The Dynamics of Corporate Credit Spreads

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Abstract

We examine how default and systematic risk measures influence corporate credit spreads for investment and non-investment grade corporate bonds over the 1987 to 1997 time period. We find a long-run relation between credit spreads and default risk as measured by the level and the slope of the Treasury term structure. However, the relation between credit spreads and the term-structure variables can vary based on the time to maturity and credit quality of corporate bonds. In the short-run, credit spreads are influenced by default risk and the Fama and French systematic risk factors. The results have implications for parameterizing bond and credit derivative pricing models.

Keywords: credit spreads, bond pricing, treasury term structure

JEL Classification: C4, E4

1. Introduction

Recently, a great deal of attention has been devoted to understanding the stochastic nature and determinants of credit spreads. This issue plays a central role in the fixed income literature, primarily because of its importance in the pricing of risky debt and credit derivatives (e.g., Duffee (1999), Duffie and Singleton (1997), Longstaff and Schwartz (1995b), and Jarrow and Turnbull (1995)). In the literature, there are two theoretical approaches to the pricing of risky debt. First, reduced form, or hazard rate, models, which take as a premise that bonds when grouped by ratings are homogeneous with respect to risk (e.g., Duffie and Singleton (1999), and Madan and Unal (1998), and Das and Tufano (1996)). Second, diffusion-based, or option pricing models, which approximate the asset value of the firm as a stochastic process and price the debt as an option on the value of the firm (e.g., Longstaff and Schwartz (1995a), and Merton (1974)). Both approaches take into account credit spreads as a central component in their pricing models.[1]

We extend this literature by empirically examining the determinants of credit spreads and their effects on the valuation of risky debt. We do this in four ways. First, previous research focuses on the determinants of either default risk (e.g., Duffee (1998)) or systematic risk (e.g., Elton, Gruber, Agrawal, and Mann (2001)). In this paper, we jointly model default and systematic risk measures. Second, we use cointegration analysis to examine the relation between credit spreads, and the Treasury term structure categorized by the level and slope. Third, we confirm the findings of Elton et al. (2001) that the Fama and French (1993) systematic risk factors play a role in the pricing of risky debt. Fourth, we

[1] Credit spreads, or the spread between corporate bond yields and Treasury yields with a corresponding duration, are the risk premium associated with holding risky debt; they represent the payment to a risk averse investor for accepting default risk. Since default risk premium changes over time due to a change in the perception of the probability or severity of default, average credit spreads measure the general perception of the risk of investing in general risk categories.

include an analysis of investment and noninvestment grade bonds to better understand how these risk factors change across risk classes.

Elton et al. (2001) examine corporate bond spreads based on reduced form models and measure credit spreads as a function of local and state taxes, default risk, and systematic risk factors. In contrast, Duffee (1998) and Morris, Neal, and Rolph (1998) apply macroeconomic changes captured in the Treasury curve as a proxy for changes in default risk. While these studies provide useful insight into the empirical determinants of credit spreads, they leave several questions unanswered. For example, by analyzing how systematic risk and default risk influence credit spreads separately, previous research fails to account for the potential correlation between these variables. Hence, the Treasury curve variables found in Duffee (1998) and Morris et al. (1998) may proxy for the systematic risk measures in Elton et al. (2001) or visa versa. In addition, with the exception of Morris et al., these studies focus on the short run dynamics and have not examined the long-run relation among the determinants of credit spreads. In the case of Morris et al., the focus is solely on the long run relation. These studies also examine investment grade bonds only, leaving out the most volatile segment of the market, the non-investment grade bond market. In this paper, we examine the short- and long run relation between the default and systematic risk factors and jointly estimate these determinants to separate out the interaction among the variables

Bond pricing models, either implicitly or explicitly, include a correlation between credit spreads and the level of interest rates. However, theoretical models reach different conclusions with respect to the sign of this relation. For example, most of the recent research documents a negative correlation between changes in credit spreads and changes in the level of interest rates (e.g., Duffee (1998), and Das and Tufano (1996)). A negative relation between credit spreads and the Treasury yield is consistent with Merton's (1974) contingent claims approach where the firm is valued in an option framework. An increase in the level of the Treasury rate should increase the value of firm moving it farther away from the exercise price and hence lowering the probability of default. This implies that an increase in the level of the Treasury rate should have a negative relation with yield spreads. In contrast, Leland and Toft (1996) discuss the possible direct influence and positive relation between the Treasury yield and credit spreads. The Treasury yield influences not only the discount rate but also directly influence the value of the underlying asset. Thus, the value of the firm would decrease and the probability of default would correspondingly increase, implying a positive relation between credit spreads and the level of Treasury yields. Therefore, we examine the sign of the relation between Treasury yields and credit spreads and whether this relation is consistent in the short versus long run and whether the relation changes for intermediate and long-term bonds, or by the riskiness of the bonds.

Additionally, we examine the effect of the slope of the Treasury yield curve on credit spreads. The slope provides information about the default-free term structure (e.g., Litterman and Iben (1991), and Chen and Scott (1993)) and credit spreads (e.g., Duffee (1998)). We examine the relation of the slope of the Treasury yield curve in both the long and short run to credit spreads.

Elton et al. (2001) and Guitteriez (2001) find that similar to stock returns there are systematic risk factors in the returns of bonds. They both find that the systematic risk factors identified by Fama and French (1993) are priced in bond returns. These factors include: market risk premium (excess of the return on the market minus the risk-free rate), SML (size variable--small minus large portfolio returns), and HML (book-to-market variable--high minus low book-to-market portfolio returns). While controlling for changes in default risk, measured by the Treasury yield curve, we examine if the systematic risk variables have a significant influence on credit spreads.

We also test for the significance of other variables, which have been found to influence corporate yield spreads.[2] We examine whether the leading or coincidental economic indicators are better default indicators than the Treasury term variables. To examine this, we test the economic indicators in the cointegrating vectors and the error correction models (ECM) and find they do not provide statistically significant explanatory power to the models.[3] In addition, most interest rate models (e.g., Hull and White (1990), Heath, Jarrow, and Morton (1992), Vasicek (1977)) include volatility as a factor. We test for the significance of interest rate volatility in the ECMs and find it to be statistically insignificant. Finally, Barnhill, Joutz, and Maxwell (1999) document the influence of mutual fund flow on noninvestment grade bond yields. When including systematic risk factors, we find mutual fund flow to be statistically insignificant in the models.

The results of this study have a number of implications. First, future researchers who study the effect of Treasury rates and other macroeconomic variables on credit spreads should focus on both the long- and short-run dynamics of the model. Information about the long-run equilibrium provides information about short-run changes in credit spreads. Second, in terms of the pricing models of risky debt that incorporate a correlation to interest rates, we find a complex relation between interest rates and credit spreads. The relation between credit spreads and interest rates differ based on the maturity, credit ratings, and the sign of the relation changes based upon the time frame. The slope of the Treasury curve provides explanatory power in understanding changes in credit spreads, but this relation changes based upon maturity and the riskiness of the debt. Finally, accounting for changes in the Treasury yield

[2] In order to be succinct, we do not report all the results. However, the results are available upon request from the authors.

