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Abstract

This paper examines the predictive power of credit spreads from the corporate bond market. The high-yield bond spread and investment-grade spread can explain 68 per cent and 42 per cent of output variations one year ahead, while the term spread based on government debts can explain only 12 per cent of them. For output forecasts up to one year ahead, the corporate bond spreads also outperform popular indicators such as the paper-bill spread, federal funds rate, consumer sentiment index, Conference Board leading indicator, and the Standard & Poor's index both in-sample and out-of-sample. The forecasts from the high-yield spread are more accurate than those from the investment-grade spreads. For forecasts beyond the one-year horizon, the term spread and the federal funds rate dominate the corporate spreads. The author finds that linear models based on stock market movements, the risk-free short rate, and the term spread can explain only 7 per cent of the variations in the high-yield spread. The credit channel theory in monetary economics suggests that the functional form should be non-linear. Statistical tests reject the linearity assumption for both corporate spreads in favour of a threshold non-linear specification that is consistent with the credit channel theory. The threshold models explain 63 per cent of the variations in the high-yield spread and 75 per cent of the variations in the investment-grade spread.

JEL classification: E3, E5, G1
Bank classification: Financial markets; Monetary and financial indicators; Transmission of monetary policy

Résumé

L'auteur se penche sur le pouvoir prédictif des écarts de taux observés sur le marché des obligations de sociétés. Les écarts relatifs aux obligations à rendement élevé et aux obligations de bonne qualité peuvent expliquer respectivement 68 et 42 % des variations de la production à l'horizon de un an, tandis que le différentiel d'intérêt entre les titres d'État à long terme et à court terme n'en explique que 12 %. Lorsque l'horizon de prévision est de un an ou moins, les écarts de taux sur les obligations de sociétés surclassent également les indicateurs couramment utilisés, comme l'écart entre le taux du papier commercial et celui des bons du Trésor, le taux des fonds fédéraux, l'indice des attitudes des consommateurs, l'indicateur avancé du Conference Board et l'indice Standard & Poor's, tant à l'intérieur qu'à l'extérieur de l'échantillon. Les prévisions s'avèrent plus justes lorsqu'elles reposent sur les écarts de taux relatifs aux obligations à rendement élevé plutôt qu'aux obligations de bonne qualité. Cependant, dans le cas des horizons d'au-delà de un an, le différentiel d'intérêt sur titres d'État et le taux des fonds fédéraux sont plus utiles que les écarts de taux relatifs aux obligations de sociétés. L'auteur constate que les modèles linéaires fondés sur les variations du marché boursier, le taux sûr à court terme et le différentiel d'intérêt sur titres d'État ne peuvent expliquer que 7 % des variations de l'écart relatif aux titres à rendement élevé. La théorie du canal du crédit, en économie monétaire, donne à penser que la forme fonctionnelle devrait être non linéaire. Les tests statistiques réfutent l'hypothèse de linéarité pour les deux écarts relatifs aux obligations de sociétés, au profit d'une spécification non linéaire à seuil conforme à la théorie du canal de crédit. Les modèles à seuil expliquent 63 % des variations des écarts dans le cas des obligations à rendement élevé et 75 % de ces variations dans le cas des obligations de bonne qualité.

Classification JEL : E3, E5, G1
Classification de la Banque : Marchés financiers; Indicateurs monétaires et financiers; Transmission de la politique monétaire

1. Introduction

Previous literature[1] that relates output forecasts to financial variables has focused on information from the stock market, government debt market, and short-term corporate debt market. The prominent financial leading indicators for private investors and central bankers are stock market indexes, the term spread (the difference between the long-term government bond rate and short-term Treasury-bill rate), and the paper-bill spread (the difference between yields on commercial paper and Treasury bills). It has been documented that the predictive power of these variables has deteriorated since the 1980s.[2] This highlights the need for alternative leading indicators for business cycles.

This paper examines the forecasting ability of credit spreads from the long-term corporate debt market. One unique feature of this market is that corporate bonds are explicitly labelled into two categories in terms of the credit quality of their issuers: high-yield bonds and investment-grade bonds. Although bonds in both markets are subject to default risks, the default rate in the high-yield bond market is higher and more cyclical than that in the investment-grade market, which indicates that the high-yield spread could give more accurate forecasts than the investment-grade spread. Figures 1 and 2 plot the high-yield bond spread and the investment-grade bond spread[3] against the employment growth rate in the United States. There is a clear lead-lag relation between the credit spreads and the employment growth rate, which suggests that the credit spreads are good candidates to be leading indicators. We focus on U.S. data in this paper because of the lack of Canadian corporate bond data. However, the empirical finding of this paper is relevant to the Canadian economy because of Canada's strong ties with the U.S. economy. In fact, many Canadian corporate bonds (especially high-yield bonds) are issued in the U.S. market.

We report three major findings from this study. First, compared with many other variables, both corporate bond spreads have strong predictive power for the business cycles since the late 1980s. The high-yield and investment-grade spreads explain 68 per cent and 42 per cent of output variations one year ahead, while the term and the paper-bill spreads explain only 12 per cent and 1 per cent, respectively. Corporate bond spreads also outperform other popular indicators such as the federal funds rate, stock market index, consumer sentiment index, and the Conference Board

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1. The literature is reviewed in section 2.
2. Emery (1996) and Dotsey (1998) illustrate the decay of the predictive power and discuss plausible causes.
3. The investment-grade bond spread is defined as the yield for Baa grade bonds minus the yield for Treasury bonds. The high-yield bond spread is defined as the Moody's high-yield bond yield index minus the yield for Treasury bonds. These spreads are adjusted for maturity mismatch by Moody's.

leading indicator, by large margins. Real-time out-of-sample forecasts for the 2001 economic slowdown support our findings.[4]

Second, variables from different financial markets seem to have significantly different forecast content. Both the paper-bill spread and the variation of the Standard & Poor's stock market index forecast poorly. The corporate spreads dominate the term spread and the federal funds rate for forecasts up to one year ahead. Beyond the one-year horizon, the predictive power of the corporate spreads deteriorates, while the term spread and the federal funds rate become better leading indicators.

Third, the predictive power of the investment-grade spread is dominated by the high-yield spread for forecasts up to 18 months ahead. Beyond this horizon, the ability of the high-yield spread to forecast deteriorates rapidly, while the ability of the investment-grade spread remains strong for up to 30 months ahead.

These findings motivate further investigation of the driving forces behind corporate spreads. The substantial difference among forecasts from the corporate spreads and other variables indicates that the predictive power of corporate spreads does not come from the factors that affect other financial markets. A simple linear regression shows that the term spread, the Standard & Poor's index, and the federal funds rate can explain merely 7 per cent of the high-yield spread.[5] The forecast experiment in this paper, however, is based on linear models. The credit channel theory in monetary economics (Bernanke and Gertler 1989, 1995) suggests that the relation between the federal funds rate and corporate bond spreads could be non-linear. The theory claims that an external finance premium exists owing to asymmetric information between firms and investors. The impact of monetary policy on the external finance premium depends on the credit quality of firms. Gertler and Lown (1999) argue that credit spreads are good measures of the external finance premiums. This implies a non-linear relation between the federal funds rate and the corporate spreads. This is examined by statistical tests based on Andrews and Ploberger (1994) and Hansen (1997). The linearity assumption is rejected in favour of a threshold non-linear specification for both corporate spreads. The threshold models fit the data significantly better. Compared with the linear models, the adjusted R-squares rise from 0.07 to 0.61 for the high-yield spread and from 0.44 to 0.59 for the investment-grade spread. This finding supports the credit channel theory as one plausible explanation for the strong predictive power of credit spreads.

4. The importance of the out-of-sample forecasts is discussed at the end of section 2.
5. Most papers in the previous literature focused on investment-grade bond spreads.

This paper is organized as follows. Section 2 reviews the previous literature on forecasting business cycles. Section 3 examines the predictive power of the corporate bond spreads. Section 4 interprets the predictive power of the corporate spreads. Section 5 summarizes the main findings of this study.

2. Forecasting Business Cycles: Previous Literature[6]

The predictive power of the term spread for future output has been studied by Harvey (1988, 1989), Chen (1991), Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), and Stock and Watson (1989), among others. The term spread contains information on inflation expectations as well as monetary policy. Because the underlying assets are default risk free, the term spread does not capture information about credit risk.

