

The Feedback from Stock Prices to Credit Spreads

Master in Financial Engineering Program

BA 230N Applied Finance Project

Ka Fai Law (Keith)

1. Introduction

The current literature assumes that credit spread captures fluctuations in unexpected and expected returns. It is known that credit spread is a risk factor (Chen et al. (1986)). There is also literature that uses the credit spread to proxy for time-varying expected returns (Fama and French (1989)).

However, the inverse effect, the effect of stock price movements on the credit spread has not been analyzed.

Credit spread analysis is very important today because of the popularity of the credit derivatives. Modeling credit spread is also very important for pricing a lot of corporate fixed income securities and even more complex security like the convertible bonds. This paper will study in depth the credit spread behavior with respect to investment grade bonds and the non-investment grade bonds. Demonstration of how to apply this study to price various instruments will be briefly discussed in the last section.

There are two reasons why changes in prices might have an effect on the credit spread.

1. Lower price (ex-post returns), the equity value of the company decreases, the firm is more levered, probability of default increases, resulting in changes in the credit spread. This channel will likely be strongest for companies that are already in financial distress.
2. Feedback effect (as in Campbell and Hertschel).

Dividing bonds into investment grade and non-investment grade allows us to better understand the credit spread responsiveness to stock returns. For investment grade bonds, assuming the company is financially healthy, we would expect that even as the stock price drops, the market participants will not lose all confidence. The default probability will not increase significantly and so the credit spread will not react strongly. In other words, the stock price movement is not the sole determinant for the credit spreads for the investment grade bonds.

However, for non-investment grade companies, stock price movements may be very sensitive to the market participants about her ability to meet the debt obligations. We would expect the credit spread is very sensitive to the stock price movements.

Determining whether a company is investment grade or non-investment grade is easily done by looking at the rating of the bonds by the rating agencies, say Standard & Poor and the Moodys. I will not further sub-divide the bonds into AAA sample, AA sample... because there might be slight difference in the ratings assigned for the same bonds by different agencies. Also, further sub-division will lead to smaller sample and may lead to sample bias.

This paper has three main findings: By classifying the corporate bonds into investment grade and non-investment grade bonds, the latter one has significant negative relationship between the credit spread and the stock returns, and the magnitude is huge. While for the investment grade bonds, there does not exist a strong negative relationship, and even if any, the magnitude is small when compared with the non-investment grade bonds. This may be due to the fact that there exists other determinants (other than movement of stock price) for the investment grade bonds.

Geske and Delianedis (2001) has studied “The Components of Corporate Credit Spreads: Default, Recovery, Tax, Jumps, Liquidity, and Market factors” and found that the credit risks and credit spreads are not primarily explained by default and recovery risk, but are mainly attributable to tax, liquidity, and market risk factors. This may help to explain my finding about the weak responsiveness of the investment grade bonds to the stock price.

In the long horizon regressions, I also have some evidence about the liquidity factor in the determination of credit spread for the non-investment grade bonds while this factor seems weak for the investment grade bonds.

Finally, the distribution of the beta coefficients is also surprising, nearly normal for the investment grade bonds and no special distribution for the non-investment grade bonds.

2. Data

50 (randomly chosen) non-investment grade corporate bonds' yield spreads with daily frequency are provided by Merrill Lynch Fixed Income division database. But since 5 of them are not listed companies and 7 of them have less than 4 months data, I can only study 38 of them.

86 benchmark investment grade bonds are randomly chosen from US Corporate Weekly and their daily yields are collected from Bloomberg. But after the First Stage regression (Section 3), when I conduct the long horizon regression, I can only study 77 companies since 9 of them have missing data that does not allow the long horizon regression.

Data span from as early as Jan 1, 1997 (if that corporate bond was alive already) to December 6, 2001 (the date we started the research), in daily frequency. I use high frequency data because the response of the credit spread to returns is hypothesized immediate and it will be tested in later section.

Credit spread is the yield spread between a corporate bond and a comparable default-free bond solely due to the credit quality. The proxy for the default free bond is the Treasury bond. Therefore, the credit spread is constructed by subtracting the Treasury bonds' yield, which has similar maturity and the coupon rate from the corporate bond yield. From the list of the Treasury bonds, I choose the closest maturity first, and then find the closest coupon rate. Then the yield spread is more or less only due to the credit quality. Throughout the paper, credit spread is measured in Basis Points.

A corporate bond is defined as non-investment grade if its credit rating is below BBB by Moody's and is defined as investment grade if its credit rating is at BBB or above.

3. Methodology

3.1 First Stage Regression

The first regression we first look at is:

$$CR_t^i - CR_{t-1}^i = \alpha^i + \beta^i (\ln P_t^i - \ln P_{t-1}^i) + \varepsilon_t^i$$

For different bonds (i), over time $t = 1, \dots, T$. The hypothesis is that the change in stock price over the period $t-1$ to t will be correlated to a corresponding, but opposite in sign, change in the credit spread. The results of the above regressions for non-investment grade bonds and the investment grade bonds are shown in Table 1 below.

Table 1: Proportion of negative beta coefficients

	Proportion of Negative betas	Min.	Max.	Standard deviation
Non-investment grade	84.21%	-564.8	165.7	115
Investment grade	60.5%	-94.4	42.7	22

For non-investment grade bonds, out of 38 companies, 32 have negative betas, or 84.2%. Negative beta is the intuition, which means credit spread decreases with positive return, and increases with negative returns.

But for the investment grade bonds, 52 out of 86 companies (or 60.5%) have negative betas. Compared with the non-investment grade bonds, we see the difference between the proportions.

From the results of the First Stage Regression, I plot the histogram of the Beta coefficients for the Non-investment grade bonds (figure 1a) and the investment grade bonds (figure 1b) respectively in Appendix. Two main findings are:

1. The dispersion of the beta coefficients for the non-investment grade bonds is very large, ranging from -564 to 165 , while the dispersion is small for the investment grade bonds.
2. Distributions of the beta coefficients are very different, looks like normal (but a little skewed) for the investment grade bonds while no special distribution for the non-investment grade bonds.

The economic intuition behind the findings is that even for the bonds that are among non-investment grade, the market perception about their financial ability can be quite

disperse. Therefore, care should be taken in modeling the credit spread of non-investment grade bonds, since the dispersion is very large and the non-normality makes the location of confidence interval impossible.

3.2 Second Stage Regression

The dispersion of the beta coefficients is very large for the non-investment grade bonds. I suspect that some of the outliers might be due to credit spread reacting to returns in a down swing. So I run the following regressions for the 38 non-investment grade companies:

$$CR_t^i - CR_{t-1}^i = \alpha^i + \beta_1^i r_t^i 1\{r_t^i \geq 0\} + \beta_2^i r_t^i 1\{r_t^i < 0\} + \varepsilon_t^i$$

where $r_t^i = \ln P_t^i - \ln P_{t-1}^i$

$1\{r_t^i \geq 0\}$ is a dummy variable (index function) that equals to one if $r_t^i \geq 0$ and zero otherwise.