[3] The first systematic risk factor, the return on the market minus the risk-free rate, or a close variation is actually included in the leading economic indicator. Hence, an argument could be made that the stock market return instead of measuring systematic risk could in fact be measuring default risk.

curve, which serves as a proxy for default risk, we find that the Fama and French systematic risk factors are also priced in the bond market.

The remainder of the paper is organized as follows. Section II describes the data. Section III examines the long-run relation between credit spreads and the level and slope of the Treasury curve using cointegration analyses. Section IV estimates error-correction models to investigate the determinants of credit spreads, and section V concludes the paper.

2. The Data and the Statistical Properties of Credit Spreads

2.1. Constructing Indexes of Credit Spreads

We utilize the Lehman Brothers Bond database (LBBD) to construct yields on corporate bond indexes. The LBBD contains institutional month-end transaction data for Treasury and corporate bonds for the 1973-1997 time period and is commonly used in the fixed income literature. The database contains debt security information such as bid price, accrued interest, coupon, duration, convexity, yield, credit ratings, call and put provisions, and sinking fund characteristics. Although the database does not contain the universe of traded debt, we have no reason to suspect any systematic bias within the sample.[4]

We use a sub-sample of bonds in the LBBD to construct bond indexes. We eliminate all bonds that are matrix priced rather than trader priced.[5] A trader price is a dealer quote from which the yield on the securities is determined. We also eliminate all bonds that are not included in the Lehman Brothers Indexes as more care is taken in assigning the dealer quote (see Elton et al. (2001)). Given

[4] Elton, Gruber, Agrawal, and Mann (2001) compare the accuracy of trader quoted bond price information in the LBBD and CRSP and conclude the LBBD is comparable in accuracy to the CRSP data.

this restriction, all bonds with less than a year to maturity are eliminated. We further eliminate all bonds with embedded options (either puts or calls[6]) or have a sinking fund provisions. From this sample, we segment the bonds by Standard and Poor's rating category (AAA, AA, A, BBB, BB, and B) and by time to maturity (intermediate from 3 to 7.5 years and long-term greater than 7.5 years) to create indexes.[7]

Given our selection criteria, our sample is limited, with the elimination of callable bonds as the most significant restriction. As a result, we cannot create a reliable index for the AAA, BB, and B category. For example, in the early 1990s we only find nine AAA noncallable intermediate bonds in our sample. In addition, we find a consistent crossing of yields between AAA and AA rated indexes for both the long and intermediate ranges (the AA rated bonds have a lower yield than AAA securities). Therefore, we eliminate the AAA index from our analysis.[8] For the noninvestment grade bonds (BB and B), very few bonds are noncallable and for a series of months, there are no noncallable B rated bonds. However, instead of eliminating the BB and B categories from our sample, we use the Lehman Brothers Bond Indexes for these categories, which include both callable and noncallable bonds.[9] This clearly limits our ability to directly compare the results of the investment and noninvestment grade indexes. Even with this restriction, we believe it is informative to examine the noninvestment grade categories.

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[5] Elton, Gruber, Agrawal, and Mann (2001) and Schultz (2001) discuss the problems inherent in using matrix prices.
[6] Duffee (1998) finds a difference in the sensitivity of callable and noncallable bonds to changes in the Treasury yield and slope of the Treasury curve.
[7] Our selection criteria is similar to those of Elton et al. (2001).
[8] Duffee (1998) is able to create indexes for AAA securities from the LBBD using a less restrictive selection criteria.
[9] We do not create index for these categories because there is some concern about the accuracy of the bond rating before 1992 for noninvestment grade bonds. Instead we rely on the Lehman Brothers Indexes.

To create credit spreads, we subtract the spreads on corporate bond indexes from the Treasury index with a similar maturity (A intermediate spread = A intermediate index yield – Treasury intermediate index yield). This provides us with a complete data set for all indexes and maturities for the period January 1987 through March 1998.

Table 1 provides descriptive statistics for the intermediate and long-term indexes. Included are the means for maturity, duration, and yield to maturity, and standard deviation of yield to maturity for intermediate and long-term indexes for all bond rating categories. The intermediates indexes have with a mean maturity of 5.5 to 7.4 years and a mean duration in the range of 4.3 to 4.6. Long-term indexes have maturity in the range of about 13.3 to 17.7 years, with a mean duration in the range of about 6.5 to 8.4 years.

In comparing the mean YTM for the indexes, the term structure for investment grade bonds is on average upward sloping while the term structure for noninvestment grade bonds is on average downward sloping. These results are consistent with the theoretical models of Merton (1974), Longstaff and Schwartz (1995a), and Leland and Toft (1996), and the empirical results of Sarig and Warga (1989). The latter suggest an upward sloping or humped yield curve for low risk debt and a downward the sloping term structure of credit spreads for high risky debt.

Table 1 also provides descriptive statistics for intermediate and long term credit spreads. The mean and standard deviation of credit spreads for intermediate- and long-term indexes increases as ratings decline. This increase becomes larger as ratings change from investment to noninvestment grade categories. Figure 1 provides various graphs of credit spreads for long and intermediate indexes of A and B rated bonds.[10] The results show a gradual drift downward in the

[10] We only show graphs of two representative categories. However, the A rated bonds are representative of the investment grade category and the B rated bonds are representative for the noninvestment category.

spread for A rated bonds and a less noticeable drift in the B rated bonds. The yield on the long-term Treasury also has a downward drift.

2.2. Explanatory Variables

To measure the level of the Treasury yield curve, we use a long-term index (Treasuries with maturities greater than 15 years). This is in contrast to Duffee (1998) who uses a 3 month T-Bill rate. We find that long-term indexes provide more explanatory power. We also find that long-term Treasury indexes with maturities greater than 10 years have correlations greater than 0.98, and therefore, the choice of the long-term index is insignificant to the final results. To measure the slope of the yield curve, we subtract the 30-year Treasury bond yield from the 30-day Treasury bill yield. We use the Fama and French factors to measure systematic risk, which includes the excess return on the market, the return on a portfolio of small stocks minus the return on a portfolio of large stocks, and the return on the portfolio of high minus low book-to-market stocks.

2.3. Stationarity of Credit Spreads

The stationarity of credit spreads is a significant issue in the pricing models of risky debt and credit derivatives as well as in the choice of the appropriate econometric method.[11] We examine the stationarity of credit spreads and of the explanatory variables using the augmented Dickey-Fuller test statistic. As shown by Shiller and Peron (1985), the power of unit-root tests is a function of the span of the data and not the number of observations. Hence, our conclusions

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[11] For example, Das and Tufano (1996) and Jarrow, Lando, and Turnbull (1997) assume a stationary process of credit spreads in their valuation models.

are appropriate when describing monthly data over 12 years. Since a non-stationary process implies an explosive volatility structure over time, it seems implausible that the Treasury yield, the slope of the Treasury curve, or credit spreads are non-stationary over long periods of time. However, since most pricing models have a relatively short time horizon, it seems plausible over an investment horizon that credit spreads could be non-stationary. That is, the investment horizon drives the data frequency chosen and the form of the model considered**.**

We test the stationarity of credit spreads for all bond ratings categories, AA through B, for both intermediate and long-term indexes and for other explanatory variables in Panel A of Table 2. The beta estimates in the augmented Dickey-Fuller (lag = 2) ranged from .97 to .95 for the spread on the intermediate indexes and from .85 to .96 for the spread on long-term indexes. We find similar results for the level and the slope of the Treasury yield curve. The beta is .97 for the level and .98 for the slope of the yield curve. We fail to reject the null hypothesis of non-stationarity for any of the credit spreads or for the Treasury yield curve variables. For the Fama and French systematic risk factors measures, we can conclude that the processes do not have a unit root. Figure 1 also shows the time-series plots of the variables of interest. The graphical analysis seems to be consistent with the test statistics. Given the lack of power in the augmented Dickey-Fuller, we cannot conclusively conclude that credit spreads or the Treasury curve variables are nonstationary.[12] However, the evidence suggests that credit spreads and the Treasury curve variables are a unit-root or near unit-root process, again subject to using monthly data.[13]

[12] The nonstationarity of the risk-free interest rate has been well documented by Fama (1976, 1977) and Rose (1988).

