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The Determinants of Credit Spread Changes: Evidence from the U. K. market

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**Διατριβή υποβληθείσα προς μερική εκπλήρωση
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Abstract

With this study we have tried to investigate changes in credit spreads on individual bond rates. The study of credit spread changes is very useful for hedge funds or corporations that take highly levered positions in corporate bonds and they hedge interest rate risk with treasuries. Moreover, it is very useful for the pricing of credit derivatives, one of the fastest growing segments in the global market of derivatives.

In order to find the variables that we thought that they could have an explanatory power on credit spread changes, we were based on structural models of default. Moreover, we proposed some more variables- macroeconomic and economic state ones-which were within the theoretical framework of structural models. The data for our sample were derived from the U.K. market. Using these factors and this data we have proposed two models.

Our first model is a conditional contemporaneous model, similar to the ones proposed by other authors, like Collin-Dufresne, Goldstein and Martin (2001). With this model we have achieved R^2s- adjusted ranging from 37% for low rated bonds to 55% for high rated bonds. This result is supportive for the explanatory ability of structural models of default on credit spread changes. We have estimated that credit spread changes are mainly driven by changes in the term structure slope and by changes of the spot rate. Average and low rated bonds are, also, affected by equity and market return. High and low rated bonds are strongly affected by the changes of the inflation rate.

Our second model is an unconditional, non-contemporaneous model. We examine whether credit spread changes can be explained by the variables used in our previous model (plus two economic state variables), but at a t-1 period of time. With this model we have achieved R^2s-adjusted ranging around 20%. According to the second model, credit spread changes are affected, similarly, by changes in the spot rate. However, the term structure slope seems to have a much smaller explanatory power in this model. Moreover, the change in the industrial index has a bigger effect on credit spread changes, contrary to our previous model. On the other hand, equity and market return don't seem to have any effect in our second model.

Although the R^2s are much smaller in the second model we find it more preferable and credible, since it gives us the ability to conduct forecasts on the level of credit spread changes across credit risk groups.

I. Introduction

The first question that we have to answer is: "Why is the study of the determinants of credit spread changes so important? "

The factors that affect bond returns is a subject that has been widely studied, mostly at the aggregate level. We will refer to some studies very briefly. Fama and French (1993) have tried to identify some common risk factors in the returns on stocks and bonds. Their main findings are the following:

- There are three stock market factors; an overall market factor and factors related to firm size and book to market equity.
- There are two bond market factors, which are related to maturity and default risks.
- In general, those five factors seem to explain average returns on stocks and bonds.

Kwan (1996) has studied the relation between stock and bond returns at the individual firm level. His main conclusions are:

- High - grade bonds behave like treasury bonds
- Low - grade bonds are more sensitive to stock returns.

However, the conclusions of those studies may be of limited usefulness in many cases. For example, there are many hedge funds or corporations that take highly levered positions in corporate bonds and they hedge interest rate risk with treasuries. Thus, their portfolio is extremely sensitive to changes in credit spreads, rather than changes in bond yields.

Moreover, the study of credit spreads is very important for the pricing of credit derivatives. Credit derivatives are one of the fastest growing segments in the global market of derivatives. Particularly, according to recent researches the market of credit derivatives has grown from $250 million in 1997 to $1.2 trillion in 2001 and to $5 trillion in 2004.[1]

So, the studies discussed above can give us little information on what determines those changes in credit spreads. Therefore, the study of the determinants of changes in credit spreads is totally different from the study of the characteristics of bond returns. We have to admit that the research on this subject is limited, generally, and there are a few articles, which deal with this topic.

II. Literature Review

a. Theoretical Models

There are two types of models that give us a theoretical background on credit spreads. These are the structural models of default and the reduced form models of default.

The structural models of default are based on Black and Scholes 's (1973) famous article, in which they show that equity and debt can be valued by using contingent - claims analysis, and they were firstly introduced by Merton (1974).

In his article, Merton introduces a model for pricing corporate debt, when there is a probability of default, or in other words a theory of the risk structure of interest rates, based on the Black - Scholes methodology for the pricing of financial instruments. Merton supposes the existence of a bond with the restrictions that the firm promises to pay an amount to debt holders on a very date and if it doesn't, the bondholders take over the company (and the shareholders receive nothing). The firm has no other claims but this bond and its equity. By applying the Black - Scholes formula for the pricing of this "risky" discount bond, Merton comes to the conclusion that the value of the firm' s debt is equal to

[1] Source: Credit Derivatives Report 2002, British Bankers' Association, 2002

holding a similar risk free debt claim and having sold to shareholders an option to put the firm at the value of the risk free claim. Because when we talk about bonds it is better to use yields, Merton's main finding has to do with the term R_t- r , where R_t is the yield of the bond and r is the risk free rate. In other words, this is the risk premium or the credit spread of the bond.

Merton's finding is that the credit spread is a function of two variables: a) the volatility (N^2) of the firm's variation and b) the ratio of the present value of the promised payment (discounted at the riskless rate) to the current value of the firm. Or, in other words, the leverage of the firm. So, according to Merton we can write the credit spread *CS (t)* of a firm's bond as:

$$CS(t) = CS(V_t, r_t) \quad (1)$$

where V_t is firm value and r_t is the spot rate(which is considered to be constant).

Merton's model has been further investigated by many authors. Black and Cox (1976) have considered bankruptcy costs in their analysis (while Merton has considered them as equal to zero) and they prove that they affect credit spreads. Longstaff and Schwartz (1995) have not used the hypothesis that the interest rate is constant and they have given a more general model than that of Black and Cox. The empirical part of this study will be later analyzed. Collin - Dufresne and Goldstein (2001) have taken into account in their analysis that a firm can adjust its capital structure to reflect changes in asset value. With their model they predict that the sensitivity of credit spreads to changes in firm value is much lower and, also, that there is a negative correlation between credit spreads and interest rates.

So, we can rewrite equation (1) as:

$$CS(t) = CS(VT, RT, \{Xt\}) \quad (2)$$

, where {XT} represents all other "state variables" needed to specify the model, such as bankruptcy costs, the volatility of the firm's asset value, or time- varying interest rates.

In general, there has been an academic conflict of whether structural models of default have an explanatory ability of credit spreads. For example, Jones, Mason and Rosefeld (1984) and Kim, Ramaswamy and Sundaresan (1993) find that the variables that are included in structural models of default can explain only a small part of credit risk. On the other hand, Campbell and Taksler (2003) prove a strong co-movement between aggregate bond spreads and an aggregate measure of idiosyncratic volatility.

Moreover, one of the most popular and commercially successful systems for evaluating default risk, Moody's / KMV's expected default frequency (EDF) methodology, as well as their recent RiskCalc credit scoring system, are based on Merton's initial model.

The reduced form models of default are more recent than the structural models of default. This approach views risky debt as paying off a fraction of each promised dollar in the event of bankruptcy of the firm. The time of the bankruptcy is given as an exogenous process and is specified exogenously and does not explicitly depend on the firm's underlying assets. A representative article of those models is that of Jarrow, Lando and Turnbull (1997). In this particular article the authors view the bankruptcy process as a finite state Markov process in the firm's credit ratings. The reduced-form models of default have the advantage towards the structural models of default that they allow exogenous assumptions to be imposed on the observables. However, their main drawback is that they typically abstract from the firm value process and they are much better at "fitting" to the observed credit spreads than they are at offering a theoretical background for the fundamental determinants of credit spreads.

b. Empirical Research

One of the first articles that studies empirically the determinants of credit spreads is that of Longstaff and Schwartz (1995). After elaborating a theoretical model, which was analyzed at part (a), the authors prove that credit spread for corporate bonds are driven by two factors: an asset-value factor and an interest rate factor. This was in contrast with what was up to then believed that credit spreads depend on only an asset value factor.

