WP/01/158

IMF Working Paper

Corporate Bond Risk and Real Activity: An Empirical Analysis of Yield Spreads and Their Systematic Components

Jorge A. Chan-Lau and Iryna V. Ivaschenko

INTERNATIONAL MONETARY FUND

IMF Working Paper

International Capital Markets Department

Corporate Bond Risk and Real Activity: An Empirical Analysis of Yield Spreads and Their Systematic Components

Prepared by Jorge A. Chan-Lau and Iryna V. Ivaschenko[1]

Authorized for distribution by Garry J. Schinasi

October 2001

Abstract

This paper finds that the yield spread of investment-grade bonds relative to Treasuries, a proxy of default risk, predicts marginal changes in industrial production in the United States up to 12 months in the future, even upon controlling for a commonly used predictor such as the commercial paper spread. The paper also finds that systematic risk factors associated with the yield spread of investment-grade bonds to a variety of risk-free benchmarks – Treasuries, agency bonds, and AAA-rated bonds – have significant predictive content for future growth rate of industrial production at 3 to 18 months forecasting horizon, both in- and out-of-sample. Finally, a regime-switching estimation shows that the systematic risk component is also able to capture "industrial production business cycle" well.

JEL Classification Numbers: E32, E37, E43, E44

Keywords: Investment grade bonds, corporate spreads, business cycle, forecasting, GMM estimation, systematic risk, principal components analysis, regime-switching, Markov process, United States.

Authors' E-Mail Addresses: jchan-lau@imf.org, iivaschenko@imf.org

---

[1] We wish to thank Paul Soderlind, Garry Schinasi and Steven Dunaway for detailed useful comments on this paper. This paper also benefited significantly from comments by Eduardo Borensztein, Giovanni Dell' Ariccia, Gaston Gelos, Charles Kramer, Eswar Prasad, Jorge Roldos, Todd Smith, Kenichi Ueda, and Jeromin Zettelmeyer as well as participants of the IMF Research Seminar and 2001 Australasian Econometric Society Meetings. Some empirical results were obtained using Matlab codes provided by James P. LeSage.

Contents

Page

Figures

I. INTRODUCTION

The yield spread of corporate bonds to a risk-free security, also referred to as the credit spread or quality spread, is a measure of the risk premium corporations pay investors to compensate them for a number of risks associated with corporate debt. These risks include, among others, default risk, when issuers are unable to make interest and principal payments on time; liquidity risk, when unwinding a position could result in adverse price changes as some corporate debt instruments are thinly traded; and prepayment risk, when issuers keep a call provision allowing them to buy back all or part of the issue prior to maturity. Default risk, in particular, is clearly affected by current and expected economic conditions. The ability of corporations to honor their obligations hinges on their net worth and earnings prospects, which are affected by the current stage of the business cycle and investors' expectations about the future strength of the economy.

Financial market practitioners have long recognized that changes in expectations and economic conditions result in changes in credit spreads, and have documented a number of interesting empirical regularities between credit markets and economic conditions. For example, Wojnilover (1980) emphasizes that the emergence of serious default problems in major institutions or markets could prompt an interruption in the supply of credit, which will impair real activity. Duca (1999) documents that increases in default risk are correlated with economic downturns, and, consequently, default premiums tend to rise during recessions. The usefulness of credit indicators to predict future conditions in the aggregate economy should not be surprising, given the importance of the bond market as a source of funding for corporations. The share of bond financing in total credit to the corporate sector has increased steadily since the mid-1980s at the expense of bank financing. By the first quarter of 2000, it accounted for almost 55 percent of total corporate credit or 25 percent of GDP (Figure 1).

The relationship between credit spreads and the economic cycle has not been overlooked by the academic community, though the number of contributions to the literature has been scarce. On the theoretical side, Bernanke, Gertler and Gilchrist (1998) developed a financial accelerator theory which suggests that the premium for external funds, which can be proxied by the corporate spread to a risk-free security, depends inversely on the net worth of the firm. Since net worth exhibits a procyclical pattern, an increase in the premium for external funds, and hence a widening of credit spreads, is associated with economic slowdowns. The countercylical behavior of credit spreads can also be derived from option pricing theory, as shown by Merton (1974). Merton's model states that the risk premium of corporate debt depends positively on the volatility of the firm value and its leverage. Leverage builds up during an economic expansion as lending standards relaxed gradually, and by the time the expansion ends, increased evisions of corporate earnings expectations increase the volatility of the firm value. Thus, credit spreads increases before an economic slowdosn. On the empirical side, Gertler and Lown (2000) tested the empirical implications of the financial accelerator theory by studying to what extent the yield spread between high yield to AAA-rated bonds could explain changes in the output gap. They found that this spread outperformed traditional indicators such as the term spread, the paper-bill spread, and the Federal Funds rate.

This paper attempts to fill the gap in the empirical literature by evaluating whether the yield spread of investment-grade bonds issued by U.S. domestic corporations can predict changes in industrial production in the United States. The evaluation uses monthly data for investment-grade corporate bonds of different maturities and different credit classes and considers a variety of proxies for a risk-free benchmark security including Treasury and agency securities, and AAA-rated bonds. There are two complementary approaches used in the paper.

The first approach uses a simple linear model linking changes in yield spreads to future changes in industrial production. In-sample estimation results indicate that positive changes in spreads to Treasuries predict negative changes in industrial production up to a 12 month horizon for all-maturity bond index and up to 9 month horizon for intermediate maturity bond index, confirming our expectations. This model produces more accurate out-of-sample forecasts than random walk benchmark at 9 and 12 months horizons. Furthermore, the estimation results indicate that credit spreads have significant marginal predictive power after the inclusion of the commercial paper spread as another regressor. At the same time, long-maturity bond spreads lack explanatory power both in- and out-of-sample across almost all credit classes and forecasting horizons. One possible explanation is that markets may become more discriminating during bad times, shutting out the weakest corporations from the long maturity market. Hence, credit quality in the bond market improves and offsets somewhat the increase in spreads associated with an economic downturn.

When securities other than Treasuries are used as proxies for a risk free benchmark, spreads of lower-rated bonds exhibit predictive power at some horizons, while spreads of higher-rated bonds lack predictive power. Spreads of long-maturity A- and Baa-rated bonds to agency bonds can predict real activity at 6 to 12 months horizon. Spreads of intermediate maturity A- and Baa-rated bonds to AAA-rated bonds are able to predict future growth rate of industrial production up to 9 month horizon. These results suggest that non-government bonds with the lowest credit risk – Agency bonds and AAA corporate bonds – may capture most of the systematic component of credit risk in the economy. Thus, the spreads of other bonds to those benchmarks represent idiosyncratic risks associated with each credit tier. Intuitively, since idiosyncratic risks can be diversified away, the average risk premium in the economy or the price of credit for corporations should depend on the systematic component only. Thus, only the systematic risk component should be related to aggregate real activity.

The second approach suggests one way to capture the systematic component of risk and test its predictive power for future real activity. The systematic component of aggregate credit risk is identified using principal components analysis, an approach widely used in empirical studies of financial markets. Then, its predictive power for future changes in industrial production is tested in a linear model. It is found that the systematic risk component explains changes in industrial production up to an 18 month horizon for all risk-free benchmark proxies used. In addition, the predictive power of the systematic risk component is not greatly influenced by the choice of bond maturity.

This paper differs from previous empirical work in a number of ways. In particular, and in contrast to Gertler and Lown (2000), it uses investment-grade bonds because their prices reflect economic fundamentals, such as expected investment returns, better than the prices of below-investment-grade bonds. This assertion rests on the presumption that corporations issue investment-grade bonds mostly for investment purposes and investors in high-quality corporate debt usually pursue buy-and-hold strategies. Hence, in equilibrium, their prices must correspond to fundamentals such as investment returns and the credit quality of an issuer. Also, the market for investment-grade bonds is large and liquid, so their prices are less affected by pure supply and demand imbalances.[2] Moreover, even during recessions, high-quality corporations still retain access to bond markets to meet their borrowing needs, while low-quality and smaller corporations would not be able to get credit at any price. Thus, prices of investment-grade bonds may be a better measure of credit tightness in the economy. Finally, data on investment grade bonds are less subject to selection bias, since the probability of transition to a lower-notch rating category is close to zero for highly-rated corporations (Keenan et al, 2000).

In contrast, high yield bonds have been mostly issued for equity buyback purposes, leveraged buyouts, and financing mergers and acquisitions. Therefore, their risk premia reflect factors other than economic fundamentals, especially those arising from asymmetric information such as suboptimal managerial compensation structure, principal-agent problems, and so on. Also, these bonds are seldom held to maturity, so demand and supply imbalances can affect their prices significantly. Selection bias for these bonds could be a problem, given their high default rate.

The rest of this paper is organized as follows. Section II describes the data and empirical methodology used for the analysis of the predictive power of both corporate spreads and the systematic component of credit risk. Section III presents and discusses the estimation results for corporate spreads, including those corresponding to the benchmark case, where Treasury securities are used as a risk-free security, and a number of specifications using alternative benchmarks. Checks for robustness and coefficient stability, as well as the assessment of the quality of simulated forecasts are also presented in this section. Section IV presents principal components analysis of spreads for different maturities. This section also describes and discusses results of estimations using the first principal component of corporate spreads as an explanatory variable. Conclusion are presented in Section V.

II. Data and Empirical Methodology

This section describes the definitions of the variables used in the analysis and data sources. It also describes the empirical methodology used.

A. Definitions and Data

This paper uses monthly data from February 1973 to February 2001 on the Industrial Production Index provided by the Federal Reserve. Industrial production, although only a part of aggregate real activity, is used instead of real GDP because of availability of data at

[2] Our bond data include only issuances of $150 million and above.

monthly frequency.[3] 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 production index:

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

where k denotes the forecasting horizon k in month, 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. Another dependent variable used in the analysis is the *marginal*, year-to-year percentage change in the index of industrial production k months ahead.

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

For simplicity, the dependent variable (1) is referred to as cumulative and dependent variable (2) as marginal growth rate of industrial production. Marginal growth rate provides more precise indication of how far in the future our model can predict.[4]

The two explanatory variables used in this analysis are a corporate spread over some proxy for a risk-free security, and a systematic component of all corporate spreads that belong to a particular credit class. In addition, the model uses paper-bill spread to evaluate the marginal significance of corporate spreads for future real activity. The credit spreads of a corporate bond rated *C*, $SPREAD^C$, is defined as the difference between the redemption yield on the corporate bond index, R^C, and the redemption yield on the risk-free security of the same maturity, R^T:

$$SPREAD^C_t = R^C_t - R^T_t. \quad (2)$$

The U.S. Treasury bond is used in the paper as the main proxy for a risk-free benchmark security. Corporate spreads over other benchmark securities – Agency bonds[5] and AAA-rated corporate bonds – are defined in a similar fashion. This study uses data for four investment grade credit tiers, AAA, AA, A, and Baa, as defined by Moodys' Investors Service. For each credit tier, three different Lehman Brothers Investment Grade Indices, which differ in the bond maturities included, are used: an all maturities index, a long maturities index, and an intermediate maturities index.[6] The paper-bill spread is defined as a difference between

---

[3] GDP and industrial production are highly correlated. For the sample Q1:1973 – Q2:2001, correlation between growth rates of real GDP and industrial production is 0.772

[4] Estrella and Hardouvelis (1991) found that the marginal growth rate was more difficult to predict than the cumulative growth rate.

[5] Agency bonds comprise those issued by government agencies such as Fannie Mae and Freddie Mac.

yields on the 3-month commercial paper and a matching maturity Treasury bill. We postpone the definition of another explanatory variable, the systematic risk component of credit spreads, until Section IV.

All spread variables have conventional dating: variables dated *t* are aggregates for month *t*. Table 1 presents sample statistics of all data series used in the analysis. Tables 2 and 3 present the correlation between corporate spreads to Treasuries and the growth rate of industrial production at different horizons, for different credit tiers and for different maturities.

B. Estimation Issues

A simple linear relationship between industrial production growth and changes in financial variables is assumed in the analysis:

$$Y_t(k)=X_t'\beta + u_t, \qquad (3)$$

where X_t is a (2 x 1) vector consisting of 1 and any of the explanatory variables, $\Delta SPREAD^C$ or changes in the systematic component of credit risk. Changes in corporate spreads, rather than their levels, indicate the expected direction of changes in credit quality, and hence, should foresee changes in real activity. Because spread variables are forward looking, the model is estimated using the Generalized Method of Moments (GMM) (Hansen, 1982), which allows conditioning the estimation on the information set available at time t, Ω_t, and relaxing the assumptions about the distribution of residuals.[7] However, because the regressors, X_t, are endogenous with respect to the dependent variable, as suggested by theories outlined in the introduction,[8] the condition $E[(Y_t(k)- X_t'\beta)|\Omega_t] = \mathbf{0}$ can not be imposed. Instead, a vector of instrumental variables, $Z_t \subset \Omega_t$, orthogonal to the error term u_t, is used under the following moment conditions:

$$E_t[\,(Y_t- X_t'\beta)\otimes Z_t] = \mathbf{0}_{4\mathrm{x}1}, \qquad (4)$$

[6] Intermediate maturities are those below ten years and long maturities are those above ten years. The classification corresponds to that used in the Lehman Brothers Bond Indices used in this study. See the data appendix for mnemonics and short descriptions of the series.

[7] For a detailed discussion of the GMM estimation and appropriate moment conditions, see also Davidson and McKinnon (1993).

[8] The results of exogeneity tests (not reported here) of both corporate spreads and commercial paper spread as suggested by Engle and Hendry (1993) show that that both variables are endogenous with respect to the future growth rate of industrial production.

where $Z_t' = (Y_{t-1}, Y_{t-2}, X_{t-1}, X_{t-2})$.[9] Using instruments we ensure that the GMM estimates of β are still consistent. Moreover, imposing (two) overidentifying restrictions improves the efficiency of estimators.

Besides of not being independent of the explanatory variable, the error term, u_t, is not independently distributed because of the temporally aggregated and overlapping dependent variable. The overlapping observations induce a moving average process of order 11 in the error term. Therefore, the Newey and West (1987) technique is used to correct for autocorrelation and heteroskedasticity in residuals. The goodness-of-fit of the model is tested using the overidentifying restrictions test (Hansen, 1982).

III. Corporate Spreads: Testing The Predictive Power

This section presents estimates and robustness checks corresponding to the benchmark model, and other models using alternative proxies for risk-free securities and explanatory variables. It also assesses of the quality of the out-of-sample predictive power of the benchmark model.

A. The Benchmark Model

Equation (4) is estimated using corporate bond spreads over treasuries for all investment-grade credit tiers and different maturities as explanatory variables. Their predictive power is tested for 3, 6, 9, 12, 18 and 24 months horizons. The results of the single-equation GMM estimation are presented in Table 4. There are sub-tables for each credit rating, maturity, and growth horizon used in the estimation.

For all-maturity indexes, the results indicate that coefficients of the corporate spread variable are significant at 5 percent level across all credit tiers at 3 to 12 months horizon for AAA- and AA-rated bond spreads; and at 3 to 9 months for A- and Baa-rated bonds. Note that all coefficients reported in tables are GMM estimates of (4) and thus have an opposite sign when interpreted in the context of model (3). As expected, for all maturities, an increase in the corporate spreads signals a decline in the growth of industrial production in the future.

The results for long maturity indexes are not encouraging. First, only few coefficients are significant at 5 percent level. Spreads on long maturity bonds are significant at 9 and 12 month forecasting horizon for AAA-rated bonds, and at 3 and 6 month forecasting horizon for A-rated bonds, and are not significant at any forecasting horizon and maturity for AA- and Baa-rated bonds. Second, coefficients of long-maturity AAA-rated bonds are negative, while coefficients of A bonds are positive. Results for AAA-rated bonds are apparently at odds with economic intuition and results for other spreads. This behavior can be attributed to movements of the long end of the Treasury yield curve arising from the shrinking supply of

[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.

Treasury securities and "flight to quality" episodes that may be affecting the predictive power of the long AAA spreads.

Finally, intermediate maturity spreads are significant at 3 and 6 months for AAA-rated bonds and at 3, 6, and 9 months horizon for AA- and A-rated bonds, and have the same sign as all-maturity spreads.

B. Alternative Benchmarks and Explanatory Variables

The explanatory power of the corporate spreads is tested using two alternative benchmarks instead of Treasury securities – Agency bonds and AAA-rated bonds. The rationale behind this is to alleviate possible problems related to technical factors in the treasury market affecting both demand and supply. On the demand side, the role of U.S. Treasury securities as a "safe haven" has increased as a result of the turmoil experienced by financial markets during recent years, especially in the fall of 1998. The flight to quality, concentrated mostly on the ten-year Treasury note, introduced significant distortions to the Treasury term structure, and had no impact whatsoever on real economic activity. On the supply side, the shrinking supply of U.S. Treasury securities during the recent years has decreased liquidity and depth in the market for U.S. government securities, especially for some maturities. As a result, the informativeness of the Treasury yield curve has declined (Fleming, 2000; and Schinasi, Kramer and Smith, 2001). Agency bonds may be considered close substitutes for Treasury securities because of their low credit risk and deep and liquid markets (Fleming, 2000). Similarly, AAA-rated bonds also have very low credit risk, as their default rate since 1970 has been only 0.05 percent (Keenan et al, 2000). The GMM estimates for corporate spreads to agencies are presented in Table 5, and for spreads to AAA are presented in Table 6. As in the benchmark case, equation (4) is estimated for different credit ratings, maturities, and forecasting horizons.

The results for spreads to agencies indicate that spreads of long-maturity A-rated bonds are significant at 6 and 12 months horizon, and spreads of Baa-rated bonds are significant at 6 to 12 months horizon. Spreads to AAA-rated bonds are significant for intermediate maturities, at 6 to 12 months for A and at 3 to 9 months for Baa credit classes. For AA-rated bonds, coefficients are insignificant across all maturities and forecasting horizons, which suggests that the difference in the risk premia between two nearest credit notches is economically insignificant.

The lack of significance for spreads over alternative benchmarks suggest that non-government bonds with the lowest credit risk – Agency bonds and AAA corporate bonds – may capture most of the systematic component of credit risk in the economy. Thus, the spreads of other bonds to those benchmarks represent idiosyncratic risks associated with each credit tier. Intuitively, since idiosyncratic risks can be diversified away, the average risk premium in the economy or the price of credit for corporations should depend on the systematic component only. Thus, only the systematic risk component should be related to aggregate real activity. Therefore, it is useful to disentangle between idiosyncratic and systematic risk and analyze the predictive content of the latter. We undertake this approach in the next Section where a proxy for systematic risk is constructed and tested.

C. Model Robustness and Coefficient Stability

The robustness of estimated coefficients to changes in the number of lags included in the weighting matrix and changes in the instrument set is tested. The stability of coefficients in recursive estimations is also analyzed. Since models using spreads to alternative benchmark securities perform poorly, these checks are performed only for the model using spreads to Treasuries.

The results are robust to changes in the number of lags used in the Newey-White estimator. The results using 12 or 36 lags do not differ much, although some of the coefficients become less significant with 12 lags. An analysis of the correlogram of changes in the industrial production index suggests using 36 lags.

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, the sign and the magnitude of the coefficients are not affected. However, including too many restrictions erodes the goodness-of-fit of the models at longer forecasting horizons, as indicated by the 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 *Xs* than the first and the second lags. Therefore, these additional instruments increase the model's restrictions without adding too much new information, and, hence, adversely affect the model's goodness-of-fit. When we modify Z_{1t}' by throwing away either lagged values of *Y* or lagged values of *X*, the corporate spread model looses its goodness-of-fit across all forecasting horizons. This modification of instrumental variable vector does not affect the significance of the coefficient estimates.

To test the stability of the coefficients, the model was estimated from January 1973 to December 1989, and then re-estimated recursively up to February 2001. The coefficients obtained this way appear to be stable over the whole estimation period. Coefficients obtained from the static estimation over the entire sample and recursive estimations are significant across the same credit classes, maturities, and forecasting horizons. Figure 2 presents p-values of spread coefficients, which are below 5 percent at 3 to 12 months forecasting horizon for all-maturity bonds spreads for all credit classes; and at 3 to 9 months horizon for intermediate-maturity AAA- AA- and A-rated bond spreads. Coefficients of the long maturity bonds spreads are mostly insignificant beyond the 3 month horizon. The majority of the significant coefficients from recursive estimations appear to be stable. Indeed, over the whole period December 1989-February 2001 they change by less than one standard deviation of respective coefficient for all credit classes (see Figure 3). There is one interesting pattern worth noting in the behavior of recursive coefficients: they appear to be much more volatile during the recession period of 1990-1991 than during the expansion period. In addition, there is an apparent break in all coefficient trajectories that occurred in late 1998. These changes in coefficient values, although statistically insignificant, are the most pronounced for lower-rated, A and Baa, bonds, and may be connected to the high volatility and flight to quality away from risky securities observed in financial markets in the aftermath of the Russia-LTCM crisis. Notably, this very parsimonious model shows no statistically significant structural breaks since 1982. Out-of-sample forecasts produced by the model are presented in Figure 4.

D. Evaluating the Quality of Predictions

This paper analyses both in-sample marginal predictive power of corporate spreads for future growth rate of industrial production, and the accuracy of simulated out-of sample forecasts produced by the basic model. The marginal performance of corporate spreads is evaluated including a commonly used predictor of real activity, the commercial paper spread, as an additional regressor into model (3).[10] The results of this estimation show that, except for AA-rated bonds, corporate spreads preserve their significance and signs even upon inclusion of the commercial paper spread (see Table 7). All-maturity corporate spreads are significant at 3 to 9 month forecasting horizon for AAA and A bonds and at 3 to 12 month forecasting horizon for Baa-rated bonds. Long and intermediate maturity spreads mostly lack explanatory power, with intermediate maturity spreads being significant at 3 to 9 month forecasting horizon for Baa-rated bonds only. Spreads of AA-rated bonds lose their significance at all forecasting horizons and maturities.

The accuracy of the predictions of the model using credit spreads as explanatory variable was evaluated relative to the performance of a simple random walk model. For these models, rolling out-of-sample forecasts were estimated for the period from January 1990 to February 2001 and Root Mean Squared Errors (RMSE) were computed.[11] The 24 month forecasting horizon was excluded from the analysis because corporate spreads lack the explanatory power at this horizon during the aforementioned estimation period. Results of this exercise indicate that our model performs as well as the random walk in out-of-sample forecasting at 6 month, and outperforms it at 9, 12 and 18 month forecasting horizon (see Table 8). It is worth noting that corporate spreads outperform the random walk model during the period after 1990. Conversely, other financial variables, such as U.S. Treasury curve have lost their predictive power compared to the random walk model (see Stock and Watson (2001) and references herein).

IV. Systematic Risk: Measuring and Testing the Predictive Power

This section describes the factor analysis of corporate spreads that helps extracting common factors driving corporate spreads across all credit classes. Then it analyses the predictive power of the main common factor – a proxy for systematic credit risk – for future

---

[10] The choice of commercial paper spread is guided by its wide use as a predictor of the economic cycle. For example, Stock and Watson (1989) and Friedman and Kuttner (1992) documented strong predictive power of the commercial paper spread to matching maturity Treasury bill (paper-bill spread). See Stock and Watson (2000) for an excellent survey of literature on the use of different financial variables, including the commercial paper spread in, for predicting real economic activity.