[13] Pedrosa and Roll (1998) examine the daily time-series properties of credit spreads from October 1995 to March 1997, and cannot reject the null hypothesis that credit spreads are non-stationary. However, they conclude that it is implausible for credit spreads to have a unit root.

Panel B of Table 2, provides the results of the stationarity test on the first differences of credit spreads and Treasury curve variables. The evidence suggests that first differences are stationary. Based on the analysis, our results are consistent with the level of the Treasury curve, the slope of the Treasury curve, and credit spreads as being non-stationary at least when examining the variables over a monthly time frame. The systematic risk factors, changes in credit spreads, and the Treasury curve variables, are stationary. We also find, interestingly, that credit spreads seem to follow the pattern found in the risk-free term structure in which long term bonds have less volatility than intermediate term bonds. This same pattern is generally found in credit spreads.

3. Cointegration Analysis

Our analysis of monthly credit spreads suggests that credit spreads follow a process that is non-stationary.[14] This has implications with respect to the appropriate statistical methodology. Longstaff and Schwartz (1995a and 1995b) and Duffee (1998) avoid the problem of a spurious regression by examining factors that influence changes in credit spreads. While focusing on changes in credit spreads eliminates the problem of spurious regressions, it also results in a potential loss of information on the long-run interaction of variables (e.g., Engle-Granger (1987)). Therefore, instead of directly moving to a model utilizing differences, we first test for a cointegrating vector. The implication of a cointegrating vector is that while the variables may be individually non-stationary, a linear combination of variables is stationary. Hence, a cointegrating vector indicates a long-run relationship between the variables.

To perform the cointegration analysis, we must identify the variables to test in the cointegrating vector. The implication of a cointegrating vector is that the individual variables are nonstationary but a linear combination of the variables produces a stationary error structure. We test for the presence of a cointegrating vector between credit spreads and the level and slope of the yield curve using the Johansen maximum likelihood procedure for a finite-order vector autoregression (e.g., Johansen (1988 and 1991)).

We estimate a system of equations with credit spreads (AA, A, BBB, BB, B), the level of the Treasury curve, and the slope of the Treasury curve, using two lags (similar to the ADF tests). We also include the three Fama and French systematic risk factors as unrestricted variables.[15] The Johansen procedure is used to test for a cointegrating vector. The null hypothesis is that there is no cointegrating vector (rank=0), and the alternative hypothesis is that there is a single cointegrating vector (rank=1). We further test for the significance of a second cointegrating vector (rank ≤ 1).

Tables 3 and 4 provide the cointegration results for credit spreads on the intermediate- and the long-term indexes, respectively. We report the Johansen maximal eigenvalue and trace statistics. For both the intermediate and long-term credit spread indexes, we reject the null hypothesis at the 1% level that there is no cointegrating vector for all the different credit spread models implying a cointegrating vector exists for each of the indexes. We interpret the cointegrating relation as an equilibrium expression for the determinants of credit spreads.

Before examining the long-run relation between the variables, we test the significance of the level and the slope of term structure as well as joint test of both variables in the cointegrating

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[14] Elliott (1998) points out the pitfalls in using cointegration methods when the data are stationary. However, this is a limitation of any paper using this methodology. We thank the referee for this comment.

[15] We also ran the models with a trend term but did not include it in our final analysis as it did not add additional explanatory power to the models.

vector. To test the significance of the different variables in the vector autoregressions, we place general restrictions on the cointegrating vector. To do this, we normalize the system by restricting the beta coefficient of the variable being tested to zero to examine if the beta coefficient is significantly different from zero. The Chi-Square (χ^2(d.f.)) p-values for the significance of the level and slope of the term structure in the cointegrating vector are at the bottom of Tables 3 and 4.

The standardized eigenvectors are the estimated cointegrating vectors for the different spreads. For example, the cointegrating vector for the credit spread on long-term and intermediate AA bonds can be written as (p-values):

$$\text{Credit Spread } AA_{LT} = \underset{(0.001)}{0.097} \text{ Level of Treasury } - \underset{(0.000)}{0.114} \text{ Slope of Treasury} \quad (1)$$

$$\text{Credit Spread } AA_{INT} = \underset{(0.000)}{0.163} \text{ Level of Treasury } + \underset{(0.000)}{0.203} \text{ Slope of Treasury} \quad (2)$$

The long-term AA credit spread relation suggests that a 100 basis point change in the level of Treasuries leads to a 10 basis point increase in the spread. There is a roughly offsetting effect for a 100 basis point increase in the slope of the yield curve. The intermediate AA credit spread is more sensitive to changes in the level of Treasuries, but in contrast to the long-term credit spread, the slope is positively related to the intermediate credit spread.

When examining all the results, the level of the Treasury curve is statistically significant at a minimum 5% level for all the credit spreads. The beta (standardized eigenvalue) of the level of the Treasury curve suggests a positive relation to credit spreads. The positive relation between the level of the yield curve and credit spreads suggests that over the long run the Leland and Toft (1996) model is correct. The Treasury coefficient is increasing in magnitude as rating declines and is higher for similar rated intermediate indexes as compared to the long-term indexes. We find this to be consistent with the additional risk inherent in long-term bonds relative to short-term ones.

The effect of slope on credit spreads is more complex. For the intermediate credit spreads in Table 3, the slope of the yield curve has a positive relation and is statistically significant at a minimum 5% level for the intermediate indexes rated AA through BB. For the long-term indexes, the slope has a negative relation and is statistically significant for the AA (1% level) and A (10% level) credit spreads. This suggests a complex relation between credit spreads and the slope of the Treasury curve. For intermediate indexes rated BB and higher there is a statistically significant positive relation. In contrast, for the long-term indexes there is a statistically significant negative relation at least for the AA and A rated categories. These results seem consistent with the idea that the highest risk bonds (low rated and longest maturity) are more sensitive to long-term changes in the slope of the yield curve, which is related to economic activity. For example, if the yield curve inverts, which is typical during economic downturns, the spreads on the lowest rated bonds and bonds with long maturities increase.

The alpha coefficients represent the speed of adjustment back towards the long-run equilibrium. The alphas for the intermediate indexes are relatively small suggesting that a pull back towards an equilibrium is relatively quick. In comparison, the alphas for the long-term indexes are a higher magnitude suggesting a slower pull back towards a long-term equilibrium.