The data that the authors used were the monthly data for Moody's industrial, utility and railroad corporate bond yields and also the corresponding yields for 10-year and 30-year Treasury bonds. The regression which was estimated was the following:

$$DS = a + bDY + cI + M \tag{3}$$

, where DS denote the change in the credit spread, DY denote the change in the 30-year Treasury yield and I denote the return on the appropriate equity index.

The results are provided for each rating class of bonds and for each sector. The main results are:

- The correlation between credit spread changes and changes in the interest rate and the return of equity index is proved to be negative.
- The estimates of *b* are economically and statistically significant in all cases. The coefficient *b*, also, generally decreases with the credit rating of the bonds.
- Most of the estimates of *c* are statistically significant, although not as significant as the estimates of *b*. The estimates of c decline monotonically with the credit rating of bonds.
- This two-factor model does not capture all of the variation in credit spreads. For utility bonds the R^2 ranges from 0.015 to 0.146. For the other bonds, however, the R^2s are quite high and range from 0.459 to 0.742, and they are generally higher for lower rated bonds.

A very important article about the determinants of credit spread changes is that of Collin - Dufresne, Goldstein and Martin (2001). The authors based on the structural models have determined which are the theoretical determinants of credit spread changes and, also, whether their correlations with the changes are positive or negative. The theoretical determinants proposed by Collin - Dufresne et. al are the following:

1. *Changes in the Spot rate*. The authors believe that there is a negative correlation between the credit spread changes and changes in the interest rate. This is based on the evidence provided by Duffee (1998), who finds such a negative relationship. In their data the authors use the 10-year treasury rates and to capture non- linear effects due to convexity, they also use the squared level of the term structure.
2. *Changes in the slope of the yield curve*. This determinant is also believed to have a negative relationship with the credit spread changes, based on the assumption that a decrease in yield curve slope implies a weakening economy. For this reason, we should expect that the expected recovery rate would decrease in times of economic recession. In their model, the slope of the yield curve has been determined as the difference between the 10-year and the 2-year treasury rates.
3. *Changes in leverage*. Based on the structural models' conclusions, there is a positive relation between the firm's leverage and the credit spread changes. This also means that there is a negative correlation between the firm's return on equity and credit changes. In the model the leverage ratio has been determined as the following ratio:

$$\frac{\text{Book value of Debt}}{\text{Market value of equity} + \text{Book value of debt}} \qquad (4)$$

The firm's monthly return on equity has also been used as an explanatory variable.

4. *Changes in volatility.* Based on the contingent- claims approach used by the structural models, there is a positive relationship between the changes in volatility and credit spreads. However, it is very difficult to calculate a firm's volatility. In theory, it can be determined by using the changes in implied volatilities of its publicly traded options. But most of the firms haven't such traded options. For this reason, the authors use the changes in the VIX index, which is a weighted average of eight implied volatilities of near -the- money options on the S & P 100 index.
5. *Changes in the probability or magnitude of a downward jump in firm value.* Those implied volatility smiles suggest that the market believes that a large negative jump in the firm's value is very possible. For this reason, the correlation between changes in credit spread and the probability or magnitude of a downward jump is believed to be negative. In order to determine this probability the authors use the implied volatilities of options on S & P 500 options.
6. *Changes in the business climate.* The authors use the return on the S & P 500 as a proxy for the overall state of the economy and believe that there is a negative relationship between the return on the index and credit spread changes.

Using the treasury rates for maturities of 3, 5, 7, 10 and 30 years an entire rate curve is created. The credit spread is been determined as the difference between the rate of each bond *i* and the associated rate of the treasury curve at the same maturity.

The sample used for the analysis are observations on bonds from the U.S.A. market for the period from July 1988 to December 1997. The final sample rises to the number of 688 bonds from 261 issuers. The regressions estimated for each bond are the following:

$$DCS_t^i = \alpha + b_1^i Dlev_t^i + b_2^i Dr_t^{10} + b_3^i (Dr_t^{10})^2 + b_4^i Dslope_t + b_5^i DVIX_t + b_6^i S\&P_t + b_7^i jump_t + e_t^i \quad (5)$$

and

$$DCS_t^i = \alpha + b_1^i Ret_t^i + b_2^i Dr_t^{10} + b_3^i (Dr_t^{10})^2 + b_4^i Dslope_t + b_5^i DVIX_t + b_6^i S\&P_t + b_7^i jump_t + e_t^i \quad (6)$$

where,

DCS_t^i : Change in credit spread

$Dlev_t^i$: Change in firm leverage ratio

Ret_t^i : Return on firm's equity

Dr_t^{10} : Change in 10-year treasury rate

$S\&P_t$: Return on S&P 500

$Dslope_t$: Change in 10-year minus 2-year treasury rates

$DVIX_t$: Change in implied volatility of S&P 500

$Djump_t$: Change in slope of volatility smirk

The results of both of the regressions give some explanation of the credit spread changes. For the ease of the analysis, each bond is assigned to a very group according to the firm's leverage and the results are given for short and long- term bonds. The main conclusions are the following:

- The change in firm's leverage and the return on equity are of low economic significance and several times smaller from the return of the S&P 500 index. This is an indication that credit spread changes are possibly not attributed to firm-specific determinants.
- The sensitivity to changes to leverage tends to increase as leverage does.

- The change in the spot rate is statistically and economically significant and there is a negative correlation with credit spread changes.
- The slope of the rate curve is not statistically significant. It is interesting, however, that, the coefficients tend to be of a positive sign, which is contrary to the authors' expectations.
- The change in VIX is statistically significant but its economic significance is rather weak.
- The return of the S&P 500 proves to be the most important determinant of the credit spread changes.

However, in general the adjusted R^2 is around 25%, which shows that there is variation in the data not captured by those regressions. The authors conduct a principal component analysis on the residuals in order to understand the nature of remaining variation. The results show that there is a systematic component outside the framework given by the structural models.

For this reason, the authors have thought a list of other variables that could determine credit spread changes. Some of those variables are: measures in changes in liquidity, SMB and HML factors - used by Fama & French (1993)-, economic state variables ($r_{t-1}^{10}, lev_{t-1}^{i}, VIX_{t-1}, Spread_{t-1}$) and leading effects on stocks and bonds ($r_{t-1}^{S\&P500}$).

So, a regression with a great number of variables has been created. The main finding of this regression is that although the number of the explanatory variables has increased a lot, the adjusted R^2 has not rised analogically.

The general conclusion of the authors is that based on the structural model's framework, the results for the explanation of credit spread changes are not very satisfactory. There is a great deal of variation not explained by this theoretical background. The imperfections in the bond market data or in bond market institutions could give an explanation to those findings. In general, the need for further investigation is undoubted.

Elton, Gruber, Agrawal and Mann (2001) have followed a totally different methodology for the explanation of the credit spread on corporate bonds. The authors believe that spreads between corporate and government bonds across rating classes should be positive for each rating class due to the following reasons:

1. *Expected default loss.* Some corporate bonds will default and investors require a higher promised payment to compensate for the expected loss from defaults.
2. *Tax premium.* Interest payments on corporate bonds are taxed at the state level whereas interest payments on government bonds aren't. The authors point out that no other relative studies have examined the tax effect on credit spread differences.
3. *Risk premium.* The return on corporate bonds is riskier than the return on government bonds, and investors should require a premium for the higher risk. It is proved that this happens because a large part of the risk on corporate bonds is systematic rather than diversifiable.

The analysis continues with the decomposition of rate spreads into that part which is due to expected loss due to default, that part which is due to taxation differences and, finally, that part which is due to the presence of systematic risk.