[11] Since GMM estimation does not indicate how much of the variation in the dependent variable is explained by the regressor (like R^2 in the OLS estimation), the accuracy of predictions is evaluated using out-of-sample forecasts.

marginal changes in industrial production. Finally, it evaluates the stability of coefficients and the accuracy of out-of-sample predictions.

A. Factor Analysis of Yield Spreads

Statistical techniques have proved very useful in the empirical study of fixed income markets. Among these techniques, one that has been widely applied in diverse fields of economics and finance is principal components analysis, as exemplified by Garbade (1986), Litterman and Scheinkman (1988), Knez et al (1994), and Bertocchi et al (2000), among many other studies. Garbade used this statistical method to identify three major models of fluctuations in U.S. Treasury securities. The same technique was applied by Litterman and Scheinkman to analyze bond returns, by Knez et al to analyze money market returns, and by Bertocchi et al to model fluctuations in the yield curve of corporate bonds and derive portfolio immunization strategies.

Principal components analysis, if applied to a cross-sample of yield spreads corresponding to different credit classes, provides a simple but effective way to extract and identify systematic risk since it extracts common factors that affect yield spreads regardless of their credit class. Hence, by definition, these factors can be identified as sources of systematic risk. In order to apply the method, let m be the number of different bond classes, classified according to their credit rating. For each credit rating, it is assumed that the yield spread to a given risk-free benchmark security, *SPREAD*, defined as the difference between the redemption yield of the corporate bond and the redemption yield of a Treasury security with the same maturity, is generated by a m-factor linear model of the form:

$$SPREAD_t = a + b_{1t} f_1 + b_{2t} f_2 + \ldots + b_{nt} f_m + \varepsilon_t , \tag{5}$$

where a is a constant, f_i represents the i-th common factor, the coefficient b_{it} is referred to as the loading of the factor, and ε is the error term. Let S be the $N \times$ m matrix, where N is the number of observations, such that the i-th column corresponds to the spread of the i-th credit class, with the credit classes ordered from higher to lower creditworthiness. The principal components serve as factors. The principal components analysis extracts those linear combinations of elements of S such that they provide the best fit to all the columns of S, that is, the i-th principal component could be represented as $z_i = Xc_i$. Importantly, each subsequent principal component is composed of all combinations that are orthogonal to the previous component. Thus, this technique is especially useful in dealing with multicollinearity, a problem we face when dealing with the yield spreads of investment-grade corporate bonds, which are highly correlated. It is not difficult to show that the coefficients of each of the principal components correspond to the eigenvectors of the matrix $C = S' \times S$. Also, the importance of each component in explaining the total variance of C is simply given by the ratio of its corresponding eigenvalue to the total sum of eigenvalues.[12]

---

[12] See Amemiya (1985), Garbade (1986), or Greene (1993) for a derivation.

Principal component methodology is applied to the yield spreads to U.S. Treasury securities of four Moody's investment grade credit tiers, AAA, AA, A, and Baa for the period January 1973 – February 2001. The redemption yields for each credit tier are obtained from three different Lehman Brothers Investment Grade Indices, which differ in the maturity of the bonds included: an all maturities index, a long maturities index (ten years or above), and an intermediate maturities index (less than ten year maturities). The results clearly indicate that the first principal component accounts for 98 percent of the variation of the yield spread, regardless of bonds maturity (Table 9). The importance of the first principal component can also be assessed from Figure 5, which plots the four principal components.

Principal components for the yield spreads of AA, A, and BAA-rated bonds to AAA-rated bond are also identified. Table 9 also reports the results corresponding to the alternative benchmarks. As in the case of Treasury securities, the first principal component explains about 95 percent of the variation of yield spreads, regardless of the choice of a benchmark or bond maturity. The principal components corresponding to the yield spreads to agency securities and AAA-rated bonds are also shown in Figure 5.

These results suggest that most of the systematic risk is being captured by the first principal component, and very little information would be lost if the other principal components were dropped from the analysis. Hence, this paper analyses only the information content of the first principal component, a measure of systemic risk in corporate spreads. The results are presented in the next section.

B. Testing the Information Content of the Main Common Factor

This section attempts to measure the information content revealed by the measure of systematic credit risk estimated in the previous section. Following the approach described in Section II.B, this section studies whether the first principal component of corporate spreads predicts future changes in industrial production.

The estimation results are summarized in Table 10. It is observed that the systematic risk of corporate spreads to Treasuries predicts future marginal growth rate of industrial production at 3, 6, 9, 12, and 24 month forecasting horizon for all maturity bond index, at 3 to 12 month horizon for long maturities; and at 3, 6, 9, and 18 month horizon for intermediate maturities. So, compared to plain spreads, systematic components can explain future real activity at a wider range of forecasting horizons. Improvement in the explanatory power is the most prominent for long and intermediate maturity bonds, as well as for spreads to Agencies and AAA-rated bonds. Indeed, systematic risk associated with spreads to Agencies is significant at 3, 6, and 18 month forecasting horizon for all-maturity; 3 to 18 months for long-maturity; and at 3 to 9 months horizon for intermediate-maturity bonds. The systematic risk associated with spreads to AAA-rated bonds is significant at 3 to 12 months horizon for all maturities. These results stand in sharp contrast to uniform insignificance of plain spreads to Agencies and AAA bonds in predicting growth rate of industrial production.

There is an interesting finding worth reporting. Conversely to the mixed results exhibited by corporate spreads in Section III, an *increase* in the systematic risk measure of long-term bonds unambiguously predicts future *slowdown* in the growth rate of industrial production, with significant results for up to 12 month forecasting horizon, irrespective of the choice of a benchmark security. This confirms that the principal component analysis helps to filter idiosyncrasies associated with particular credit class, effectively isolating the systematic component of risk. An increase in this component, as intuition suggests and our results show, precedes a slowdown in industrial production.

C. Stability Check

The out-of-sample forecasting performance of the systematic component of corporate spreads was compared to the random walk model. The recursive estimations, obtained for the period from January 1990 to February 2001 in a way described in Section III.C, show that coefficients are significant up to 9 months forecasting horizon across all maturities for systematic component of spreads to Treasuries and AAA-rated bonds, and up to 6 months for spreads to Agencies (see Figure 6). Significant coefficients trend upwards for 3 and 6 months forecasting horizon and downwards for 12 to 24 month horizon, irrespective of the choice of a benchmark (see Figure 7). However, despite an obvious trend, especially during 1994-1998, 3 and 6 months coefficients on systematic risk of spreads to Treasuries and Agencies did not change by more than one standard deviation over the entire period. Coefficients for 9 month forecasting horizon did not change over the whole period, except for a number of data points in early 1990. Conversely, coefficients at horizons 12 months and beyond exhibit some instability as their changes are statistically different from zero. Coefficients on the systematic risk of AAA-spreads are unstable at 3 and 6 month forecasting horizon, and stable at 9 months and onwards for all maturities.

Concluding, the trajectories of all coefficients present two interesting regularities. First, all coefficients are the least stable during the 1992 – 1998 period, with coefficients for 9 month forecasting horizon being the sole exception. Coefficients at 3 and 6 month forecasting horizons were trending upwards; at 18 to 24 month horizons were trending downwards during the aforementioned period. Since all coefficients are negative, the upward trend should be interpreted as a decline in their absolute values. All in all, these developments suggest that a weakening of the relationship between aggregate risk and future real activity in the light of the strong economic expansion in the United States. For example, in January 1994 a 10 basis point increase in the all-maturity systematic risk of spreads to Treasuries would have translated into 0.8 percent decline in the year-to year growth rate of industrial production 3 months ahead. In December 1998, the same change would have translated into a 0.6 percent decline in the future growth rate of industrial production. The second regularity observed in the data is that all coefficients leveled off in 1998 and have remained stable ever since, probably as markets have become aware of the build up in the corporate risk and its potential adverse impact on future real activity.

D. Evaluating the Quality of Predictions

The predictive performance of the corporate spread variable is compared to the random walk model. For this evaluation, the out-of-sample forecasts for the period January 1990 – February 2001 were simulated in the same way as described in Section III.D. The results presented in Figure 8 show that systematic components of spreads to all benchmark securities predict growth rate of industrial production very well at 3, 6, and 9 month horizon.

More formally, Root Mean Squared Errors show that in out-of-sample forecasting the corporate spread model performs as well as the random walk model at 6 month horizon for systematic risk component of spreads to Treasuries and Agencies. Moreover, it outperforms the random walk at 9, 12 and 18 month horizon for spreads to all benchmark securities (see Table 11). Systematic risk component outperforms plain spreads at 6 month horizon and onwards.

E. Testing the Ability of the Main Component to Predict Different Growth Regimes

The analysis in this paper presents evidence that the systematic component of corporate spreads contains useful information about future growth of industrial production within sample, and is able to predict it out-of-sample. However, the metrics used to evaluate the predictive ability of the regressor in both exercises put equal weight on every correct prediction, regardless of whether the model has captured a continuing trend or has been able to identify a turning point. The ability of the model to predict turning points is intimately related to the important question of predicting future recessions, which defines whether the variable can be considered as a good leading indicator.

Evaluating the ability of the common factor to predict turning points in the growth rate of industrial production is complicated by the fact that there is no formal definition of turning points or business cycle for industrial production. However, one can think about the "industrial production business cycle" as of the process with tow different regimes: a regime of positive and a regime of negative growth. Thus, evaluating whether the regressor can correctly predict switches between these two regimes helps to assess the directional accuracy of the predictions. Since the zero growth level may not be an exact cutting point between these two regimes, we use the regime-switching technique developed by Hamilton (1989) that identifies different regimes endogenously.

The following regime-switching model was estimated using EM algorithm:[13]

$$Y_{t+k,\,t+k+12} = \alpha(s_t) - \beta(s_t)\,SPREAD_t + \varepsilon_t\,, \tag{6}$$

where ε_t is i.i.d. standard normal, s_t is assumed to follow a two-state Markov process with transition probabilities p_{ij}, $i,j = 1,2$. k is forecasting horizon, and $k = 3, 6, 9, 12, 18,$ and 24 months. Estimation results show that systematic component of corporate risk is able to identify future regime of industrial production and predict its growth rate at 3 to 24 month horizon, with the best fit achieved at horizons beyond 6 months. Systematic risk associated with long maturity bonds is especially successful in capturing future movements of industrial production growth. The best fit for this variable is achieved at 6, 9 and 24 months forecasting horizon. Systematic risk associated with intermediate maturity bonds is able to track future movements in industrial production growth at the shortest, 3 months, and the longest, 24 months, horizons. Predicted values of industrial production obtained from the regime-switching estimation plotted against growth rate of industrial production are presented in

---

[13] See Demster, Laird, and Rubin (1977).

Figure 9. For comparison purposes this figure also presents fitted values obtained from the regime-switching model using Treasury yield curve as an explanatory variable.

V. Conclusions

Corporate bonds represent claims on the real economy. Absent price bubbles and significant market frictions, their prices may convey useful information on market's expectations about future economic developments. The use of financial instrument prices is also justified by the fact that financial markets are relatively quick and efficient in recognizing and pricing new information, and that prices are readily available at high frequencies. 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.

In particular, corporate spreads reflect default risk, which conveys information about the business cycle. This empirical study supports this assertion and indicates that corporate spreads to U.S. Treasuries predict changes in real activity up to a twelve-month horizon, as increases in corporate spreads precede industrial production slowdowns. Moreover, the corporate spread variable has marginal explanatory power for future growth rate of industrial production beyond what is already captured by a well-known predictor such as the commercial paper spread. In fact, upon inclusion of the corporate spreads, commercial paper spreads loses its significance at all forecasting horizons. When Agency bonds and AAA-rated bonds were used as benchmark securities the spreads to these securities lacked power in explaining future changes in economic growth. The assessment of stability of the relationship between corporate spreads to U.S. Treasuries and growth rate of industrial production shows that the majority of coefficients have been stable since January 1990, although point estimates of coefficients exhibit higher volatility during the recession period. Out-of-sample forecasting exercise shows that corporate spreads perform better than the random walk model.

The analysis in this paper is also extended to measures of systematic risk of corporate spreads. These risk measures are constructed using principal components analysis, and tested for their predictive power in explaining future marginal growth rate of industrial production. Estimation results indicate that these systematic risk components have significant predictive power up to 18 month horizon across all maturities, and perform very well in out-of-sample forecasting. The relationship between the systematic risk component and growth rate of industrial production has been mostly stable for spreads to Treasuries and Agencies. However, the decline in absolute values of coefficients observed between 1994 and late 1998, though mostly statistically insignificant, suggests that over the course of the strong economic expansion enjoyed by the U.S. economy, market players became less aware about aggregate risk and its adverse impact on real activity. The systematic component of corporate spreads also performed well in the regime-switching model.

DATA APPENDIX

Bond Data

The redemption yields used to construct the yield spreads were obtained from the following monthly series compiled by Lehman Brothers:

Corporate bonds	
LHIGAAA	AAA-rated bonds, all maturities.
LHINGAA	AA-rated bonds, all maturities.
LHINVGA	A-rated bonds, all maturities
LHIGBAA	BAA-rated bonds, all maturities
LHIAAAL	AAA-rated bonds, long maturities.[14]
LHIGAAL	AA-rated bonds, long maturities.
LHINGAL	A-rated bonds, long maturities.
LHIBAAL	BAA-rated bonds, long maturities.
LHIAAAI	AAA-rated bonds, intermediate maturities.[15]
LHIGAAI	AA-rated bonds, intermediate maturities.
LHINGAI	A-rated bonds, intermediate maturities.
LHIBAAI	BAA-rated bonds, intermediate maturities.
Treasury securities	
LHUSTRY	U.S. Treasury securities, all maturities.
LHTRYLG	U.S. Treasury securities, long maturities.
LHTRYIN	U.S. Treasury securities, intermediate maturities.
Agency bonds	
LHAGNCY	Agency bonds, all maturities.
LHAGLNG	Agency bonds, long maturities.
LHAGINT	Agency bonds, intermediate maturities.

Industrial Production data

Changes in industrial production were computed from changes in the seasonally-adjusted industrial production index, USINPRODG, compiled by the Federal Reserve.

Other data:

Commercial paper spread series were constructed using data on yields of the three-month commercial paper and Treasury Bill compiled by the Federal Reserve.

[14] Long maturities are those above or equal to ten years.

[15] Intermediate maturities are those below ten years

Table 1. Sample Statistics for Differenced Series

	Mean	Variance
Growth rate of Industrial Production	2.8280	21.2030
Paper-Bill Spread	-0.0010	0.0630
Corporate Spreads		
AAA		
All Maturirities	-0.0003	0.0400
Intermediate Maturities	0.0020	0.0392
Long Maturities	0.0009	0.0130
AA		
All Maturirities	0.0066	0.0470
Intermediate Maturities	0.0025	0.0400
Long Maturities	0.0022	0.0422
A		
All Maturirities	0.0016	0.0450
Intermediate Maturities	0.0035	0.0470
Long Maturities	0.0027	0.0180
Baa		
All Maturirities	0.0028	0.0560
Intermediate Maturities	0.0040	0.0720
Long Maturities	0.0030	0.0320

Table 2. Contemporaneous Correlations Between Corporate Spreads To Treasuries And Growth Rate of Industrial Production (USPRODG)

Corporate spreads are defined as a difference between the yield on a corporate bond and the yield on the Treasury security with the same maturity.

	USPRODG, year-to-year	**USPRODG, month-to-month, annualized**
All Maturities		
AAA	-0.166	0.005
AA	-0.225	-0.033
A	-0.345	-0.108
Baa	-0.501	-0.219
Intermediate Maturities		
AAA	-0.233	-0.124
AA	-0.294	-0.130
A	-0.422	-0.212
Baa	-0.534	-0.274
Long Maturities		
AAA	-0.353	-0.213
AA	-0.358	-0.214
A	-0.516	-0.292
Baa	-0.618	-0.350

Table 3. Correlations Between Lagged Corporate Spreads to Treasuries and the Year-to-Year Growth Rate of Industrial Production

Corporate spreads are defined as a difference between the yield on a corporate bond and the yield on the Treasury security with the same maturity. Spreads are lagged *k* times.

	AAA	**AA**	**A**	**Baa**
***k*=0**	-0.166	-0.225	-0.345	-0.509
***k* =3**	-0.075	-0.142	-0.267	-0.455
***k* =6**	0.067	-0.008	-0.122	-0.311
***k* =9**	0.242	0.153	0.076	-0.092
***k* =12**	0.434	0.333	0.306	0.171
***k* =18**	0.501	0.423	0.466	0.438
***k* =24**	0.369	0.317	0.362	0.382

Table 4. GMM Estimation of the Relationship Between Corporate Spreads to Treasury Securities and the Future Growth Rate of Industrial Production

The moment conditions estimated are as follows $E_t[(Y_t(k) - X_t`\beta) \otimes Z_t] = \mathbf{0}_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and Xt is either $SPREAD_t$ defined as a difference between corporate bond yield and treasury yield. $Y_t(k)$ is calculated as year-to-year percentage change in the Index, where k denotes forecasting horizon in months, k = 0, 3, 6, 9, 12, 18, 24. $Z_t` = (X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. Model has three over-identifying restrictions. Under the null hypothesis (1), the number of observations times the minimized value of the objective function (2), the J-statistics, is distributed $\chi^2_{(3)}$. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are coefficients standard deviations, corrected for heteroskedasticity and autocorrelation.

AAA

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-7.643*	26.482*	0.004	-7.776*	0.630	0.000	-7.850*	14.206*	0.002
		(9.226)			(14.259)			(4.431)	
k = 6	-5.580*	26.013*	0.007	-5.625*	-6.282	0.000	-5.725*	9.886*	0.000
		(11.125)			(12.719)			(4.719)	
k = 9	-3.775*	26.175*	0.009	-4.050*	-14.216*	0.000	-4.129*	4.805	0.000
		(10.062)			(7.062)			(4.432)	
k = 12	-2.506*	16.384*	0.673	-2.565*	-23.662*	0.030	-2.782*	2.900	0.059
		(7.167)			(9.876)			(4.598)	
k = 18	-1.901*	8.230	0.767	-1.895*	-2.501	0.828	-1.941	4.922	0.883
		(7.105)			(6.225)			(3.797)	
k = 24	-2.542*	-4.155	0.380	-2.434*	3.895	0.209	-2.423*	-2.302	0.326
		(5.152)			(6.562)			(3.798)	

AA

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-7.610*	22.701*	0.023	-7.692*	-0.429	0.000	-7.931*	22.910*	0.007
		(7.842)			(2.577)			(9.193)	
k = 6	-5.543*	21.713*	0.003	-5.605*	-1.700	0.000	-5.786*	20.323*	0.000
		(9.226)			(2.780)			(9.181)	
k = 9	-3.755*	22.142*	0.002	-6.076*	-2.246	0.000	-4.074*	16.589*	0.000
		(8.552)			(2.908)			(7.571)	
k = 12	-2.526	12.395*	0.441	-2.766*	-5.585	0.014	-2.726	7.308	0.088
		(5.663)			(5.243)			(6.994)	
k = 18	-1.909	5.941	0.876	-1.905	-1.170	0.776	-1.958	9.326	0.902
		(5.073)			(1.397)			(5.997)	
k = 24	-2.537*	-3.392	0.414	-2.426	0.270	0.268	-2.445*	-3.778	0.351
		(4.406)			(1.207)			(5.256)	

Table 4. GMM Estimation of the Relationship Between Corporate Spreads to Treasury Securities and the Future Growth Rate of Industrial Production (concluded)

A

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	**β**	***J-stat (p-value)***	**α**	**β**	***J-stat (p-value)***	**α**	**β**	***J-stat (p-value)***
k = 3	-7.745*	26.562* (8.789)	0.056	-8.571*	48.895* (22.690)	0.006	-8.278*	31.913* (11.942)	0.053
k = 6	-5.542*	25.495* (10.638)	0.005	-6.272*	29.473* (13.619)	0.000	-6.004*	28.112* (12.319)	0.002
k = 9	-3.681*	24.223* (9.714)	0.002	-4.118*	-4.531 (11.009)	0.000	-4.081*	22.569* (10.349)	0.000
k = 12	-2.556*	12.568 (6.582)	0.315	-2.467	-11.555 (11.316)	0.029	-2.761*	6.978 (7.204)	0.037
k = 18	-1.938	7.814 (7.170)	0.661	-1.942	2.026 (0.812)	0.859	-1.998*	8.440 (9.049)	0.952
k = 24	-2.522	-3.773 (4.935)	0.353	-2.357*	-2.814 -8.377	0.230	-2.412*	-3.898 (5.820)	0.327

Baa

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	**β**	***J-stat (p-value)***	**α**	**β**	***J-stat (p-value)***	**α**	**β**	***J-stat (p-value)***
k = 3	-8.201*	28.077* (10.016)	0.196	-9.117*	49.418 (28.604)	0.350	-8.745*	31.804 (20.050)	0.173
k = 6	-5.921*	26.723* (11.028)	0.025	-6.367*	33.246 (19.080)	0.025	-6.408*	29.220 (18.963)	0.013
k = 9	-3.990*	25.295* (9.322)	0.006	-4.476	29.950 (21.150)	0.000	-4.340*	26.113 (14.208)	0.001
k = 12	-2.723*	12.172 (6.505)	0.050	-2.486	-11.422 (18.552)	0.000	-2.833*	7.690 (6.809)	0.008
k = 18	-1.997	5.830 (8.241)	0.661	-1.978	2.411 (14.335)	0.759	-2.060	8.045 (11.717)	0.893
k = 24	-2.474*	-4.195 (5.052)	0.359	-2.235	-10.595 (15.502)	0.524	-2.369*	-4.142 (5.515)	0.290

* 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 Corporate Spreads to Agencies and the Future Growth Rate of Industrial Production

The moment conditions estimated are as follows $E_t[\,(Y_t(k) - X_t\,'\beta)\otimes Z_t\,] = \mathbf{0}_{5x1}$ (1), where $Y_t(k)$ is an Index of Industrial Production, and Xt is either $SPREAD_t$ defined as a difference between corporate bond yield and agency bond yield of matching maturities. $Y_t(k)$ is calculated as year-to-year percentage change in the Index, where k denotes forecasting horizon in months, k = 0, 3, 6, 9, 12, 18, 24. $Z_t' = (X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. Model has three over-identifying restrictions. Under the null hypothesis (1), the number of observations times the minimized value of the objective function (2), the J-statistics, is distributed $\chi^2_{(3)}$. We estimate the model for four investment grade credit tiers, AAA, AA, A, and Baa. The numbers in parentheses are coefficients' standard deviations, corrected for heteroskedasticity and autocorrelation.

