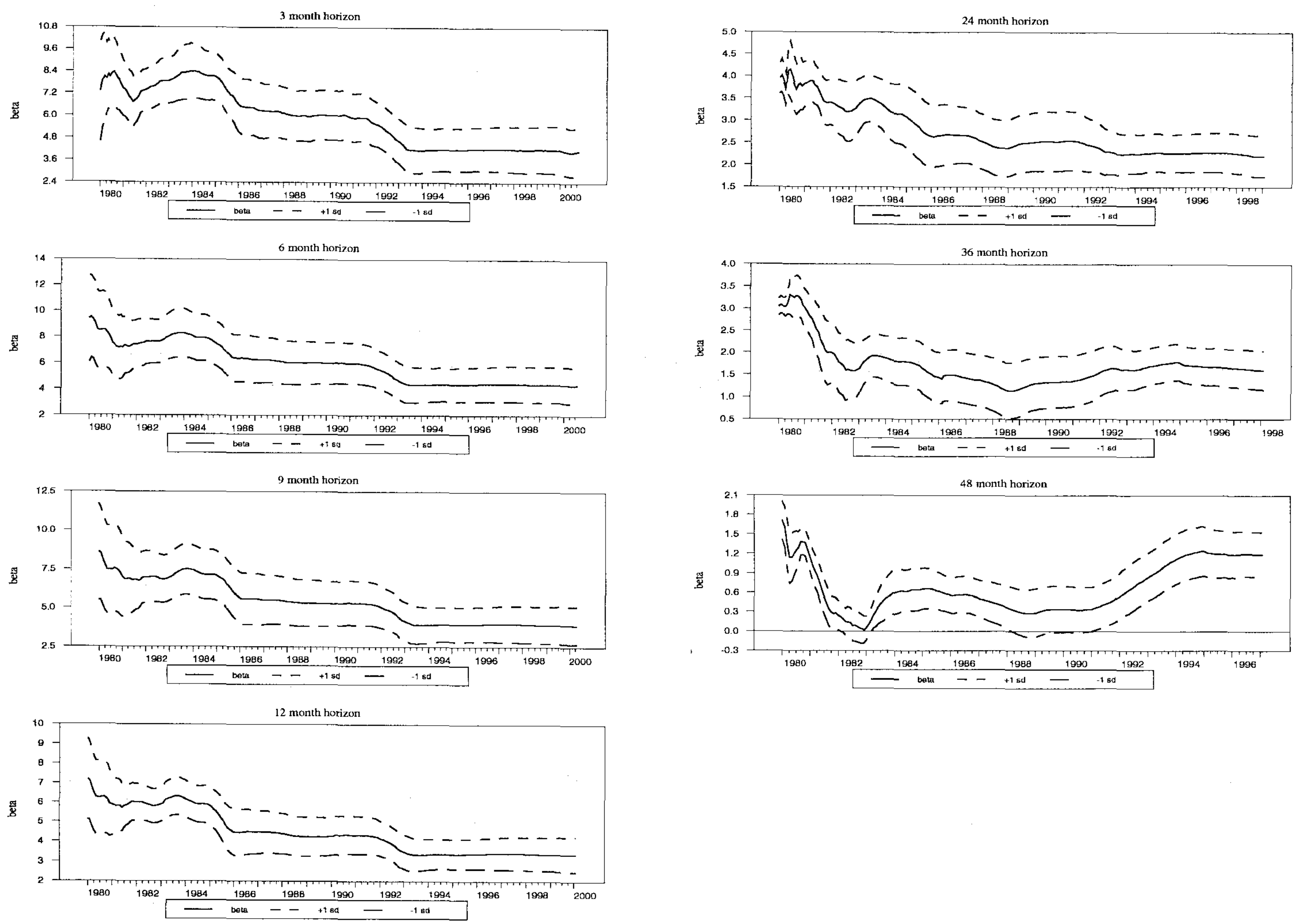


Figure 6. Treasury Yield Curve Coefficients Estimates and Standard Errors



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