The impact of investment grade cut-offs on firms' investment decisions and performance

Authors

Seonhyeon Kim (Present Author)
Business School, Korea University, Republic of Korea
(02841) Business School of Korea University, 145, Anam-Ro, Seongbuk-Gu, Seoul, Korea
E-mail : ejejfl3@naver.com

Changki Kim (Corresponding Author)
Business School, Korea University, Republic of Korea
(02841) Business School of Korea University, 145, Anam-Ro, Seongbuk-Gu, Seoul, Korea
E-mail : Changki@korea.ac.kr; Tel: 82-2-3290-2628

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Abstract

A downgrade to speculative grade leads to a higher debt reduction, a more negative market reaction, and a rising cost of capital than downgrades to other intervals. We examine whether investment grade cut-offs affect firms' investment decisions and find that as a firm's rating improves, managers tend to increase capital investment, whereas this effect reduces or disappears for firms with near-BBB ratings. This result is consistent irrespective of the matching procedure adopted as well as when using non-parametric tests. We also find in mergers and acquisitions that near-BBB bidders have greater cumulative average returns. These results show that the investment grade cut-off affects both the quantity and the quality of firms' investment. This study thus provides strong evidence that managers adjust their decision making to manage their firms' credit rating.

Keywords: Credit rating, Investment grade cut-off, Investment decision, merger and acquisition

JEL classification: G31, G32, G34

1. Introduction

Credit rating agencies use sophisticated methodologies to evaluate managerial risk, affiliate risk, industry risk, business risk, and financial risk. They measure the creditworthiness of a firm through credit ratings (Yi and Mullineaux, 2006). Many studies have used credit ratings as a proxy for financial constraints (Aktas et al., 2018; Faulkender and Petersen, 2005) and the ability to access debt markets (Campello et al., 2010; Karampatsas et al., 2014). Credit ratings can thus affect firms' decision making (Aktas et al., 2018; Graham and Harvey, 2001; Harford and Uysal, 2014; Kim and Shin, 2017; Kisgen, 2009).

We focus on the classification of credit ratings into speculative grade and investment grade. According to related research, a downgrade to speculative grade leads to a more negative market reaction (Jeong and Chung, 2014; Ryu et al., 2013), a higher corporate lending rating (Sul and Jung, 2017), and a greater debt reduction (Kisgen, 2009) than other downgrades. Chernenko and Sunderam (2012) show that the investment activity of speculative grade (BB+) firms is highly influenced by the capital flows into high-yield funds more than that of investment grade (BBB-) firms owing to the increase in the cost of capital. Firms with BBB categories face the threat of a downgrade to speculative grade because their ratings will become speculative grade if downgraded to the BB+ category. Thus, we suggest that a downgrade has a greater impact on firms with credit ratings at or near BBB (termed near-BBB firms hereafter). In addition, managers strive to maintain a minimum or target rating (Kisgen, 2009). We examine whether this threat affects the investment decisions of near-BBB firms.

The increase in debt can increase the default probability, which is related to the credit rating. Thus, if near-BBB firms are subject to the threat of a downgrade to speculative grade, debt financing is limited. Near-BBB firms are likely to cut their potentially good projects (i.e., those with a net present value (NPV) above 0) than firms with lower credit ratings due to these additional financial constraints. However, this does not mean that their access to the debt market is worse than that of lower rating firms. Rather, near-BBB firms have access to the debt market via investment grade but are wary of the threat of a downgrade when they use debt. We therefore analyze whether the impact of the threat of a downgrade on firms' investment decisions varies depending on their credit rating.

Since a downgrade to speculative grade leads to a higher cost of capital and a more negative market reaction than other downgrades, near-BBB firms suffer a larger financial loss if an investment that downgrades their credit rating fails. When evaluating related potential projects, the discount rate (or minimum attractive rate of return) will increase and the NPV will decrease.[1] Therefore, the

[1] The decline to speculative grade is associated with a higher financial loss than declines to other grades (i.e.,

same project with a risk of a credit rating decline will have a lower NPV for near-BBB firms than for other firms. Thus, the former are likely to stop the project and this will result in reducing investment. In this situation, projects selected by near-BBB firms are more likely to earn higher returns on average than projects selected by other firms because near-BBB firms select more profitable projects than other rated firms on average.