Previous literature that relates output forecasts to credit risk focused on the paper-bill spread (Bernanke and Blinder 1992; Stock and Watson 1989; and Friedman and Kuttner 1992, 1993a, b, 1998, among others). As a leading indicator, the paper-bill spread faces at least two problems. First, the underlying assets—commercial paper and Treasury bills—are short-term debts that are not affected by long-term credit risks. Therefore, they cannot reflect investors' expectations regarding business cycles in the future. Second, as Friedman and Kuttner (1998) point out, commercial paper and Treasury bills could be nearly perfect substitutes because of the low default rate in the commercial-paper market. The empirical failure of the paper-bill spread to anticipate the 1990–91 recession calls into question its extra predictive power beyond the federal funds rate.

The performance of stock market indicators is still open to debate. Fama (1981) and Harvey (1989) show that the linkage between stock prices and future output growth is not clear, while Stock and Watson (1989, 1999) and Estrella and Mishkin (1998) find evidence for marginal predictive content in stock prices.

Two prominent non-financial variables studied in the literature are the consumer sentiment index from the University of Michigan (Carroll, Fuhrer, and Wilcox 1994, Howrey 2001) and the leading indicator from the Conference Board[7] (Hamilton and Perez-Quiros 1994, Camacho and

6. For a comprehensive survey, see Stock and Watson (2001).
7. The Conference Board leading indicator is a weighted average of the following series: average weekly hours in manufacturing, average weekly initial claims for unemployment insurance, manufacturers' new orders for consumer goods and materials, vender performance measured by a slower deliveries diffusion index, manufacturers' new orders for non-defense capital goods, building permits for new private housing units, stock prices (Standard & Poor's 500 common stocks), M2 money supply, 10-year Treasury-bond yield less federal funds rate, and index of consumer expectations.

Perez-Quiros 2002). These two variables capture information on a wide range of real economic activities. They are closely monitored by private investors and central bankers.

The literature on the relationship between corporate bond spreads and business cycles is limited. Chan-Lau and Ivaschenko (2001, 2002) illustrate the predictive power of the investment-grade spread. The only paper on the high-yield bond spread that we are aware of is by Gertler and Lown (1999). They use quarterly data to compare the in-sample forecasts from the high-yield spread and other variables. Duca (1999) points out that the conclusion of their experiment largely relies on the collapse of the high-yield bond market in the late 1980s and early 1990s, which could be coincidental.

Duca's argument highlights the importance of better understanding the predictive power of the high-yield spread in a longer sample. In section 3, we extend the sample to include the recession that began in March 2001 and compare the forecast ability of the corporate spreads with other variables in terms of their in-sample forecasts and out-of-sample forecasts for the 2001 economic slowdown.

3. The Predictive Power of the Corporate Bond Spreads

3.1 Data description and method of forecast comparison

The measure of output we forecast in this paper is the employment growth rate.[8] We chose this variable because of its broad coverage of the economy and its stability. The National Bureau of Economic Research (NBER) business cycle dating committee states in a recent report (NBER 2001) that "employment is probably the single most reliable indicator" at a monthly frequency. The employment data are downloaded from NBER's Web site. We take the log differential between employment in month *t* and month *t*-12 as the variable to forecast. The leading indicators included in this paper are the high-yield bond spread, investment-grade spread, federal funds rate, term spread, paper-bill spread, log difference of the Standard & Poor's stock market index, University of Michigan consumer sentiment index, and the difference of the Conference Board leading indicator.[9] The paper-bill spread is based on yields for three-month commercial paper and Treasury bills. The term spread is based on yields for ten-year Treasury bonds and three-month

8. Chan-Lau and Ivaschenko (2001, 2002) use industrial production as the measure of output. We got similar results using industrial production.
9. Following the previous literature (for example, Howrey 2001), we transform the Standard & Poor's index and the Conference Board leading indicator, because they have linear trends.

Treasury bills. The sample is monthly from January 1997 to November 2001. Figures 1 to 8 plot the alternative leading indicators against the employment growth rate.

We base the comparison of different forecasts on conventional measures, such as in-sample adjusted *R*-square and out-of-sample mean-squared forecast errors. Formal statistical tests are desirable, but they require certain conditions that do not hold empirically in many of our experiements.[10] Fortunately, the differences in forecast accuracy measured by the conventional methods are substantial in most cases, as we show in the following subsections.

3.2 High-yield spread and investment-grade spread

It is natural to expect that the high-yield spread can forecast output better than the investment-grade spread, because credit risks of high-yield bonds are more cyclical. We estimate two bivariate models using the high-yield spread and the investment-grade spread, respectively. The models take the form of:

$$Y_{t+k} = c + \alpha Y_t + \beta X_{i,t} + \varepsilon_{t,k} , \quad (1)$$

where Y_{t+k} is the employment growth rate *k* months ahead, Y_t is the employment growth at month *t*, $X_{i,t}$ is the high-yield spread or the investment-grade spread at month *t*. To keep the inference robust for different forecast horizons, we estimate each model for *k*=3, 6, 9, and 12. We use data from January 1988 to December 1997 to evaluate the in-sample forecast performance. For out-of-sample evaluation, we use data from January 1998 to November 2001. The criteria for evaluation are the adjusted *R* square, denoted as $\bar{R}^2$, and the square root of mean-squared forecast errors, denoted as MSFE. We estimate bivariate models because we are also interested in the marginal predictive power of the two spreads, which can be readily examined by a comparison with a univariate model using Y_t but not $X_{i,t}$ on the right-hand side.

Table 1 reports the results from the three models. Both corporate spreads show marginal predictive power at every forecast horizon. The point estimates for the spreads are significantly negative in all eight models. As expected, higher expected credit risks imply lower employment in the future. Compared with the univariate model, the marginal improvements are substantial both in-sample and out-of-sample. For example, the two corporate spreads explain 68 per cent and 50 per cent of the in-sample variations in the employment growth rate one year ahead, while the univariate

10. For example, the Diebold-Mariano test (Diebold and Mariano 1994) requires that the transformed forecast residual series have a short memory. Many of the series in our experiment have a long memory or even unit roots. For cases where the conditions are satisfied, we calculated the Diebold-Mariano statistics. The results are consistent with our findings. A detailed report is available upon request.

model explains only 21 per cent. The one-year-ahead out-of-sample MSFE from the high-yield spread is 0.23 less than that from the univariate model, which implies a 28 per cent error reduction.[11]

The high-yield spread forecasts more accurately than the investment-grade spread for all four horizons. The differences are pronounced both in-sample and out-of-sample. For the real-time forecasts, the MSFE differentials are 0.07, 0.14, 0.15, and 0.23 for the four horizons. These imply a 22 per cent error reduction, on average.

3.3 Corporate spreads and other financial variables

The long maturity of the corporate spreads suggests that they should forecast more accurately than the paper-bill spread. To verify this argument, we forecast the employment growth rate using the paper-bill spread and the corporate models separately. The three models take the form of

$$Y_{t+k} = \alpha + \beta X_{i,t} + \varepsilon_{t,k}. \tag{2}$$

Lag terms of output are not included in equation (2) because our main interest is the difference in the forecast ability of x_i.[12] Table 2 shows that the paper-bill spread is dominated by the two corporate spreads. In fact, the paper-bill spread is not significant at any forecast horizon, while the corporate spreads are in every scenario.

From a theoretical viewpoint, it is not obvious whether the corporate spreads should have stronger predictive power than the term spread and the federal funds rate. The corporate spreads contain information about expected credit risk, which is what the term spread and the federal funds rate lack, while the information about future inflation is not explicitly contained in the corporate spreads.

Table 3 reports the results for models based on the high-yield spread, the federal funds rate, and the term spread. The high-yield spread outperforms the term spread and the funds rate in every scenario. The differences in out-of-sample MSFEs are persistent and substantial. The MSFEs for one-year-ahead forecasts are 0.60 for the high-yield spread, 0.80 for the funds rate, and 0.97 for the term spread. These translate into a 25 per cent error reduction from the funds rate and a 38 per cent

11. The error reduction is calculated as the differential of the MSFEs from two models divided by the larger MSFE.

12. We also tried to include one lag of output in each equation to compare the marginal predictive power of different variables. The results are similar. A detailed report is available upon request.

reduction from the term spread. The investment-grade spread (reported in Table 2) also dominates the funds rate and the term spread at all horizons.