For the estimation of the default premium it is assumed that the investors are risk neutral. The discount of the expected cash flows from a bond at the appropriate government spot rate produces the same value as discounting promised payments at corporate spot rates. So, under the risk neutrality assumption, the difference between corporate and government forward rates is proved that is given by the following equation:

$$e^{-(r_{t+1}^{C}-r_{t+1}^{G})}=(1-P_{t+1})+\frac{aP_{t+1}}{V_{t+1T}+C} \tag{7}$$

, where C is the coupon rate, P_{t+1} is the probability of bankruptcy in period t+1, K is the recovery rate, r_{t+1}^{C} is the forward rate for corporate bonds, r_{t+1}^{G} is the forward rate for government (risk free) bonds and V_{t+1T} is the value of a T period bond at time t+1. The authors compute them the recovery rates as a function of the rating at the time of issuance. The probability of default is calculated based on transition matrixes, issued by the two principal agencies for corporate debt, Moody's and Standard & Poor's. The transition matrixes show the probability that a bond with a very rating will end up one year later in the same or another rating category.

By applying equation (7) the spreads due to expected default are calculated. The results are presented for AA, A, and BBB rated bonds. However, the major conclusion is that the spread due to expected default proves to be very small and doesn't account for much of the corporate spread.

The second part of the analysis deals with the estimation of the state tax premium. For this analysis the assumptions used for the derivation of equation (7) are used again, but taxes are also introduced. The equation derived is the following:

$$e^{-(r_{t+1}^{C}-r_{t+1}^{G})}=(1-P_{t+1})+\frac{aP_{t+1}}{V_{t+1T}+C}-\frac{[C(1-P_{t+1})-(1-a)P_{t+1}]}{C+V_{t+1T}}t_s(1-t_g) \tag{8}$$

where t_s is the state tax rate, t_g is the federal tax rate, and the other terms are as before.

As it is not very easy to measure the size of the tax terms, the authors use three different procedures to calculate them. However, whichever tax rate is used, it is insufficient to explain the corporate spreads found empirically. For this reason the inability of tax and expected default losses to explain the corporate credit spread suggests the existence of a nonzero risk premium.

In the third part of the analysis, the authors try to estimate those risk premiums for systematic risk. There are two questions that have to be answered. What causes a risk premium and, given the small size of the expected default loss, why is the risk premium so large?

If corporate bonds' returns move systematically with other assets in the market whereas government bonds do not, then corporate bond expected returns would require a risk premium to compensate for the nondifersifiability of corporate bond risk, just like any other asset. However, the literature of financial economics provides evidence that government bond returns are not sensitive to the influences driving stock returns. There are two reasons why changes in corporate spreads might be systematic. First if expected default loss were to move with equity prices, so while stock prices rise default risk goes down and as stock prices fall default risk goes up, it would introduce a systematic factor. Second, the compensation for risk required in capital markets changes over time. If changes in the required compensation for risk affect both corporate bond and stock markets, then this would introduce a systematic influence. The authors believe that that the second reason is the dominant influence. And they prove that such a relationship exists and explains the spread, not explained by expected default losses and taxes.

This is accomplished by using variables that have been used as systematic risk factors for common stocks to explain the spread unexplained by expected default losses and taxes. The following simple return- generating model is used:

$$R_t = a + \sum_j b_j f_{jt} + e_t \qquad (9)$$

where R_t is the return during month t, b_j is the sensitivity of changes in the spread to factor j, and f_{jt} is the return on factor j during month t.

Let $r^c_{t,m}$ and $r^G_{t,m}$ be the spot rates on corporate and government bonds that mature m periods later. The price of a pure discount bond with a face value equal to one dollar is:

$$P^C_{t.m} = e^{-r^c_{t,m} \cdot m} \tag{10}$$

and

$$P^G_{t.m} = e^{-r^G_{t,m} \cdot m} \tag{11}$$

and one month later the price of m period corporate and government bonds are:

$$P^C_{t+1.m} = e^{-r^c_{t+1,m} \cdot m} \tag{12}$$

and

$$P^C_{t+1.m} = e^{-r^c_{t+1,m} \cdot m} \tag{13}$$

The part of the return on a constant maturity m period zero-coupon bond from t to t+1 due to change in the m period spot rate is:

$$R^C_{t,t+1} = \ln \frac{e^{-r^C_{t+1,m} \cdot m}}{e^{-r^C_{t,m} \cdot m}} \tag{14}$$

and

$$R^G_{t,t+1} = \ln \frac{e^{-r^G_{t+1,m} \cdot m}}{e^{-r^G_{t,m} \cdot m}} \tag{15}$$

and the differential return between corporate and government bonds due to a change in spread is:

$$R^C_{t,t+1} - R^G_{t,t+1} = -m[(r^C_{t+1,m} - r^G_{t+1,m}) - (r^C_{t,m} - r^G_{t,m})] = -mDS_{t,m} \tag{16}$$

where $DS_{t,m}$ is the change in spread from time t to t+1 on an m period constant maturity bond. However, the interest is on the unexplained spread that is the difference between the corporate government spread and that part of the spread that is explained by expected default loss and taxes. For this reason, equation (16) can be rewritten:

$$R_{t,t+1}^{UC} - R_{t,t+1}^{G} = -m[(r_{t+1,m}^{UC} - r_{t+1,m}^{G}) - (r_{t,m}^{UC} - r_{t,m}^{G})] = -mDS_{t,m}^{U} \qquad (17)$$

Between the multi-index models that exist in literature, the authors choose the three- factor model of Fama and French (1993) to investigate the unexplained spreads. The model uses the excess return on the market, the return on a portfolio of small stocks minus the return on portfolio of large stocks (SMB factor) and the return on portfolio high minus low book-to-market stocks (HML factor).

The results of the regressions are quite satisfactory. The sensitivity to all these factors tends to increase as maturity increases and to increase as quality decreases. In general, it seems that the remaining spread is partly explained by the Fama & French factors. The regression of the average unexplained spread against sensitivities of the bonds gives a cross sectional R^2 ranging between 0,32 and 0,58. Almost one-third to half of the cross-sectional variation is accounted. The authors have also tried to use other multi-index models, but the three-factor model of Fama & French has given the best results.

In general, Elton, Gruber, Agrawal and Mann have managed to account for almost all differences between corporate and government rates. Both state taxes and risk premiums have proved to be more important than the literature of financial economics has suggested.

A study relevant with the topic we deal with is that of Duffee (1998). The author has conducted a research on the relation between treasury yields and corporate bond yield spreads. Duffee points out the differences between the yields of callable and non-callable bonds. The presence of the bond's call options affects their behavior in many ways. Variation over times in yields on callable bonds will reflect, partly, variations in their option values. If non-callable bond prices rise, prices of callable bonds should not rise as much because the values of their imbedded short call options also rise.

For this reason, the author differentiates his analysis between yields on non-callable treasury bonds and spreads of corporate bond yields over treasury yields. But with callable corporate bonds, this relation should also reflect the fact that higher prices of non-callable treasury bonds are associated with higher values of the call options. Therefore the relation between treasury yields and credit spreads of callable corporate bonds should be more negative than the relation between treasury yields and non- callable corporate bonds. Those theoretical assumptions are verified by the empirical analysis.

The data used come from the American bond market and covers the period between January 1985 through March 1995. The sample contains price information on 2,814 non- callable bonds and 2,477 callable bonds. Over this period, Duffee estimates the following regression using ordinary least squares (O. L. S)

$$DSPREAD_{s,i,m,t+1} = b_{s,i,m,0} + b_{s,i,m,1}DY_{T,1/4,t+1} + b_{s,i,m,2}DTERM_{t+1} + e_{s,i,m,t+1} \quad (18)$$

In equation (15) the change from month t to month $t+1$ in the mean yield spread on non- callable bonds issued by firms in industry s with rating i and maturity m is regressed on contemporaneous changes in the three month treasury bill yield $Y_{T,1/4,t+1}$ and the slope on the treasury term structure $TERM_{t+1}$.

The results indicate that an increase in the three-month bill yield corresponds to a decline in yield spreads. The relation between yield spreads and the slope of the treasury term structure is also generally negative.