In addition, Harford and Uysal (2014) argue that constrained access to the debt market could lead to underinvestment, which affects investment quality. They find that such investments tend to be more value-increasing and less costly (the financial constraints hypothesis). Therefore, if the threat of a downgrade to speculative grade causes additional financial constraints, near-BBB firms tend to reduce their capital investment and their investments are likely to earn a higher return.

Thus, our empirical prediction is that a firm's credit rating has a positive effect on its investment, whereas the credit rating effect weakens (or disappears) when the rating interval is around BBB. Following the empirical prediction of the financial constraints hypothesis (Harford and Uysal, 2014) and the effect of investment grade cut-offs on evaluating potential projects, these firms' investments will gain higher returns on average than firms with other ratings. In particular, this will show more clearly in investments that can lower credit ratings if the investment fails. We demonstrate this through the acquirers' cumulative abnormal return (CAR) at the M&A announcement date. An acquisition can lead to increased leverage and the associated default risk (Bessembinder et al., 2009; Furfine and Rosen, 2011). As the default risk increases, the probability of a downgrade increases. Therefore, acquisition is likely to downgrade credit ratings (Aktas et al., 2018).

However, according to the free cash flow hypothesis, if there is no constraint on financing, managers may increase their discretion and this results in less effective monitoring. This then causes agency problems (e.g., empire building and overinvestment), increasing the likelihood of value destruction. In this case, companies with lower financial constraints are more likely to be value-decreasing than those with higher financial constraints. In this regard, Harford and Uysal (2014) find that a rated firm has easy access to the debt market, whereas the rated acquirer's CAR has a statistically significant positive value that cannot be explained by the free cash flow hypothesis. According to our evidence using Korean data, the acquirer's CAR and the CAR of acquirers belonging to the investment grade show a significant positive value. Further, the near-BBB acquirer's CAR is the highest. Thus, it cannot be explained by the free cash flow hypothesis. If near-BBB firms' high returns are the result of preventing the value decrease through financial constraints (or effective monitoring), it should be stronger for speculative grade where credit monitoring is more severe and

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a more negative market reaction, greater debt reduction, and increased cost of capital). This raises the potential loss of investment failure and increases risk. Such risk increases the discount rate for evaluating the investment.

financial constraints are higher. However, no such evidence is found.

We suspect that since near-BBB firms have different financial characteristics or investment opportunities, they show different results to firms in other grades. To address this concern, near-BBB and near-A firms are analyzed by constructing a matched sample using the Mahalanobis distance method for seven financial variables. As a result, our argument is supported.

We use growth in tangible assets (i.e., change in tangible assets + depreciation / lagged tangible assets) as a proxy for a firm's investment following Kim and Shin (2017). Chava and Roberts (2008) use capital expenditure / net PPE as a proxy for investment. In the Korean market, studies use tangible assets as a proxy for PPE and capital expenditure calculated as the sum of the change in tangible assets and depreciation of tangible assets (Kim and Kim, 2017; Kim and Shin, 2017; Yoon, 2016). We test our hypotheses empirically using a sample of 2,633 companies in the Korean public market. We employ a two-way random effects model, a two-way fixed effects model, pooled ordinary least squares (OLS), and a non-parametric model for panel data.

Our main findings are as follows. First, the effect of credit rating on capital investment is positive; however, the joint effect of credit rating and proximity to the BBB rating is significantly negative. This negative effect is stronger than expected. Therefore, we can infer that managers of near-BBB firms perceive a greater risk of having their rating downgraded than other managers do and thus tend to underinvest. These regression results are also shown in the matched samples. When matched with near-A firms that are in a higher interval than near-BBB firms, the joint effect of credit rating and near-BBB has a significantly negative coefficient. These results show that our assertions are robust. Second, non-parametric and semi-parametric tests are performed with respect to the first finding. We plot the relationship between credit rating and investment using the generalized additive model and locally estimated scatterplot smoothing (LOESS). The result shows that the smoothing component in the near-BBB dummy decreased (negative value) and increased again from A- consistently. Third, we find that the CAR of the near-BBB acquirer is greater than that for acquirers with other ratings. In our pooled OLS, the coefficient of the joint effect of credit rating and the near-BBB dummy is significantly positive at the 5% level. Overall, our evidence consistently supports our hypothesis.