Overall, when examining the cointegration results, we find a long-run relation between credit spreads and the level and slope of the Treasury term structure. The level is statistically significant in all the models while the slope is statistically significant in 6 out of the 10 categories. This suggests that there is a long-run pull towards equilibrium over time. Thus by differencing the variable to induce stationarity, a researcher would lose the information contained in the long run interaction of the variables.

4. Determinants of Credit Spreads

To fully understand the dynamics of credit spreads, we must understand the determinants of credit spreads and examine if these factors differ in strength based upon the risk or maturity of the bonds. General risk categories are measured by bond ratings, and bond ratings are relative measures. This leads to credit spreads changing over time due to changes in macroeconomic conditions as the perceived risk of owning a bond fluctuates over time (Fridson, Garman, and Wu, 1997). In this section, we examine the factors that can cause the premium for owning risky debt to fluctuate over time. Consistent with Elton et al. (2001), we include measures of default risk and systematic risk in the analysis.

4.1. Error-Correction Models

After determining the long-run relation between the Treasury curve and credit spreads, we next estimate error correction models (ECMs) to determine the factors which influence credit spreads over the short and long run. ECMs combine the information from the short-run dynamics of the credit spreads while directly incorporating the long-run relation found in the cointegration analysis. In addition, we include Fama and French's three factors to measure systematic risk. Table 5 provides the results of the analysis.

We find that all models are statistically significant at the 1% level. With the exception of the AA category, we find that the models explain more of the changes in the intermediate than long-term indexes as measured by the coefficient of determination, R-square. Even though credit spreads volatility increases as bond ratings decline (see Table 1), we find that we can generally explain more of this volatility.

4.2. Determinants of Credit Spreads

Consistent with the time period plots, we find that the constant is negative in 9 out of the 10 categories and is statistically significant at the 5% level in 5 out of 10 of the categories. In particular, the constant is significant in both the BB and B models for the intermediate and long-term indexes. The declining spread is consistent with the growing optimism regarding the U.S. economy from the late 1980s to the late 1990s.

The error correction coefficient is negative for all the categories and is statistically significant for all the long-term indexes. However, for the intermediate indexes it is only statistically significant for the BB and B categories. The results from the cointegration analysis and from the error correction models suggest there is long-run relation for long-term bonds and for the noninvestment grade intermediate bonds, but the results for the intermediate investment grade bonds suggest only a weak relation. However, for the BB and B intermediate models the error correction term suggests a speed of adjustment 2-3 times slower than for the long-term indexes.

There is a statistically significant negative relation between changes in the credit spreads and changes in the Treasury yield in 9 out of the 10 categories (significant at a minimum 5% level). Thus, the sign of the relation between the level of the risk-free rate and credit spreads differs based the length of time analyzed. In the long-run there is a positive relation (see Table 3 and 4), and in the short-run (Table 5) there is a negative relation.

A negative relation between credit spreads and the Treasury yield is consistent with Merton's (1974) contingent claims approach where the firm is valued in an option framework. In the short run, the theoretical pricing models are correct in that there is a negative relation between changes in credit spreads and changes in the Treasury yield.

The change in the slope is statistically significant and positive at a minimum 5% level for all the intermediate indexes. For the long-term indexes, the slope is only significant for the B category. Overall, we find the slope is a significant variable in understanding intermediate credit spreads. For the intermediate indexes, we find the slope to be highly significant and positive related to credit spreads in both the long run (from the cointegration analysis) and the short run. The effect of the slope of the yield curve and long-term credit spreads is less significant and more complex. In the long run we find a negative relation between the slope and long-term credit spreads, at least for the AA and A category. In the short run the slope is only significant for the credit spread on B rated long-term bonds but positive. This suggests the information contained in the slope of yield curve has very different implications for long-term versus intermediate maturity credit spreads.

We find results that are consistent with Elton et al. (2001) and Gutierrez (2001). The Fama and French three factors are generally negative and significant, which support a systematic component to credit spreads similar to stock returns. The market risk premium is statistically significant in for all ten categories, and in 8 out of the ten categories it has the highest explanatory power. The second systematic factor, small minus large returns, is statistically significant in 6 of the categories. Generally, the SMB factor has more explanatory power for the intermediate credit spreads. The high minus low book-to-market factor is significant in 8 categories and similar to the SMB factor seems to explain more of the variation in the intermediate versus long-term credit spreads.

When comparing the overall models for the intermediate versus long-term credit spreads, we find the long-run relation between the level and the slope of the yield curve to have a more significant effect on long-term credit spreads. On the other hand, the systematic risk factors seem to have a greater effect on the intermediate credit spreads. This is consistent with the conclusion that long-term bonds are more sensitive to changes in default risk and intermediate bonds are driven more by the systematic component of credit spreads.

Finally, we examine the stability of the ECMs using recursive analysis. We estimate the ECMs using the first three years of observations and then examine the stability of these estimates as an additional observation is added. The easiest way to examine the output is in graphical form. Figures 2 through 5 show the beta estimates for the explanatory variables in the ECMs. In the figures, the beta estimates are bounded by lines representing two standard deviations from the coefficient estimates. We show results for the A rated and BB rated credit spreads for both the intermediate and long term. While we find some volatility over the first half of the model, the beta estimates appear to be relatively stable and constant over time[16].

5. Conclusion

We examine the dynamics of changes in corporate credit spread risk for investment and noninvestment grade bonds. Our evidence, based on monthly data, suggests that over a twelve year period credit spreads are a non-stationary or at least close to a unit-root process, but the changes in credit spreads are stationary. To induce stationarity, researchers difference the

[16]We also ran N-down Chow tests to test for structural breaks in the model and find no evidence of any structural breaks in the model. (available upon request).

variables, but this can lead to a loss of information. Therefore, we examine the presence of stationary cointegrating vectors between credit spreads and the Treasury term structure. Using the Johansen maximum likelihood procedure for finite-order vector autoregressions, we find a stationary long-run relation between credit spreads and the level and slope of the Treasury term structure. We then use error correction models to determine the factors that influence credit spreads over the short and long run. The rationale is that estimating the short- and long-run dynamics of credit spreads simultaneously allows us to investigate the speed of adjustment to disequilibrium in the long-run relation, while examining the short-run dynamics of credit spreads.

In aggregate, the results suggest that Treasury yields are positively related to credit spreads in the long run, but negatively related in the short run. This has implications in the contingent claims and the reduced form approaches for valuing risky debt. In the contingent claims approach framework, an increase in Treasury yields is a negative signal to the market over the long run about the firm's future cash flows. In the short run, however, an increase in the Treasury yield indicates an increase in the value of the call option. As for the slope of the term structure, the relation between credit spreads and the slope is complex. For intermediate investment grade bonds, there is a positive relation in both the short and long run, but for long-term bonds the predominant relation in the long run is negative and there is no statistically significant relation in the short run. We also find that Fama-French systematic risk factors influences changes in credit spreads over time. Hence, corporate credit spreads are driven by both default and systematic risk.

Finally, our study has two main implications. The first is methodological. Future researchers who study the effect of Treasury rates and other macroeconomic variables on credit spreads should consider using cointegration analysis when conducting their empirical tests. Our results demonstrate a complex relation between credit spreads, the level, and the slope of the Treasury yield curve. In the long run there is a positive relation but in the short run this relation turns negative. The second implication relates to pricing risky debt. The determinants of credit spreads differ based upon time to maturity and credit risk, but also the sign of these relations change based upon the maturity and the credit rating of the bond. This has implications for the development of accurate models to price risky debt and credit derivatives.