AAA

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-6.164*	19.313	0.188	-6.393*	-11.008	0.002	-6.304*	20.366*	0.032
		(12.519)			(6.322)			(8.057)	
k = 6	-5.086*	18.821	0.177	-5.321*	-15.458	0.003	-5.279*	13.624	0.025
		(15.218)			(9.261)			(10.133)	
k = 9	-3.851*	25.111	0.506	-4.331*	-12.035	0.002	-4.094*	17.569	0.023
		(16.423)			(7.472)			(11.795)	
k = 12	-3.263*	10.608	0.680	-3.415*	-14.198	0.295	-3.179*	18.137	0.900
		(9.995)			(7.684)			(10.859)	
k = 18	-2.774*	0.256	0.746	-2.701*	2.065	0.978	-2.689*	3.218	0.964
		(4.160)			(2.467)			(4.753)	
k = 24	-3.395*	-7.825	0.724	-3.173*	4.789	0.396	-3.254*	-7.179	0.610
		(7.758)			(5.098)			(9.015)	

AA

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-6.101*	19.388	0.278	-6.416*	-2.192	0.006	-6.125*	24.205	0.117
		(11.078)			(1.980)			(16.079)	
k = 6	-5.030*	18.584	0.281	-5.340*	-2.411	0.006	-5.087*	20.993	0.146
		(13.613)			(2.713)			(19.105)	
k = 9	-3.762*	23.962	0.716	-4.336*	-1.677	0.003	-3/752*	30.620	0.499
		(14.899)			(2.039)			(21.636)	
k = 12	-3.115*	12.317	0.995	-3.425*	-2.765	0.406	-2.964*	25.496	0.999
		(9.886)			(2.404)			(17.612)	
k = 18	-2.751*	0.837	0.829	-2.697*	-0.416	0.992	-2.706*	6.238	0.736
		(4.302)			(0.525)			(9.894)	
k = 24	-3.375*	-5.749	0.769	-3.170*	0.148	0.480	-3.374*	-9.060	0.739
		(6.574)			(0.849)			(9.659)	

Table 5. GMM Estimation of the Relationship Between Corporate Spreads to Agencies and the Future Growth Rate of Industrial Production, Allowing for Endogeneity in Explanatory Variables (concluded)

A

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-6.162*	19.624	0.168	-6.422*	-5.407	0.001	-6.306*	18.953	0.059
		(12.173)			(5.302)			(11.764)	
k = 6	-5.047*	18.384	0.107	-5.400*	-21.513	0.002	-5.211*	16.189	0.041
		(14.639)			(11.181)			(14.061)	
k = 9	-3.804*	24.472	0.110	-4.350*	-22.705*	0.002	-3.983*	22.858	0.082
		(15.318)			(11.644)			(15.791)	
k = 12	-3.242*	10.207	0.724	-3.377*	-21.280**	0.268	-3.261*	10.584	0.801
		(9.333)			(11.782)			(8.818)	
k = 18	-2.771*	0.210	0.741	-2.701*	-0.083	0.993	-2.275*	1.568	0.880
		(4.284)			(2.884)			(4.239)	
k = 24	-3.391*	-7.270	0.668	-3.170*	3.356	0.461	-3.276*	-4.748	0.526
		-7.488			-5.259			(7.044)	

BAA

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***	***α***	***β***	***J-stat (p-value)***
k = 3	-6.330*	29.892	0.640	-6.439*	-7.662	0.004	-6.403*	17.187	0.051
		(18.005)			(9.556)			(9.572)	
k = 6	-5.125*	29.332	0.393	-5.402*	-20.937**	0.014	-5.285*	14.712	0.029
		(22.302)			(10.870)			(10.852)	
k = 9	-3.862*	34.977	0.700	-4.342*	-24.840*	0.015	-4.074*	19.303	0.029
		(22.784)			(10.410)			(11.498)	
k = 12	-3.185*	15.480	0.997	-3.254*	-22.439*	0.345	-3.291*	7.824	0.646
		(14.257)			(9.410)			(5.644)	
k = 18	-2.758*	-0.768	0.821	-2.661*	-3.453	0.981	-2.733*	2.172	0.849
		(7.195)			(4.672)			(4.016)	
k = 24	-3.347*	-8.565	0.729	-3.204*	3.619	0.506	-3.220*	-2.606	0.412
		(7.563)			(6.401)			(5.387)	

* indicates estimator significant at 5 percent level, ** indicates estimator 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 Corporate Spreads to AAA-rated Corporate Bonds and the Future 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 Xt is either $SPREAD_t$ defined as a difference between corporate bond yield of particular rating and AAA-rated corporate bond of matching maturity. $Y_t(k)$ is calculated as year-to-year percentage change in the Index, where k denotes forecasting horizon in months, k = 0, 3, 6, 9, 12, 18, 24. $Z_t' = (X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. Model has three over-identifying restrictions. Under the null hypothesis (1), the number of observations times the minimized value of the objective function (2), the J-statistics, is distributed $\chi^2_{(3)}$. We estimate the model for three investment grade credit tiers, AA, A, and Baa. The numbers in parentheses are coefficients standard deviations, corrected for heteroskedasticity and autocorrelation.

AA

	All Maturities			Long Maturities			Intermediate Maturities		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-7.631*	1.012	0.002	-7.624*	0.899	0.003	-7.671*	17.489	0.002
		(4.363)			(1.721)			(30.777)	
k = 6	-5.583*	2.294	0.000	-5.579*	1.084	0.000	-5.542*	16.900	0.000
		(3.791)			(1.277)			(21.760)	
k = 9	-4.089*	1.313	0.000	-4.085*	0.741	0.000	-4.021*	21.450	0.000
		(0.692)			(1.226)			(13.048)	
k = 12	-2.821*	-2.044	0.096	-2.809*	-0.534	0.103	-2.773*	7.284	0.110
		(4.170)			(1.081)			(10.370)	
k = 18	-1.908	-0.731	0.940	-1.905	-0.706	0.925	-1.871	19.828	0.770
		(2.392)			(0.737)			(10.607)	
k = 24	-2.440*	-2.439	0.479	-2.433*	-0.835	0.499	-2.477*	-2.902	0.414
		(4.161)			(1.440)			(13.965)	

A

	All Maturities			Long Maturities			Intermediate Maturities		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-8.587*	242.577	0.901	-7.978*	57.543	0.004	-8.772*	146.049	0.855
		(195.429)			(34.755)			(44.043)	
k = 6	-5.754*	182.955	0.122	-5.716*	-2.811	0.000	-6.300*	148.542*	0.437
		(159.457)			(25.127)			(51.265)	
k = 9	-3.833*	158.109	0.004	-3.817*	-28.900	0.001	-4.081*	136.844*	0.255
		(156.932)			(38.560)			(45.523)	
k = 12	-2.893*	12.767	0.006	-2.537	-31.137	0.140	-2.737*	60.981*	0.032
		(62.650)			(31.851)			(31.163)	
k = 18	-1.981	32.777	0.986	-1.930	5.147	0.955	-1.948	12.027	0.898
		(47.519)			(15.487)			(27.671)	
k = 24	-2.397	-41.030	0.655	-2.398*	-7.130	0.486	-2.312	-29.090	0.461
		(76.483)			(16.930)			(27.756)	

Baa

	All Maturities			Long Maturities			Intermediate Maturities		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-9.237*	82.280	0.536	-8.352*	39.013	0.015	-8.460*	38.930*	0.129
		(59.027)			(24.030)			(11.391)	
k = 6	-6.452*	58.699	0.055	-5.676*	-8.187	0.000	-6.077*	33.682*	0.005
		(37.253)			(24.782)			(10.981)	
k = 9	-4.665*	61.603	0.003	-3.550*	-37.135	0.003	-4.256*	32.831*	0.000
		(43.169)			(33.152)			(12.397)	
k = 12	-3.167*	19.319	0.000	-2.038	-41.977	0.218	-2.902*	5.621	0.000
		(12.430)			(25.244)			(4.982)	
k = 18	-1.921	0.380	0.961	-1.871	-3.022	0.961	-1.951	2.490	0.893
		(9.542)			(10.479)			(5.592)	
k = 24	-2.282	-10.984	0.545	-2.350*	-5.596	0.515	-2.335	-6.121	0.337
		(11.560)			(12.908)			(5.734)	

* 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. Multivariate Estimation of the Relationship Between the Corporate Spreads, Paper-Bill Spread, the Future 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 vector of explanatory variables, $X'_t = [c, \Delta SPREAD_t, CP_t]$, where $\Delta SPREAD_t$ is change in the spread of a bond of a particular credit rating and maturity; and CP_t is a commercial paper spread, defined as a difference between the three month commercial paper yield and three-moth constant maturity Treasury bill yield. $Y_t(k)$ is calculated as a year-to-year percentage change in the Index. $Z_t' = [X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k)]$ 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 coefficients standard deviations, corrected for heteroskedasticity and autocorrelation.

AAA

	All Maturities				Long Maturities				Intermediate Maturities			
	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*
$k = 3$	-5.295*	21.782*	0.100	0.013	-6.432*	8.852	2.694	0.097	-6.050*	-8.806	0.322	0.015
		(7.242)	(2.871)			(14.219)	(3.023)			(6.289)	(1.785)	
$k = 6$	-4.660*	21.268*	-2.367	0.003	-5.157*	13.538	-1.293	0.008	-4.890*	-7.604*	-1.768	0.002
		(8.024)	(2.632)			(11.284)	(1.795)			(3.844)	(1.785)	
$k = 9$	-3.896*	11.994*	-1.284	0.002	-4.060*	7.278	-2.11-	0.001	-4.058*	-7.381*	-2.126	0.002
		(6.443)	(1.631)			(8.215)	(2.212)			(3.487)	(1.749)	
$k = 12$	-3.360*	7.350	-0.105	0.173	-3.214*	-6.740	-2.628	0.112	-3.339*	-3.784	-1.010	0.183
		(5.533)	(2.100)			(5.904	(3.187)			(3.091)	(1.474)	
$k = 18$	-2.611*	-0.945	0.550	0.963	-2.558*	-0.941	0.338	0.952	-2.561*	-0.781	0.321	0.982
		(6.794)	(1.447)			(8.679)	(2.680)			(2.482)	(1.383)	
$k = 24$	-3.100*	-9.968	3.877*	0.581	-3.015*	3.467	1.163	0.726	-3.034*	3.096	3.176*	0.663
		(6.392)	(1.443)			(7.414)	(1.709)			(3.070)	(1.379)	

AA

	All Maturities				Long Maturities				Intermediate Maturities			
	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*
$k = 3$	-6.061*	4.649	4.086	0.017	-6.269*	3.452	3.433	0.049	-5.984*	-6.652	0.054	0.008
		(5.145)	(2.651)			(3.798)	(2.526)			(5.717)	(1.749)	
$k = 6$	-4.845*	7.286	-0.396	0.002	-4.957*	3.554	-0.864	0.003	-4.889*	-1.807	-2.004	0.001
		(6.740)	(3.352)			(3.418)	(2.023)			(3.724)	(1.647)	
$k = 9$	-3.893*	8.557	-2.578	0.004	-4.037*	2.837	-2.299	0.004	-4.104*	-4.326	-1.730	0.004
		(6.998)	(3.030)			(2.792)	(2.569)			(3.153)	(1.617)	
$k = 12$	-3.158*	7.281	-2.344	0.257	-3.257*	-0.138	-2.405	0.188	-3.422*	-0.875	-0.874	0.155
		(6.762)	(3.070)			(0.864)	(2.611)			(3.230)	(1.705)	
$k = 18$	-2.521	2.133	0.374	0.988	-2.563*	-0.952	0.317	0.942	-2.738*	-2.876	0.592	0.774
		(2.608)	(2.082)			(1.548)	(2.283)			(3.234)	(1.629)	
$k = 24$	-3.055*	2.959	3.771*	0.603	-3.002*	0.704	3.015	0.774	-3.182*	0.464	4.526*	0.341
		(3.628)	(1.772)			(1.214)	(1.700)			(4.589)	(1.982)	

Table 7. Multivariate Estimation of the Relationship Between the Corporate Spreads, Paper-Bill Spread, the Future Growth Rate of Industrial Production (concluded)

A

	All Maturities				Long Maturities				Intermediate Maturities			
	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*
k = 3	-6.104*	19.568*	2.970	0.176	-7.074*	32.343	6.819	0.608	-6.129*	16.948	5.100	0.064
	(1.263)	(9590)	(2.358)			(25.428)	(5.537)		(1.291)	(9872)	(3.394)	
k = 6	-4.784*	22.472*	-0.069	0.037	-5.733*	28.580	1.995	0.150	-4.839*	17.756*	2.528	0.006
	(0.611)	(7.190)	(2.808)			(17.517)	(3.195)		(0.600)	(6.474)	(2.919)	
k = 9	-3.762*	24.110*	-1.749	0.009	-4.549*	28.617*	-0.994	0.011	3.808*	10.899	-0.075	0.002
	(0.692)	(12.336)	(2.954)			(13.878)	(2.804)		(0.598)	(7.556)	(2.534)	
k = 12	-3.265*	13.838	-1.164	0.158	-3.449*	7.275	-0.328	0.047	-3.302*	4.878	-0.098	0.116
	(0.942)	(9.909)	(2.690)			(5.361)	(2.330)		(0.869)	(4.526)	(2.024)	
k = 18	-2.669*	5.787	0.205	0.923	-2.562	-1.141	0.430	0.963	-2.638*	-3.829	-0.069	0.917
	(1.310)	(6.900)	(1.383)			(9.697)	(3.140)		(1.312)	(6.338)	(1.612)	
k = 24	-3.105*	-12.704	2.242	0.418	-2.946*	1.930	2.992	0.583	-3.092*	-7.592	2.018	0.183
	(1.123)	(7.296)	(1.539)			(8.512)	(1.825)		(1.115)	(4.627)	(1.685)	

Baa

	All Maturities				Long Maturities				Intermediate Maturities			
	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*	α	β_{spr}	β_{cp}	*J-stat (p-value)*
k = 3	-6.251*	11.572*	4.598	0.240	-7.247*	22.789	11.099	0.772	-6.158*	10.087*	4.707	0.080
	(1.350)	(6.243)	(2.052)		(1.580)	(15.705)	(7.566)		(1.288)	(4.933)	(2.876)	
k = 6	-4.907*	11.576*	0.768	0.057	-6.094	-6.094	7.999	0.556	-4.791*	9.459*	0.424	0.013
	(0.663)	(3.475)	(1.624)		(1.246)	(1.246)	(5.621)		(0.594)	(3.603)	(2.115)	
k = 9	-3.886*	17.380*	-0.714	0.019	-5.164*	-5.164*	7.464	0.205	-3.703*	15.173*	-1.887	0.011
	(0.585)	(6.781)	(2.545)		(0.832)	(0.832)	(5.482)		(0.621)	(7.949)	(2.588)	
k = 12	-3.279*	14.851*	0.264	0.126	-3.918*	16.203*	3.359	0.023	-3.127*	18.787	-0.197	0.207
	(0.920)	(7.493)	(3.148)		(0.675)	(3.945)	(4.150)		(1.001)	(10.399)	(3.315)	
k = 18	-2.607	-3.876	-0.423	0.902	-2.570	0.016	0.244	0.971	-2.650*	-3.521	-0.453	0.819
	(1.332)	(6.202)	(1.477)		(1.445)	(6.286)	(4.438)		(1.283)	(1.283)	(1.170)	
k = 24	-3.088*	-7.020*	1.545	0.215	-2.908*	1.259	2.476	0.436	-3.124*	5.449	2.588*	0.369
	(1.113)	(3.521)	(1.030)		(1.207)	(5.663)	(2.225)		(1.086)	(3.584)	(0.934)	

* 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 8. Comparison of the Out-of-Sample Forecasting Performance of Different Models

Figures in the table are the Root Mean Squared Errors (RMSE) for out-of-sample forecasts of the 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 commercial paper spread as explanatory variable, and third model uses different corporate spreads as explanatory variable. Commercial paper spreads is defined as a difference between the three month commercial paper yield and three-moth constant maturity Treasury bill yield, and a corporate bond spread is defined as a difference between yields on a corporate bond and the Treasury security with matching maturities. Models that use corporate spreads allow for endogeneity in explanatory variables.

	$k = 3$	$k = 6$	$k = 9$	$k = 12$	$k = 18$
Random Walk	1.785	3.072	4.098	4.93	5.628
Corporate Spreads:					
AAA					
All Maturirities	4.612	4.045	3.823	3.562	3.221
Intermediate Maturities	3.351	3.099	3.107	3.239	3.383
Long Maturities	4.971	4.589	3.735	4.642	3.213
AA					
All Maturirities	5.416	4.665	4.209	3.628	3.246
Intermediate Maturities	3.848	3.278	3.256	3.262	3.527
Long Maturities	4.001	3.730	3.262	4.112	3.211
A					
All Maturirities	4.527	3.950	3.633	3.366	3.257
Intermediate Maturities	4.042	3.531	3.462	3.215	3.599
Long Maturities	5.259	4.225	3.220	3.555	3.571
Baa					
All Maturirities	5.541	4.603	4.050	3.385	3.395
Intermediate Maturities	3.661	3.466	3.964	3.264	4.267
Long Maturities	7.733	4.650	3.301	3.134	5.237

Table 9. Principal Components Coefficients

	All Maturities Component				Long Maturities Component				Intermediate Maturities Component			
	1	2	3	4	1	2	3	4	1	2	3	4
Treasuries												
AAA	0.497	0.696	-0.500	0.135	0.498	0.622	0.555	-0.238	0.494	0.768	-0.407	-0.093
AA	0.502	0.183	0.814	0.225	0.500	0.277	-0.812	-0.121	0.504	0.102	0.685	0.516
A	0.503	-0.218	-0.030	-0.836	0.503	-0.192	0.121	0.834	0.504	-0.285	0.255	-0.775
BAA	0.498	-0.659	-0.292	0.482	0.498	-0.706	0.138	-0.483	0.498	-0.572	-0.548	0.353
Percent of variance explained	98.30	1.38	0.23	0.00	98.30	1.19	0.00	0.00	97.70	1.89	0.00	0.00
Agencies												
AAA	0.489	0.721	-0.474	0.131	0.485	0.810	0.289	-0.160	0.472	0.797	-0.362	-0.099
AA	0.508	0.154	0.819	0.217	0.505	-0.013	-0.858	-0.088	0.516	0.066	0.675	0.522
A	0.509	-0.230	-0.053	-0.828	0.511	-0.226	0.221	0.800	0.513	-0.293	0.235	-0.772
BAA	0.494	-0.635	-0.319	0.500	0.500	-0.541	0.361	-0.572	0.498	-0.523	-0.598	0.347
Percent of variance explained	95.45	4.09	0.00	0.00	94.61	4.06	1.22	0.00	92.56	6.70	0.60	0.00
AAA securities												
AA	0.567	0.818	0.105	—	0.562	0.824	0.081	—	0.571	0.772	0.281	—
A	0.585	-0.309	-0.750	—	0.588	-0.328	-0.740	—	0.585	-0.142	-0.798	—
BAA	0.580	-0.486	0.653	—	0.583	-0.463	0.668	—	0.576	-0.620	0.533	—
Percent of variance explained	95.65	3.91	0.00	—	94.44	5.24	0.00	—	96.22	3.27	0.00	—

Table 10. GMM Estimation of the Relationship Between Systematic Risk and the Future 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 Xt is the systematic risk measure corresponding to a given risk-free benchmark security. $Y_t(k)$ is calculated as year-to-year percentage change in the Index, where k denotes forecasting horizon in months, k = 0, 3, 6, 9, 12, 18, 24. $Z_t' = (X_{t-1}, X_{t-2}, Y_{t-1}(k), Y_{t-2}(k))$ is a vector of instrumental variables. Model has two over-identifying restrictions. Under the null hypothesis (1), the number of observations times the minimized value of the objective function (2), the J-statistics, is distributed $\chi^2_{(3)}$. The numbers in parentheses are coefficients' standard deviations, corrected for heteroskedasticity and autocorrelation.

Systematic Risk, Spreads to Treasury Securities

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-21.573*	6.726*	0.000	-19.735*	7.572*	0.000	-19.734*	6.674*	0.000
		(1.606)			(0.991)			(1.478)	
k = 6	17.077*	4.891*	0.000	-18.626*	7.199*	0.000	-16.938*	5.436*	0.000
		(1.277)			(0.882)			(1.256)	
k = 9	-12.125*	2.895*	0.000	-17.950*	6.907*	0.000	-16.495*	5.134*	0.000
		(0.942)			(0.925)			(1.319)	
k = 12	5.5.880*	-3.661*	0.000	-16.686*	6.190*	0.000	-3.491	-0.332	0.000
		(0.627)			(1.044)			(0.643)	
k = 18	29.054	-11.491	0.002	-6.241*	0.914	0.000	30.702	-13.427*	0.002
		(6.311)			(0.915)			(6.773)	
k = 24	18.062	-7.526*	0.000	-9.141	2.184	0.000	20.196	-9.300	0.000
		(3.700)			(2.371)			(4.803)	

Systematic Risk, Spreads to Agencies

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-13.280*	4.216*	0.000	-14.176*	7.146*	0.001	-12.4722*	4.838*	0.001
		(1.689)			(1.206)			(1.472)	
k = 6	-11.487*	3.235*	0.000	-13.079*	6.517*	0.000	-10.524*	3.503*	0.000
		(1.471)			(1.108)			(1.356)	
k = 9	-12.450*	3.626	0.000	-12.587*	6.272*	0.000	-11.572*	4.0281*	0.000
		(2.144)			(1.241)			(2.077)	
k = 12	-8.188*	1.787	0.000	-13.004*	6.558*	0.000	-10.137*	3.186	0.000
		(1.391)			(1.604)			(1.900)	
k = 18	-14.324*	4.416*	0.000	-18.399*	9.953*	0.000	-14.859*	5.641	0.001
		(1.561)			(4.467)			(3.042)	
k = 24	-21.032*	7.340	0.011	-28.501	15.372	0.321	-18.572*	7.671	0.008
		(4.408)			(13.878)			(4.788)	

Systematic Risk, Spreads to AAA-rated bonds

	All Maturities			**Long Maturities**			**Intermediate Maturities**		
	α	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*	*α*	*β*	*J-stat (p-value)*
k = 3	-18.379*	13.118*	0.000	-20.661*	14.945*	0.010	-16.309*	10.648*	0.000
		(2.639)			(2.332)			(2.100)	
k = 6	-17.311*	12.234*	0.000	-19.469*	14.080*	0.000	-15.425*	9.954*	0.000
		(2.437)			(2.048)			(1.939)	
k = 9	-18.081*	12.568*	0.000	-20.225*	14.431*	0.000	-15.299*	9.548*	0.000
		(2.972)			(2.342)			(2.203)	
k = 12	-16.644*	11.0773*	0.000	-17.520*	11.844*	0.000	-14.582*	8.618*	0.000
		(3.017)			(2.443)			(2.582)	
k = 18	-15.144*	9.330*	0.000	-8.583*	3.753	0.000	-6.535*	1.596	0.000
		(4.594)			(2.372)			(1.668)	
k = 24	-42.937	30.950	0.179	-33.575	23.979	0.013	-30.522	19.588	0.025
		(22.987)			(13.738)			(12.131)	

* 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 11. Comparison of the Out-of-Sample Forecasting Performance of Different Models, Using Systematic Risk as Explanatory Variable

Figures in the table are the Root Mean Squared Errors (RMSE) for out-of-sample forecasts of the growth rate of industrial production produced by different models. First model is a random walk model of the growth rate of industrial production, and other models use systematic risk measures of different maturities corresponding to a given risk-free benchmark security. Models that use systematic risk variables allow them to be endogenous.