3.4 Stock market movements and non-financial indicators

Information from the stock market does not improve output forecasts. Table 4 shows that changes in the Standard & Poor's index are not significant for in-sample forecasts. The $\bar{R}^2$ s are negative for all four horizons. The out-of-sample forecasts from the Standard & Poor's index are much larger than those from the corporate spreads.

Table 4 also reports the performance of the two non-financial variables. The in-sample forecasts from the consumer sentiment index are decent, although they are still dominated by the high-yield spread. Previous literature (Carroll, Fuhrer, and Wilcox 1994; Howrey 2001) also reports that the consumer sentiment index forecast the 1990 recession well. The Conference Board leading indicator does not provide strong in-sample forecasts. The $\bar{R}^2$ s are similar to those from the stock market movement. The consumer sentiment index and the Conference Board leading indicator forecast poorly out-of-sample. The MSFEs from the consumer sentiment index are more than 80 per cent higher than the MSFEs from the high-yield spread.

3.5 Relative forecast accuracy and multivariate regressions

To facilitate the comparison among the eight variables discussed in the previous subsections, we use the high-yield model as the benchmark and compute the $\bar{R}^2$ differential, which is defined as $\bar{R}^2_{(HY, X_i)} = \bar{R}^2_{HY} - \bar{R}^2_{X_i}$, where $\bar{R}^2_{HY}$ denotes the $\bar{R}^2$ for the high-yield model and $\bar{R}^2_{X_i}$ denotes the $\bar{R}^2$ for the X_i model. A positive $\bar{R}^2$ differential means that the in-sample forecasts from the high-yield model are superior to those from the alternative model. To evaluate the relative out-of-sample forecast accuracy, we define the MSFE ratio as $MSFE_{(HY, X_i)} = MSFE_{HY}/MSFE_{X_i}$, where $MSFE_{HY}$ and $MSFE_{X_i}$ are MSFEs from the high-yield model and the X_i model. If this ratio is below one, it means that the high-yield spread gives more accurate real-time forecasts than the variable X_i.

Table 5 reports the $\bar{R}^2$ differentials for models based on the eight variables, taking the high-yield spread model as the benchmark. The table highlights the strong predictive power of the high-yield spread in all 28 pair-wise comparisons. All the $\bar{R}^2$ differentials are positive, which indicates that the high-yield spread explains more in-sample variations of the employment growth rate than all the models for every forecast horizon. The investment-grade spread performs better than financial variables except for the high-yield spread. Averaged across four horizons, the investment-grade spread explains 33 per cent less than the high-yield spread, but all the $\bar{R}^2$ differentials for the other financial variables are higher than 50 per cent.

The same pattern is repeated in the out-of-sample experiments. Table 6 shows that the MSFEs from the high-yield spread are smaller than those from the alternative models. More importantly, the marginal differences are quite large. Averaged across four forecast horizons, the high-yield spread predicts 29 per cent better than the paper-bill spread, 32 per cent better than the term spread, 25 per cent better than the federal funds rate, 43 per cent better than the consumer sentiment index, 59 per cent better than the Conference Board leading indicator, and 29 per cent better than the Standard & Poor's index growth rate. The difference between the two corporate spreads narrows to 7 per cent.[13]

To determine whether the predictive power of the corporate spreads is robust in multivariate regressions, we put all eight variables on the right-hand side of the equation and estimated for four different forecast horizons, using data from the whole sample. Table 7 shows the results, which confirms the relative strength of the high-yield spread. Its point estimates are significant in all four regressions. In fact, it is the only significant variable among the eight for three-months-ahead forecasts. On the contrary, the investment-grade spread is significant only for 12-months-ahead forecasts, but with a counterintuitive sign. The federal funds rate is significant with sensible signs for forecasts over six months, which is what we expected, because the transmission of monetary policy takes time. The paper-bill spread and the term spread are also significant in some cases, but their signs are not consistent with simple bivariate models in Tables 2 and 3. Consumer sentiment, changes in the Conference Board leading indicator, and variations in the Standard & Poor's index are not significant in any scenario.

3.6 Forecasts beyond the one-year horizon

Private investors and central bankers are also interested in output forecasts beyond the one-year horizon. Table 8 shows the in-sample forecasts for four horizons: 18, 24, 30, and 36 months ahead. Because of space limitations, we consider only the corporate spreads, term spread, federal funds rate, and stock market movements in this experiment. The high-yield spread is significant for forecasts up to 24 months ahead, and the investment-grade for 30 months ahead. Both the term spread and the federal funds rate are significant for all four horizons, while changes in the Standard & Poor's index are not significant in any case. The $\bar{R}^2$ s show that the term spread and the funds rate explain more output variation than corporate spreads beyond one year. The predictive

13. Their difference is much more pronounced when one lag of a dependent variable is added into both models, as shown in Table 1.

power is especially strong for the funds rate, explaining 57 per cent output fluctuations two years ahead. The relative advantage of the high-yield spread to the investment-grade spread vanishes for forecasts beyond 24 months. This pattern indicates that high-quality corporate bonds are more similar to Treasury bonds than low-quality corporate bonds, which is consistent with the bond pricing literature that we review in section 4.

To summarize, three major findings were described in this section. First, the high-yield spread has superior predictive power than the term spread, federal funds rate, investment-grade spread, paper-bill spread, consumer sentiment index, and the Conference Board indicator for forecasts up to one year ahead. Second, variables from different financial markets give quite different forecasts. The stock market variables forecast poorly for all horizons. The corporate spreads dominate other variables for short-term forecasts, while the term spread and the federal funds rate dominate for forecasts beyond the one-year horizon. Third, in terms of output forecasts, the high-yield spread behaves quite differently from the term spread and the federal funds rate, while the investment-grade spread is more similar to those two variables.

The strong performance of the corporate spreads raises questions regarding the sources of their predictive power. Section 4 studies their response to other relevant variables.

4. Interpreting the Predictive Power of the Corporate Spreads

Numerous studies on bond returns (for example, Keim and Stambaugh 1986; Fama and French 1989, 1993; Campbell and Ammer 1993; Kwan 1996; Blume, Keim, and Patel 1991; Cornell and Green 1991) show that investment-grade bonds behave like Treasury bonds, while high-yield bonds are more sensitive to risk factors derived from stock returns. Recently, empirical research on investment-grade bond spreads focused on their relation with variables from the Treasury-bonds market. Longstaff and Schwartz (1995) find that there is a negative correlation between the risk-free rate and the changes of credit spreads. Duffee (1998) documents a negative correlation between the credit spreads and the level and the slope of the term structure of Treasury bond rates. Studies including both investment-grade and high-yield spreads have different findings. Elton et al. (2001) show the importance of common factors explaining risk premiums in the stock market, while Collin-Dufresne, Goldstein, and Martin (2001) find that variables suggested in the previous literature have limited explanatory power for spreads. Most of the empirical research on credit spreads is based on reduced form regressions.

Our findings in section 3 were based on the level of corporate spreads rather than their changes. Since our interest is mainly on the predictive power of the spread, we focus on the determinants of the credit spreads in level terms. We regress the high-yield spread and the investment-grade spread on the federal funds rate, term spread, and the growth rate of the Standard & Poor's index. The explanatory variables are those that the previous literature suggested would be useful. Table 9 reports the results from these reduced form regressions. The three variables can explain only 7 per cent of the variations in the high-yield spread. None of the three explanatory variables is significant.

The $\bar{R}^2$ is 0.41 in the case of the investment-grade spread. Both the federal funds rate and the term spread become significant with positive signs.[14]

The implications of the linear regressions seem to be counterintuitive. Since tight monetary policy usually precedes an economic slowdown, one would expect the federal funds rate to have more impact on the low-quality bond spreads, because their credit risks are more cyclical. What we find in the linear regression is the opposite. The risk premium for high-quality bonds responds as expected, but the risk premium for high-yield bonds does not.