When equation (18) is applied on callable bonds, the results are generally the expected ones. Regardless of the credit quality, yield spreads are all negatively related to treasury yields and to the slope of the treasury term structure. The coefficients estimated are, also, many times bigger than the ones estimated for the non- callable bonds.

In general, Duffee has managed to confirm that yield spreads on both callable and non- callable corporate bonds fall when treasury yields rise and that there is also a negative correlation between credit spreads and the slope of the treasury term structure. This relation has also proved to be much stronger for callable bonds. This result has important implications for interpreting the behavior of yields on commonly used corporate bond indexes, which are composed primarily of callable bonds.

On the above study it is very interesting that Duffee has given a theoretical explanation for the negative correlation between credit spreads and the spot rate and the slope of the treasury term structure. This theoretical framework is totally different than that Collin- Dufresne et al. have used, who are based on the structural model of default risk.

A totally different perspective on the study of credit spreads has been introduced by John, Lynch and Puri (2003). The authors have proved in their study that variables like credit ratings, collateral and loan characteristics have a major role on the yield of the bond over the yield of a maturity. The authors wish to research at the beginning of their study to check if credit rating is the only variable needed to explain credit spreads. To do this, the following regression using O.L.S. is estimated:

$$BPS = b_0 + b_{cr} CREDIT\ RATING + b_{mat} MATURITY + b_{ln} LN(AMOUNT) + b_{sec} SECURED + b_p PRESTIGIOUS + b_r REF\ BK\ DEBT + b_n NEW\ ISSUE + b_e EXCHANGE + b_{in} INDUSTRY \quad (19)$$

where,

1. *BPS*. The basis point spread over the treasury rate of comparable maturity

2. *CREDIT RATING*. A set of seven credit-rating dummy variables, CR0–CR6, that correspond to Moody's Caa–C, B1–B3, Ba1–Ba3, Baa1–Baa3, A1–A3, Aa1–Aa3, and Aaa categories.
3. *MATURITY*. Three dummy variables are constructed based on the maturity of the debt issue. LOWMAT, MEDMAT, and HIMAT: LOWMAT is one if the security matures in less than 5 years, MEDMAT is one if it matures between 5 and 15 years, and HIMAT is one if the maturity is greater than 15 years. All dummy variables are zero otherwise.
4. *LN(AMOUNT)*. The natural log of the issue amount in millions of dollars.
5. *SECURED*: A dummy variable that takes the value of one if the issue is secured, zero otherwise.
6. *PRESTIGIOUS*: A dummy variable created based on market share rank of dollar volume of underwritings of debt issues. PRESTIGIOUS is a dummy variable that is one if the underwriter is one of the top five underwriters, based on market share, zero otherwise.
7. *REF BK DEBT*: A dummy variable that takes the value of one if the purpose of the issue is to refinance bank debt, zero otherwise.
8. *NEW ISSUE*: A dummy variable that is one if the debt issue is a new one, zero otherwise.
9. *EXCHANGE*: A dummy variable that takes the value of one if the firm is listed on an exchange, zero otherwise.
10. *INDUSTRY*: A number of industry dummy variables that are constructed based on one-digit SIC codes. All industries save for financial firms are included in the sample and a dummy variable constructed for each one.

The data comes from the American market. The results prove that the credit ratings play indeed an important role, as the dummy variables used are economically and statistically significant. It is also proved that the higher the credit rating the better the prices and, consequently, the lower the yields. However, other variables have, also, proved to be of great significance, like collateral (determined by the variable SECURED- negative correlation), maturity (negative correlation), purpose (positive correlation) and whether it is of new issue (positive correlation).

The authors, after those results, pose the question whether problems in the rating process and agency problems between insiders and claim holders are responsible for those results. In order to find this they conducted research about the rating process followed by Moody' s, which entailed both interviews with executives of the agencies and the use of the agencies' publications. After that they elaborated a theoretical model based on their previous conclusions on the rating process of Moody' s. Their major conclusions are the following: First, rating agencies fail to fully incorporate the effects of these agency problems when determining credit ratings for debt. Second, these agency problems have a larger incremental impact on the yields of collateralized than general debt issues. The model elaborated provides predictions about how collateral and loan characteristics affect the yield differential between secured and unsecured debt after controlling for credit rating.

The first proxy, which is examined if it affects credit spreads, is whether the type of the collateral is a proxy that can be added to the regression (19). Two additional variables are added:

1. *MORTGAGE*: A dummy variable that takes the value of one if the issue has a mortgage as the underlying collateral, zero otherwise.
2. *NONMORTGAGE*: A dummy variable that takes the value of one if the issue is secured but does not specifically have a mortgage as the underlying collateral, zero otherwise.

Mortgages are usually land or buildings. The main result of this regression is that the yield differential is strengthened when we examine nonmortgages as distinct from mortgage secured issues.

The second variable which is used is that of the firm' s default probability. To determine this variable the authors use the credit ratings and they split their sample into two: the top two credit ratings and all the remaining. The main conclusion is that that the effect of securing (determined by the variable non mortgage) is significantly higher in the low-rated debt category.

The third variable is the volatility of the value of the bond. As the volatility the bond increases with its maturity the authors use maturity to determine this variable. By dividing the sample (of the nomortgage and unsecured bonds) into bonds with short and long maturity the main result of this regression is that the effect of nonmortgage collateralization on yields is significantly higher for long maturity issues.

The fourth variable is that of the effect of monitoring. One proxy for monitoring intensity is that of whether the issue is new or not. Seasoned issues are, in general, characterized by a large analyst following and continuous production of information and thus are likely to be characterized by more monitoring than new issues. Hence, the yield differential (between nomortgage secured and unsecured) should be higher for new issues as compared to seasoned issues. By dividing the sample into bonds of new and seasoned issue this hypothesis is affirmed.

In conclusion, the authors have proved that credit ratings are a very important variable for the explanation of credit spreads. They also prove how collateral and some loan characteristics (the default likelihood, the nature of the secured assets, the volatility of the general assets, and the intensity of monitoring) can also be used as an explanatory variable. So, they find that credit spread, after controlling for credit rating, between secured and unsecured debt is found to be larger for low credit rating, nonmortgage assets, longer maturity, and with proxies for lower levels of monitoring.

III. Empirical Analysis

a. Model

We derive the determinants of credit spread changes from the structural models of default, which were thoroughly analyzed in the theoretical part of this study. As we have seen, the academic literature has not given a straightforward answer in whether structural models provide us with an adequate theoretical background of credit spread determinants.

Structural models include variables like interest rates, market return, market volatility, variables that capture the general economic situation and firm variables, like leverage. In addition to the variables that have already been used, in our model we will use, as proxies for the general state of the economy, inflation and the industrial index.

Obviously, as we will study the changes in credit spreads in our models, we will use the changes of the variables we believe that affect credit spreads. The entire set of those variables is the following:

- Spot rate. Longstaff and Scwartz (1995) argue that an increase in the spot rate will lead to a decrease of the credit spread level. This relation has been empirically confirmed in Logstaff and Schwartz (1995), Duffee (1998) and Collin-Dufresne, Goldstein and Martin (2001).
- Term structure slope. According to Litterman and Scheinkman (1991) the two most important factors driving the term structure of interest rates are the level and the slope of the term structure. Thus, it is logical to assume that a change in credit spreads, apart form the change in the spot rate, will

also be affected by a change in the slope of the term structure. There are two opinions on the relation between term structure slope and credit spreads. On the one hand a decrease in the term structure slope implies an increase in the future spot rates and, thus, an increase in credit spreads. Fama and French (1989) point out that a decrease in the rate curve slope imply a weakening economy, thus a decrease in future spot rates and an increase in credit spreads. On the other hand, an increase in expected interest rates, may reduce the number of positive net - present - value (NPV) projects that the firm examines to undertake. This leads to a lower firm valuation and an increase in spreads.