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TABLE 1
Descriptive Statistics for Yield on Corporate Bond Indexes and Credit Spreads Calculated as the Difference between Yield on Corporate Bond Indexes and Treasury Yield with a Corresponding Maturity

This table shows intermediate and long term corporate bond indexes and credit spreads. The data comes from the Lehman Brothers Bond database available on a monthly basis from January 1987 through October 1998. For corporate bond indexes, included are the mean maturity, mean duration, mean yield to maturity, and standard deviation of yield to maturity for intermediate and long term indexes for all rating categories. For credit spreads, included are the mean, standard deviation, skewness and kurtosis for intermediate and long term indexes for all rating categories. Maturity and duration are in years, and yields are in basis points based on a par bond value of $100.

	Bond Indexes				Credit Spreads			
	Maturity	Duration	YTM	Std. Dev. Of YTM	Mean	Std. Dev.	Skewness	Kurtosis
Intermediate Indexes								
AA	5.548	4.459	7.706	1.335	0.927	0.308	0.419	-1.093
A	5.592	4.475	7.919	1.365	1.141	0.375	0.382	-1.013
BBB	5.661	4.497	8.262	1.393	1.483	0.510	0.708	-0.255
BB	6.790	4.348	10.505	2.318	3.813	1.439	0.984	1.498
B	7.415	4.576	12.335	2.509	5.643	1.674	1.481	2.875
Long-Term Indexes								
AA	16.421	8.395	8.127	1.151	0.408	0.219	0.654	-0.396
A	15.183	8.134	8.350	1.172	0.632	0.256	1.253	1.344
BBB	15.353	8.012	8.735	1.233	1.017	0.368	1.574	2.321
BB	17.672	7.428	10.123	1.584	2.521	0.722	1.467	3.756
B	13.305	6.543	12.137	2.327	4.535	1.564	1.579	2.174

Table 2
Augmented Dickey-Fuller Test Statistics Examining the Stationarity of Credit Spreads and Changes in Credit Spreads

The augmented Dickey-Fuller test statistics is used to test the stationarity of credit spreads and changes in credit spreads. The null hypothesis is that $\beta_{t-1}=1$ (a nonstationary process) and the alternative is that $\beta_{t-1}=0$ (a stationary process). Critical t-values are: 5%=-2.88, 1%=-3.48 with a constant included. Panel A represents a test for stationarity on the spread between corporate bonds and Treasury yields. Panel B represents a test for stationarity on the change in the spread between corporate bonds and Treasury yields. Statistical significance is denoted by [a], [b], and [c] for the 99%, 95%, and 90% confidence levels respectively.

	Panel A – Test of Stationarity - Levels			Panel B – Test of Stationarity - First Difference		
	β_{t-1}	Std. Dev.	t-statistic	β_{t-1}	Std. Dev.	t-statistic
Intermediate Index Credit Spreads						
AA	0.965	0.080	-1.50	-0.614	0.149	-6.48[a]
A	0.966	0.095	-1.51	0.129	0.096	-5.42[a]
BBB	0.962	0.119	-1.79	0.198	0.119	-5.53[a]
BB	0.947	0.438	-1.87	0.106	0.444	-5.48[a]
B	0.947	0.470	-2.04	0.177	0.475	-5.48[a]
Long-Term Index Credit Spreads						
AA	0.949	0.068	-1.77	-0.281	0.066	-8.09[a]
A	0.936	0.082	-2.17	-0.399	0.109	-7.27[a]
BBB	0.936	0.119	-2.14	-0.080	0.119	-6.94[a]
BB	0.853	0.381	-2.81	-0.182	0.393	-5.85[a]
B	0.959	0.555	-1.31	-0.137	0.551	-5.46[a]
Treasury Curve Variables						
Level	0.971	0.263	-1.21	-0.007	0.264	-6.05[a]
Slope	0.977	0.198	-1.62	0.472	0.200	-4.36[a]
Measures of Systematic Risk						
Market excess return	0.017	4.056	-8.10[a]			
Small minus large firm	0.082	2.640	7.82[a]			
High minus low book/market	0.097	2.313	-7.80[a]			

Table 3
Cointegration Analysis of Credit Spreads, the Level of the Treasury Curve, and the Slope of the Treasury Curve Using the Johansen Methodology with the Fama and French Risk Factors as Unrestricted Variables for Intermediate Indexes

λ_{max} and λ^{α}_{max} are Johansen's maximal eigenvalue statistics, and λ_{trace} and λ^{α}_{trace} are Johansen's trace eigenvalue statistics. An α signifies the statistic is adjusted for degrees of freedom. The null hypothesis is that there is no cointegrating vector (rank=0) against the alternative hypothesis that there is one cointegrating vector (r=1). Rank<=1 tests the null hypothesis that there is more than one cointegrating vector. The Fama and French three systematic risk factors (market risk premium, small minus large firm, and high to low book-to-market) are included as unrestricted variables.

	Credit Spreads Intermediate Indexes				
	AA	A	BBB	BB	B
Cointegration Statistics					
Null Hypothesis rank = 0					
λ_{max}	36.20[a]	41.58[a]	38.14[a]	36.71[a]	34.22[a]
λ^{α}_{max}	34.55[a]	39.69[a]	36.41[a]	35.04[a]	32.67[a]
95% critical value	21	21	21	21	21
λ_{trace}	42.67[a]	46.98[a]	43.31[a]	43.11[a]	41.44[a]
λ^{α}_{trace}	40.73[a]	44.85[a]	41.34[a]	41.15[a]	39.56[a]
95% critical value	29.7	29.7	29.7	29.7	29.7
Null Hypothesis rank <= 1					
λ_{max}	4.71	4.50	4.82	6.36	7.20
λ^{α}_{max}	4.49	4.30	4.60	6.07	6.87
95% critical value	14.1	14.1	14.1	14.1	14.1
λ_{trace}	6.47	5.40	5.17	6.40	7.22
λ^{α}_{trace}	6.18	5.15	4.93	6.11	6.89
95% critical value	15.4	15.4	15.4	15.4	15.4
Standardized Eigenvalues, beta					
Level	-0.1626	-0.2097	-0.2517	-1.0146	-0.1234
Slope	-0.2029	-0.2477	-0.2905	-0.3598	-0.1200
Standardized Adjustment Coefficient					
alpha	-0.0134	-0.0039	-0.0049	-0.0822	-0.0787
Test statistic for the significance of the variable in the cointegrating variable P-value from Chi-square 1 df.					
Level	0.000[a]	0.000[a]	0.000[a]	0.000[a]	0.020[b]
Slope	0.000[a]	0.000[a]	0.000[a]	0.010[b]	0.490
Joint	0.000[a]	0.000[a]	0.000[a]	0.000[a]	0.050[b]

Table 4
Cointegration Analysis of Credit Spreads, the Level of the Treasury Curve, and the Slope of the Treasury Curve Using the Johansen Methodology with the Fama and French Risk Factors as Unrestricted Variables for Long-Term Indexes

λ_{max} and λ^{α}_{max} are Johansen's maximal eigenvalue statistics, and λ_{trace} and λ^{α}_{trace} are Johansen's trace eigenvalue statistics. An α signifies the statistic is adjusted for degrees of freedom. The null hypothesis is that there is no cointegrating vector (rank=0) against the alternative hypothesis that there is one cointegrating vector (r=1). Rank<=1 tests the null hypothesis that there is more than one cointegrating vector. The Fama and French three systematic risk factors (market risk premium, small minus large firm, and high to low book-to-market) are included as unrestricted variables.