One plausible explanation for this puzzle is that the linear models are misspecified. In fact, the credit channel theory in monetary economics indicates that the functional form should be non-linear. Bernanke and Gertler (1989, 1995) argue that there exists external finance premiums, defined as the cost differential between internal and external finance, because of asymmetric information between firms and investors. The sensitivity of the premiums to shocks is determined by the credit quality of the bond issuers. If investors believe that the credit quality is strong, they would charge less to compensate for the expected credit risks. It is natural to take credit spreads for bonds of different credit ratings as measures of the external finance premiums.[15] The credit channel theory has two implications for credit spreads. First, spreads for high-quality bonds should be less responsive to the impact of monetary policy than spreads for low-quality bonds. Second, the response from a corporate spread to monetary policy should be time-varying, because the credit condition of the bond issuers changes over time. The second implication implies a non-linear model for credit spreads where the parameter for the federal funds rate is a function of investors' expectations of credit quality.

To test whether this is the case, we estimate threshold non-linear models for credit spreads:

14. The negative correlation between the risk-free rate and corporate rates reported in Longstaff and Schwartz (1995) and Duffee (1998) is based on changes of the variables rather than the levels, so our finding here does not conflict with theirs. The difference caused by using levels rather than changes is an interesting topic for future research.

15. For example, see Gertler and Lown (1999).

$$Spread_t = \alpha + \beta_1 \times FFR_t + \beta_2 \times TSP_t + \beta_3 \times SP + \beta_4 \times FFR_t \times I_{(Spread_{t-1} > K)} + \varepsilon_t, \quad (3)$$

where *FFR* is the federal funds rate, *TSP* is the term spread defined as in section 3, *SP* is the changes in the Standard & Poor's index, and *I* is the dummy variable, which takes the value of one if the spread in the previous period is higher than a certain threshold value, *K*. We take the lag value of the spread to measure the credit quality perceived by investors in the previous month. The credit channel theory suggests that the linearity hypothesis, $\beta_4 = 0$, should be rejected.

Hypothesis testing for $\beta_4 = 0$ is not straightforward, because the threshold parameter *K* is not defined under the null. We follow the approach suggested by Andrews and Ploberger (1994) and Hansen (1997) to calculate the exponential *F*-statistics. Table 9 reports the test statistics and parameter estimates. Linearity is rejected for both spreads at the 5 per cent significance level. The point estimates for threshold *K* are 5.06 for the high-yield spread and 0.63 for the investment-grade spread. The two implications from the credit channel theory are tested and accepted. Both point estimates for β_4 are positive, which suggests that monetary policy affects the spreads more when the perceived credit risk is already high in the previous month. The point estimate for β_4 is 0.46 for the high-yield spread, much larger than that for the investment-grade spread, which is 0.08. Under adverse situations, the risk premium on high-yield bonds responds more to tight monetary policy.

The threshold models substantially improve our understanding of corporate spreads. Compared with the linear models, the $\bar{R}^2$ statistics rise from 0.07 to 0.63 for the high-yield spread, and from 0.47 to 0.75 for the investment-grade spread. The dramatic improvement indicates that a large part of the credit spreads can be explained by their non-linear response to monetary policy. This has important implications for the monetary transmission mechanism. The point estimates for β_2 in two non-linear models are insignificant, which means that the credit channel is effective only when investors already perceive high credit risk in the bond market.

5. Conclusion

This paper has illustrated the strong forecasting power of corporate bond spreads and investigated their responses to monetary policy. We have shown that credit spreads dominate the term spread, federal funds rate, paper-bill spread, stock market movements, consumer sentiment index, and changes in the Conference Board leading indicator in terms of output forecasts up to one year ahead, both in-sample and out-of-sample. The high-yield spread outperformed the investment-grade spread in our experiments. The term spread and the federal funds rate forecast more accurately beyond the one-year horizon. The relation between the level of credit spreads and the federal funds rate was non-linear. Threshold models based on the credit channel theory explained 63 per cent of the variations in the high-yield spread and 75 per cent in the investment-grade spread.

The findings in this paper have important implications both empirically and theoretically. The strong predictive power of the credit spreads indicates that they have the potential to help private investors and central bankers to improve their output forecasts. Compared with non-financial leading indicators, credit spreads are available real-time on a daily basis. Compared with information from the stock market, credit spreads are much less volatile. Our analysis also shows that their information content is quite different from those in government debt markets.

On the theoretical side, we argue that the determination of credit spreads is a topic overlapped by both financial economics and monetary economics. Our analysis shows that a combination of these two lines of research can enhance our knowledge of both of them. Proving the empirical relevance of the credit channel has been a challenging task for monetary economists, partly owing to the lack of good measures for external finance premiums. Corporate spreads are natural proxies for these premiums and they therefore provide a straightforward way to test for the existence of the credit channel. The non-linear specifications suggested by the credit channel theory lead to substantial improvement in $\bar{R}^2$, which indicates the importance of non-linearity that has been neglected in the bond pricing literature.

There are two concerns regarding the predictive power of credit spreads for future output. First, our analysis is based on data from 1988. One could argue that the lack of historical data limits the strength of our conclusion. Second, the credit spreads sometimes give out false signals when financial markets are under stress (Duca 1999). The long-term capitall management (LTCM) crisis is one example. The stressed financial markets widened credit spreads in 1998, but economic growth did not slow down in 1999.

We agree that a longer sample with more business cycles would make our conclusions more convincing. We argue, however, that the importance of the credit spreads does not come from their track record as good leading indicators, but from their information content on expected long-term credit risks, which is not available in indicators from other financial markets. This unique information content justifies its complementary value to conventional leading indicators, such as the term spread and the federal funds rate.

We also agree that warning signals from credit spreads should be treated with caution. The alarms, however, do reflect real-time concerns from financial market participants. Before the LTCM crisis was settled, there were considerable risks that the collapse of the firm could cause huge damage to the financial system and the real economy. Real-time forecasts should take these risks into consideration. We intentionally included 1998 in the forecast sample in our experiment. The results show that the predictive power of the credit spreads is strong even in the presence of false alarms.

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Table 1: Marginal Forecast Power of the Corporate Bond Spreads[a]

Forecast horizon K months ahead	Explanatory variable X_i	In-sample forecast				Out-of-sample MSFE
		c	α	β	$\bar{R}^2$	
K=3	High-yield spread	1.57 (6.85)	0.75 (19.67)	-0.25 (5.82)	0.95	0.25
	Inv.-grade spread	0.78 (3.55)	0.88 (18.78)	-0.77 (2.75)	0.93	0.32
	Univariate	0.09 (0.55)	0.93 (14.21)		0.89	0.35
K=6	High-yield spread	3.07 (7.61)	0.47 (7.39)	-0.47 (6.26)	0.86	0.37
	Inv.-grade spread	2.02 (5.38)	0.62 (8.94)	-1.91 (4.05)	0.82	0.51
	Univariate	0.31 (1.61)	0.80 (8.41)		0.66	0.55
K=9	High-yield spread	4.30 (8.10)	0.20 (2.64)	-0.63 (6.20)	0.77	0.52
	Inv.-grade spread	2.71 (5.64)	0.44 (4.99)	-2.37 (3.96)	0.68	0.67
	Univariate	0.59 (1.90)	0.63 (6.25)		0.41	0.74
K=12	High-yield spread	5.21 (7.21)	-0.02 (0.22)	-0.73 (5.30)	0.68	0.60
	Inv.-grade spread	3.06 (5.31)	0.29 (2.75)	-2.42 (3.49)	0.50	0.73
	Univariate	0.91 (2.77)	0.45 (4.74)		0.21	0.83

a. For each forecast horizon K, we estimate three models. The first two take the form $Y_{t+k} = C + \alpha Y_t + \beta X_{i,t} + \varepsilon_{t,k}$, where Y_{t+k} is employment growth rate k months ahead from month t, Y_t is employment growth rate in month t, and $X_{i,t}$ is the high-yield spread or the investment-grade spread. The third model is univariate: $Y_{t+k} = C + \alpha Y_t + \varepsilon_{t,k}$. Four forecast horizons are considered: k=3, 6, 9, and 12. The numbers in brackets are t-statistics based on Newey-West standard errors. MSFE is the root of mean-squared forecast errors. The sample is monthly from January 1988 to November 2001.