	$k = 3$	$k = 6$	$k = 9$	$k = 12$	$k = 18$
Random Walk	1.785	3.072	4.098	4.93	5.628
Systematic Risk:					
Spreads to Treasury Securities					
All Maturirities	5.361	3.448	2.396	2.817	3.411
Intermediate Maturities	4.371	3.064	2.412	2.668	3.061
Long Maturities	5.526	3.520	2.234	2.686	3.474
Spreads to Agencies					
All Maturirities	5.112	3.410	2.443	2.705	3.016
Intermediate Maturities	4.708	3.363	2.419	2.429	3.088
Long Maturities	4.504	3.102	2.418	2.632	2.845
Spreads to AAA-rated bonds					
All Maturirities	7.013	4.572	2.608	2.654	3.653
Intermediate Maturities	8.238	5.440	2.860	2.679	3.999
Long Maturities	5.411	3.578	2.362	2.735	3.491

Figure 1. Bond and Bank Financing as percentage of GDP

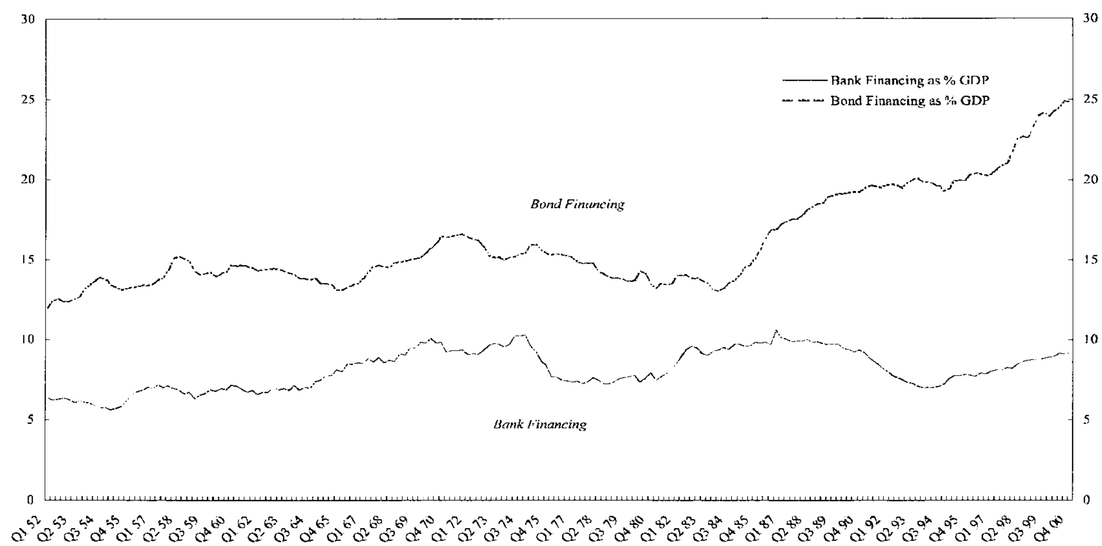


Figure 2: P-values of credit spread coefficients - Spreads to Treasuries

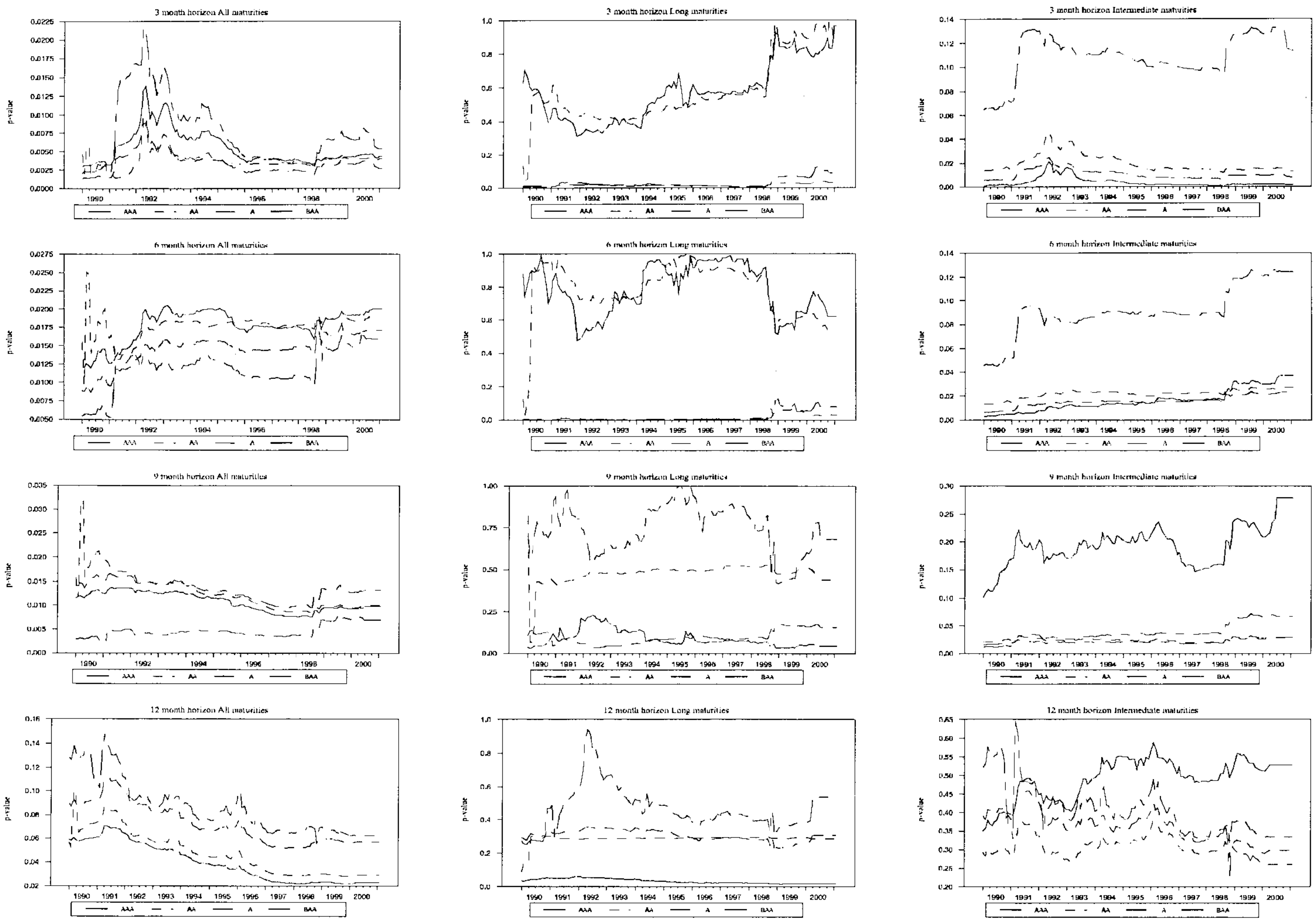


Figure 3: Spread Coefficients Estimates and Standard Errors - AAA bonds

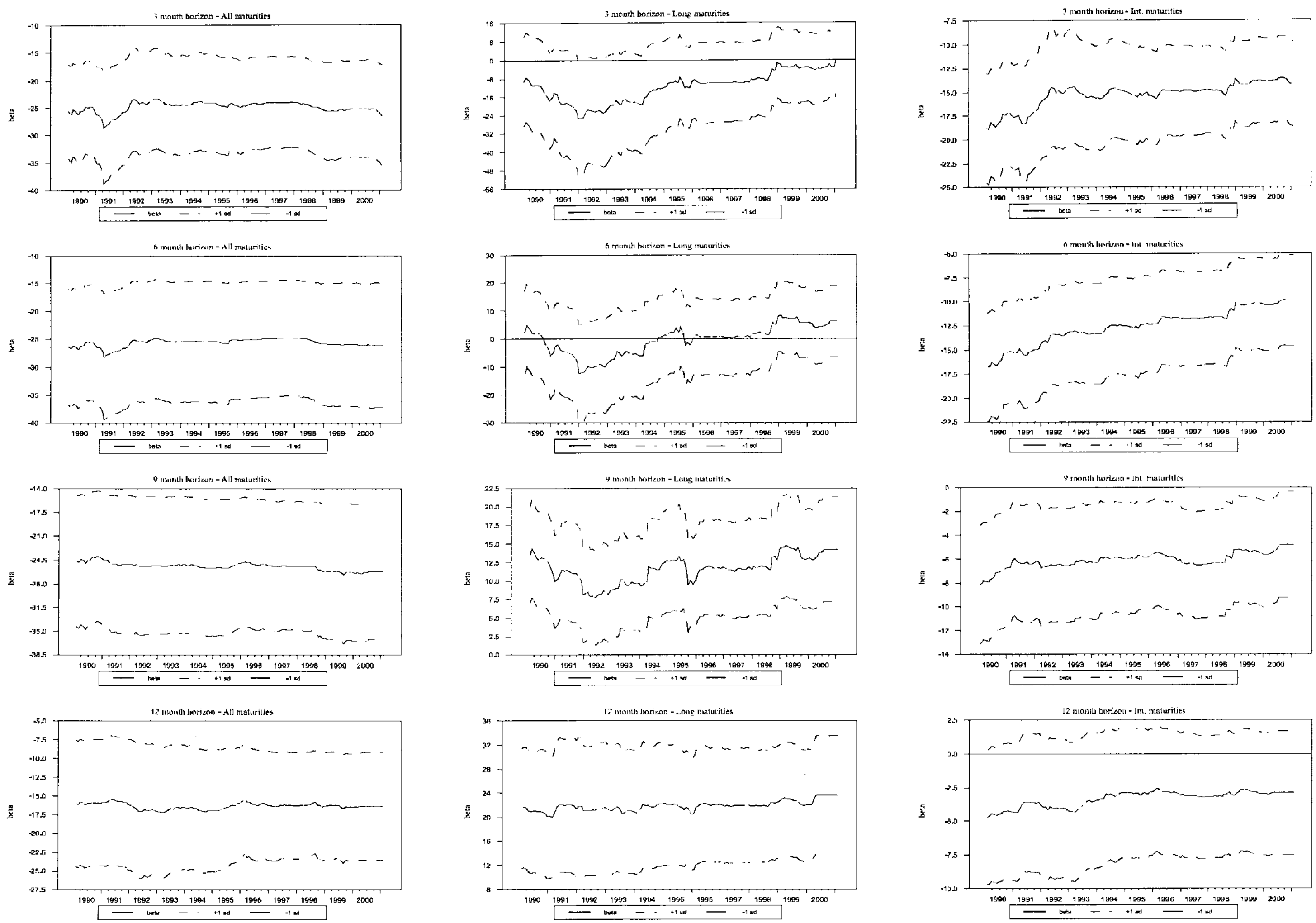


Figure 3 (cont.): Spread Coefficients Estimates and Standard Errors - AA bonds

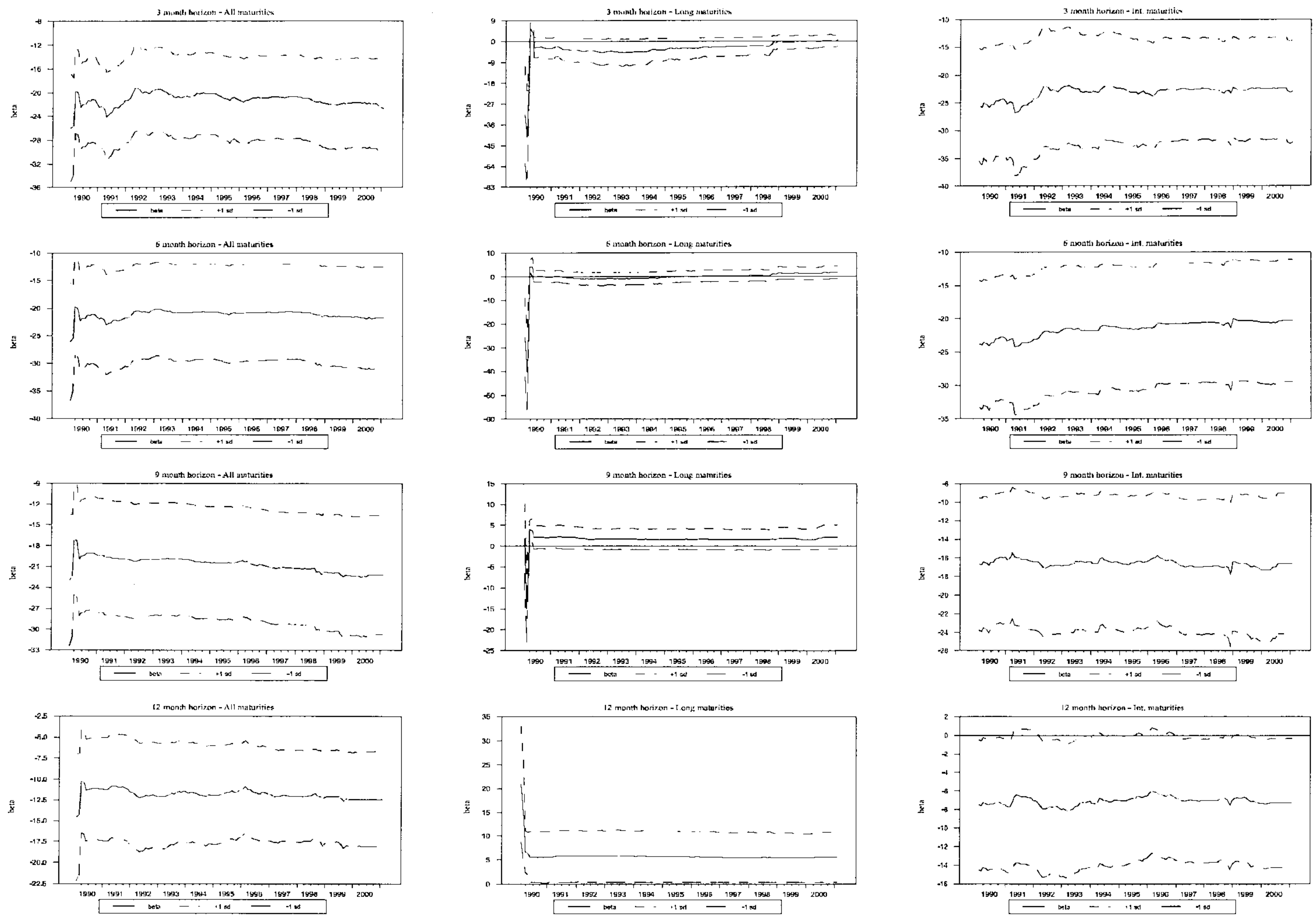