Similarly, $1\{r_t^i < 0\}$ is an index function that equals to one if $r_t^i < 0$ and zero otherwise.

The result of the Second stage regression is in Table 2 below.

Table 2: Results of second stage regression

	Beta 1	Beta 2
Number of Negative Beta	25	30
proportion	0.65789474	0.78947368

From Table 2, we see that 25 out of 38 companies (or 66%) have negative β_1 , that is, credit spread decreases with the positive return; While 30 out of 38 companies (or 79%) have negative β_2 , that is, credit spread increases with the negative return. Although the change of credit spreads seems to be more sensitive to the down swing, it suggests no clue to the large dispersion of the beta coefficients in the First Stage regressions for the non-investment grade bonds. It also suggests that there is no model misspecification for the first stage regression.

3.3 Including the S&P 500 as controlled variable

Since the market as a whole can affect the investors' perspective about each firm, I include it (S&P 500 as a proxy) as a controlled variable into our regressions and run the following:

$$CR_t^i - CR_{t-1}^i = \alpha^i + \beta_1^i \text{Stock Return}_t^i + \beta_2^i \text{S \& P Return}_t^i + \varepsilon_t^i$$

The results of the above regressions for the non-investment grade bonds and the investment grade bonds are shown in Table 3 below.

Table 3: Including S&P 500 returns as controlled variable

	Proportion of negative β_1	Proportion of neg. β_2
Non-investment grade	77%	79%
Investment grade	61%	67.5%

We see that even when I include the S&P 500 return as a control variable in the regressions, the proportion of negative betas associated with the stock return remains more or less the same, 77% for the non-investment grade bonds and around 61% for the investment grade bonds.

But one interesting point is that the S&P returns have a larger negative beta proportion than the stock returns for both the non-investment grade bonds and the investment grade bonds. The reason for this may be multicollinearity, that the stock returns and the S&P returns have correlations so that the S&P returns draw the stock return effects away.

Another interesting result can be found when we look at the histogram of both beta coefficients (stock return) and the beta coefficients (S&P return), Figure 3 in Appendix. Even we include the S&P 500 returns, our former results do not change. The distribution of the beta coefficients (stock return) is more or less the same for the case without the S&P 500, looks like a bell shape for the investment grade bonds, while very dispersed for the non-investment grade bonds. (Figure 3a and figure 3c). The proportion of the negative beta coefficients is much higher for the non-investment grade bonds than that of the investment grade bonds.

But when we look at the distribution of the beta coefficients associated with S&P return, the distribution is even more dispersed, looking uniform for the non-investment grade bonds (fig 3b), while still taking a bell shape for the investment grade bonds.

The economic intuition behind the above findings is that S&P return seems to be a very important factor in determining the credit spread for both the investment grade bonds and the non-investment grade bonds. The large proportion of negative betas is evidence. Also, the more dispersed betas for the non-investment grade bonds suggest that particular care should be taken in modeling the credit spread for them.

3.4. Long Horizon Regressions without S&P returns as controlled variable

So far, I have been running the regression:

$$CR_t^i - CR_{t-1}^i = \alpha^i + \beta^i (\ln P_t^i - \ln P_{t-1}^i) + \varepsilon_t^i \quad (1)$$

The hypothesis was that the change in the stock price over the period t -1 to t will be correlated with a corresponding, but opposite in sign, change in the credit spread.

But prices cannot adjust within a single day. For instance, if there is a jump (a big event), prices might first react, but given that the bonds market is not very liquid, it might take several days before prices reach equilibrium.

Suppose that I can also write equation (1) for period $t + 1$

$$CR_{t+1}^i - CR_t^i = \alpha^i + \beta^i (\ln P_{t+1}^i - \ln P_t^i) + \varepsilon_{t+1}^i \quad (2)$$

Therefore, putting the two equations together, we have:

$$CR_{t+1}^i - CR_t^i + CR_t^i - CR_{t-1}^i = 2\alpha^i + \beta^i (\ln P_{t+1}^i - \ln P_t^i + \ln P_t^i - \ln P_{t-1}^i) + \varepsilon_{t+1}^i + \varepsilon_t^i$$

$$CR_{t+1}^i - CR_{t-1}^i = \alpha_2^i + \beta_2^i (\ln P_{t+1}^i - \ln P_{t-1}^i) + u_{t+1}^i$$

where the subscripts below the coefficients denote the period over which we are running the regression. In fact, we want to run the 2-day change in the credit spread on the 2-day return.

The above method can be generalized to

$$CR_{t+k-1}^i - CR_{t-1}^i = \alpha_k^i + \beta_k^i (\ln P_{t+k-1}^i - \ln P_{t-1}^i) + u_{t+1}^i \quad (3)$$

where we analyze the k -day change in the credit spread to movements in the k -day return.

This method will allow us to see whether it is true that $\beta_k^i = \beta^i$, as expected from the equations above. If it turns out that $\beta_k^i > \beta^i$, then the long-horizon adjustment is bigger than the one-time adjustment. If it turns out that $\beta_k^i < \beta^i$, then the long-horizon adjustment is not as important as the immediate one.

Another interesting extension of the long-horizon regressions is related to liquidity. If we find that $\beta_k^i \neq \beta^i$, this might imply that there were liquidity problems that prevented the prices from adjusting immediately. If there are no other factors, we must have $\beta_k^i = \beta^i$.

In this section, I will conduct long horizon regressions for $k = 1$ (as before) as well as for $k = 2, 3, 4, 5$ (week), 10, 22 (month). The results for non-investment grade bonds and investment grade bonds are shown in Table 4 below:

Table 4: Long Horizon regression

Proportion of neg. β	K=1	K=2	K=3	K=4	K=5	K=10	K=22

Non-inv.	0.8421	0.9737	1	0.9737	0.9737	.9737	1
Inv.	0.605	0.597403	0.662338	0.688312	0.701299	0.701299	0.649351

The long horizon regressions give us very rich results:

1. For non-investment grade bonds, with larger K , in fact when $K=2$, all 38 bonds have negative betas associated with the stock returns. It supports the liquidity argument; with more time to adjust to equilibrium, credit spreads move opposite with the stock returns.
2. The proportion of negative betas for the investment grade bonds seems to not increase with the increase in K , the economic intuition is: there exists no liquidity problem and the proportion stays around 60% to 70%.
3. The proportion of negative betas stay around 60% and 70% for investment grade bonds through time while nearly 100% for the non-investment grade bonds, suggesting that the credit spread is less sensitive to stock returns for the investment grade bonds while very sensitive for the non-investment grade bonds.
4. We can say that stock returns are very important in the change of the credit spread for the non-investment grade bonds. This is because for the non-investment grade companies, the probability of financial distress is very high and so stock price movement is very sensitive to the default probability. While for the investment grade companies, we do not know the movement of credit spread from the stock returns because they are financially healthy and the movement of credit spread is not very sensitive to stock price movements. There are other factors at work, like taxation, capital structure and other idiosyncratic factors.