Table 2: High-Yield Spread, Investment-Grade Spread, and Paper-Bill Spread[a]

Forecast horizon K months ahead	Explanatory variable X_i	In-sample forecast			Out-of-sample MSFE
		α	β	$\bar{R}^2$	
K=3	High-yield spread	4.75 (12.38)	-0.64 (6.91)	0.56	0.66
	Inv.-grade spread	3.27 (7.05)	-1.96 (2.62)	0.21	0.67
	Paper-bill spread	1.40 (3.00)	0.79 (1.02)	0.02	0.83
K=6	High-yield spread	5.11 (15.90)	-0.72 (10.33)	0.69	0.63
	Inv.-grade spread	3.63 (7.74)	-2.45 (3.17)	0.33	0.65
	Paper-bill spread	1.68 (3.54)	0.19 (0.22)	-0.01	0.89
K=9	High-yield spread	5.20 (14.40)	-0.74 (9.55)	0.73	0.61
	Inv.-grade spread	3.82 (8.40)	-2.72 (3.70)	0.40	0.67
	Paper-bill spread	1.90 (3.97)	-0.30 (0.36)	0.04	0.91
K=12	High-yield spread	5.12 (10.89)	-0.72 (6.83)	0.68	0.60
	Inv.-grade spread	3.88 (9.17)	-2.80 (4.14)	0.42	0.69
	Paper-bill spread	2.09 (4.23)	-0.73 (0.91)	0.01	0.92

a. For each forecast horizon K, we estimate three models: $Y_{t+k} = \alpha + \beta X_{i,t} + \varepsilon_{t,k}$, where Y_{t+k} is employment growth rate k months ahead from month t, and $X_{i,t}$ are changes in the Standard & Poor's index, the consumer sentiment index, and first difference in the Conference Board leading indicator, respectively. Four forecast horizons are considered: k=3, 6, 9, and 12. The numbers in brackets are t-statistics based on Newey-West standard errors. MSFE is the root of mean-squared forecast errors. The in-sample forecasts are from January 1988 to December 1997. The out-of-sample forecasts are from January 1998 to November 2001.

Table 3: High-Yield Spread, Federal Funds Rate, and Term Spread[a]

Forecast horizon K months ahead	Explanatory variable X_i	In-sample forecast			Out-of-sample MSFE
		α	β	$\bar{R}^2$	
K=3	High-yield spread	4.75 (12.38)	-0.64 (6.91)	0.56	0.66
	Fed funds rate	1.79 (3.00)	0.004 (0.05)	-0.01	0.89
	Term spread	2.15 (7.01)	-0.17 (-0.96)	0.01	0.89
K=6	High-yield spread	5.11 (15.90)	-0.72 (10.33)	0.69	0.63
	Fed funds rate	2.53 (4.22)	-0.13 (1.20)	0.03	0.87
	Term spread	1.66 (4.37)	0.06 (0.34)	-0.01	0.90
K=9	High-yield spread	5.20 (14.40)	-0.74 (9.55)	0.73	0.61
	Fed funds rate	3.17 (5.37)	-0.24 (2.13)	0.14	0.80
	Term spread	1.22 (2.62)	0.26 (1.43)	0.04	0.91
K=12	High-yield spread	5.12 (10.89)	-0.72 (6.83)	0.68	0.60
	Fed funds rate	3.17 (5.37)	-0.24 (2.13)	0.14	0.80
	Term spread	0.83 (1.53)	0.44 (2.20)	0.12	0.97

a. For each forecast horizon K, we estimate three models: $Y_{t+k} = \alpha + \beta X_{i,t} + \varepsilon_{t,k}$, where Y_{t+k} is employment growth rate k months ahead from month t, and $X_{i,t}$ are changes in the Standard & Poor's index, the consumer sentiment index, and first difference in the Conference Board leading indicator, respectively. Four forecast horizons are considered: k=3, 6, 9, and 12. The numbers in brackets are t-statistics based on Newey-West standard errors. MSFE is the root of mean-squared forecast errors. The in-sample forecasts are from January 1988 to December 1997. The out-of-sample forecasts are from January 1998 to November 2001.

Table 4: S&P Index, Consumer Sentiment Index, and Conference Board Indicator[a]

Forecast horizon K months ahead	Explanatory variable X_i	In-sample forecast			Out-of-sample MSFE
		α	β	$\bar{R}^2$	
K=3	S&P growth rate	1.81 (6.84)	0.003 (0.08)	-0.01	0.88
	Consumer sentiment	-7.14 (5.07)	0.10 (6.73)	0.51	1.10
	Conference Board	1.82 (6.87)	4.60 (0.02)	-0.01	0.89
K=6	S&P growth rate	1.77 (6.41)	0.005 (0.10)	-0.01	0.89
	Consumer sentiment	-6.98 (4.07)	0.10 (5.44)	0.46	1.16
	Conference Board	1.77 (6.57)	13.57 (0.54)	-0.01	0.87
K=9	S&P growth rate	1.74 (5.99)	0.005 (0.10)	-0.01	0.88
	Consumer sentiment	-5.58 (2.84)	0.08 (3.95)	0.31	1.13
	Conference Board	1.73 (6.36)	25.55 (0.98)	0.00	0.87
K=12	S&P growth rate	1.69 (5.78)	0.02 (0.36)	-0.01	0.88
	Consumer sentiment	-3.05 (1.40)	0.05 (2.26)	0.12	1.03
	Conference Board	1.70 (6.17)	26.23 (1.13)	0.00	0.89

a. For each forecast horizon K, we estimate three models: $Y_{t+k} = \alpha + \beta X_{i,t} + \varepsilon_{t,k}$, where Y_{t+k} is employment growth rate k months ahead from month t, and $X_{i,t}$ are changes in the Standard & Poor's index, the consumer sentiment index, and first difference in the Conference Board leading indicator, respectively. Four forecast horizons are considered: k=3, 6, 9, and 12. The numbers in brackets are t-statistics based on Newey-West standard errors. MSFE is the root of mean-squared forecast errors. The in-sample forecasts are from January 1988 to December 1997. The out-of-sample forecasts are from January 1998 to November 2001.

Table 5: $\bar{R}^2$ Differentials[a]

	3 Months	6 Months	9 Months	12 Months	Average
Inv.-grade spread	0.35	0.37	0.33	0.26	0.33
Paper-bill spread	0.54	0.70	0.74	0.67	0.66
Term spread	0.55	0.70	0.69	0.57	0.63
Federal funds rate	0.57	0.66	0.59	0.40	0.56
U. of Mich. index of consumer sentiment	0.05	0.23	0.42	0.56	0.32
Conference Board leading indicator	0.24	0.28	0.28	0.28	0.27
S&P growth rate	0.57	0.70	0.74	0.69	0.68

a. $\bar{R}^2$ differentials for variable *X* are defined as $\bar{R}^2_{HY,K} - \bar{R}^2_{X,K}$, where $\bar{R}^2_{HY,K}$ and $\bar{R}^2_{X,K}$ are the $\bar{R}^2$ from the univariate models $Y_{t+k} = \alpha + \beta \times HY_t + \varepsilon_{t,k}$ and $Y_{t+k} = \alpha + \beta \times X_t + \varepsilon_{t,k}$. Y_{t+k} is employment growth rate *k* months ahead. HY is the high-yield spread. The sample ranges from January 1988 to December 1997.

Table 6: MSFE Ratios[a]

	3 Months	6 Months	9 Months	12 Months	Average
Inv.-grade spread	0.99	0.96	0.90	0.87	0.93
Paper-bill spread	0.81	0.71	0.67	0.65	0.71
Term spread	0.75	0.70	0.67	0.62	0.68
Federal funds rate	0.75	0.72	0.76	0.80	0.75
U. of Mich. index of consumer sentiment	0.60	0.54	0.54	0.58	0.57
Conference Board leading indicator	0.47	0.41	0.38	0.39	0.41
Changes in S&P	0.76	0.71	0.69	0.67	0.71

a. MSFE ratios for variable *X* are defined as $\frac{MSFE_{HY,K}}{MSFE_{X,K}}$, where $MSFE_{HY,K}$ and $MSFE_{X,K}$ are the $MSFEs$ from the univariate models $Y_{t+k} = \alpha + \beta \times HY_t + \varepsilon_{t,k}$ and $Y_{t+k} = \alpha + \beta \times X_t + \varepsilon_{t,k}$. Y_{t+k} is employment growth rate *k* months ahead. HY is the high-yield spread. The sample ranges from January 1988 to November 2001. The $MSFEs$ are based on errors from out-of-sample forecasts for the period January 1998 to November 2001.