Figure 3 (cont.): Spread Coefficients Estimates and Standard Errors - A bonds

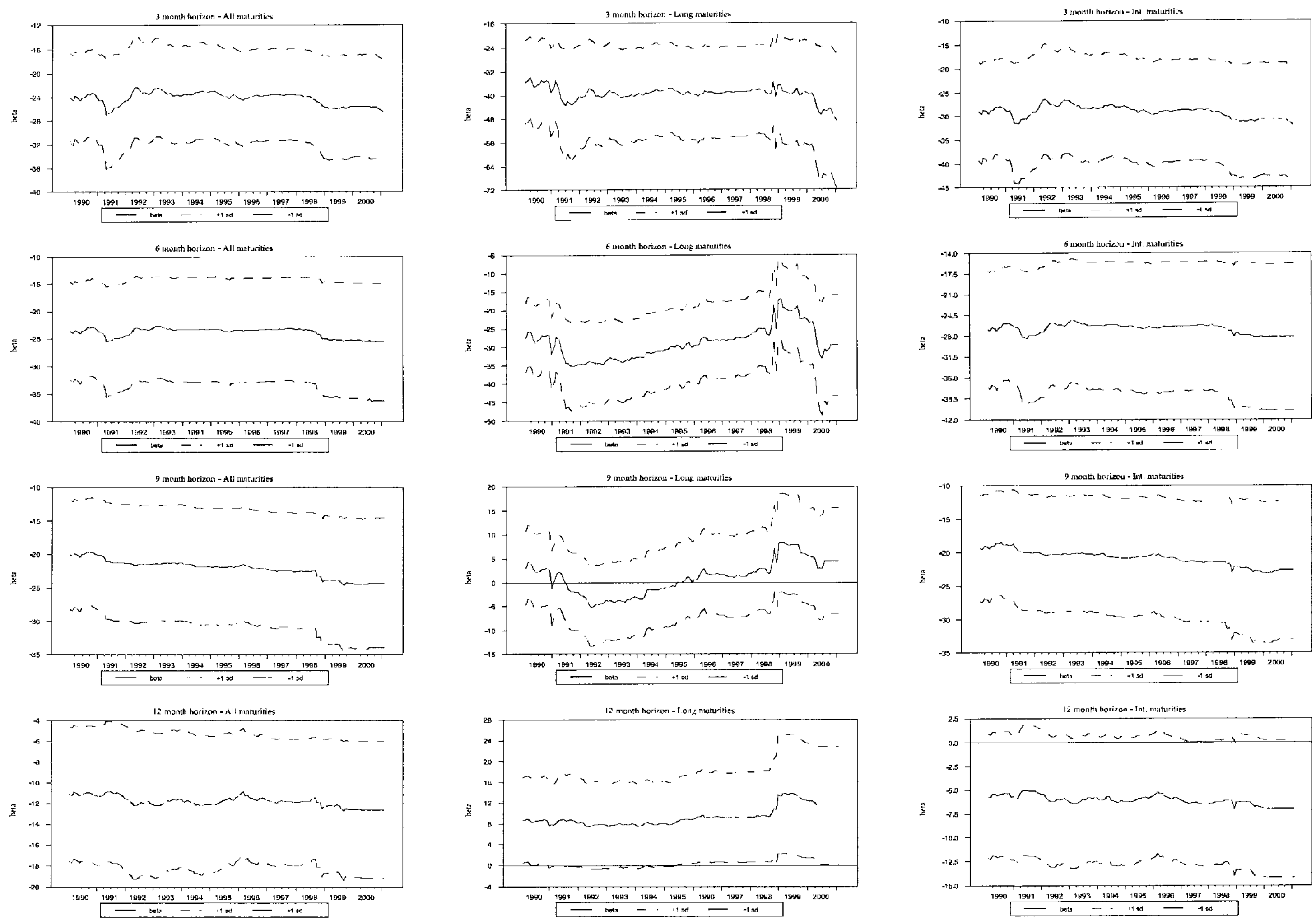


Figure 3 (cont.): Spread Coefficients Estimates and Standard Errors - BAA bonds

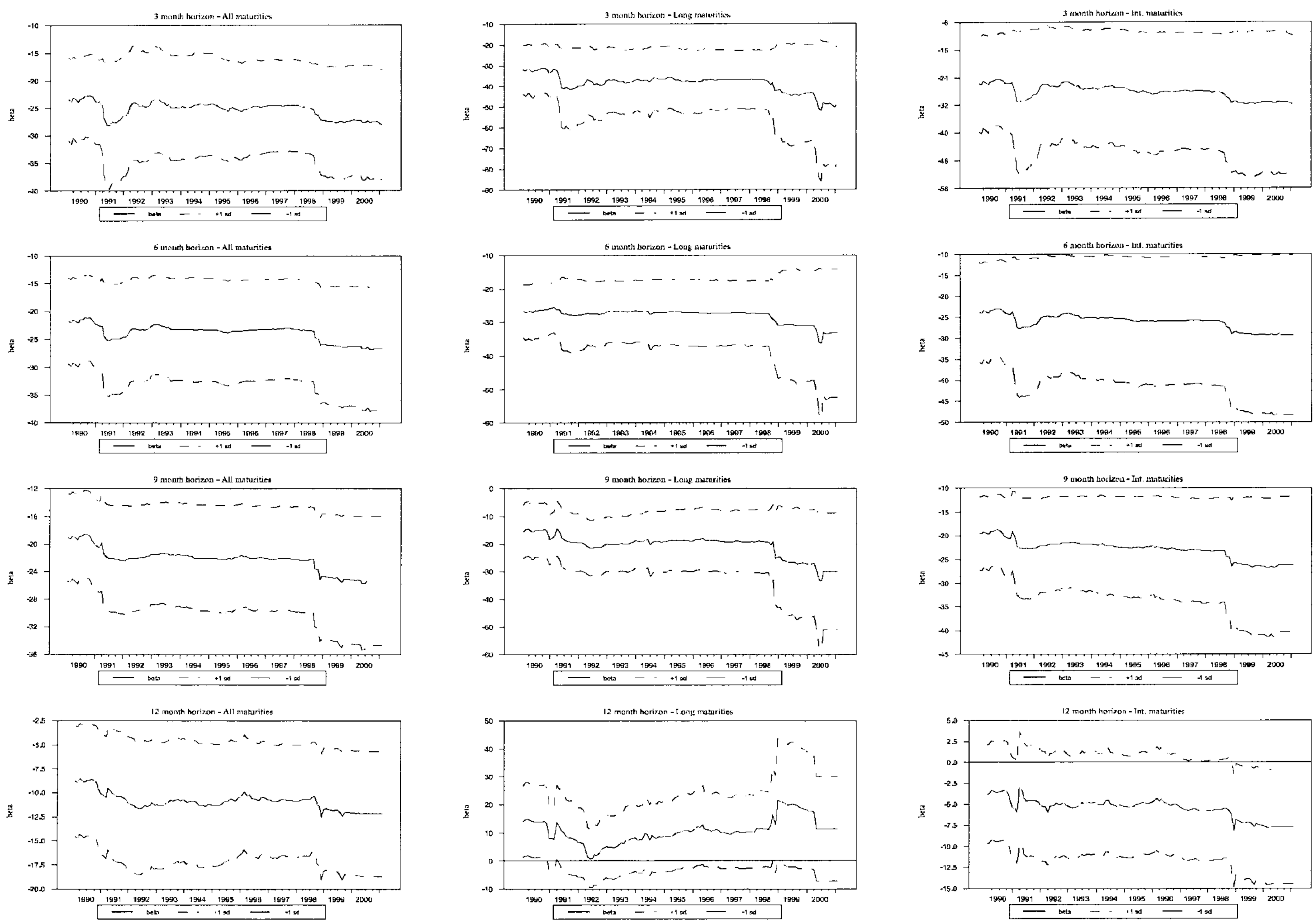


Figure 4: Industrial Production Forecasts - AAA spreads

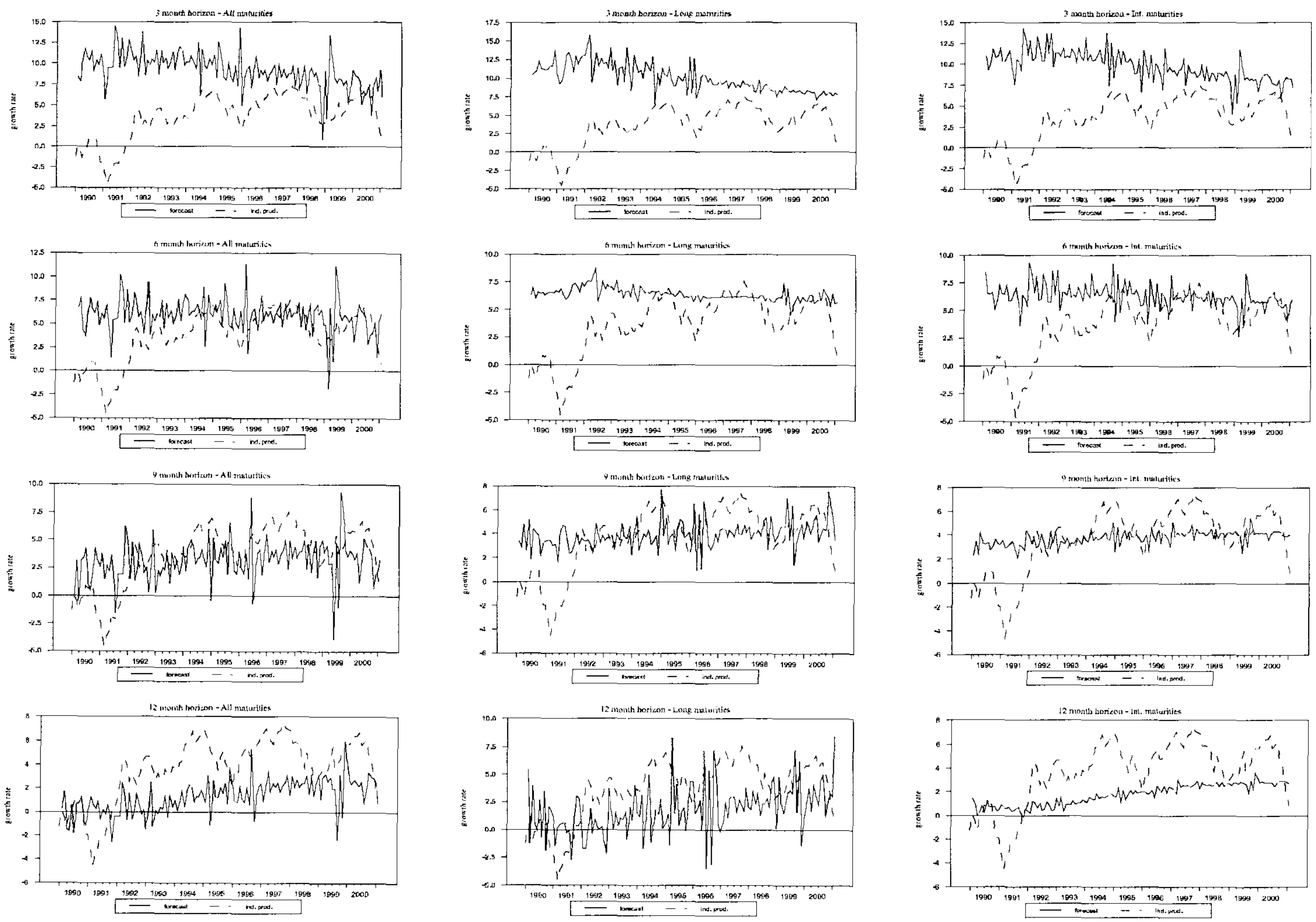


Figure 4 (cont): Industrial Production Forecasts - AA spreads

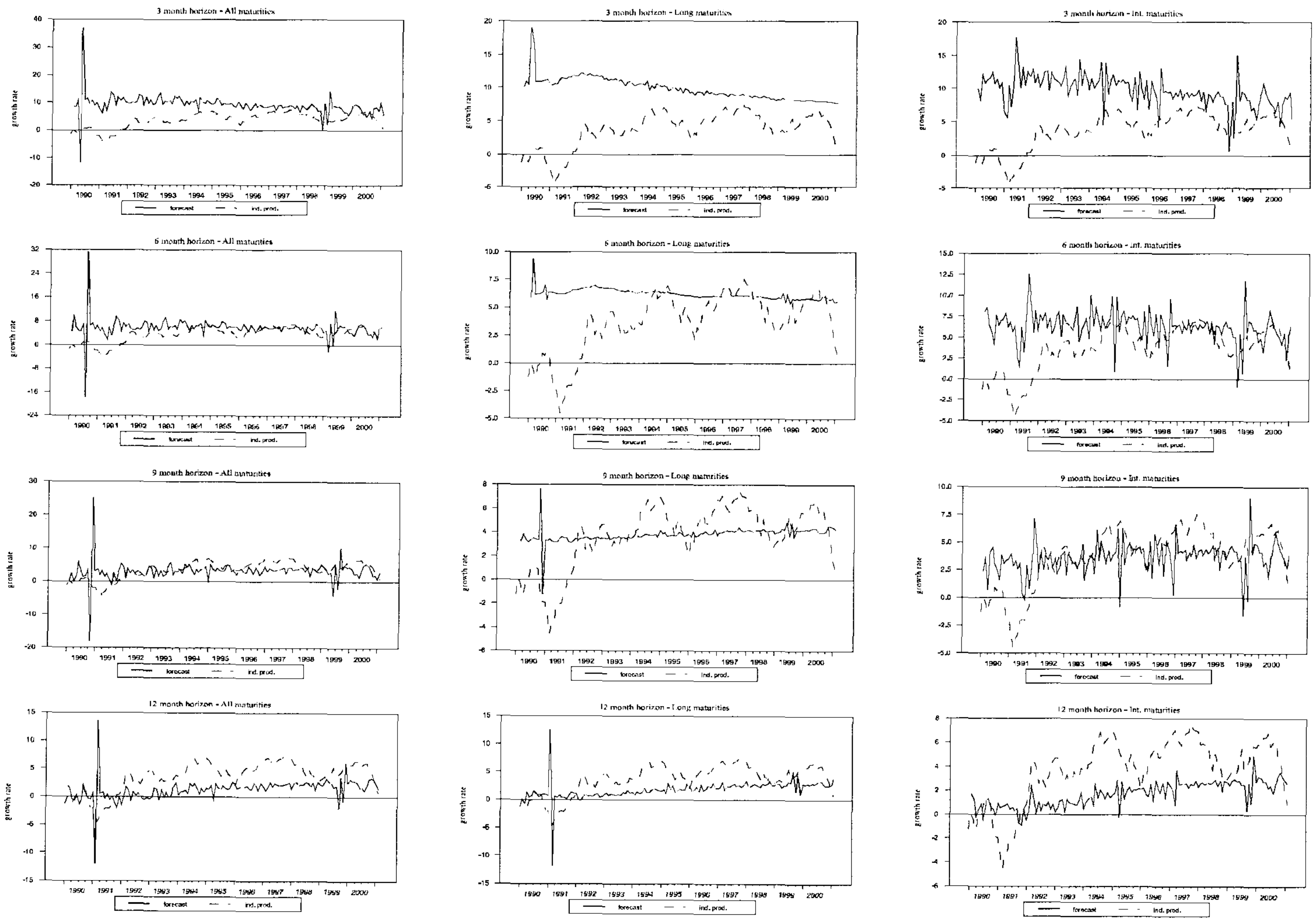


Figure 4 (cont): Industrial Production Forecasts - A spreads

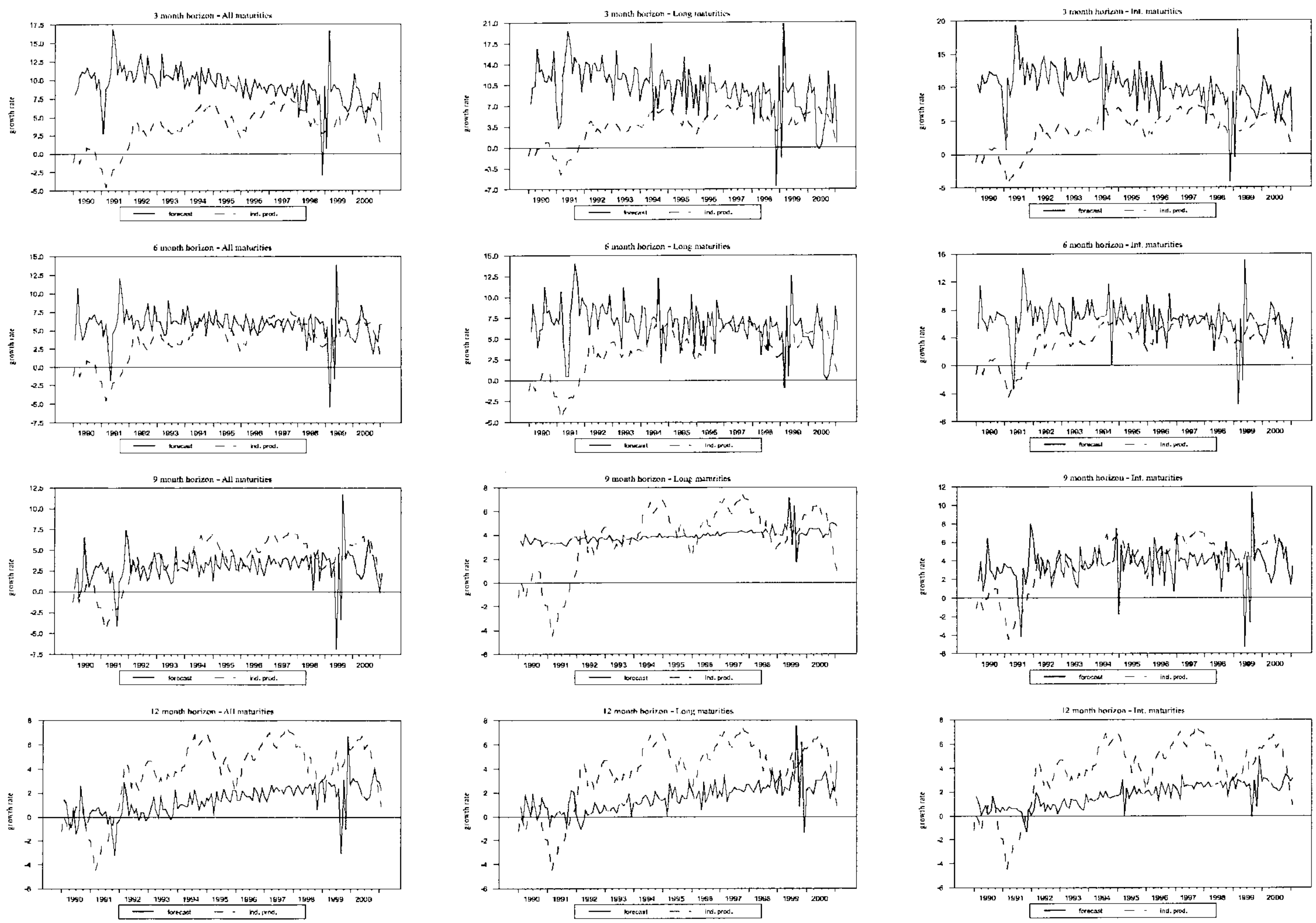


Figure 4 (cont): Industrial Production Forecasts - BAA spreads

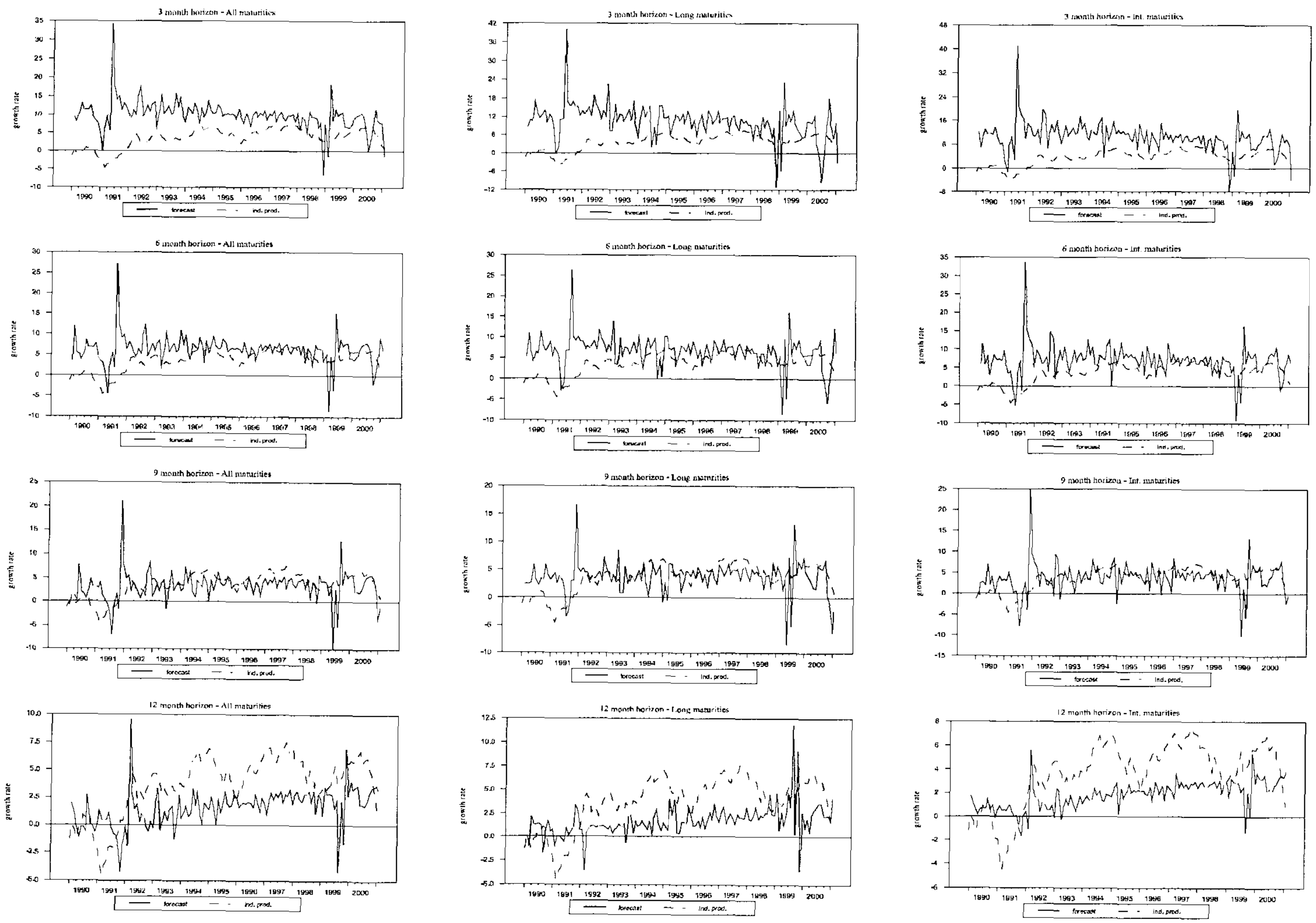


Figure 5: Principal Components of Credit Spreads

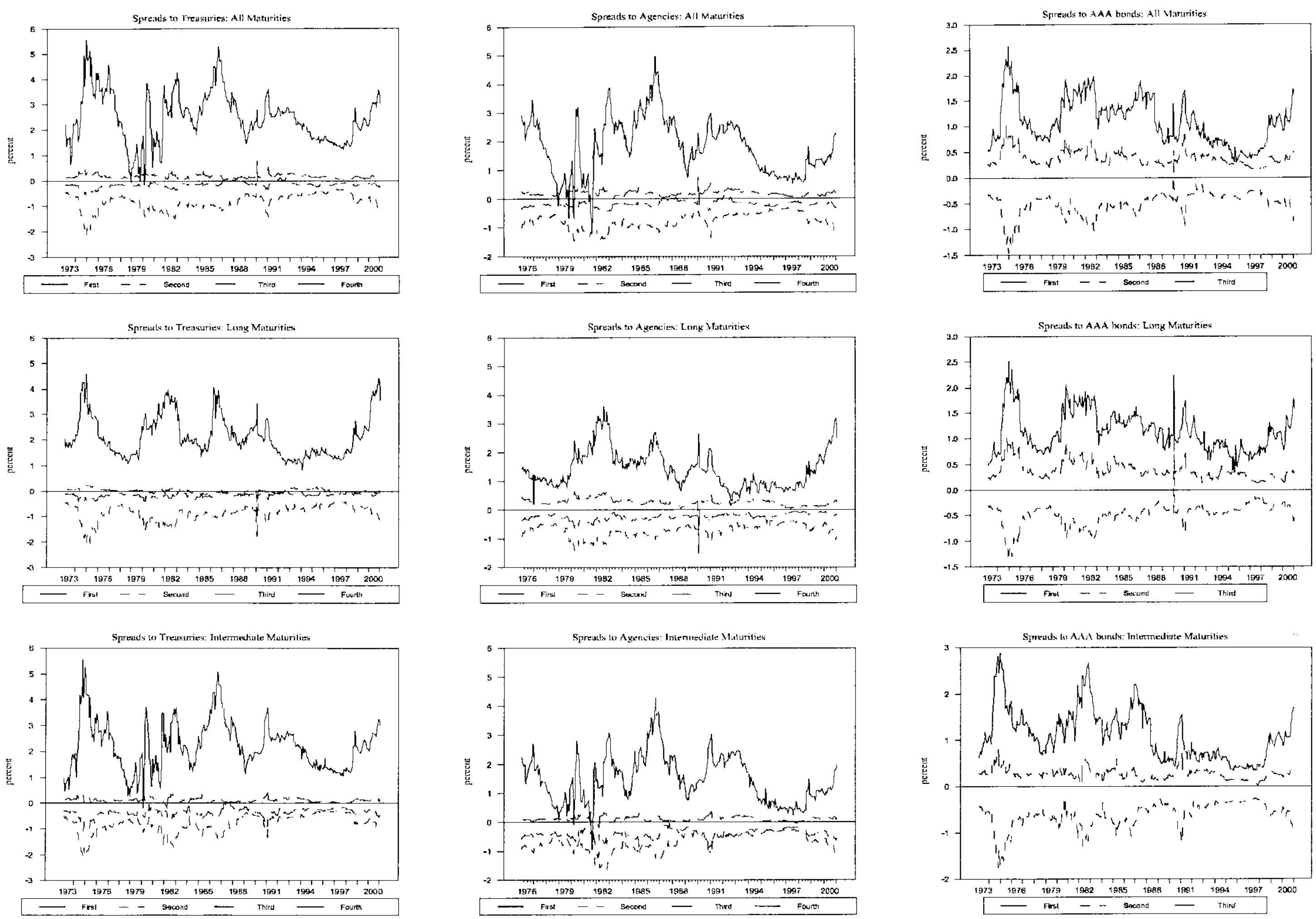


Figure 6: P-values of Systematic Risk Coefficients - All maturities

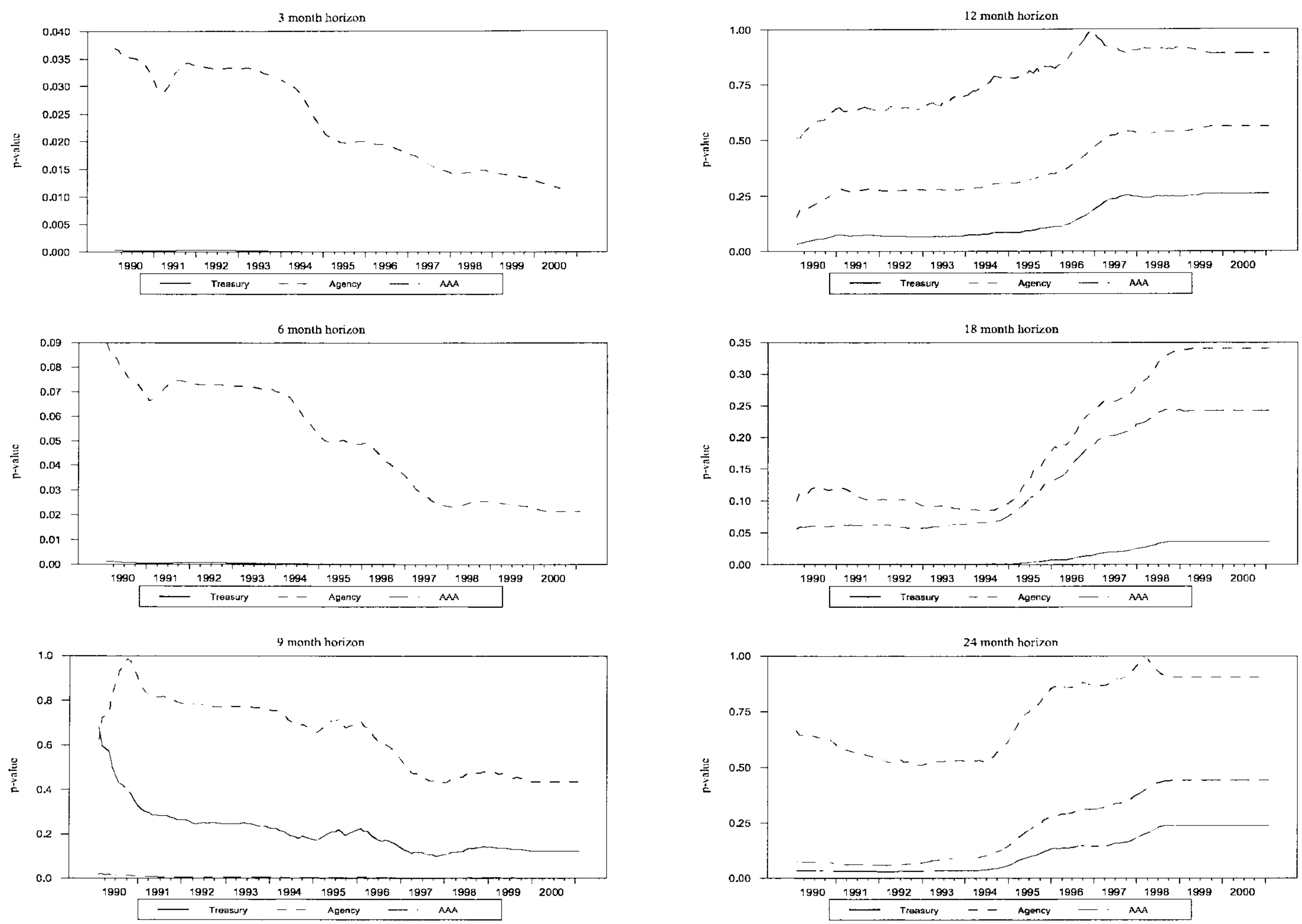


Figure 6 (cont.): P-values of Systematic Risk Coefficients - Long maturities

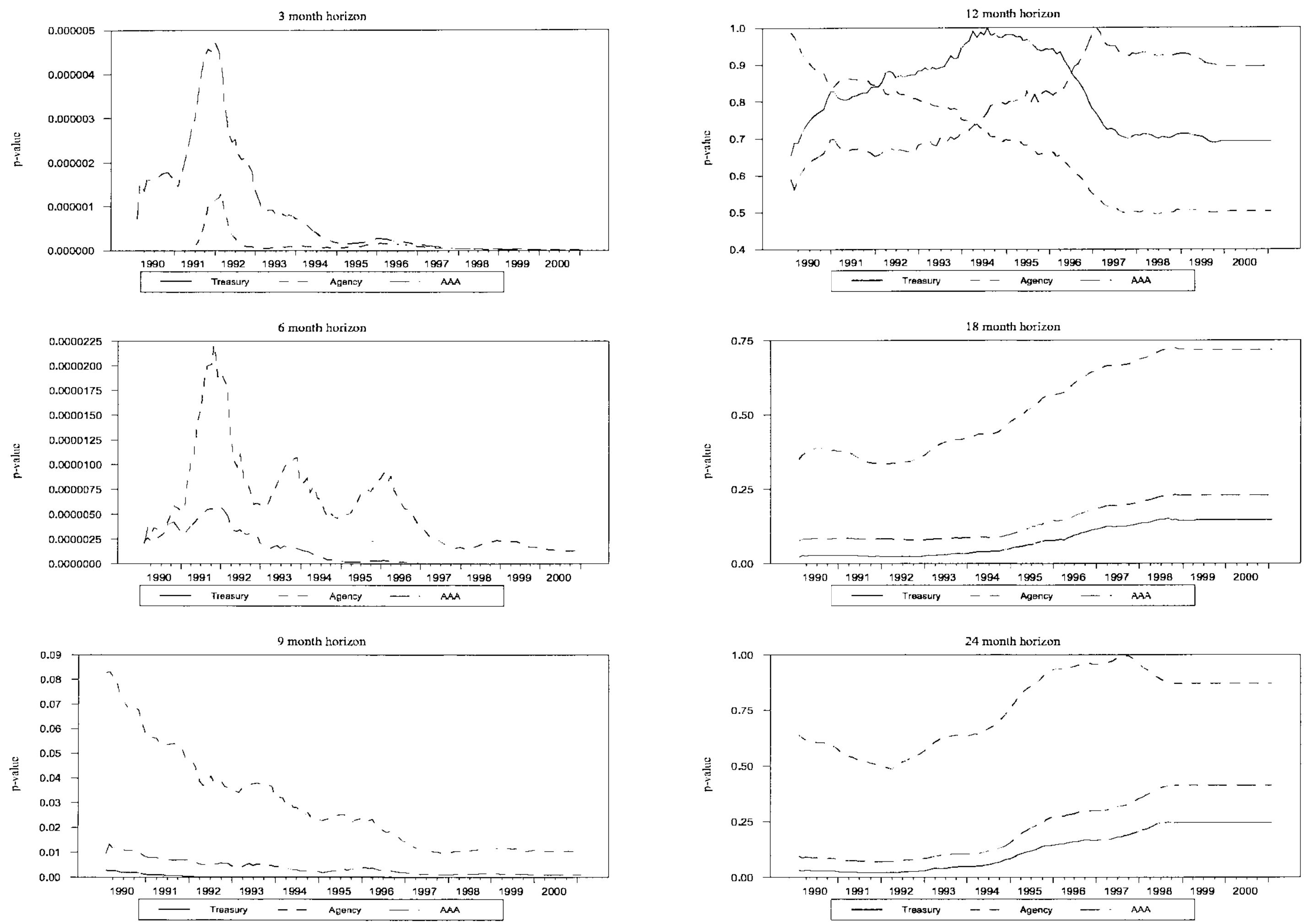


Figure 6 (cont.): P-values of Systematic Risk Coefficients - Intermediate maturities