More results can be found from the histogram with different K , see the 3D graphs for the non-investment grade (figure 4) bonds and figures 5 for the investment grade bonds.

With larger K , the distribution of the beta coefficients for the non-investment grade bonds does not change, but it is shifting leftwards, with more and more negative magnitude with the increase in K , that is, more price adjustment through time, supporting our liquidity argument.

For investment grade bonds, the distribution and the magnitude of the beta coefficients do not seem to change with different K levels, suggesting no liquidity factor involved in the price adjustment.

3.5. Long Horizon Regressions with S&P returns as controlled variable

In order to see both the effects of the stock returns and the S&P returns on the change of the credit spread through time, I run the long horizon regressions including the S&P returns as independent variables:

$$CR_{t+k-1}^i - CR_{t-1}^i = \alpha_k^i + \beta_{1k}^i \text{Stock Return}_{K\text{period}}^i + \beta_{2k}^i \text{S \& P Return}_{K\text{period}}^i + u_{t+1}^i$$

The results for the above regressions at K=2, 3, 4, 5, 10, 22 for non-investment grade bonds and investment grade bonds are shown in Table 5.

Table 5: Long horizon regression with S&P 500 return as controlled variable

Proportion of neg. β_1	K=1	K=2	K=3	K=4	K=5	K=10	K=22
Non-inv.	0.77	0.87	0.87	0.87	0.87	0.92	0.97
Inv.	0.61	0.545455	0.558442	0.584416	0.584416	0.545455	0.584416

Proportion of neg. β_2	K=1	K=2	K=3	K=4	K=5	K=10	K=22
Non-inv.	0.79	0.737	0.71	0.737	0.684	0.737	0.71
Inv.	0.675	0.74	0.79	0.805	0.82	0.82	0.805

Results from Table 5:

1. At all horizons, the number of negative betas associated with stock returns is larger than the number of negative betas associated with S&P returns for the non-investment grade bonds. The opposite is true for the investment grade bonds; that is, at all horizons, the number of negative betas associated with S&P returns is higher.
2. For non-investment grade bonds: With larger K, the number of negative betas associated with stock returns is increasing while the number of negative betas associated with S&P returns stays around the same. This suggests that it takes time for the credit spread to adjust from stock price change only but not the S&P movement.
3. For investment grade bonds: With larger K, the number of negative betas associated with stock returns and the number of negative betas associated with S&P returns stay around the same at all horizons, suggesting no time adjustment from stock price change and S&P level changes.
4. The above trend can best be visualized by the 3D graph in the appendix, Figure 6 to Figure 9. For non-investment grade bonds, the beta associated with the stock return is more and more negative with the increase in K; while for beta (S&P return), there is no trend with the increase in K. For investment grade bonds, there are no trends for both beta coefficients with increasing K.

4. Adjustment for autocorrelation due to overlapping data for the Long Horizon Regressions

The Long horizon regression above uses overlapping data which will introduce serial correlation. Serial correlation will not have an effect on the value of the beta coefficients, but nonetheless the t statistics must adjusted.

Even when the t statistics are adjusted, the main results of the above analysis do not change. The significant negative betas associated with the non-investment grade bonds are still significant though the t statistics reduce in magnitude. The result for the investment grade bonds is also unchanged.

5. Conclusion

The main result in this paper is the different responsiveness of the change in credit spread to the stock returns and the S&P returns for the non-investment grade bonds and the investment grade bonds. For non-investment grade bonds, the movement is negative while the result is quite mixed for the investment grade bonds.

The above finding is useful for pricing a Fixed Income instrument, especially in the construction of pricing models. It has the implication of using different models for pricing instruments with different credit ratings. For instance, the S&P 500 return seems to be more negatively correlated with the credit spread than the stock return for the investment grade bonds while the reverse is true for the non-investment grade bonds.

Take the example of pricing a more complicated instrument: convertible bonds using the tree method. A convertible bond has the dual feature of equity and bonds: at higher price level, it is priced as equity; while at lower price level, it is priced as bonds. When the cash flow is discounted backward using a tree, a risk free discount rate should be used at the very upper nodes where the stock price is high, since it is for sure to be converted. Different stock price levels means different firm values and possible different ratings, which is the case for non-investment grade and investment grade. As found in this paper, the responsiveness of the credit spreads is different to non-investment grade bonds and investment grade bonds. Thus, the discount rate used (risky rate = risk free rate + credit spread) should be different for pricing purposes. See Goldman Sachs research Paper (1994).

However, the results in this paper subject to two limitations:

1. Possible small sample effects: I have tried my best to get as many samples as possible, but unfortunately was only able to get 50 (38 valid) samples for the non-investment grade bonds. This may entail small sample bias.

2. Possible inclusion of Matrix Price. I was not able to contact Merrill Lynch for the method of how the database sets the price of the corporate bonds when they are not traded on some days. All I know is that investment banks always use some kind of matrix to price a bond on a day when it is not traded. As it has been shown by Sarig and Warga (1989) that matrix prices are problematic.

I believe that the above two problems potentially cause bias, but will not distort the main results I found.

I have also found that there exists liquidity problem for the non-investment grade bonds by the long horizon regressions. Thus, part of the yield spread for the non-investment grade bonds may be due to compensation for liquidity. This problem seems not exist for investment grade bonds and this will be our ongoing research topic.

Finally, the distributions of non-investment grade bonds and the investment grade bonds also seem different, but I cannot draw a strong conclusion on that because of my small sample. But this will be studied in future efforts.

Appendix

Table 1: Proportion of negative beta coefficients for First stage regression

	Proportion of Negative betas	Min.	Max.	Standard deviation
Non-investment grade	84.21%	-564.8	165.7	115
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Table 2: Results of second stage regression

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Table 3: Regression including S&P 500 returns as controlled variable