Table 7: Full-Sample Multivariate Regressions[a]

	EMP(t+3)	EMP(t+6)	EMP(t+9)	EMP(t+12)
Constant	0.43 (0.52)	2.36 (1.99)	5.14* (4.11)	10.30* (7.93)
Emp	0.84* (19.27)	0.62* (8.37)	0.36* (4.32)	0.13 (1.59)
High-yield spread	-0.18* (3.27)	-0.35* (4.13)	-0.51* (5.78)	-0.83* (8.43)
Inv.-grade spread	0.19 (0.67)	0.43 (0.93)	0.70 (2.06)	1.73* (3.27)
Term spread	0.09 (1.21)	0.02 (0.21)	-0.12 (1.01)	-0.47* (3.69)
Paper-bill spread	0.09 (0.37)	0.64 (1.87)	1.46* (3.28)	1.94* (3.79)
Federal funds rate	-0.05 (0.94)	-0.21* (2.45)	-0.40* (4.28)	-0.64* (6.56)
Consumer sentiment	0.01 (1.26)	0.005 (0.51)	-0.004 (0.45)	0.03 (3.48)
Conference Board	1.62 (0.52)	7.67 (1.68)	6.20 (1.07)	4.56 (0.76)
S&P growth rate	0.004 (0.81)	0.002 (0.42)	0.004 (0.52)	0.005 (0.62)
$\bar{R}^2$	0.96	0.90	0.86	0.86
Log-likelihood	-4.64	-70.12	-94.35	-88.65

a. Four multivariate regressions that take the form $EMP_{t+k} = C + \alpha_1 \times EMP_t + \sum_{i=1}^{8} \alpha_i \times X_{i,t} + \varepsilon_{t+k}$, where EMP_{t+k} denotes the employment growth rate k months ahead, $\{X_1, X_2, \ldots, X_8\}$, are the high-yield spread, investment-grade spread, federal funds rate, term spread, paper-bill spread, consumer sentiment index, changes of the Conference Board leading indicator, and the changes of the Standard & Poor's index, respectively. The changes of the Conference Board leading indicator are the first difference. The changes of the Standard & Poor's stock index are the first log difference.The numbers in brackets are *t*-statistics based on Newey-West standard errors. The four regressions respond to four forecast horizons: *k*=3, 6, 9, and 12. The sample ranges from January 1988 to November 2001.

Table 8: In-Sample Forecasts Beyond the One-Year Horizon[a]

Forecast horizon K	Explanatory variable X_i	β	t_β	$\bar{R}^2$
K=18	High-yield spread	-0.54	4.45	0.41
	Inv.-grade spread	-2.54	5.01	0.38
	Term spread	0.49	2.78	0.17
	Fed. funds rate	-0.47	4.87	0.48
	Changes of S&P index	0.03	1.12	0.00
K=24	High-yield spread	-0.36	3.09	0.17
	Inv.-grade spread	-2.33	4.07	0.32
	Term spread	0.64	3.57	0.30
	Fed. funds rate	-0.51	6.61	0.57
	Changes of S&P index	0.01	0.32	-0.01
K=30	High-yield spread	-0.16	1.54	0.03
	Inv.-grade spread	-1.85	2.73	0.20
	Term spread	0.61	4.06	0.27
	Fed. funds rate	-0.47	5.22	0.48
	Changes of S&P index	-0.01	0.27	-0.01
K=36	High-yield spread	0.03	0.34	-0.01
	Inv.-grade spread	-1.22	1.52	0.08
	Term spread	0.41	2.57	0.11
	Fed. funds rate	-0.36	3.99	0.28
	Changes of S&P index	-0.01	0.32	-0.01

a. For each forecast horizon K, we estimate four models: $Y_{t+k} = \alpha + \beta X_{i,t} + \varepsilon_{t,k}$, where Y_{t+k} is employment growth rate k months ahead from month t, and $X_{i,t}$ is the high-yield spread, investment-grade spread, term spread, federal funds rate, and the changes in the Standard & Poor's index, respectively. The changes of the Standard & Poor's stock index are the first log difference. Four forecast horizons are considered: k=18, 24, 30, and 36. t_β are t-statistics based on Newey-West standard errors.

Table 9: Determinants of the High-Yield and Investment-Grade Spreads

Explanatory variables	Linear models[a]		Non-linear models[b]	
	High-yield spread (*t*)	Inv.-grade spread (*t*)	High-yield spread (*t*)	Inv.-grade spread (*t*)
Constant	3.89 (2.79)	-0.20 (1.14)	4.75 (5.37)	0.44 (3.70)
Federal funds rate	0.19 (1.09)	0.13 (5.98)	-0.17 (1.27)	-0.009 (0.43)
Term spread	-0.11 (0.41)	0.11 (3.29)	0.03 (0.20)	0.05 (2.57)
S&P index growth rate	-0.05 (1.26)	-0.003 (0.75)	-0.0006 (0.02)	0.001 (0.44)
Federal funds rate * Dummy 1			0.46 (6.71)	
Federal funds rate * Dummy 2				0.08 (10.09)
$\bar{R}^2$	0.07	0.41	0.63	0.75

a. The two models regress the high-yield spread and the investment-grade spread at month *t* on the federal funds rate, term spread, Standard & Poor's stock index, and the growth rate of the Standard & Poor's index. The Standard & Poor's stock index is divided by 100. The growth rate of the Standard & Poor's stock index is the first log difference. The numbers in brackets are *t*-statistics based on Newey-West standard errors.

b. The two non-linear models regress the high-yield spread and the investment-grade spread at month *t* on the same four explanatory variables as well as the multiple of the federal funds rate and a dummy variable. Dummy 1 takes the value of one when the high-yield spread in month *t*-1 is higher than 5.02. Dummy 2 takes the value of one when the investment-grade spread in month *t*-1 is higher than 0.63. To test for linearity, we use exponential LM statistics (Andrews and Ploberger 1994). The *p*-values from Exp LM test statistics are 0.015 for the investment-grade model and 0.044 for the high-yield model (by Hansen's (1997) method).