	Credit Spreads Long-Term Indexes				
	AA	A	BBB	BB	B
Cointegration Statistics					
Null Hypothesis rank = 0					
λ_{max}	31.15[a]	27.59[a]	26.96[a]	33.83[a]	42.91[a]
λ^{α}_{max}	29.73[a]	26.33[a]	25.74[a]	32.29[a]	40.96[a]
95% critical value	21	21	21	21	21
λ_{trace}	39.33[a]	36.57[a]	36.66[a]	38.37[a]	48.85[a]
λ^{α}_{trace}	37.54[a]	34.91[a]	34.99[a]	36.63[a]	46.63[a]
95% critical value	29.7	29.7	29.7	29.7	29.7
Null Hypothesis rank <= 1					
λ_{max}	7.70	8.41	9.67	4.52	5.92
λ^{α}_{max}	7.35	8.03	9.23	4.31	5.65
95% critical value	14.1	14.1	14.1	14.1	14.1
λ_{trace}	8.18	8.99	9.69	4.54	5.95
λ^{α}_{trace}	7.81	8.58	9.25	4.33	5.68
95% critical value	15.4	15.4	15.4	15.4	15.4
Standardized Eigenvalues, beta					
Level	-0.0973	-0.1603	-0.1636	-0.4675	-0.8014
Slope	0.1143	0.0613	0.0567	-0.0577	0.0855
Standardized Adjustment Coefficient					
alpha	-0.2587	-0.1146	-0.1059	-0.2665	-0.1757
Test statistic for the significance of the variable in the cointegrating variable P-value from Chi-square 1 df.					
Level	0.001[a]	0.001[a]	0.030[b]	0.000[a]	0.000[a]
Slope	0.000[a]	0.070[c]	0.250	0.460	0.550
Joint	0.000[a]	0.001[a]	0.050[b]	0.001[a]	0.001[a]

Table 6

Error Correction Models Examining the Relation between Changes in Credit Spreads and the Error Correction Coefficient, Changes in the Level and Slope of the Treasury Curve, and the Fama and French Systematic Risk Factors

Below the estimated coefficients in parentheses are the absolute value of the t-statistic, and statistical significance is represented by: [***] at the 0.01 level, [**] at the 0.05 level, and [*] at the 0.10 level.

Δ Spread to Treasury	Constant	Error Correction$_{t-1}$	Δ Level LT Treasury Yield	Δ Slope Treasury Curve	Market	SMB	HML	Chi-Square	R^2
Panel A: Intermediate Indexes									
AA	-0.016	-0.031	-0.122[b]	0.163[b]	-0.010[b]	-0.005	0.002	3.86[a]	0.16
	(0.32)	(0.43)	(2.00)	(2.14)	(2.59)	(0.96)	(0.28)		
A	-0.017	-0.025	-0.113[a]	0.128[a]	-0.011[a]	-0.008[a]	-0.011[a]	12.85[a]	0.39
	(0.56)	(0.80)	(3.57)	(3.22)	(5.46)	(2.70)	(3.40)		
BBB	0.002	-0.006	-0.142[a]	0.110[a]	-0.015[a]	-0.011[a]	-0.017[a]	10.83[a]	0.35
	(0.06)	(0.25)	(3.34)	(2.06)	(5.27)	(2.76)	(3.81)		
BB	-0.357[b]	-0.068[b]	-0.641[a]	0.429[b]	-0.038[a]	-0.046[a]	-0.043[a]	12.85[a]	0.39
	(2.27)	(2.39)	4.43	(2.47)	(4.05)	(3.38)	(2.78)		
B	-0.166[b]	-0.069[a]	-0.712[a]	0.407[b]	-0.050[a]	-0.065[a]	-0.057[a]	19.14[a]	0.48
	(2.33)	(2.99)	(4.77)	(2.29)[b]	(5.18)	(4.70)	(3.59)		
Panel B: Long-Term Indexes									
AA	-0.040[a]	-0.234[a]	-0.054[b]	-0.052	-0.007[a]	-0.002	-0.007[a]	11.15[a]	0.35
	(3.69)	(4.87)	(2.29)	(0.98)	(4.83)	(0.89)	(2.99)		
A	-0.035	-0.093[c]	-0.050	-0.042	-0.008[a]	-0.007[c]	-0.010[b]	4.10[a]	0.17
	(1.41)	(1.82)	(1.18)	(-0.85)	(2.76)	(1.86)	(2.22)		
BBB	-0.032	-0.080[b]	-0.093[b]	-0.041	-0.013[a]	-0.0006	-0.013[a]	6.89[a]	0.25
	(1.56)	(2.35)	(2.09)	(0.76)	(4.44)	(1.51)	(2.75)		
BB	-0.333[a]	-0.236[a]	-0.431[a]	0.115	-0.017[c]	-0.007	-0.008	6.36[a]	0.24
	(4.07)	(4.42)	(2.89)	(0.68)	(1.74)	(0.51)	(0.56)		
B	-0.467[a]	-0.149[a]	-0.710[a]	0.407[c]	-0.044[a]	-0.041[b]	-0.073[a]	10.24[a]	0.34
	(4.01)	(4.54)	(3.67)	(1.81)	(3.57)	(2.29)	(3.55)		