- Leverage. Merton (1974) proves that the higher leverage means the higher the probability of default and, consequently, the higher the credit spread level. In our model, we use the equity returns as a proxy for leverage, as in Collin-Dufresne, Goldstein and Martin (2001)
- Market and economic conditions. Since the recovery rate is a function of the overall business climate, an improving economy should lead to a decrease in credit spreads. In our model we use stock market proxies for changes in market conditions, as in Collin- Dufresne, Goldstein and Martin (2001). We also use changes in inflation and in industrial index for general economic conditions. An increase in inflation implies a weakening economy and, so, an increase in credit spreads. This theory, however, cannot be stated with certainty. As we know from the macroeconomic theory, there is a negative correlation between inflation and interest rates, which means that the increase in inflation might also mean a decrease in credit spreads. An increase in the industrial index implies an improving economy and, so, a decrease in credit spreads.

- Economic state variables. If there is a mean reverting behavior in spot rates, or credit spreads, then the beginning of month levels of those variables should contain information about the current month's change in credit spreads. Those variables will be used when we will try to conduct predictions.

Another variable that has been found to have an effect on credit spreads is that of the volatility of the firm. Changes in a firm's volatility can be extracted from changes in implied volatilities of its publicly traded options. Most of the firms that we investigate lack publicly traded options. For this reason this variable will not be used in our analysis.

In Table 1 we summarize the expected signs of the correlation between the variables we will use and the changes in credit spread.

b. Data

We have obtained bond, stock and economic data from Datastream. Below we explain how we define credit spreads and which data we have used for each variable discussed above.

Below we explain how define credit spreads and which data we have used for each variable discussed above.

1. Credit spreads. Our sample includes all U.K. corporate bonds enlisted in Datastream, which satisfy a set of criteria that will be analyzed below. Our sample covers the period from January 1993 to August 2004. The initial sample is subject to the following filtering criteria:

a. We exclude bonds with no matching equity data.

b. To include a bond in the sample at least 25 consecutive monthly observations are required, as in Collin-Dufresne, Goldstein and Martin (2001).

Table 1

Explanatory variables and expected signs of their correlation with credit spread changes

Variable	Expected sign
Change in spot rate	-
Change in term structure slope	- / +
Change in firm leverage	-
Market and economic improvement	-

The final sample contains the monthly rates of 157 U.K. corporate bonds out of an initial sample of 987 bonds. The average number of monthly observations is 76.

We define the credit spread, CS_t^i, for each corporate bond *i* at month *t*, as the difference between the corporate bond rate at month t minus the corresponding monthly Benchmark Treasury rate for maturities of 3-months from Datastream .

Table 2 provides descriptive statistics for the entire sample of 158 corporate bonds and for the low, average and high credit spread terciles. The average credit spread for the entire sample is 3.110%, ranging from 0.175% to 10.617%. `The standard deviation is 1.89%.

Credit spreads have quite different characteristics across the three credit spread groups. For example, we notice that the volatility of credit spreads increases as credit risk increases. Bonds in the low credit risk tercile have a standard deviation 0.4675%, while in the average risk tercile 0.566% and at the high risk bonds 2.001%.

In the empirical analysis that follows, we form credit risk groups based on the bond 's credit spread level. The ideal would be to form such groups based on the

Table 2

The table presents descriptive statistics for the 157 U.K. corporate bonds included in our sample in the period of January 1993 to August 2004

Statistics	All Bonds	Groups based on Credit Spread Level		
		Low	Average	High
Credit Spread				
- mean	3.11045	1.52974	2.77584	6.15874
-minimum	0.17525	0.17525	2.01225	4.06823
-maximum	10.6179	1.99561	3.86887	10.6179
-standard deviation	1.89149	0.4675	0.56636	2.00117
Number of observations	157	43	83	31

bond rating. However, Datastream does not provide the rating for the bonds that we have included in our sample. For this reason, the bonds grouped in the low credit spread level are those ones which are highly rated, and those in the high credit spread level are the low rated ones.

Figure 1 displays the equally weighted average of corporate credit spread levels over the period we examine. We notice a significant downward trend from the period of 1993 to the beginning of 1998, which is followed by an upward trend in the levels of credit spreads.

Figure 2 displays the evolution of the average credit spread level and the 10-year treasury rate. We notice a strong co-movement between credit spreads and treasury rates which is consistent with the predictions of structural models of default risk.

2. Spot Rate. We use Datastream's monthly series of 10year Benchmark Treasury rates, r_t^{10}. To capture potential non - linear effects due to convexity, we also include the squared level of the term structure, $(r_t^{10})^2$.

3. Slope of the rate curve. We define the slope of the rate curve as the difference between Datastream's 10-year and 3-month Benchmark treasury rates, $slope_t = (r_t^{10} - r_t^{3m})$.

4. Firm leverage. We use each firm's monthly equity return, ret_t^i, downloaded from Datastream.

5. Market and economic conditions. We use monthly returns of the FTSE-100 index of the London Stock Exchange, r_t^m. We also use two macroeconomic factors as proxies for the general state of the economy. These are the monthly change at the inflation rate, dp, and the montly change in the industrial index, dii, downloaded from the economic series of Datastream.

6. Economic state variables. We use the 10-year spot rate of the previous month, r_{t-1}^{10}, and the level of the credit spread of the previous month CS_{t-1}^i.

We define DCS_t^i as the difference in credit spreads between two consecutive monthly periods. Also, we define correspondingly the changes in all other variables that we have previously analyzed.

As we have stated above, there is a shadow of doubt over the ability of structural models of default to explain credit spread changes. For this reason, *for each sample bond i* at date *t* with credit spread CS_t^i we estimate a regression which contains only the variables that are in particular mentioned in the theoretical models of structural models of default, in order to check on their explanatory