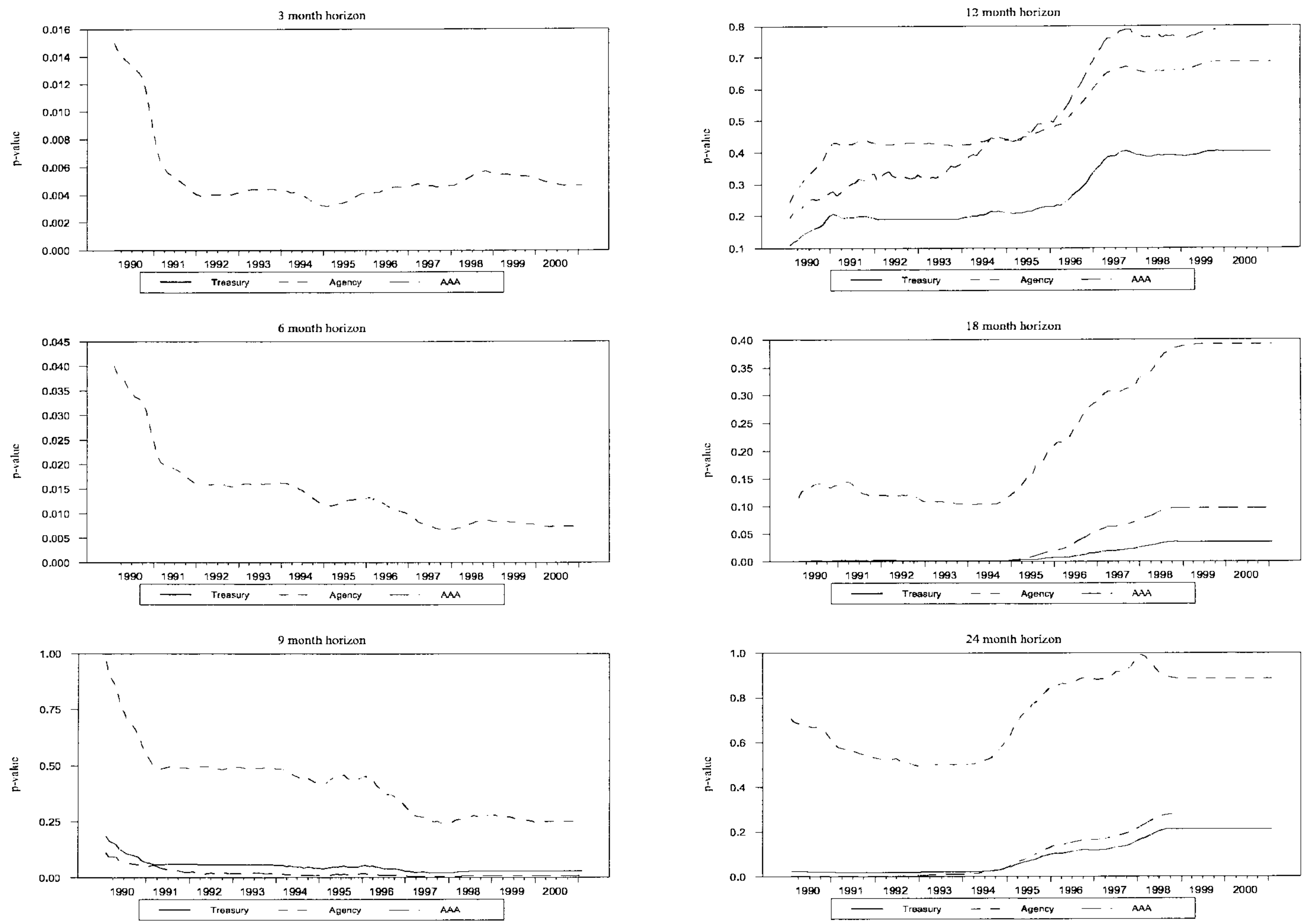


Figure 7: Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to Treasuries

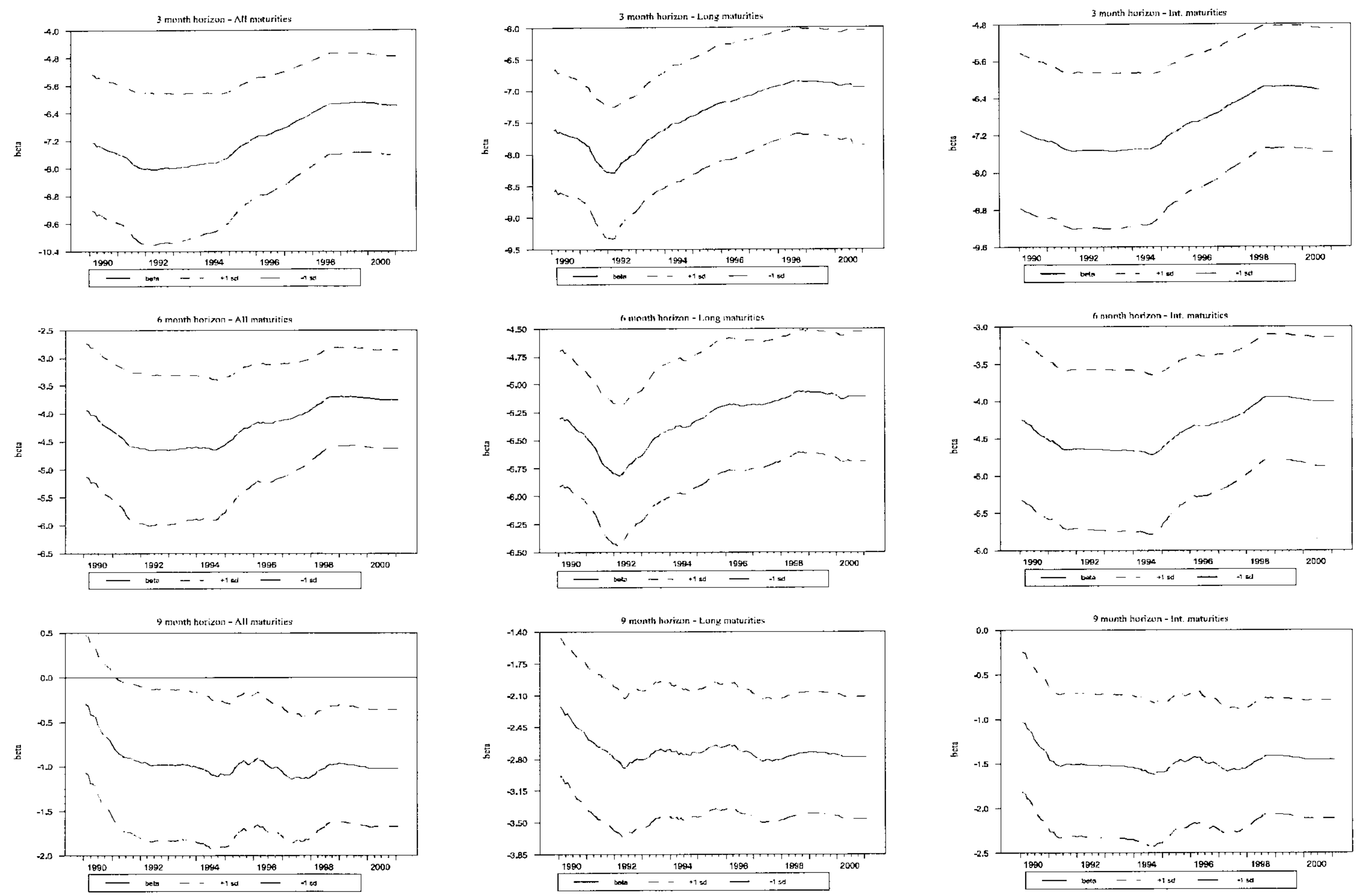


Figure 7 (cont.): Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to Treasuries

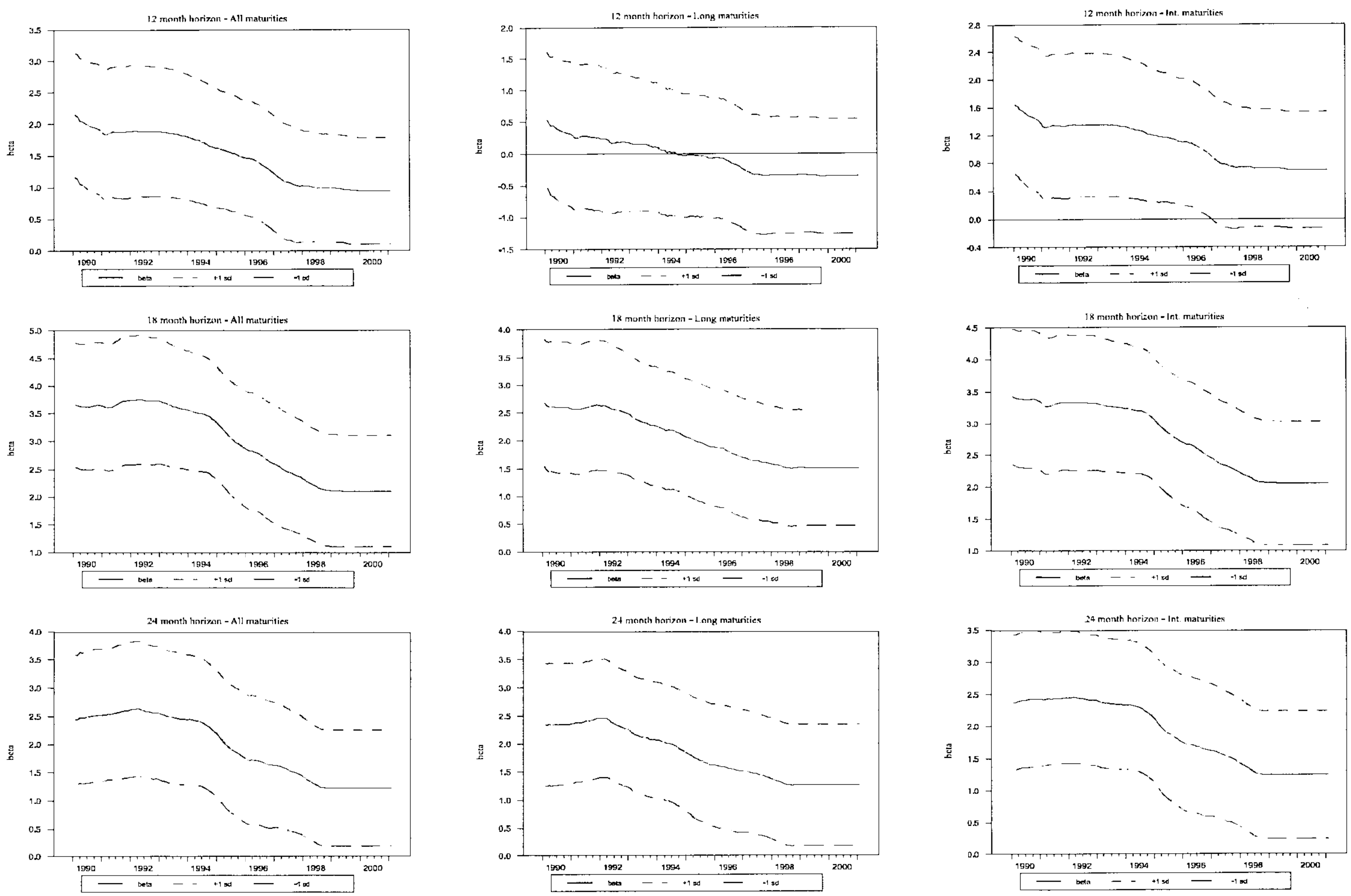


Figure 7 (cont.): Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to Agencies

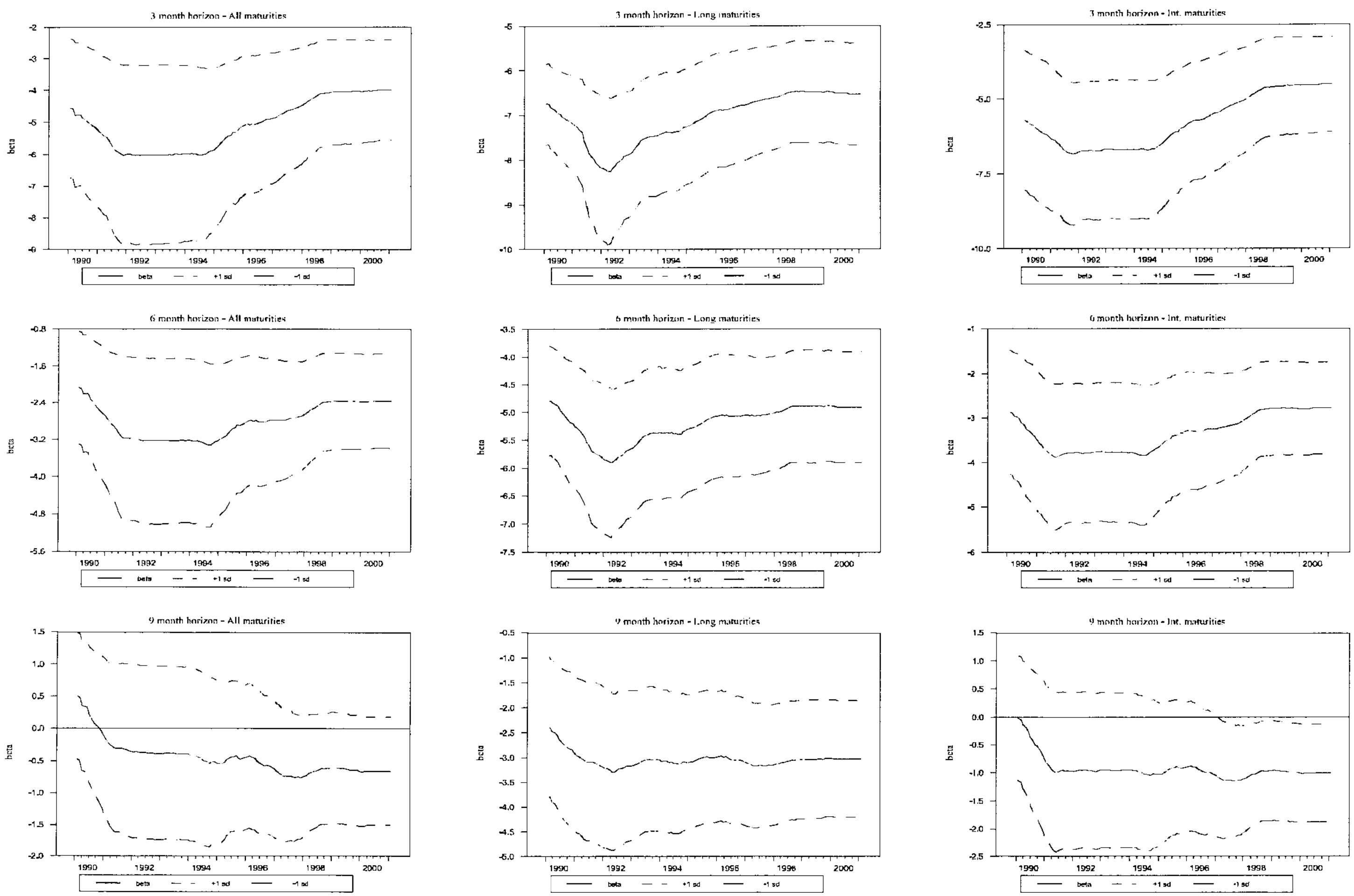


Figure 7 (cont.): Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to Agencies

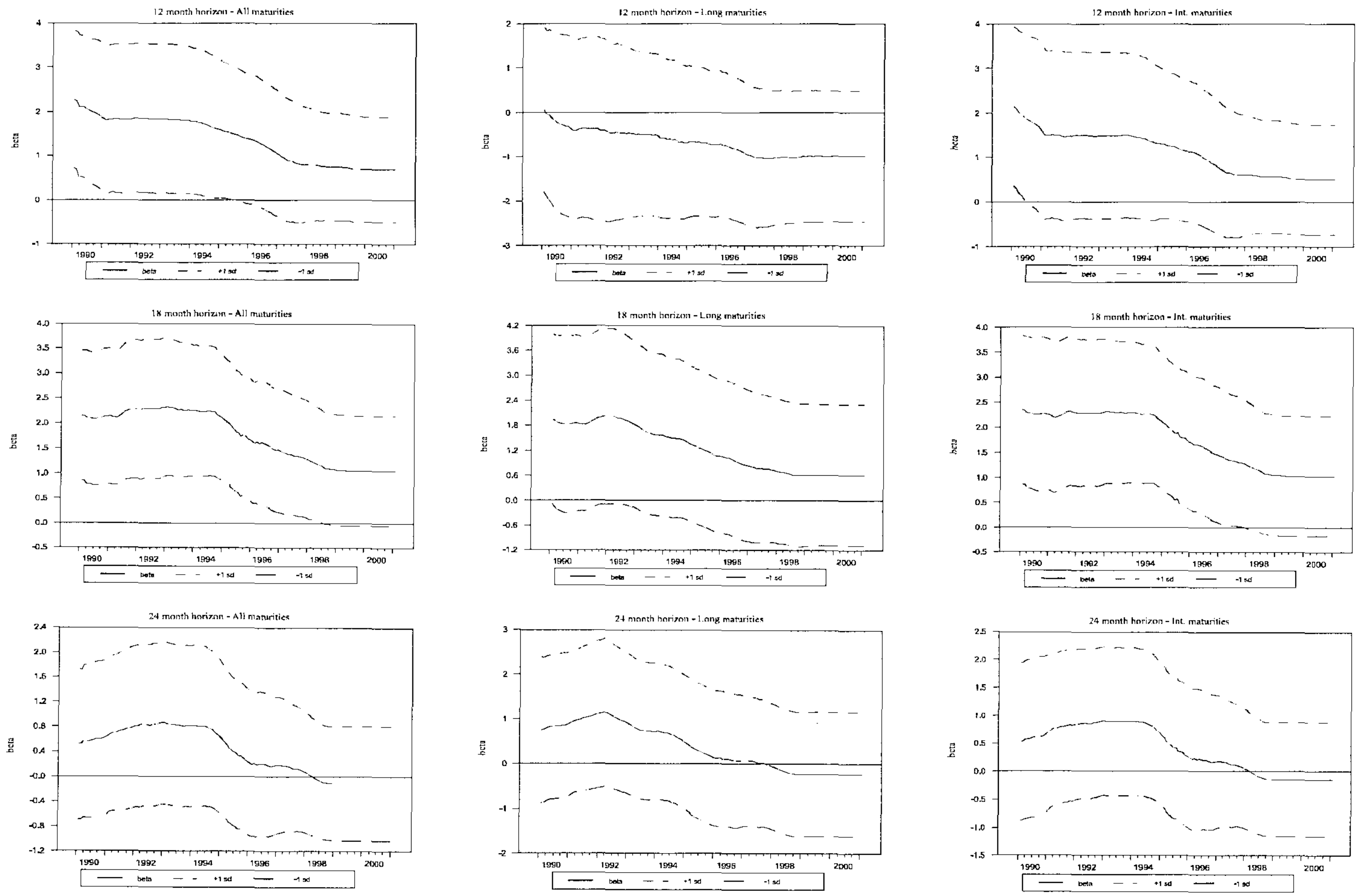


Figure 7 (cont.): Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to AAA bonds