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Non-investment grade	77%	79%
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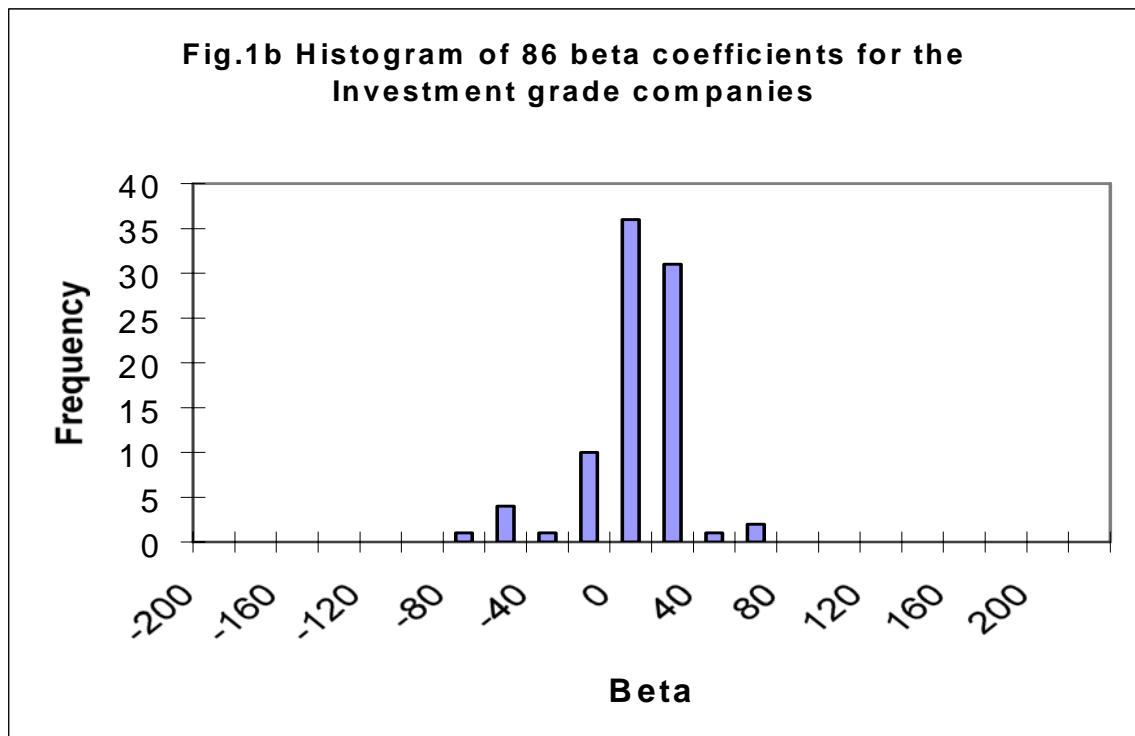
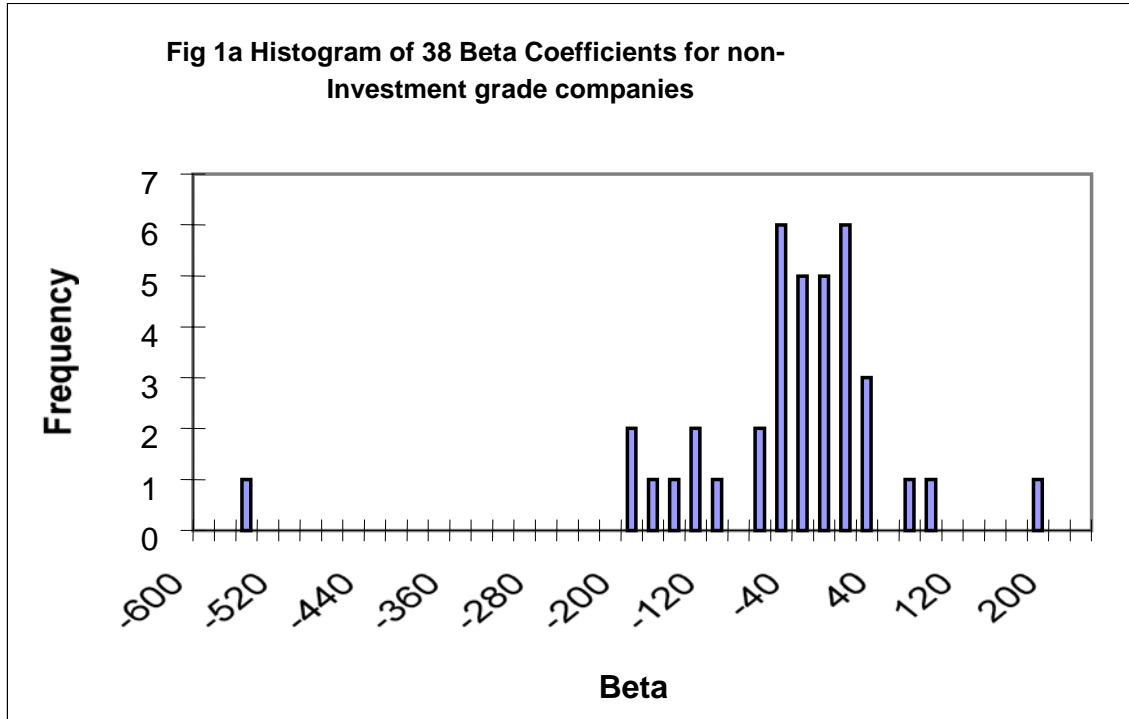
Table 4: Long Horizon regression with S&P as controlled variable

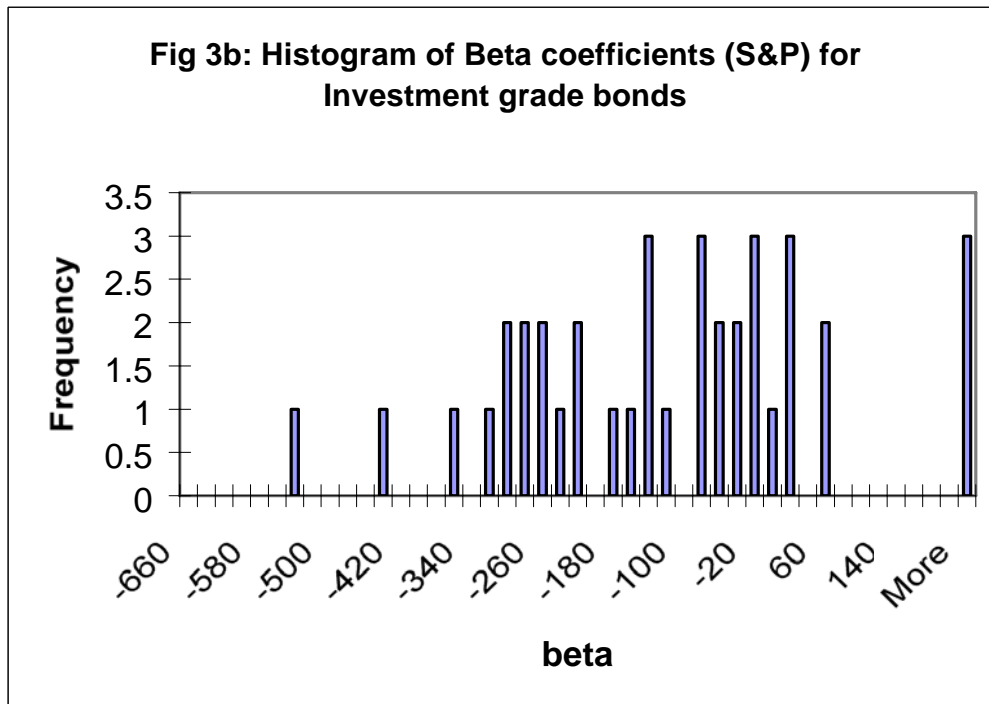
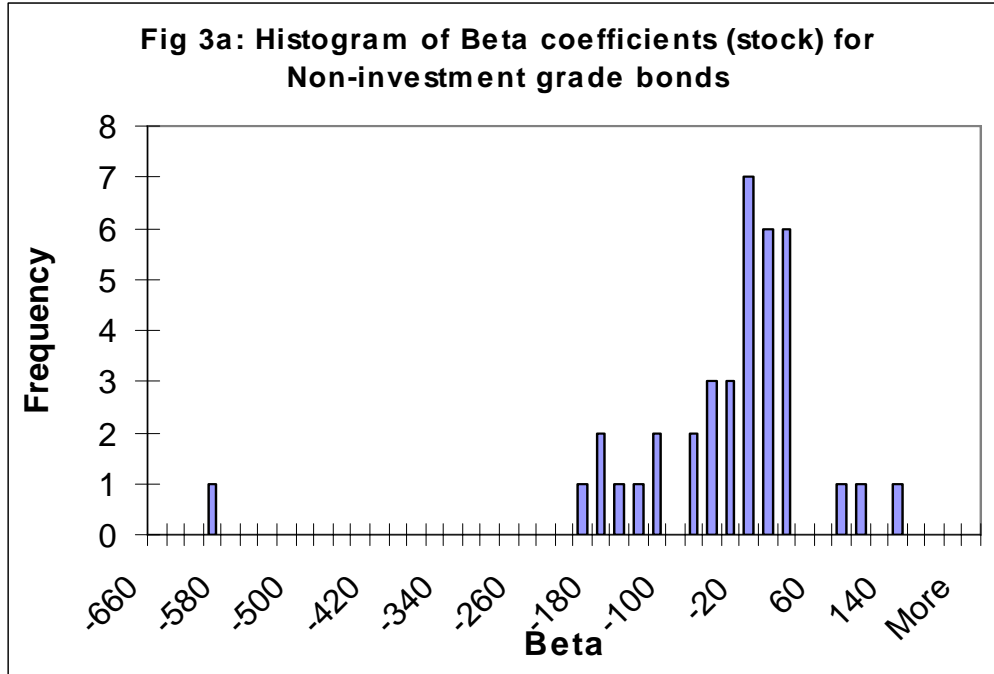
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Inv.	0.675	0.74	0.79	0.805	0.82	0.82	0.805