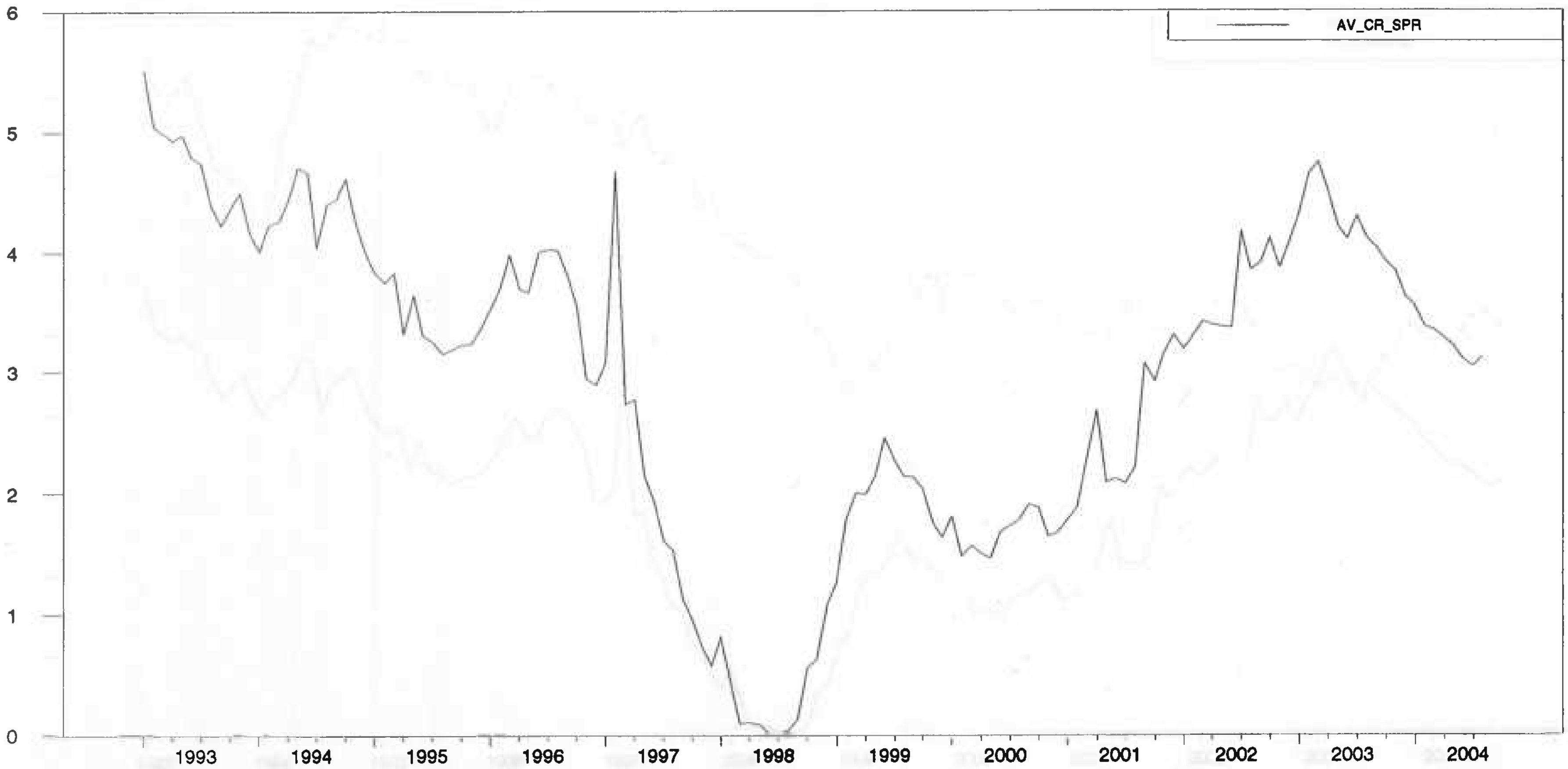

Figure 1

The plot displays the equal weighted average of credit spread level across 158 corporate bonds that are included in our sample

Figure 2

The figure compares the 10-year Treasury rate to the equal weighted average credit spread of all 158 bonds included in our sample.

ability on credit spread changes. Thus, we firstly estimate the following regression:

$$DCS_t^i = \alpha + b_1^i Ret_t^i + b_2^i Dr_t^{10} + b_3^i (Dr_t^{10})^2 + b_4^i Dslope_t + b_6^i r_{m,t} + e_t^i \quad (1)$$

Our next move is to put into our analysis those variables that we assume that will increase the explanatory ability of the above regression and we have analyzed above. These are the change in inflation rate and the change in the industrial rate. The regression that we estimate is the following:

$$DCS_t^i = a + b_1^i Ret_t^i + b_2^i Dr_t^{10} + b_3^i (Dr_t^{10})^2 + b_4^i Dslope_t + b_5^i r_{m,t} + b_6^i Dp_t + b_7^i Dii_t + e_t^i \quad (2)$$

It is of great interest to check what part of credit spread changes is explained by firm level variables, and what part is explained by common factors. For this reason, we estimate the two following regressions:

$$DCS_t^i = a + b_1^i Dr_t^{10} + b_2^i (Dr_t^{10})^2 + b_3^i Dslope_t + b_4^i r_{m,t} + b_5^i Dp_t + b_6^i Dii_t + e_t^i \quad (3)$$

to capture common factors and,

$$DCS_t^i = a + b_1^i Ret_t^i + e_t^i \quad (4)$$

to capture firm-level factors.

One last step to our analysis would be to create a model that will allow us to conduct predictions of the level of changes in credit spread for all bonds and also for the bonds across credit risk groups. This can be achieved with the estimation of the following unconditional, non-contemporaneous model:

$$DCS_t^i = a + b_1^i Ret_{t-1}^i + b_2^i Dr_{t-1}^{10} + b_3^i (Dr_{t-1}^{10})^2 + b_4^i Dslope_{t-1} + b_5^i r_{m,t-1} + b_6^i Dp_{t-1} + b_7^i Dii_{t-1} + b_8^i r_{t-1}^{10} + b_9^i cs_{t-1}^i + e_t^i \quad (5)$$

Obviously, with this model we will try to explain the variation in credit spread changes with the use of the variables stated above, but at a t-1 period.

c. Results

Table 3 shows the results of the estimation of regression 1. Throughout this study the reported values of the coefficients are computed as the averages of the resulting regression estimates for the coefficient on each variable. The associated t-statistics are calculated by dividing each reported coefficient by the standard deviation of the estimates and scaling by the square root of the number of the regressions. $(\frac{b}{\sigma / \sqrt{N}})$

At this point, what we are interested in more is the prices of the adjusted R^2. From table 3, we can see that the R^2 for all bonds is 43.4%, 50.75% for high, 44% for average and 31.8% for low rated bonds. These percentages are much higher than those estimated in Collin-Dufresne, Goldstein and Martin (2001), where the adjusted R^2 was around 25%. Of course, this result shows that structural models have strong explanatory power of credit spread changes, which is contrary to the doubts of Collin-Dufresne, Goldstein and Martin (2001). With the variables that we will introduce in our model we will try to increase the explanatory power of structural models.

Table 4 shows the results of regression 2. This is the main result of our study and we will analyze the results thoroughly.

- We have managed to increase the adjusted R^2 with the new variables that we have added in our analysis by about 1.5% for all bonds, 2% for high, 1% for average and 3% for low rated bonds. Although the rise is not very impressive, it shows, however, that those new variables have some explanatory power on credit spread changes. This result, also, gives greater support to structural models of default, since our variables are within the theoretical framework of structural models of default.

- A general remark is that average and low rated bonds have, in general, a common behavior, contrary to the high rated ones. In particular the coefficients of the variables rise when we move from the average to high rated bonds. Also, the variables that are found statistically significant at the average rated bonds are common for the low rated bonds. Moreover, we notice that the variables that are found statistically significant for the high rated bonds are, generally, different than those found also significant for the average and low rated ones. This evidence here is consistent with that in Collin-Dufresne, Goldstein and Martin (2001) who argue that credit spread changes of high-grade bonds are affected by supply and demand shocks unrelated to credit risk and equity factors.
- The variables that seem to affect more the change of credit spreads are the slope of the rate curve and the change of the 10-year government bond rate. For the slope of the rate curve we notice a positive correlation, contrary to the negative correlation which was found by Collin-Dufresne, Goldstein and Martin (2001). This means that the assumption that a decrease in the term structure slope implies an increase in the future spot rates and, thus, an increase in credit spreads doesn't seem to be right according to our model. Interestingly, the coefficients for all bonds and for bonds across rating classes is found to be very near to one. Moreover, the slope of the term structure, which is of great importance in our study, was of low significance in Collin-Dufresne, Goldstein and Martin (2001). The negative correlation between the change in credit spreads and the change of the spot rate (10-year here), that was found in Collin-Dufresne, Goldstein and Martin (2001), Duffee (1998) and Longstaff and Schwartz (1995) is, also, proved here.