Figure 1
Time Series Plot of Variables of Interest

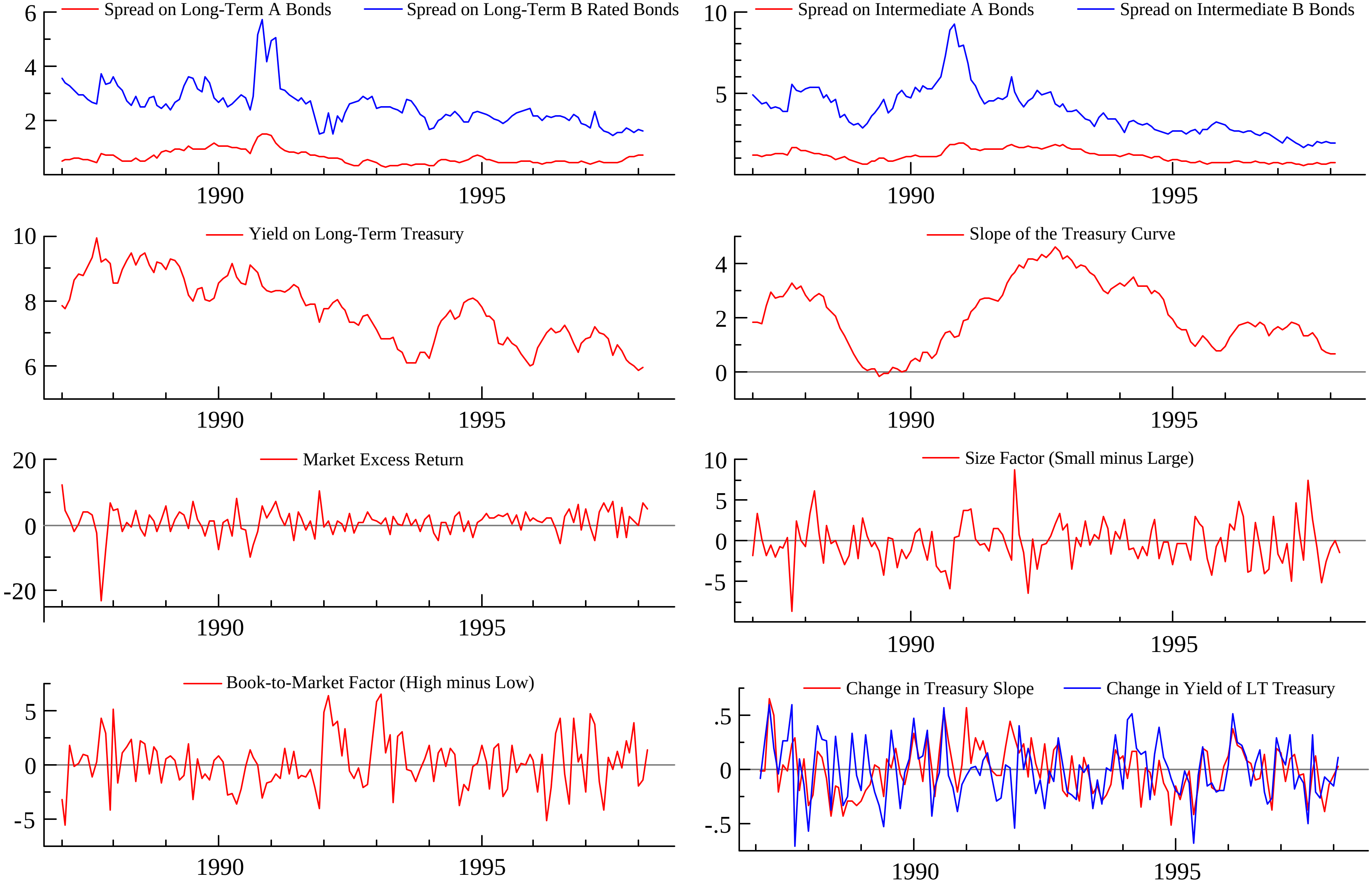

Figure 2

Stability of Beta Estimates for the Change in the Spread of the Long-Term A Index

(The Beta Estimate is Bounded +/- Two Standard Errors)

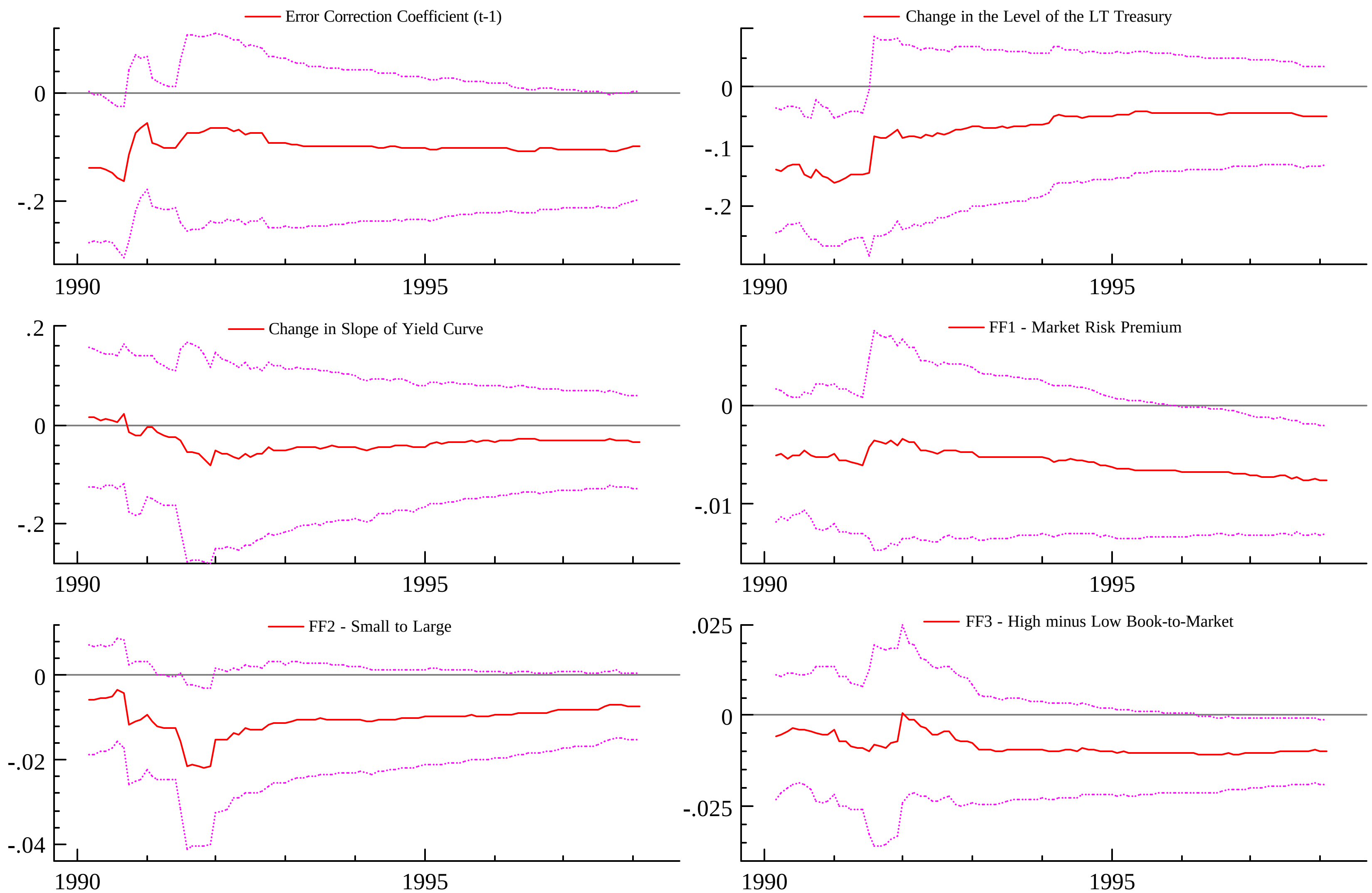

Figure 3
Stability of Beta Estimates for the Change in the Spread of the Intermediate A Index
(The Beta Estimate is Bounded +/- Two Standard Errors)