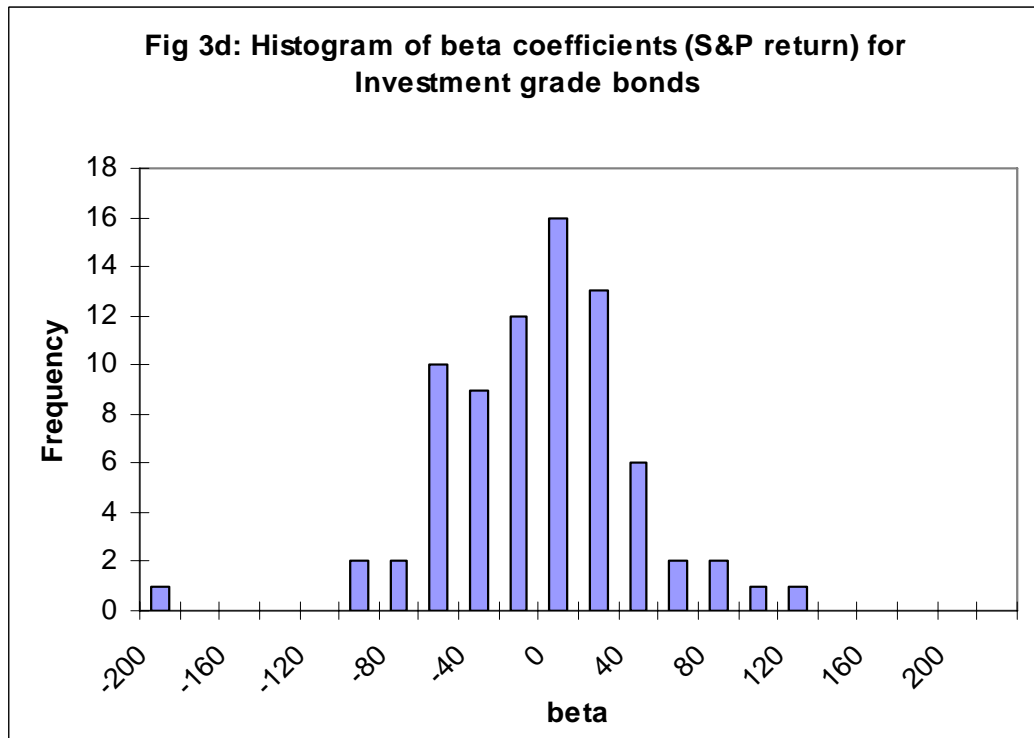
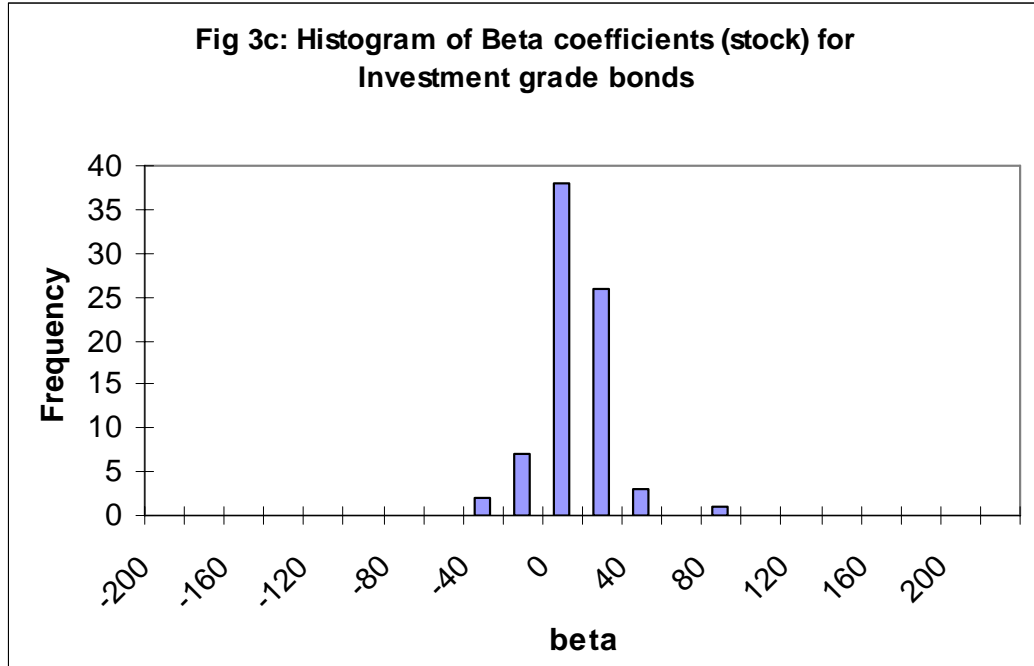