Table 3

Structural Model Determinants of Credit Spread Changes by Credit Risk group

$$D(CS_t^i) = a + 2_1 \, ret + 2_2 \, rm + 2_3 \, dr^{10} + 2_4 \, (dr^{10})^2 + 2_5 \, dlr$$

Variable	Descpription
CS_t^i	Credit spread of firm i at time t
ret_t	Equity return
rm_t	Return of the FTSE-100
dr_t^{10}	Change in 10-year Treasury rate
$dslope_t$	$D(r_t^{10} - r_t^{3m})$

	All bonds	Groups based on credit spread level		
		Low(0-2%)	Average(2-4%)	High(>4%)
Intercept	-0.01271	-0.03683	-0.00036	-0.01349
t-stat	-1.75947	**-2.34779**	-0.07658	-0.50570
Signif.level	0.08046	0.02379	0.93914	0.61676
ret_t	-0.00758	-0.00383	-0.00394	-0.02254
t-stat	-4.80056	-1.37110	**-2.94007**	**-4.22159**
Signif.level	0.00000	0.17780	0.00425	0.00021
$r_{m,t}$	-0.01318	-0.00472	-0.00388	-0.04983
t-stat	-3.89872	-1.73029	**-2.98026**	**-3.37011**
Signif.level	0.00014	0.09110	0.00378	0.00208
dr_t^{10}	-0.73097	-0.95278	-0.56360	-0.88397
t-stat	-8.62081	**-3.33051**	**-16.42840**	**-5.77262**
Signif.level	0.00000	0.00184	0.00000	0.00000

Table 3 (Continued)				
$(dr_t^{10})^2$	0.12661	0.56818	-0.04401	-0.00933
t-stat	0.59208	1.65322	-0.17305	-0.01335
Signif.level	0.55465	0.10593	0.86303	0.98944
$dslope_t$	1.03839	1.16713	0.96400	1.06556
t-stat	23.96406	**10.05842**	**32.13794**	**8.29567**
Signif.level	0.00000	0.00000	0.00000	0.00000
R^2- adj.	0.43409	0.50753	0.44005	0.31844
Nr of observ.	157	43	83	31

- The effect of the change of the equity return is found statistically significant for average and low rated bonds and at a 10% level for high rated bonds and, moreover, of a rather low economic significance. This result is a first indication that monthly changes in firm-specific variables are not the driving force in credit spread changes. The correlation is negative across all bonds. This proves the theory elaborated above and is consistent with the findings of other studies. The coefficient is bigger for low rated bonds, which shows that they are affected more then other bonds by firm- level variables. This result is consistent with Kwan (1996) who has proved that the prices of low rated bonds are mostly affected by stock returns. Table 6, which will be later analyzed, demonstrates that the apparently weak explanatory power of firm specific variables is not due to potential collinearity with the market return $r_{m,t}$.
- The effect of the market return is found statistically significant for average and low rated bonds. The correlation, as expected, is negative. This means

Table 4

Determinants of credit spread changes by Credit Risk Group

$$D(CS_t^i) = a + 2_1\, ret_t + 2_2\, rm_t + 2_3\, dr_t^{10} + 2_4\, (dr_t^{10})^2 + 2_5\, dslope_t + 2_6\, dp_t + 2_7\, dii_t$$

Variable	Descpription
CS_t^i	Credit Spread of Bond i at time t
$r_{m,t}$	Return of the FTSE-100
dr_t^{10}	Change in 10-year Treasury rate
D $slope_t$	$D(r^{10} - r^{3m})$
dii_t	Change in the industrial index
dp_t	Change in inflation
ret_t	Equity return

	All bonds	Groups based on credit spread level		
		Low(0-2%)	Average(2-4%)	High(>4%)
Intercept	-0.01072	-0.03632	0.00117	-0.00822
t-stat	-1.53969	**-2.32302**	0.30478	-0.31758
Signif.level	0.12566	0.02522	0.76130	0.75300
$r_{m,t}$	-0.01392	-0.00494	-0.00532	-0.04937
t-stat	**-4.09517**	-1.90153	**-3.46768**	**-3.31556**
Signif.level	0.00007	0.06428	0.00083	0.00240
dr_t^{10}	-0.73211	-0.95921	-0.55961	-0.89183
t-stat	**-8.55887**	**-3.33598**	**-16.75205**	**-5.59917**
Signif.level	0.00000	0.00181	0.00000	0.00000
$(dr_t^{10})^2$	0.09879	0.56007	-0.06097	-0.09327
t-stat	0.47316	1.63852	-0.24892	-0.13620

Table 4 (Continued)

Signif.level	0.63676	0.10897	0.80404	0.89257
D slope$_t$	1.03453	1.15340	0.94975	1.10319
t-stat	**22.58557**	**9.67462**	**28.19416**	**8.00649**
Signif.level	0.00000	0.00000	0.00000	0.00000
dii$_t$	0.01787	0.01267	0.01916	0.02140
t-stat	1.83729	1.84122	1.95128	0.52231
Signif.level	0.06807	0.07283	0.05440	0.60529
dp$_t$	-0.02112	-0.04992	-0.03816	0.06408
t-stat	-1.07953	**-3.25025**	**-2.35475**	0.74656
Signif.level	0.28202	0.00231	0.02090	0.46114
ret$_t$	-0.00780	-0.00454	-0.00378	-0.02313
t-stat	**-4.80677**	-1.56740	**-2.76059**	**-4.22004**
Signif.level	0.00000	0.12471	0.00710	0.00021
R^2-adj.	0.44754	0.55363	0.47117	0.37471
Nr of observ.	157	43	83	31

that credit spreads move contrary to the changes in the FTSE-100 index, which is a proxy in our analysis of the overall state of the market.

- The effect of the change in the industrial index is found statistically significant at a 10% level only for high and for average rated bonds. Interestingly, the correlation is positive across all bonds, something that doesn't confirm theory. It is also very interesting that the t-statistic for low rated bonds is found very small, which shows a definite statistical insignificance of the change in the industrial index for low rated bonds.

- The effect of the change on the inflation rate is found statistically significant for high and for average rated bonds. It is interesting that the effect is negative for all, high and average rated bonds, and positive for low rated ones. This means that the changes in the inflation can be probably considered to have an opposite impact on spot rates, something that is consistent with macroeconomic theory. In other words, our assumption that an increase in inflation, which means a worse state of the economy, will lead to an increase in credit spreads doesn't seem to be right. Commonly, the t-statistic for low rated bonds is found very small.
- In general, we can conclude for the macroeconomic factors of our model that they are found statistically significant only for high and average rated bonds. On the other hand, the economic effect on low rated bonds is found bigger, as the corresponding coefficients are found bigger than the ones for high and average rated bonds.
- The average Durbin Watson statistic is 2.139 , which is a strong indication that serial correlation doesn't affect our results.

Tables 5 and 6 show the results of regressions 3 and 4, correspondingly. Obviously, the variation in credit spreads is mainly explained by common factors. However, we notice a much bigger effect of the equity return on the credit spread variation for low rated bonds. Particularly, the R^2-adjusted is estimated 6.7% for high rated bonds and 3% for average rated bonds and almost 15% for low rated bonds. This means that bonds of that rating class are very much affected by firm-level variables. This result confirms strongly what we have previously stated and was found by Kwan (1996) that the prices of low rated bonds are mostly affected

Table 5

Common Determinants of Credit Spread Changes

$$D(CS_t^i) = a + b_1\ r_{m,t} + b_2\ dr_t^{10} + b_3\ (dr_t^{10})^2 + b_4\ Dslope_t + b_5\ dii_t + b_6\ dp_t$$

Variable	Descpription
CS_t^i	Credit Spread of Bond i at time t
$r_{m,t}$	Return of the FTSE-100
dr_t^{10}	Change in 10-year Treasury rate
$D\ slope_t$	$D\ (r_t^{10} - r_t^{3m})$
dii_t	Change in the industrial index
dp_t	Change in inflation
ret_t	Equity return

	All bonds	Groups based on credit spread level		
		Low(0-2%)	Average(2-4%)	High(>4%)
Intercept	-0.00489	-0.02224	0.00338	-0.00380
t-stat	-0.67671	-1.89266	0.54773	-0.13306
Signif.level	0.49959	0.06548	0.58535	0.89503
$r_{m,t}$	-0.01907	-0.00621	-0.00897	-0.06388
t-stat	**-4.64456**	**-3.06923**	**-4.08999**	**-3.58873**
Signif.level	0.00001	0.00380	0.00010	0.00117
dr_t^{10}	-0.78118	-0.91236	-0.59054	-1.12003
t-stat	**-9.30642**	**-3.30156**	**-12.84752**	**-7.83497**
Signif.level	0.00000	0.00200	0.00000	0.00000
$(dr_t 10)^2$	0.14761	0.21464	-0.06390	0.62991
t-stat	0.63406	1.48934	-0.27557	0.63837

Table 5 (Continued)

Signif.level	0.52697	0.14405	0.78357	0.52808
D $slope_t$	1.05136	1.14846	0.93645	1.23118
t-stat	**21.27487**	**9.47827**	**21.06135**	**8.79126**
Signif.level	0.00000	0.00000	0.00000	0.00000
dii_t	0.01811	0.01223	0.01533	0.03362
t-stat	**2.11154**	1.63344	1.84215	0.93081
Signif.level	0.03632	0.11003	0.06902	0.35938
dp_t	-0.01325	-0.05234	-0.03243	0.09168
t-stat	-0.66561	**-3.89870**	**-2.08258**	1.03696
Signif.level	0.50664	0.00035	0.04037	0.30804
R^2 adj.	0.39624	0.46090	0.41663	0.25336
Nr of observ.	157	43	83	31

by the associated stock returns.