Figure 1: High-Yield Spread and Employment Growth

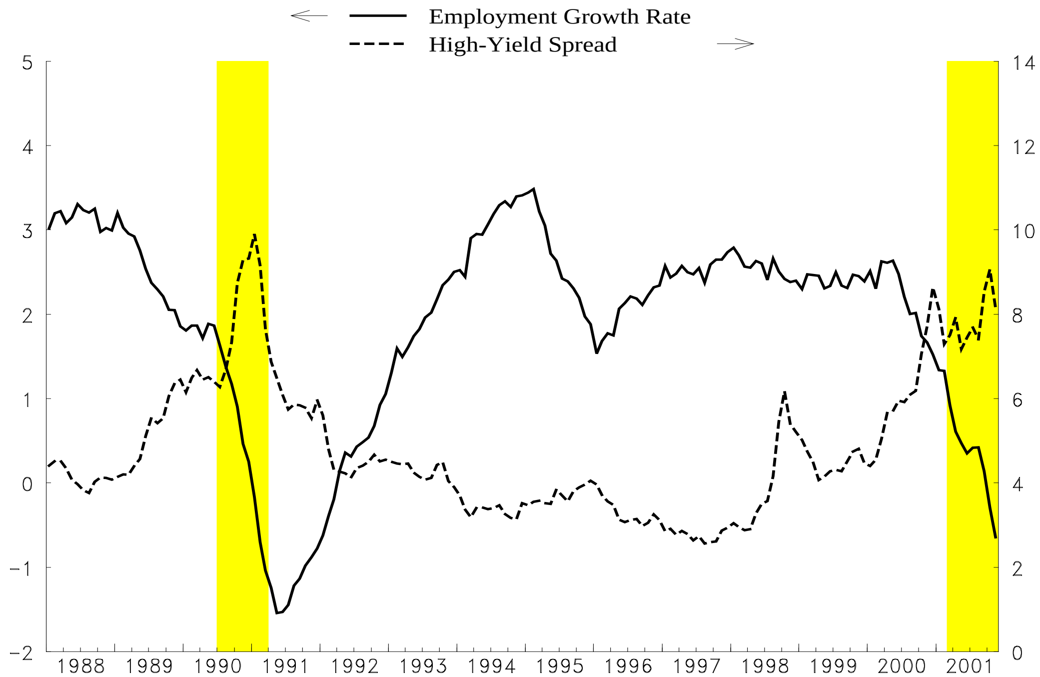


Figure 2: Investment-Grade Spread and Employment Growth

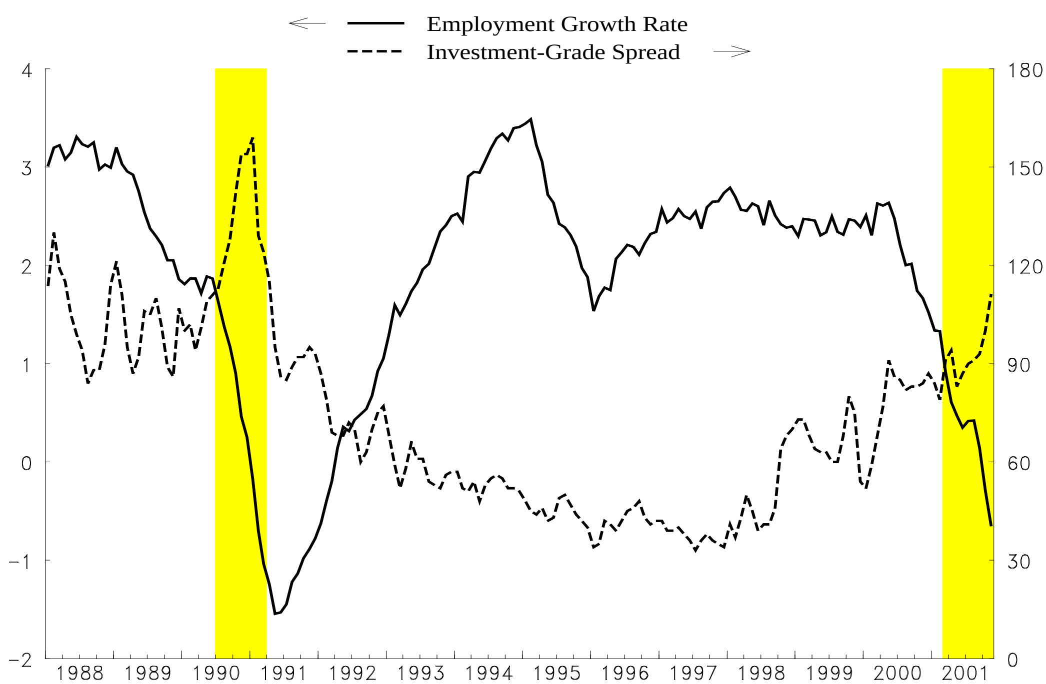


Figure 3: Federal Funds Rate and Employment Growth

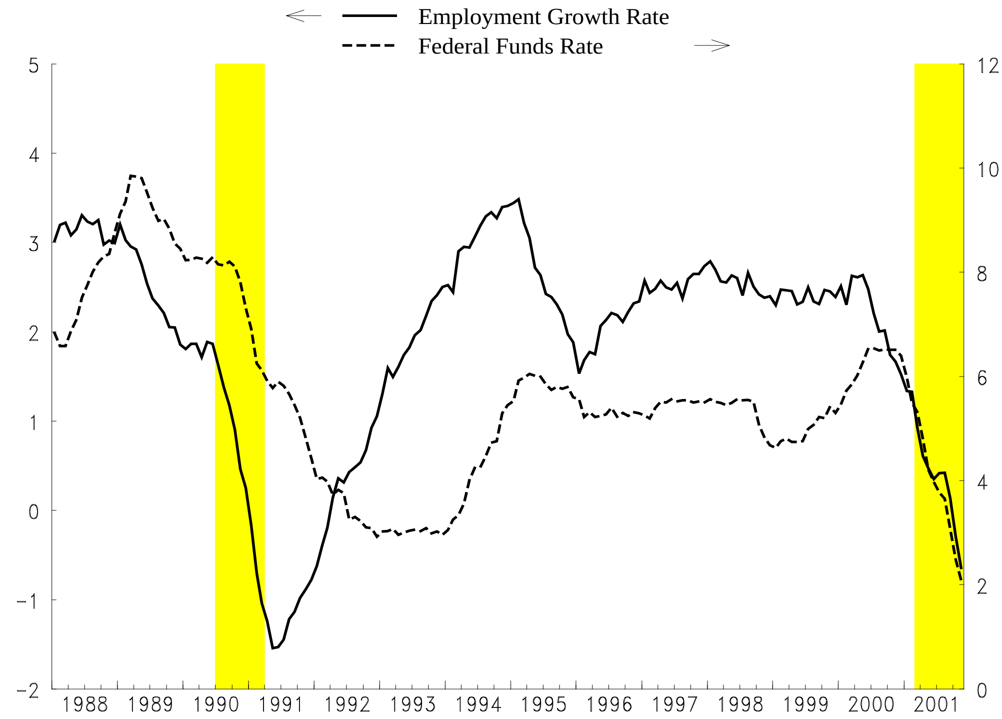


Figure 4: Term Spread and Employment Growth

Figure 5: Paper-Bill Spread and Employment Growth

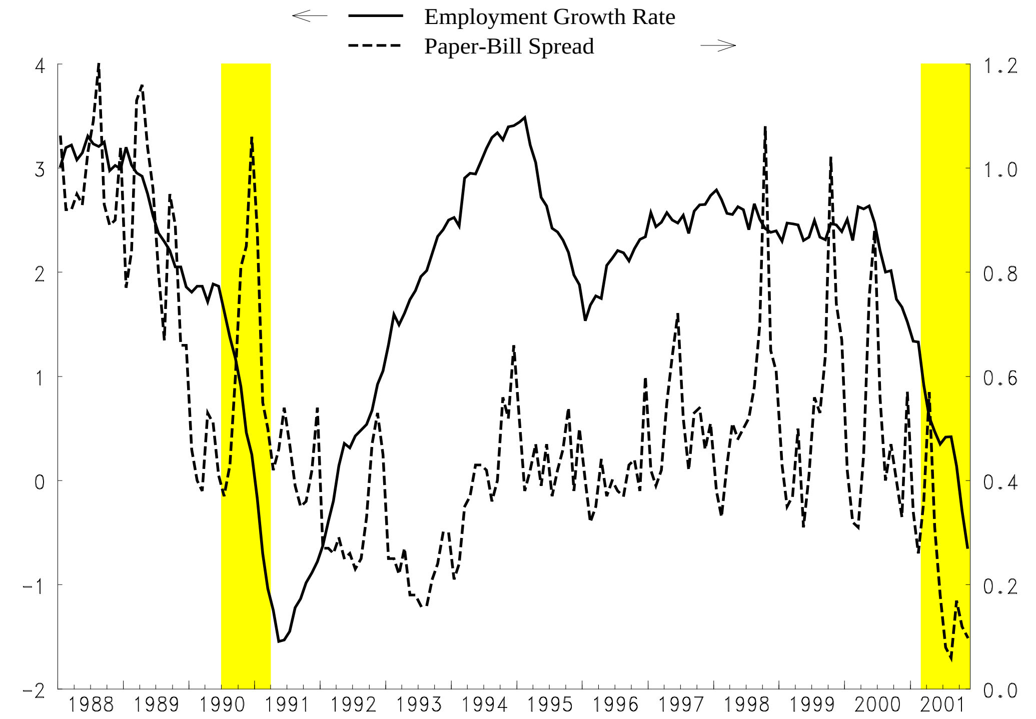
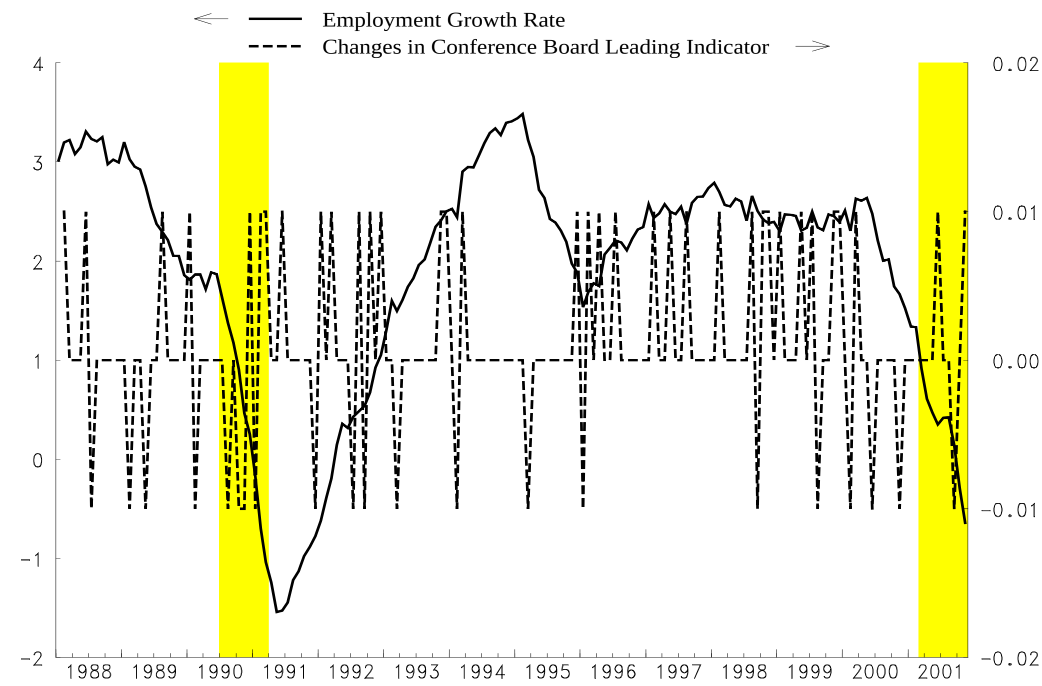