Figure 4: Histogram of beta coefficients with different K for Non-investment grade bonds

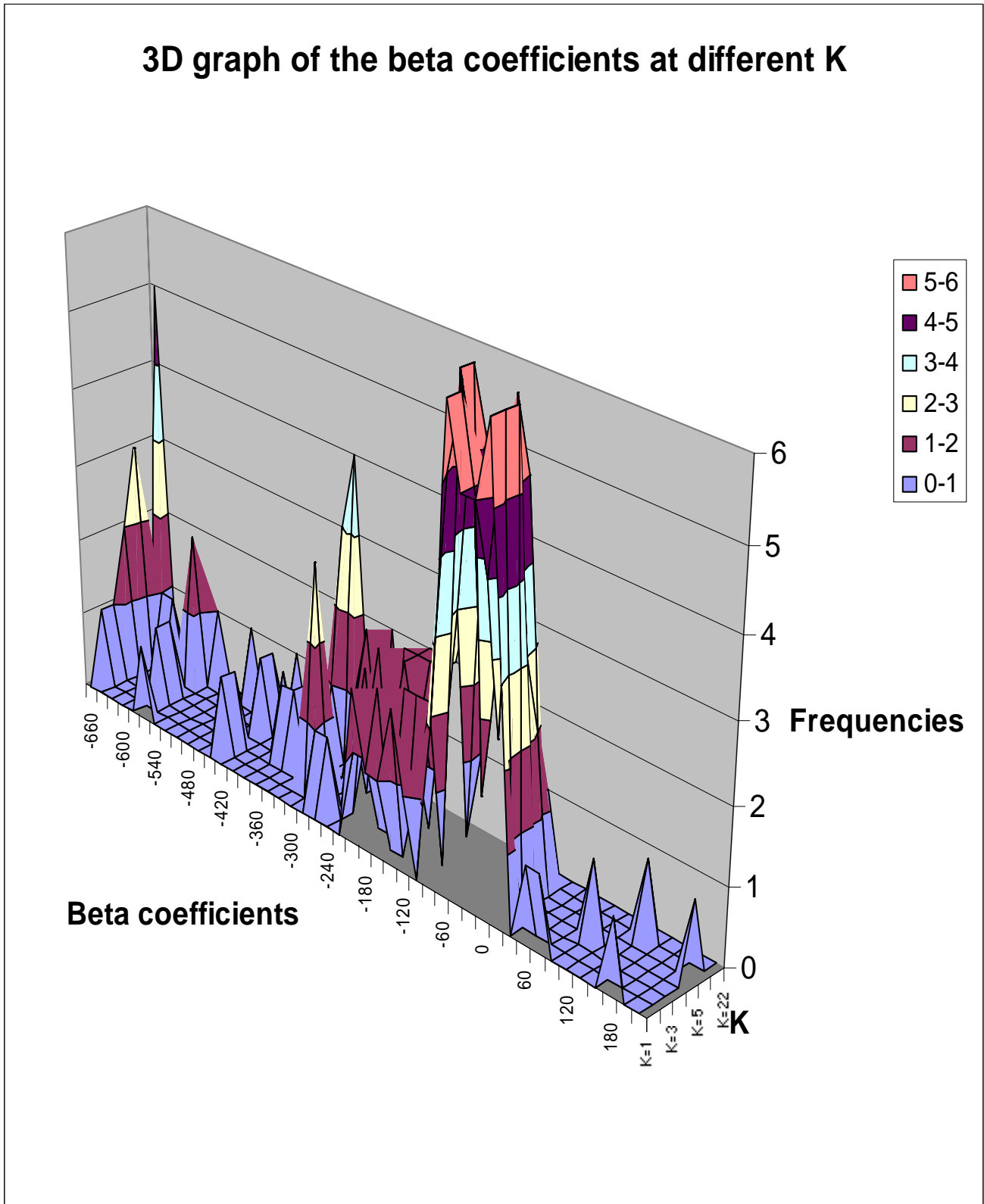


Figure 5: Histogram of beta coefficients with different K for Investment grade bonds