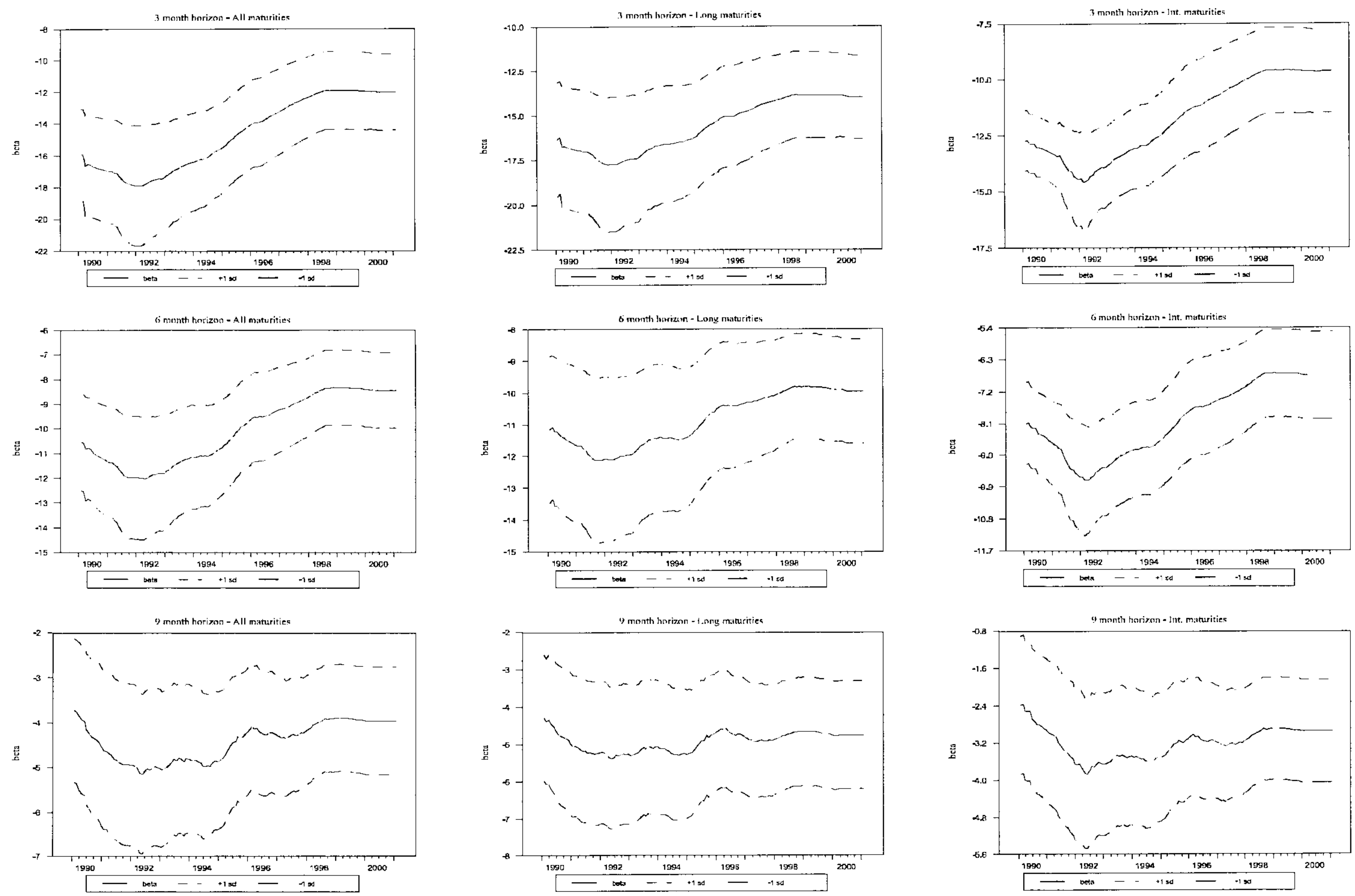


Figure 7 (cont.): Coefficients Estimates and Standard Errors
Systematic Risk of Spreads to AAA bonds

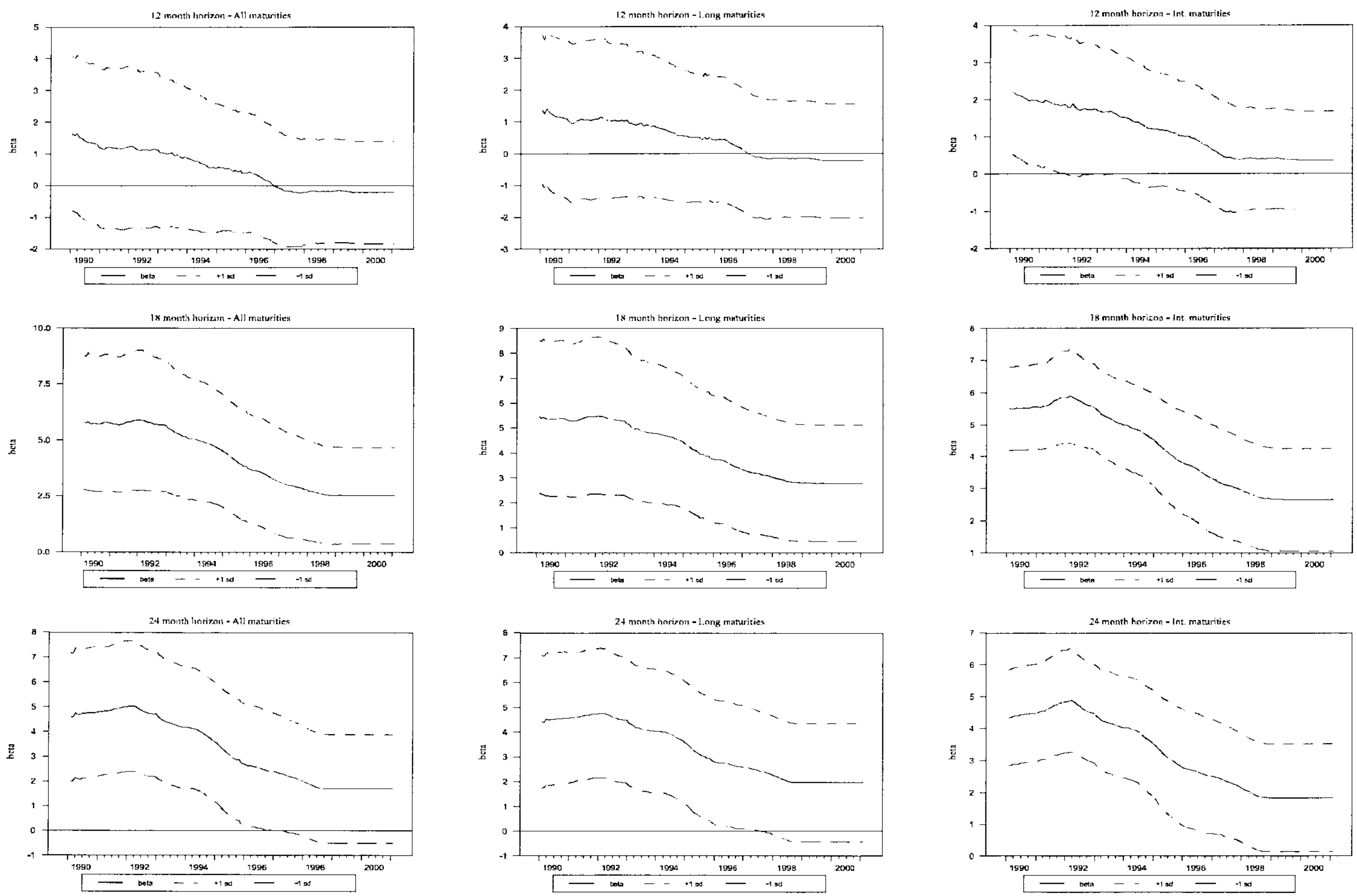


Figure 8: Industrial Production Forecasts
Systematic component of spreads to Treasuries

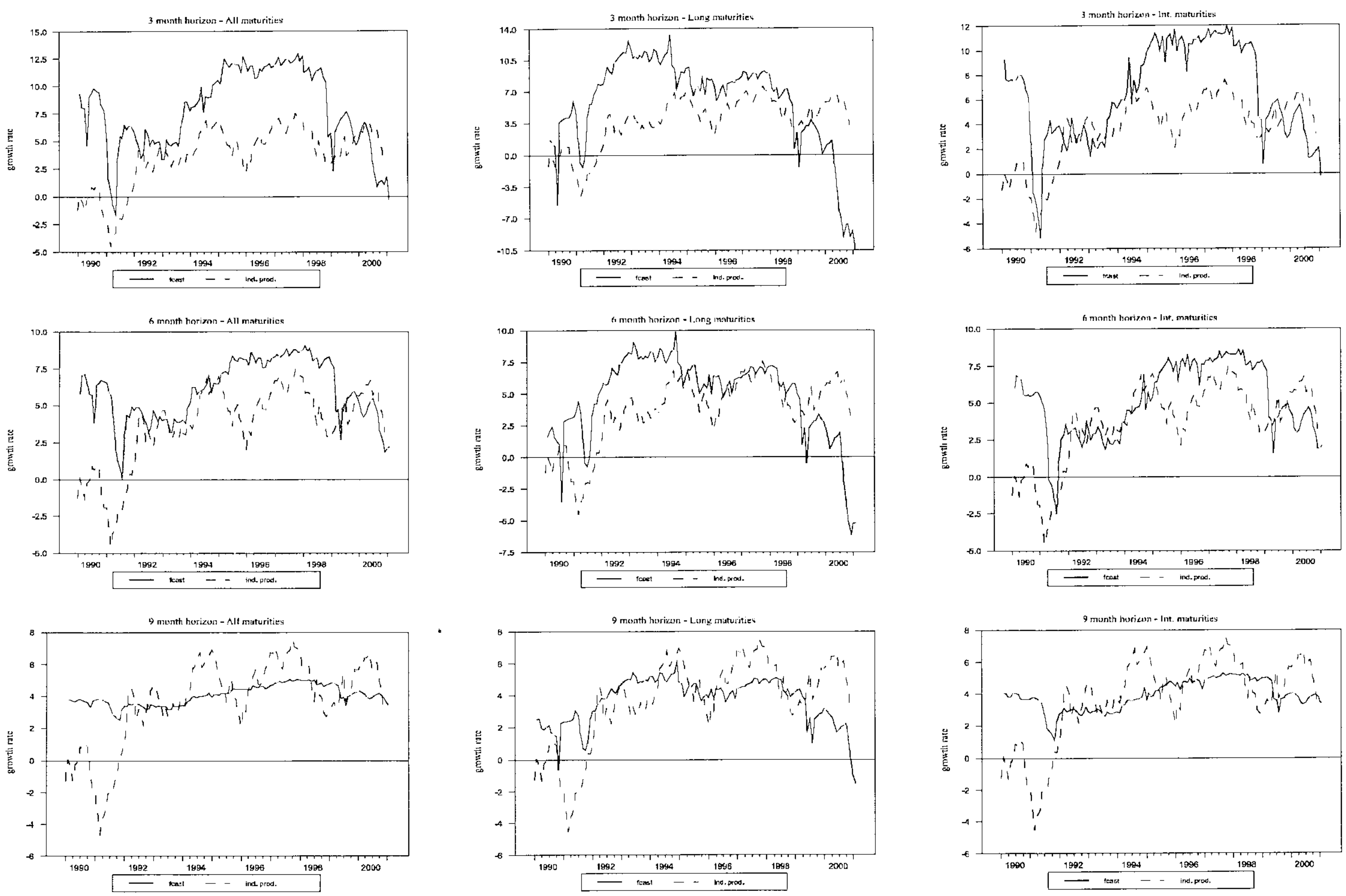


Figure 8 (cont.): Industrial Production Forecasts
Systematic component of spreads to Treasuries

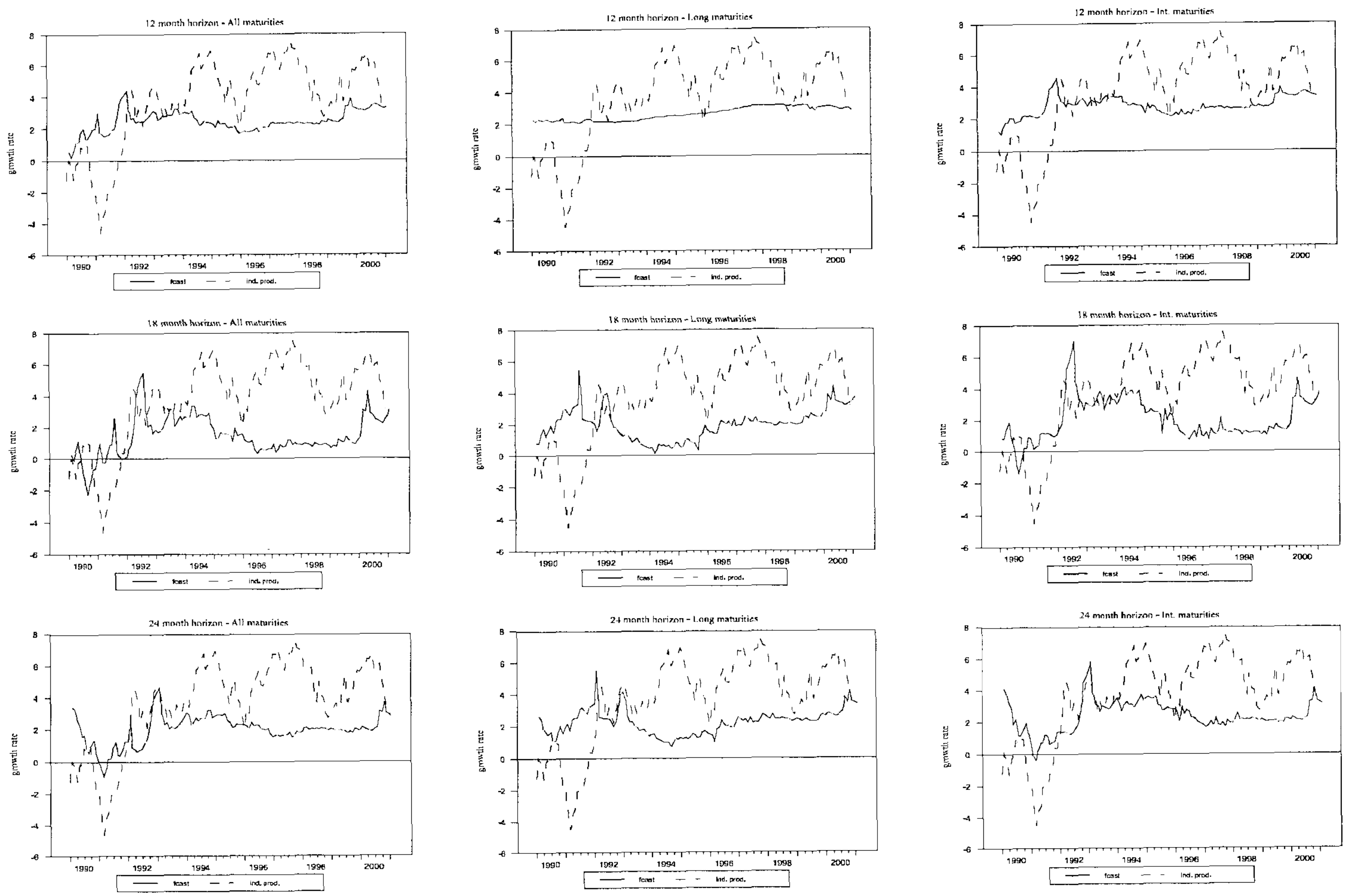


Figure 8 (cont.): Industrial Production Forecasts
Systematic component of spreads to Agencies

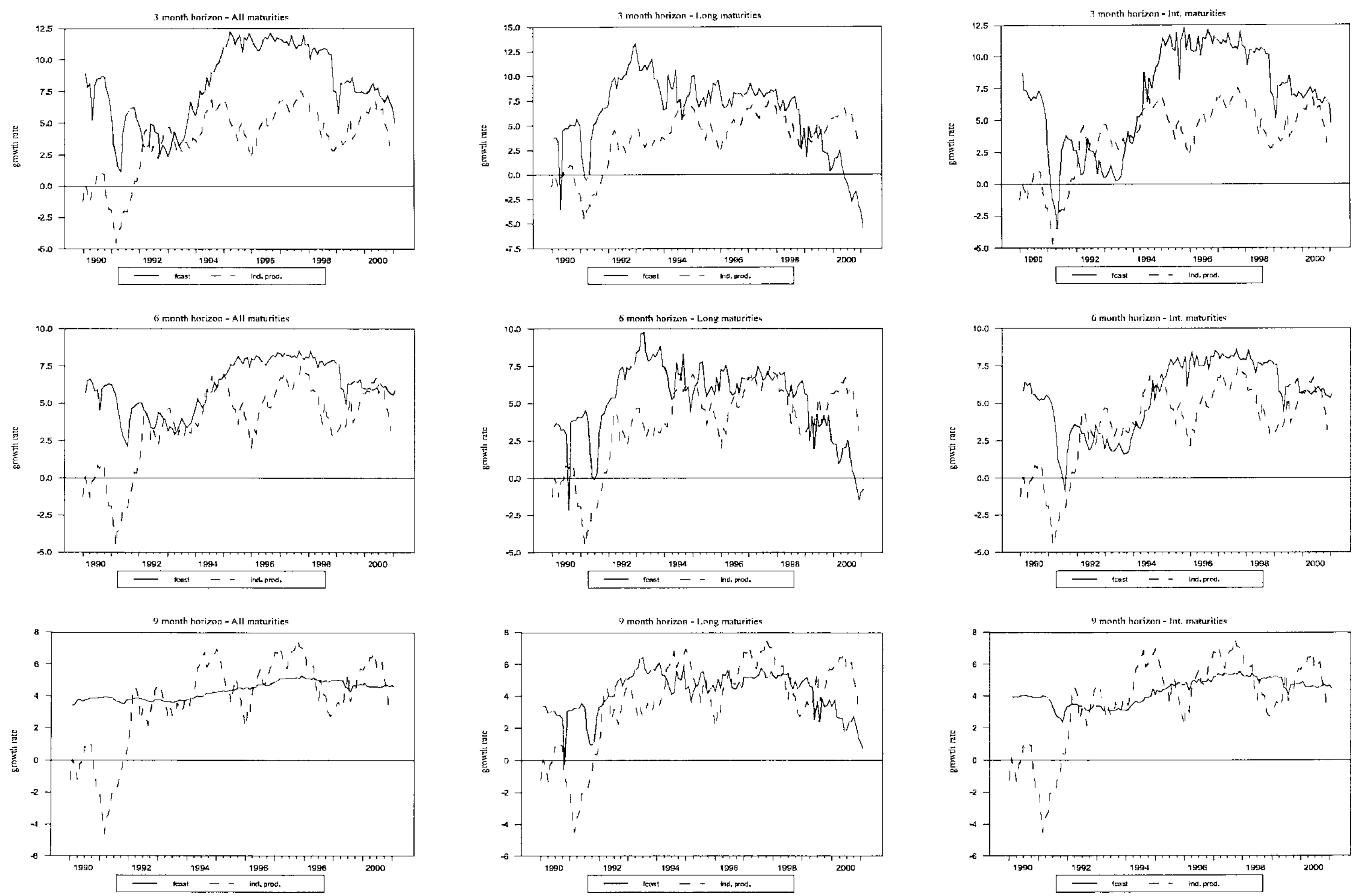


Figure 8 (cont.): Industrial Production Forecasts
Systematic component of spreads to Agencies

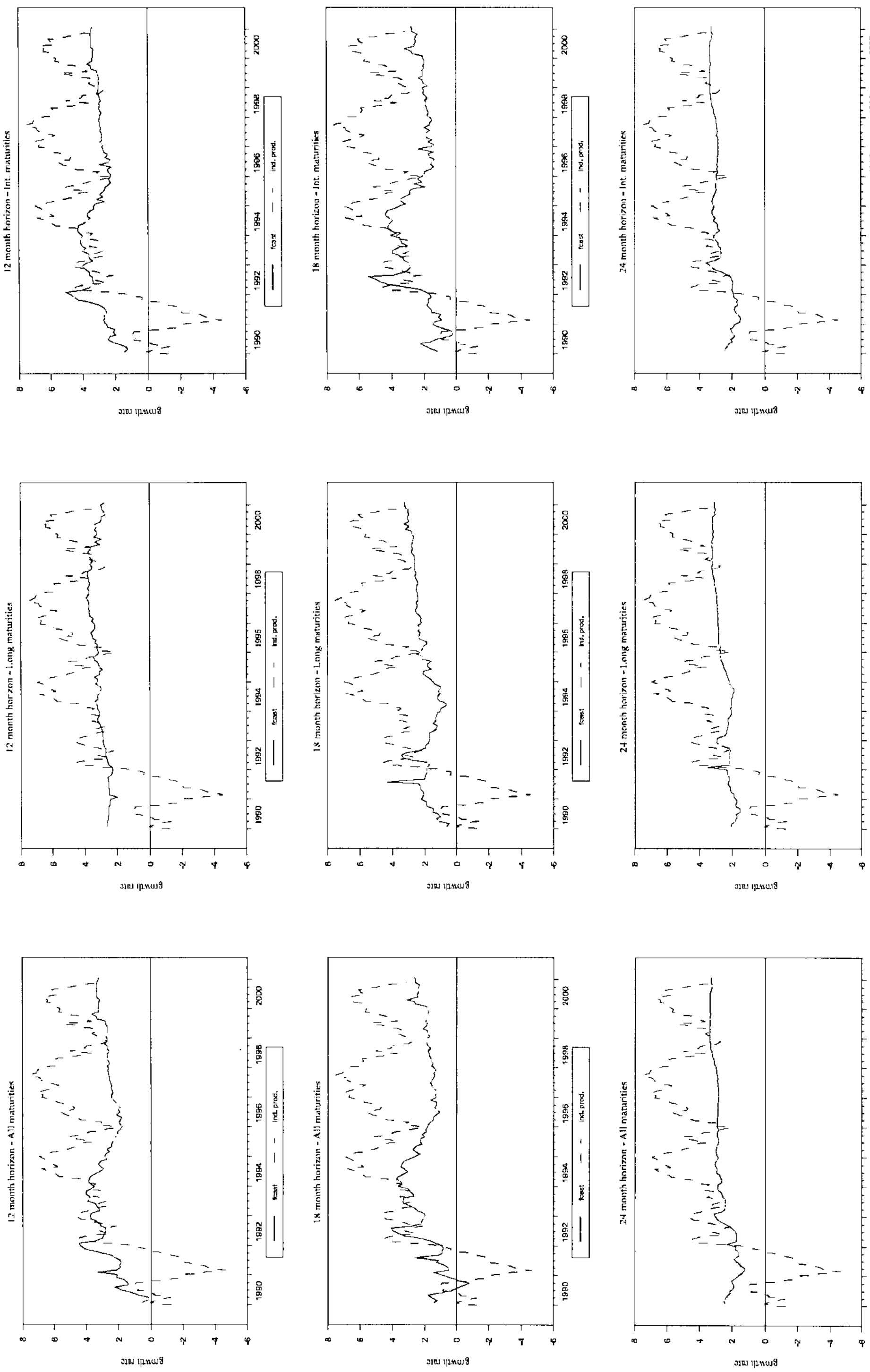


Figure 8 (cont.): Industrial Production Forecasts
Systematic component of spreads to AAA bonds