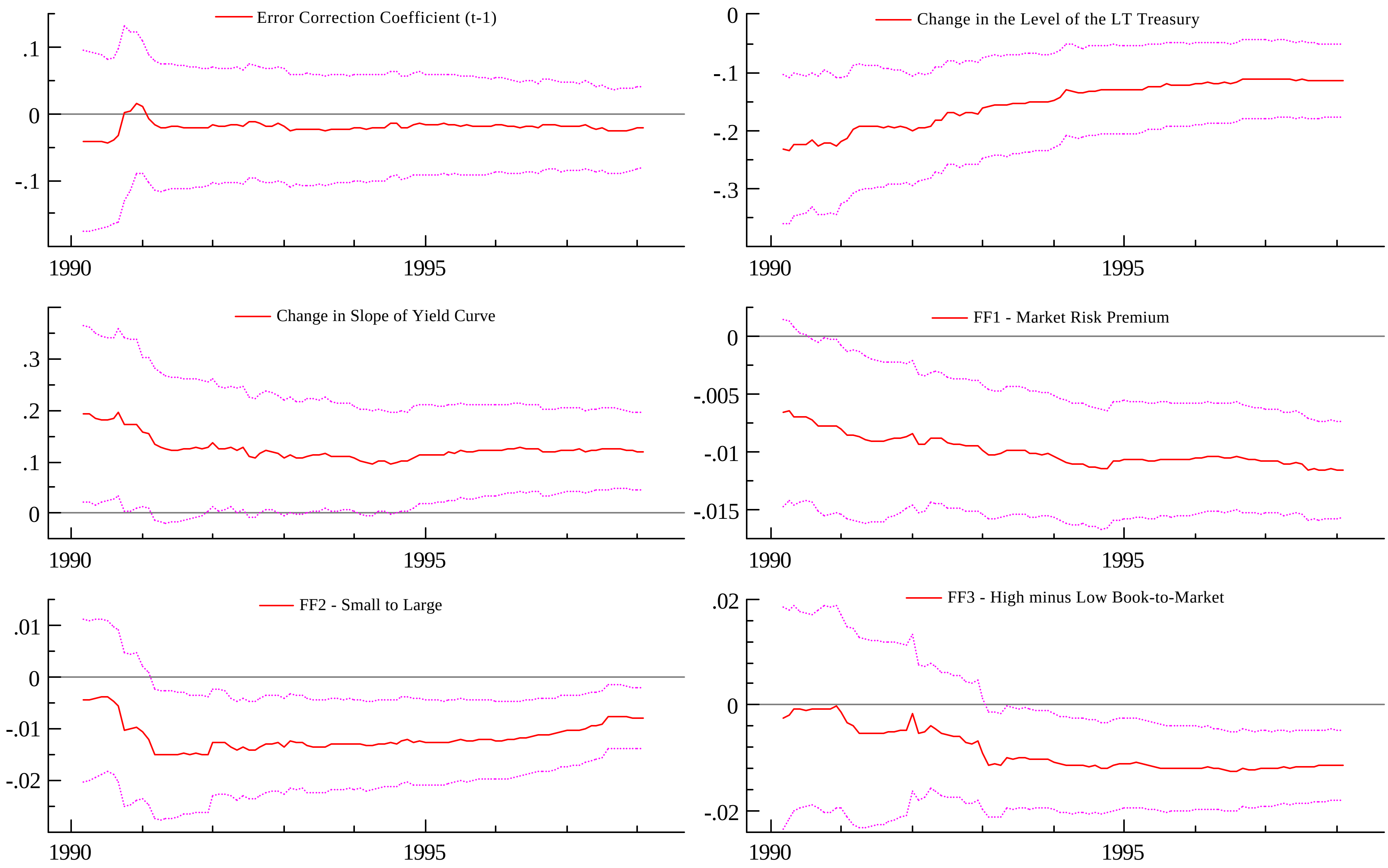

Figure 4
Stability of Beta Estimates for the Change in the Spread of the Long-Term BB Index
(The Beta Estimate is Bounded +/- Two Standard Errors)

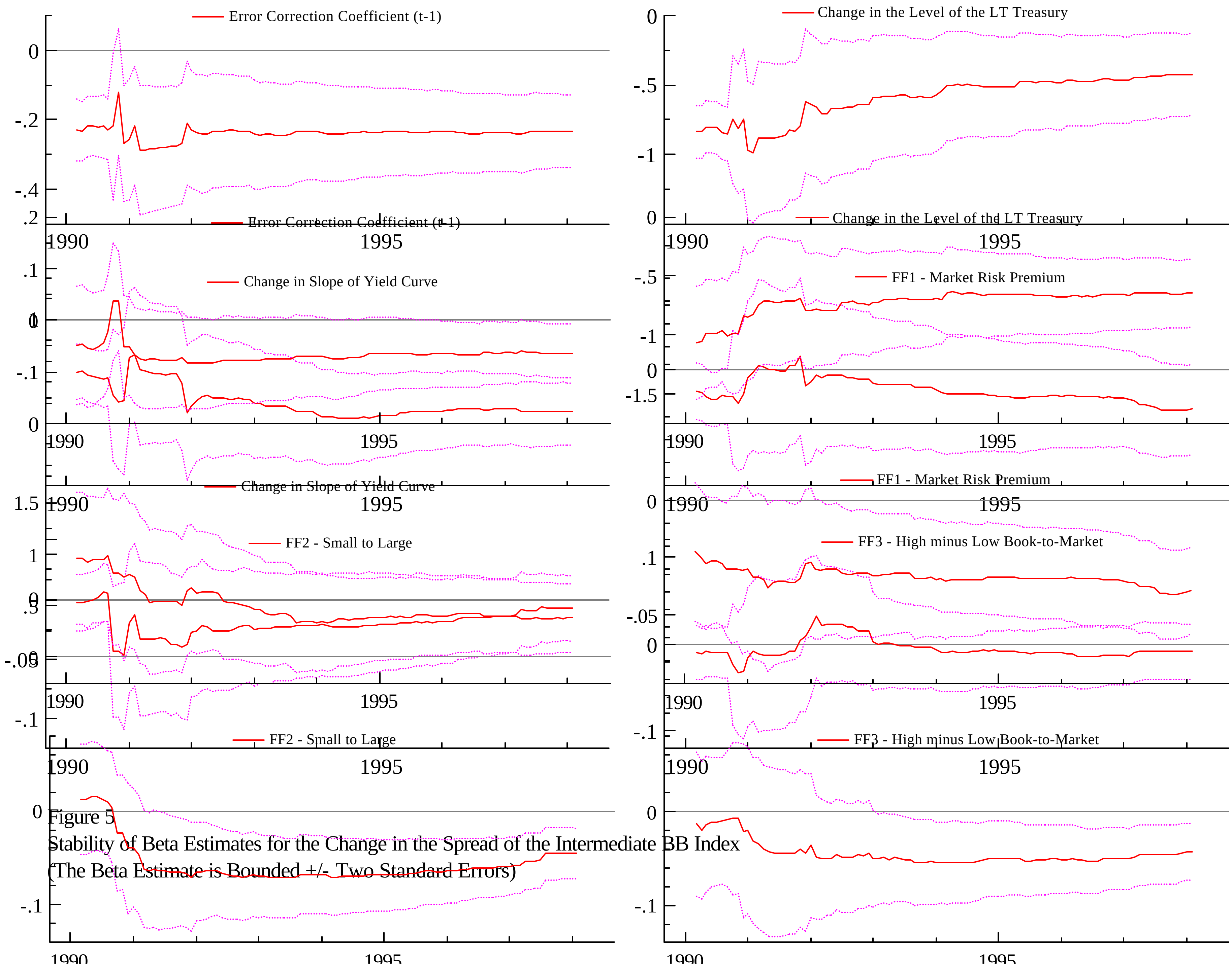

Figure 5
Stability of Beta Estimates for the Change in the Spread of the Intermediate BB Index
(The Beta Estimate is Bounded +/- Two Standard Errors)