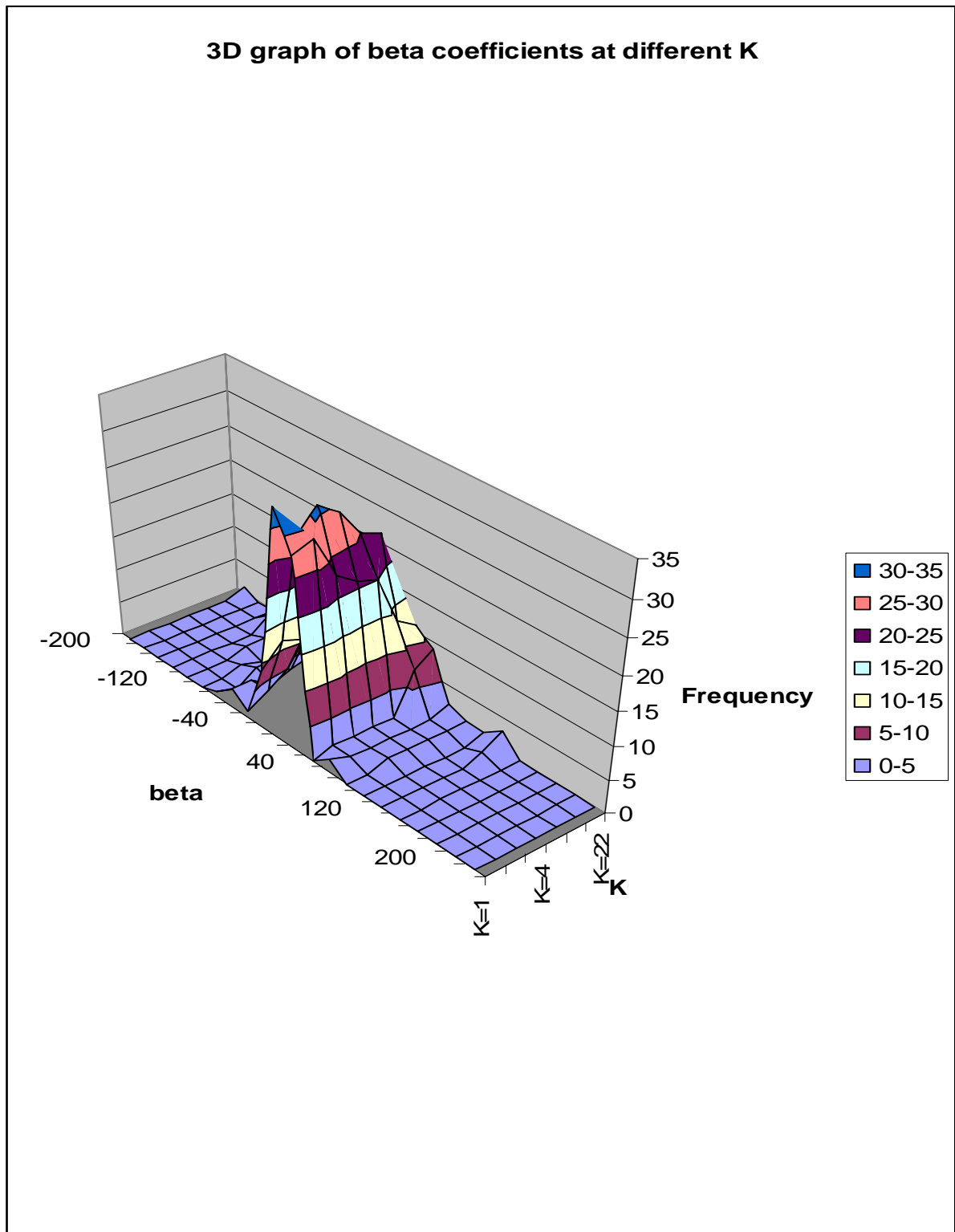


Figure 6. Beta coefficients (stock returns) for the non-investment grade bonds

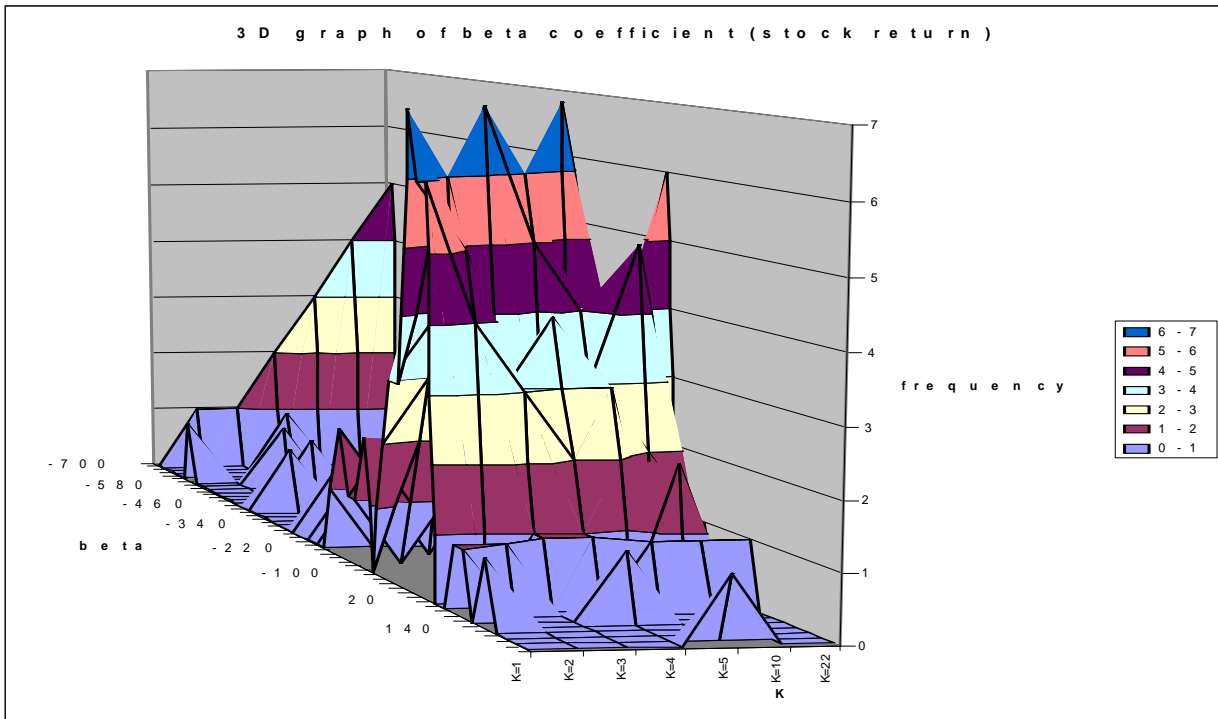


Figure 7. Beta coefficients (S&P 500 returns) for the non-investment grade bonds

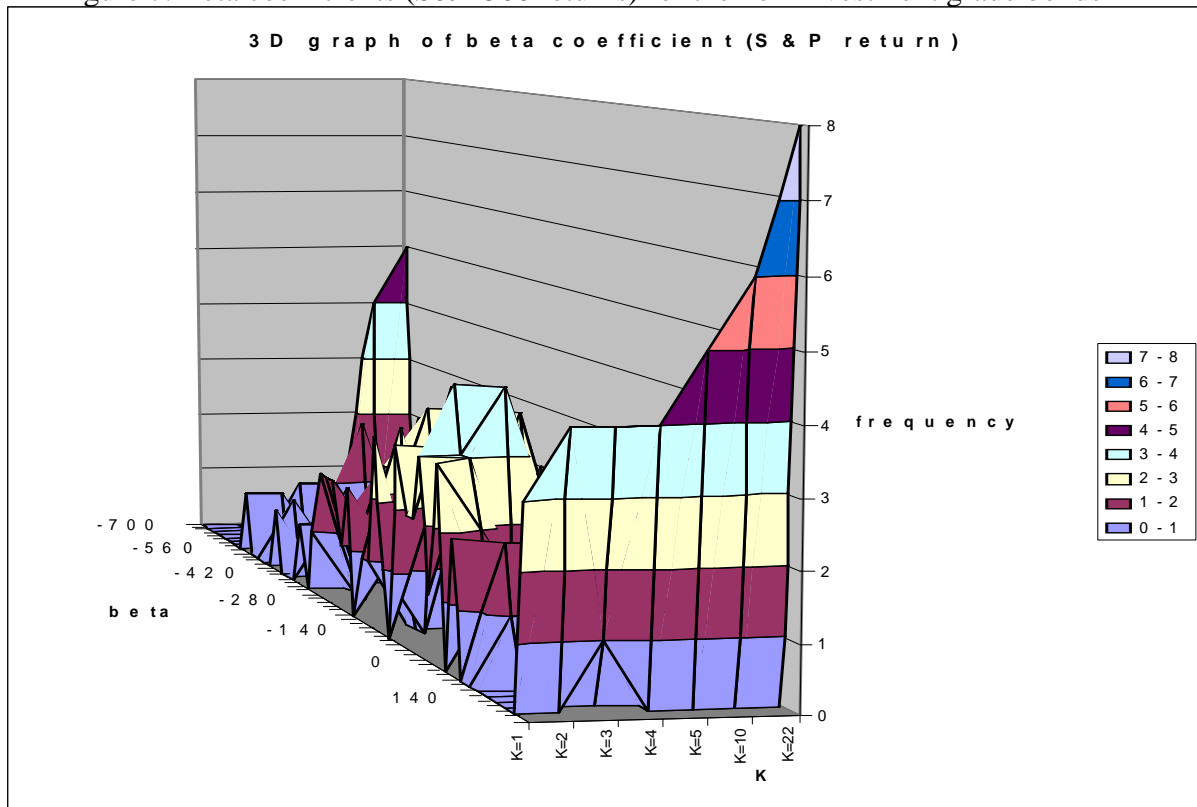