Figure 6: Conference Board Indicator and Employment Growth



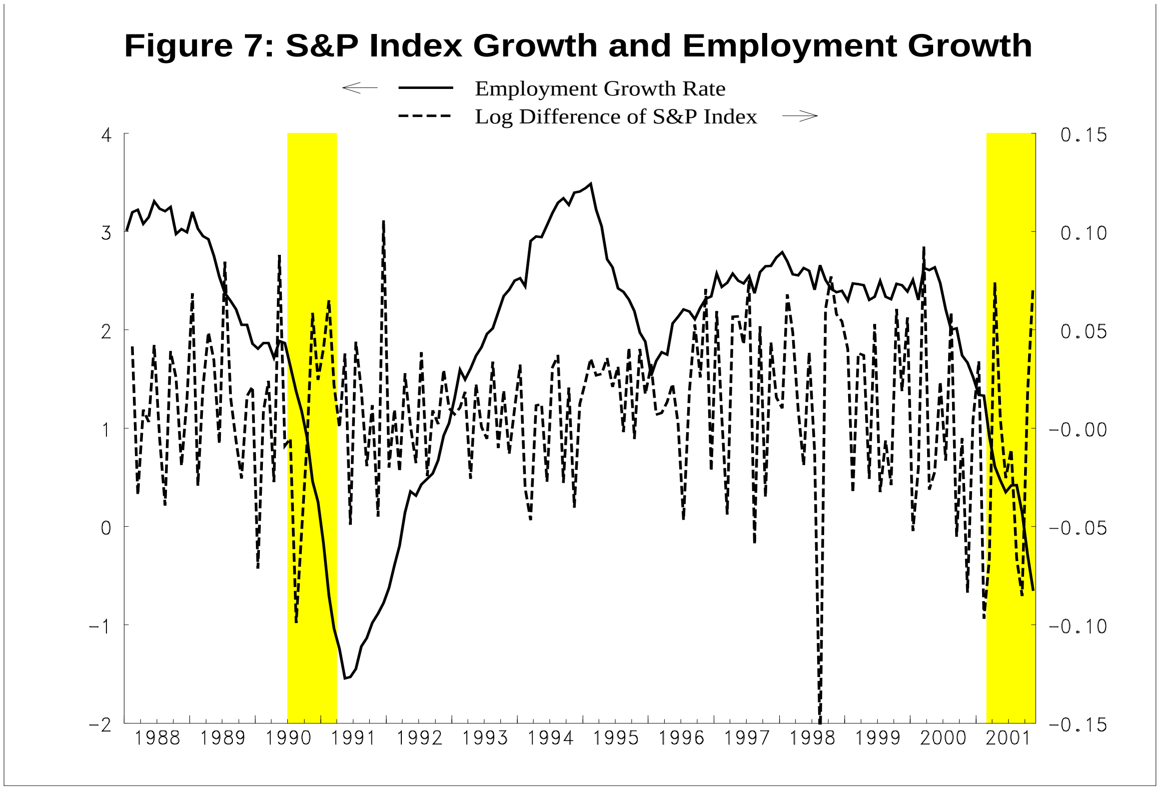


Figure 7: S&P Index Growth and Employment Growth
Employment Growth Rate
Log Difference of S&P Index
4
3
2
1
0
−1
−2
0.15
0.10
0.05
−0.00
−0.05
−0.10
−0.15
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

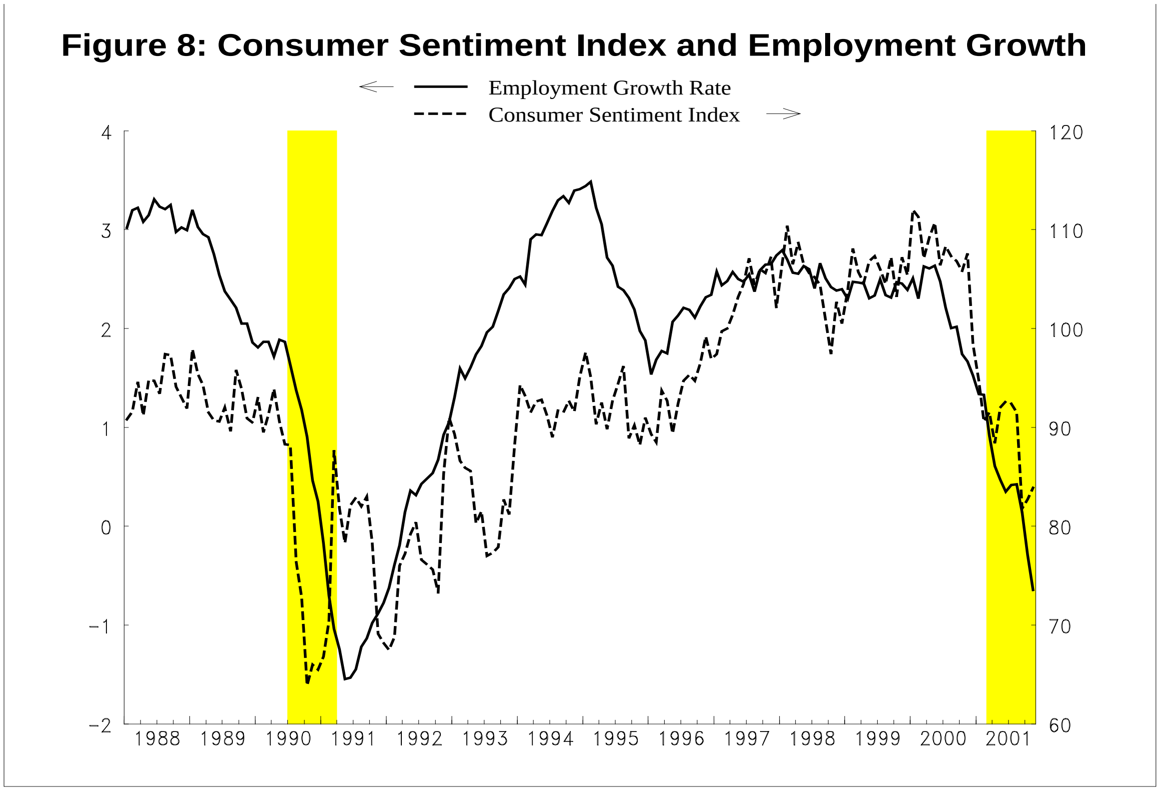


Figure 8: Consumer Sentiment Index and Employment Growth
Employment Growth Rate
Consumer Sentiment Index
4
3
2
1
0
−1
−2
120
110
100
90
80
70
60
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

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