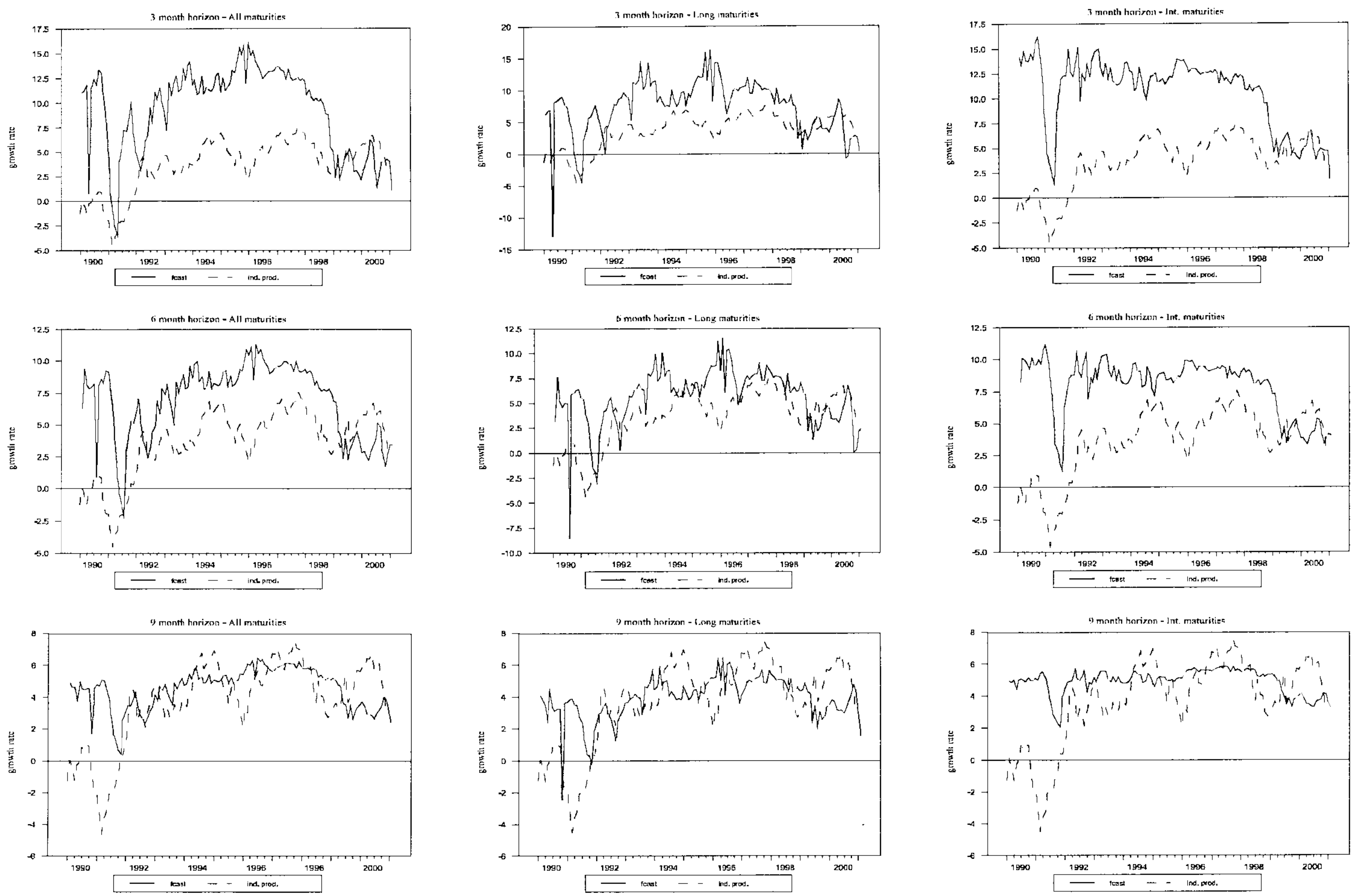


Figure 8 (cont.): Industrial Production Forecasts
Systematic component of spreads to AAA bonds

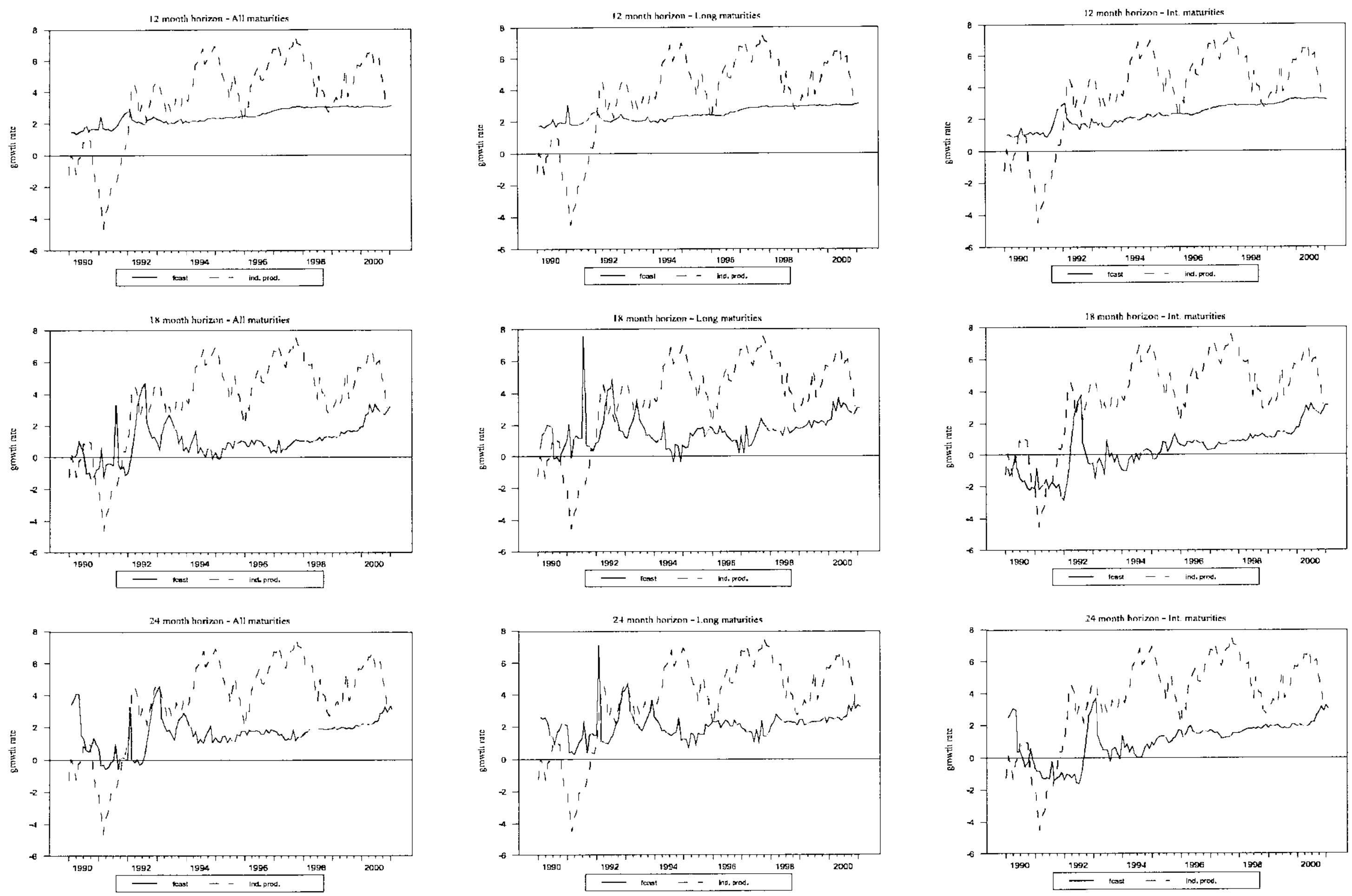


Figure 9. Regime-Switching Forecasts: Systematic Component of Corporate Spreads - All Maturities

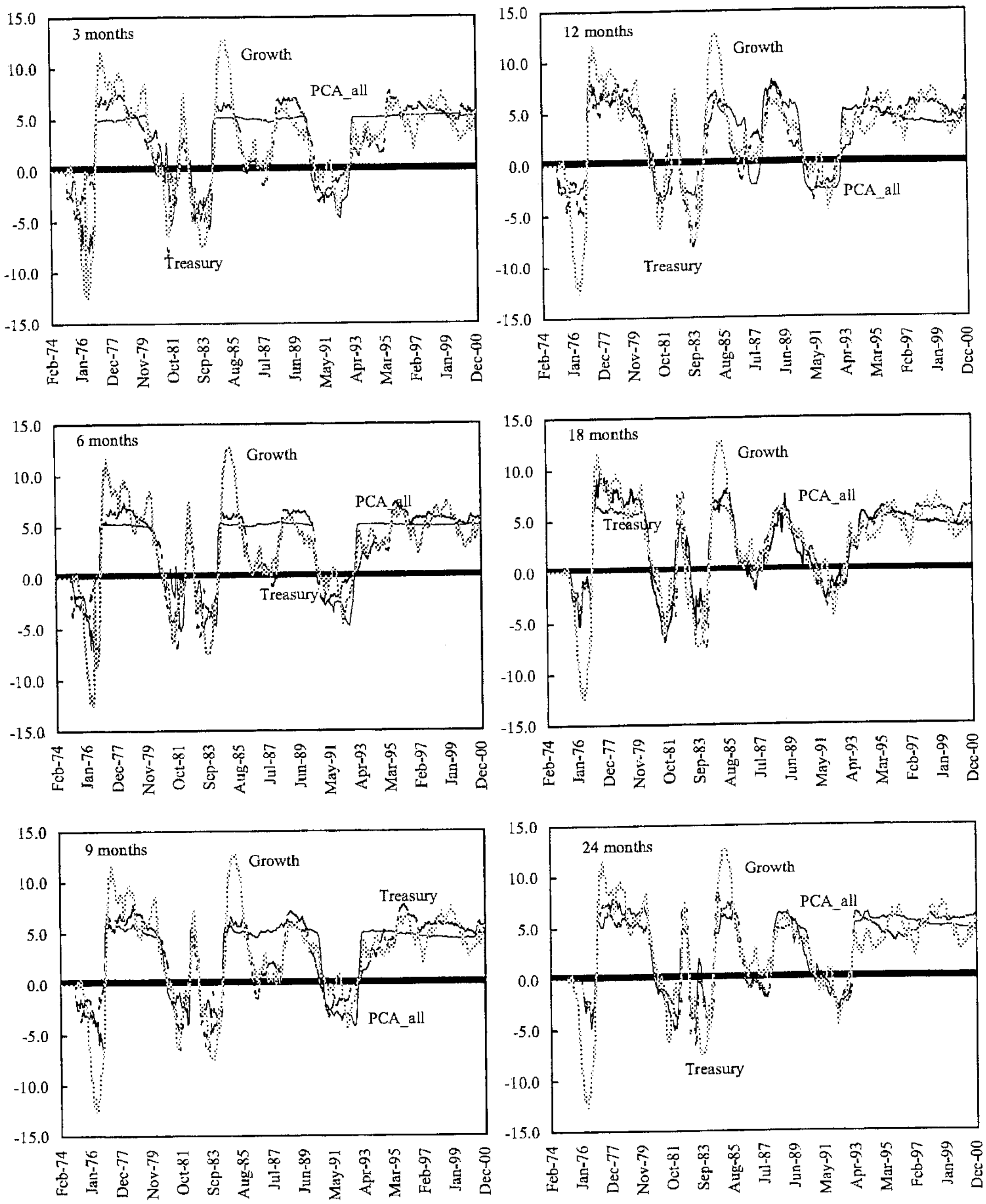


Figure 9 (cont.) Regime-Switching Forecasts: Systematic Component of Corporate Spreads - Long Maturities

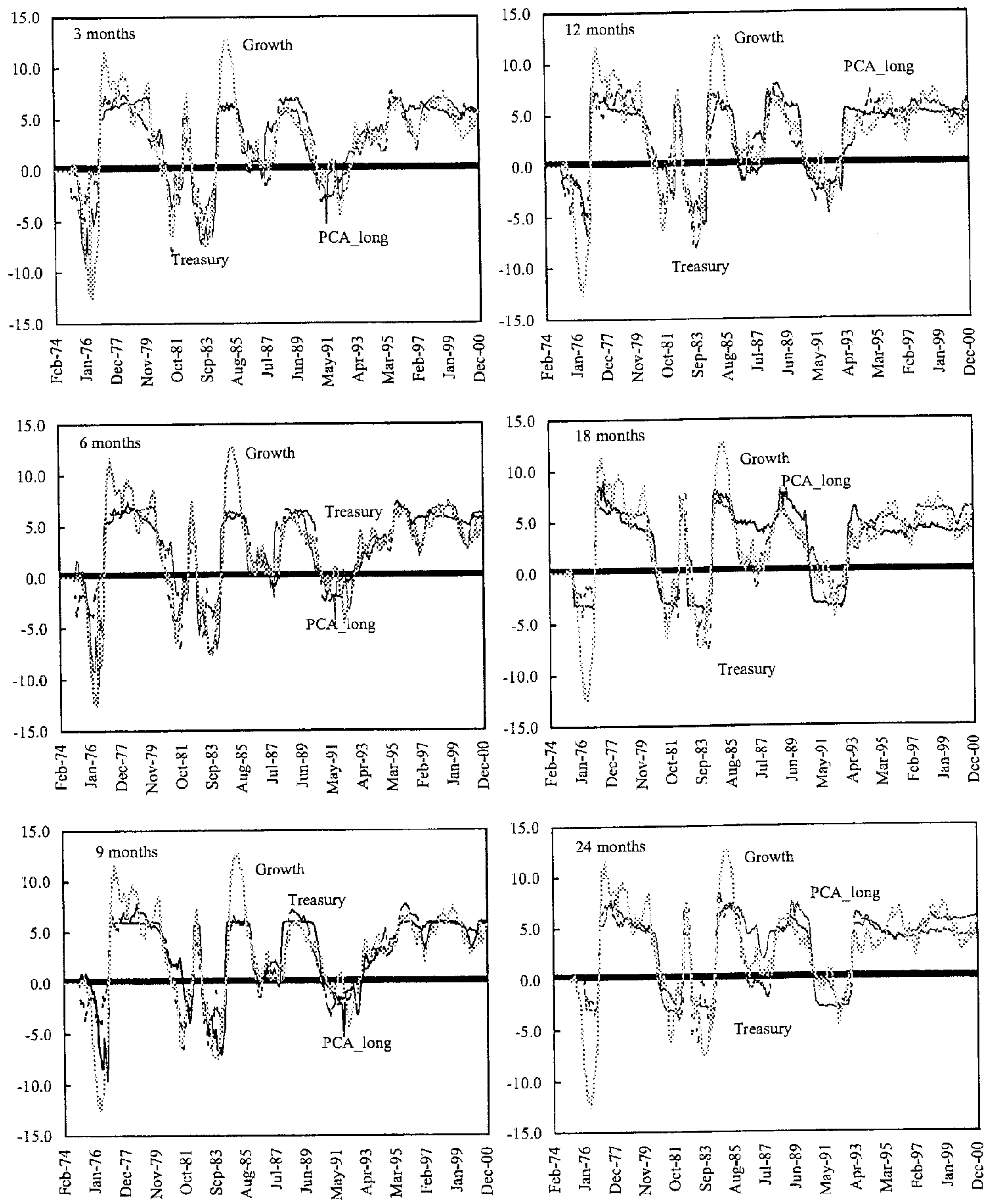
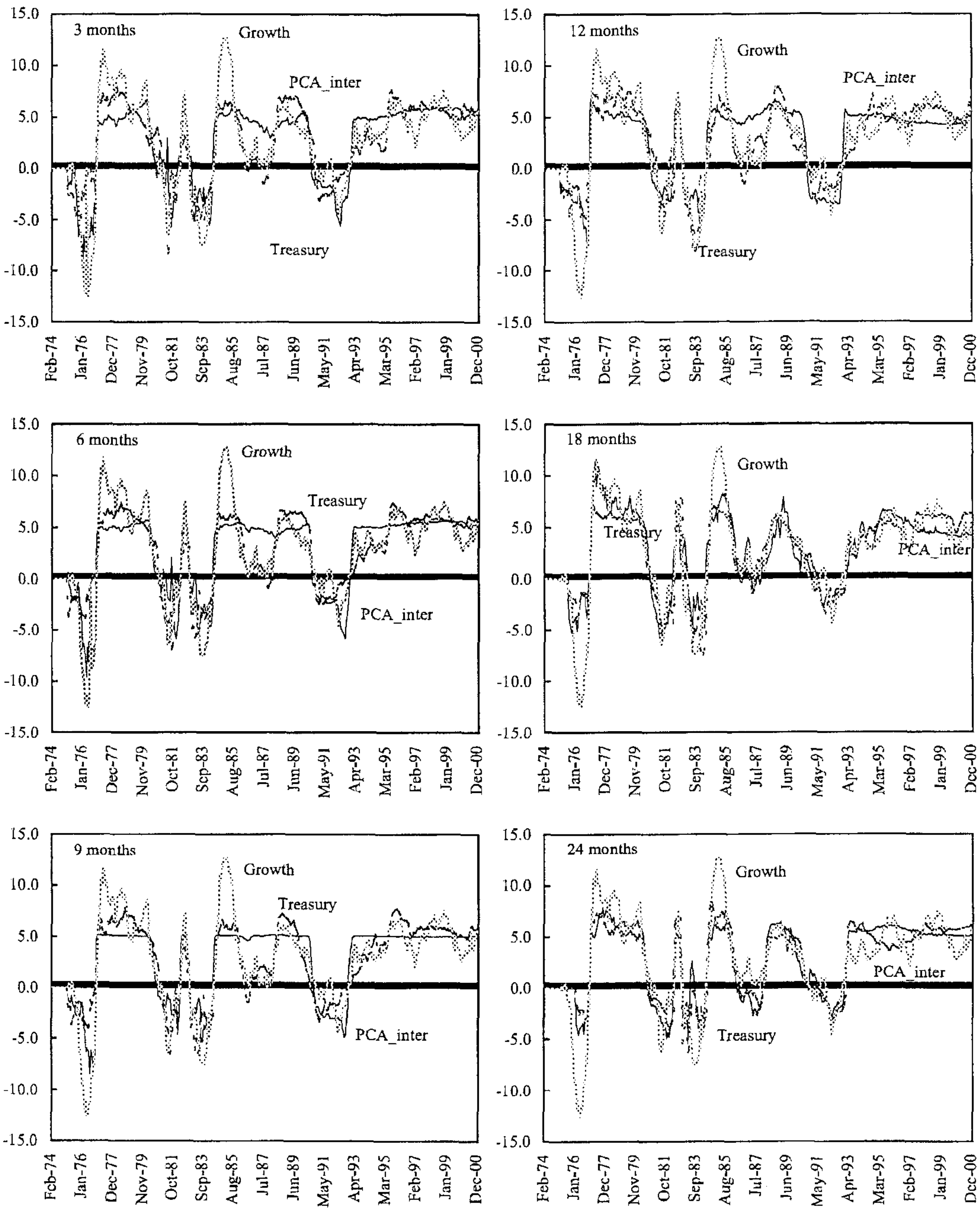


Figure 9 (cont.) Regime-Switching Forecasts: Systematic Component of Spreads to Treasuries - Intermediate Maturities



References

Amemiya, Takaheshi, 1985, *Advanced Econometrics* (Cambridge, Massachussets: Harvard University Press).

Bertocchi, Marida, Rosella Giacometti, and Stavros A. Zenios, 2000, "Risk Factor Analysis and Portfolio Immunization in the Corporate Bond Market," working paper (Philadelphia, Pennsylvania: The Wharton Financial Institutions Center, The Wharton School, University of Pennsylvania).

Bernanke, Ben, Mark Gertler and Simon Gilchrist, 1998, "The Financial Accelerator in a Quantitative Business Framework", NBER Working Paper 6455 (Cambridge, Massachusetts: National Bureau of Economic Research).

Davidson, Russell, and James G. McKinnon, 1993, Estimation and Inference in Econometrics (Oxford: Oxford University Press).

Dempster, A.P., N.M. Laird, and D. B. Rubin, 1977, "Maximum Likelihood from Incomplete Data via the EM Algorithm," *Journal of the Royal Statistical Society* Series B, 39, pp. 1-38.

Duca John C., 2000, "What Credit Markets Tell Us", *Economic and Financial Review*, Federal Reserve Bank of Dallas, Third Quarter, pp. 2-13.

Engle, Robet F., and David F. Henry, 1993, "Testing Super Exogeneity and Invariance in Regression Models, " Journal of Econometrics 56, pp. 119-139.

Fleming, Michael J., 2000, "Financial Market Implications of The Federal Debt Paydown," *Brooking Papers on Economic Activity* 2, pp. 221-251.

Friedman Benjamin M., and Kenneth N. Kuttner, 1992, "Money, Income, Prices and Interest Rates," American Economic Review 82, pp. 472-92.

Gallant, A. Ronald, and George Tauchen, 1996, "Which Moments to Match?" *Econometric Theory*, 12(4), pp. 657-681.

Garbade, Kenneth, 1986, "Models of Fluctuations in Bond Yields: An Analysis of Principal Components," in *Topics in Money and Securities Markets* (New York: Bankers Trust). Reprinted as Chapter 16 in Kenneth D. Garbade, 1996, *Fixed Income Analytics* (Cambridge, Massachussets: MIT Press).

Gertler, Mark, and Cara S. Lown, 2000, "The Information in the High Yield Bond Spread for the Business Cycle: Evidence and Some Implications," NBER Working Paper 7549 (Cambridge, Massachusetts: National Bureau of Economic Research).

Greene, William H., 1993, *Econometric Analysis*, 3rd edition (Englewood Cliffs, New Jersey: Prentice Hall).

Hamilton, James, 1989, "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," *Econometrica* 57, pp. 357-84.

Hansen, Lars P., 1982, "Large Sample Properties of Generalized Method of Moments Estimators", *Econometrica 50*, pp.1029-54.

Keenan, Sean C., David T. Hamilton, and Alexandra Berthault, 2000, "Historical Default Rates of Corporate Bond Issuers, 1920-1999," *Special Comment*, Moody's Investors Service.

Knez, Peter J., Robert Litterman, and José Scheinkman, 1994, "Explorations into Factors explaining Money Market Returns," *Journal of Finance* 49, pp. 1861-1882.

Litterman, Robert, and José Scheinkman, 1988, "Common Factors Affecting Bond Returns," *The Journal of Fixed Income* 1, pp. 54-61.

Merton, Robert C., 1974, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates", Journal of Finance 29, pp. 449-470.

Nelson, Charles R., and Richard Startz,1990, "Some Further Results on the Exact Small Sample Properties of the Instrumental Variable Estimator", *Econometrica* 58, pp. 967-76.

Newey, Whitney and Kenneth West, 1987, "A Simple Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica* 55, pp.703–708.

______, 1994, "Automatic Lag Selection in Covariance Matrix Estimation," *Review of Economic Studies* 61, pp. 631–653.

Schinasi, Garry J., Charles F. Kramer, and Todd R. Smith, 2001, "Financial Implications of the Shrinking Supply of U.S. Treasury Securities," (Washington, D.C.: International Monetary Fund).

Stock, James H., and Mark W. Watson, 2000, "Forecasting Output and Inflation: The Role of Asset Prices," working paper (Cambridge, Massachusetts: National Bureau of Economic Research).

_____, 2001, "Forecasting Output and Inflation: The Role of Asset Prices," 2001, NBER Working Paper No. 8180 (Cambridge, Massachusetts: National Bureau of Economic Research).

Wojnilower, Albert W., 1980, "The Central Role of Credit Crunches in Recent Financial History", *Brookings Papers on Economic Activity*, pp. 277-339.