Figure 8. Beta coefficients (stock return) for the investment grade bonds

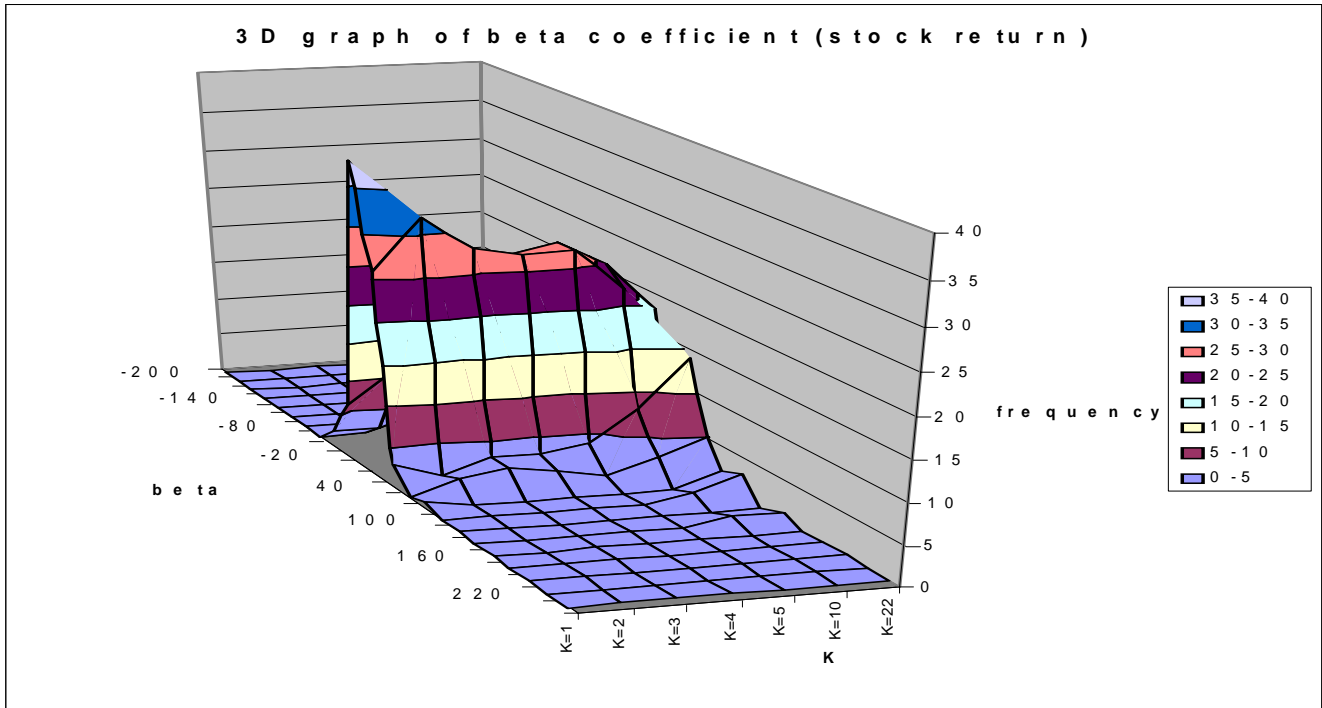
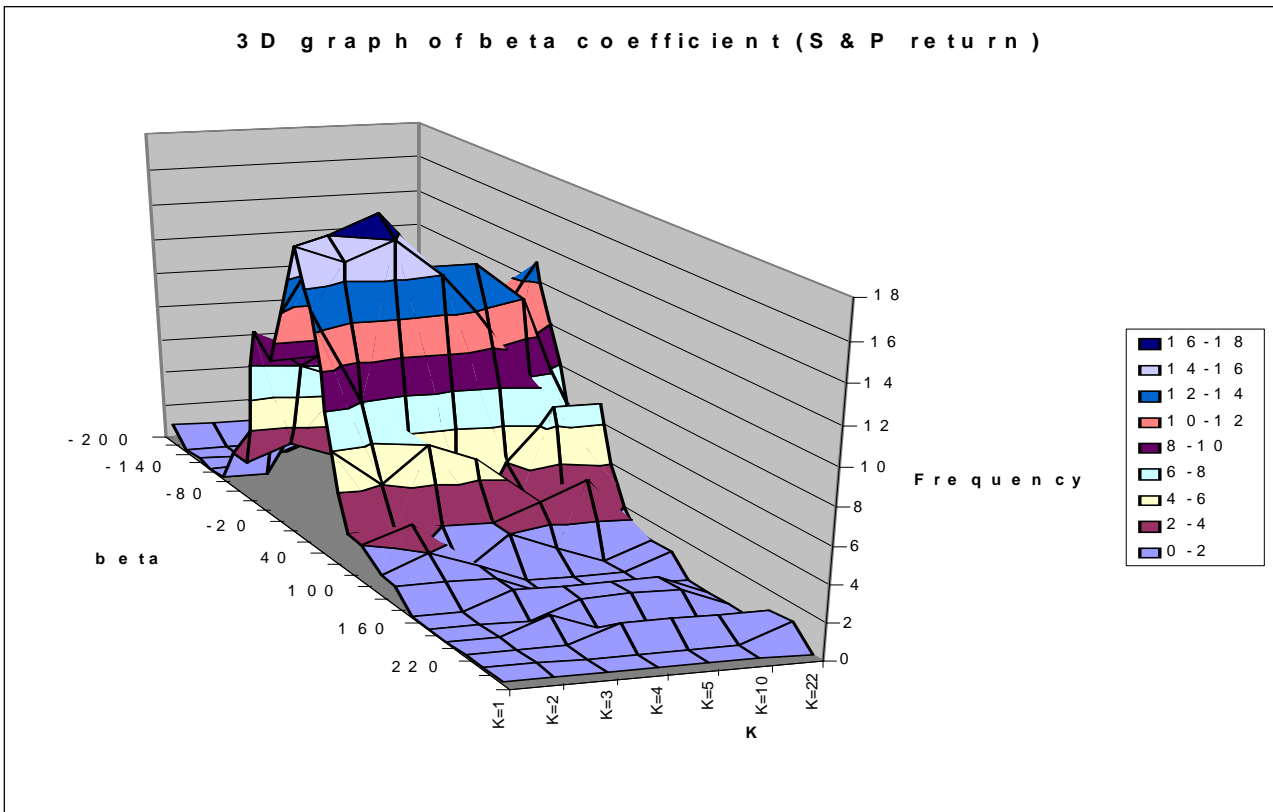


Figure 9. Beta coefficients (S&P 500 return) for the investment grade bonds



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