Table 7 shows the results of regression 4. As we can see, the results are quite different than those estimated above.

- We notice that the statistical and economic significance of the total market return is increased in our model, at least at an aggregate level and for average and low rated bonds.
- The effect of the change of the interest rate has a very strong effect on credit spread changes, as in our previous model. However, the effect of the slope of the rate curve, in this model, is found weak and for the low rated bonds the variable is found statistically insignificant.

Table 6

Firm- level determinants of credit spread changes

$$D(CS_t^1) = a + b_1\, ret_t$$

Variable	Descpription
CS_t^1	Credit Spread of Bond i at time t
ret_t	Equity return

	All bonds	Groups based on credit spread level		
		Low(0-2%)	Average(2-4%)	High(>4%)
Intercept	-0.00669	-0.00823	-0.00846	-0.00073
t-stat	**-1.63638**	**-2.13154**	**-2.28378**	-0.04797
Signif.level	0.10404	0.03909	0.02494	0.96206
ret	-0.00919	-0.00638	-0.00447	-0.02550
t-stat	**-5.12598**	**-2.71134**	**-3.17505**	**-4.15378**
Signif.level	0.00000	0.00974	0.00210	0.00025
R^2- adj.	0.05304	0.06705	0.03093	0.14922
Nr of observ.	157	43	83	31

- Equity return doesn't seem to have any effect on credit spread changes, according to this model, as it is found statistically insignificant for all rating classes.

- The change of the credit spreads seems to be affected by the credit spread of the previous period. Whereas, the spot rate of the previous period has little effect on credit spread changes. This means that there is a mean reverting behavior only for credit spreads and not for the spot rate.
- The R^2 s-adjusted for this model are much smaller than those estimated in the previous model. This is expected, as the current model contains less information than the one estimated above.
- Although we have achieved smaller R^2s we find our current model more useful and credible than the previous one. This is because it is an unconditional model, which gives us the ability to conduct forecasts for the level of the changes of credit spreads, based on observable and known variables.

IV. Conclusion

We have investigated changes in credit spreads on individual bond rates. We have reached several interesting conclusions.

In order to find the variables that we thought that they could have an explanatory power on credit spread changes, we were based on structural models of default. Moreover, we proposed some more variables- macroeconomic and economic state ones-which were within the theoretical framework of structural models. Using these factors we have proposed two models.

Our first model is a conditional contemporaneous model, similar to the ones proposed by other authors, like Collin-Dufresne, Goldstein and Martin (2001). With this model we have achieved R^2s- adjusted ranging from 37% for low rated bonds to 55% for high rated bonds. This result is supportive for the explanatory ability of structural models of default on credit spread changes. We have estimated that credit spread changes are mainly driven by changes in the term structure slope and by changes of the spot rate. Average and low rated bonds are, also, affected by equity and market return. High and low rated bonds are strongly affected by the changes of the inflation rate.

Our second model is an unconditional, non-contemporaneous model. We examine whether credit spread changes can be explained by the variables used in our previous model (plus two economic state variables), but at a t-1 period of time. With this model we have achieved R^2s-adjusted ranging around 20%. According to the second model, credit spread changes are affected, similarly, by changes in the spot rate. However, the term structure slope seems to have a much smaller explanatory power in this model. Moreover, the change in the industrial index has a bigger effect on credit spread changes, contrary to our previous model. On the other hand, equity and market return don't seem to have any effect in our second model.

Although the R^2s are much smaller in the second model we find it more preferable and credible, since it gives us the ability to conduct forecasts on the level of credit spread changes across credit risk groups.

Table7

Unconditional, non-contemporaneous model of credit spread determinants across credit risk groups

$$D(CS_t^i) = a + b_1 r_{m,t-1} + b_2 dr_{t-1}^{10} + b_3 (dr_{t-1}^{10})^2 + b_4 r_{t-1}^{10} + b_5 Dslope_{t-1} + b_6 dii_{t-1} + b_7 dp_{t-1} + b_8 ret_{t-1} + b_9 cr_{t-1}$$

Variable	Descpription
CS_t^i	Credit Spread
$r_{m,t-1}$	Return of the FTSE-100
dr_{t-1}^{10}	Change in 10-year Treasury rate
r_{t-1}^{10}	10 year Treasury rate
$D\ slope_{t-1}$	$D(r^{10} - r^{3m})$
dii_{t-1}	Change in the industrial index
dp_{t-1}	Change in inflation
ret_{t-1}	Equity return

	All bonds	Groups based on credit spread level		
		Low(0-2%)	Average(2-4%)	High(>4%)
Intercept	0.32042	0.15893	0.40550	0.30346
t-stat	**3.20709**	0.97072	**7.56414**	0.69820
Signif.level	0.00163	0.33752	0.00000	0.49043
$r_{m,t-1}$	-0.01692	-0.00345	-0.01248	-0.04677
t-stat	**-6.13434**	-1.16414	**-7.18210**	**-4.26543**
Signif.level	0.00000	0.25126	0.00000	0.00018
dr_{t-1}^{10}	-0.35336	-0.34928	-0.17920	-0.83070
t-stat	**-6.52817**	**-4.63523**	**-5.79738**	**-3.76549**
Signif.level	0.00000	0.00004	0.00000	0.00072

Table 7

(Continued)

$(dr_{t-1}^{10})^2$	-0.09144	-0.36580	-0.15311	0.43851
t-stat	-0.77706	-1.83513	-1.81794	0.92698
Signif.level	0.43831	0.07393	0.07268	0.36134
r_{t-1}^{10}	-0.02116	-0.00959	-0.04595	0.03068
t-stat	-1.03186	-0.26048	**-4.30833**	0.35325
Signif.level	0.30375	0.79583	0.00004	0.72637
D $slope_{t-1}$	0.18143	0.35407	0.06303	0.27395
t-stat	**3.13598**	**2.36639**	**2.46199**	1.37370
Signif.level	0.00205	0.02289	0.01589	0.17971
dii_{t-1}	-0.04076	-0.00535	-0.01930	-0.14575
t-stat	**-2.22697**	-0.82477	-1.13228	-1.88252
Signif.level	0.02739	0.41440	0.26078	0.06950
dp_{t-1}	-0.06606	-0.02804	-0.14306	0.09229
t-stat	-1.47482	-0.27405	**-2.90154**	0.77874
Signif.level	0.14229	0.78546	0.00475	0.44223
ret_{t-1}	0.00007	-0.00014	-0.00006	0.00070
t-stat	0.10661	-0.14212	-0.10915	0.28396
Signif.level	0.91523	0.88770	0.91334	0.77840
cs_{t-1}	-0.05902	-0.07433	-0.04852	-0.06723
t-stat	**-6.02178**	**-2.37399**	**-5.59846**	**-4.96662**
Signif.level	0.00000	0.02249	0.00000	0.00003
R^2 - adj.	0.18903	0.19702	0.17811	0.20805

Table 7

(Continued)

Nr of observ.	156	41	84	31

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