This study adds new insights to the literature on credit ratings and firms' decisions (Aktas et al., 2018; Graham and Harvey, 2001; Harford and Uysal, 2014; Kim and Shin, 2017; Kisgen, 2009). First, our evidence suggests that near-BBB firms tend to reduce their capital investment because of the threat of a downgrade to speculative grade. Previous studies have shown that a downgrade to speculative grade results in a greater penalty than xxxx. However, to the best of our knowledge, there is no direct evidence that near-BBB firms reduce investment. Our parametric and non-parametric tests consistently show that near-BBB firms tend not to increase investment even though financial constraints have reduced compared with lower rated firms. This is different from Chernenko and Sunderam's (2012) view that the market is segmented by credit rating. They show that the influence of the capital supply market differs with respect to its impact on the rated firm's investments by cut-off, whereas we show that the cut-off itself affects firms' investment. Second, our evidence adds to the previous finding that managers adjust their decisions to manage credit ratings. Previous studies have examined management decision making by debt reduction (Kisgen, 2009) and M&A activity (Aktas et al., 2018). We present evidence for capital investment. The tendency for the capital investment of near-BBB firms to decrease did not appear in the other grades. This is evidence that managers of near-BBB firms adjust their investment decisions in order not to become speculative grade. Third, we analyze direct investment cases (M&A) as well as firms' overall investment activity. The results of our empirical analysis are consistent with our hypotheses. Our results indicate that the decision making of managers who consider credit ratings differs according to the credit rating and that this affects the quantity and quality of their investments. This is different from Harford and Uysal (2014), who suggest that low access to the debt market affects the quantity and quality of firms' investment through M&A. As a result, our findings enrich the related literature.

Our empirical test uses data drawn from the Korean public market. This market has several features that make it suitable for our analyses. When a firm's credit rating is downgraded in the Korean public market, managers receive a penalty in the form of an increased lending rate (Sul and Jung, 2017) and a negative market reaction (Jeong and Chung, 2014; Ryu et al., 2013). This effect tends to be stronger for non-investment grade (or speculative grade) ratings; however, the rewards for upgraded ratings have not been as well observed as have the penalties for downgraded ratings. Kim and Shin (2017) show that the cumulative default rate of firms increases slowly from AAA to BBB but increases sharply from BB+. Thus, investors and managers perceive a downgrade to speculative grade as a risk. Specifically, in the Korean public market, the effect of credit ratings on investment activity may vary because of the 2008 global financial crisis and for small and medium-sized firms (Lee et al., 2015; Sul and Jung, 2017). We obtain consistent results when considering these features.

The remainder of this paper is organized as follows. Section 2 reviews related studies and presents our hypotheses. Section 3 describes our empirical methodology and sample data. Section 4 presents the results of the empirical analysis. Finally, Section 5 concludes.

2. Related literature and hypothesis development

The managers of rated firms consider credit ratings to be an important indicator of debt decisions (Graham and Harvey, 2001; Kisgen, 2006, 2009); they can also affect managers' investment decisions (Aktas et al., 2018; Campello et al., 2010; Harford and Uysal, 2014; Kim and Shin, 2017). A lower debt capacity (lower credit rating) can prevent firms from realizing the full potential of their investment opportunities (Harford and Uysal, 2014). Therefore, firms with higher credit ratings are more likely to exhaust their potential good (NPV > 0) projects than are firms with lower credit ratings. Campello et al. (2010) show that the policies of management regarding financial constraints change. According to their survey in 2008 (i.e., at the beginning of the global financial crisis), managers responded that they would reduce marketing expenditure, dividend payments, the number of employees, and capital expenditure. In particular, speculative rated firms intended to reduce capital expenditure by 8%, whereas firms with investment grade intended to increase capital expenditure by 0.6%. In addition, the CFOs of financially constrained firms were restricted from investing even though investment opportunities were attractive. The foregoing leads to our first empirical prediction and our first hypothesis:

H1. As ratings improve, managers tend to increase capital expenditure.

Managers strive to manage a minimum rating (Kisgen, 2009). Aktas et al. (2018) propose the managing-for-ratings hypothesis. They argue that if a manager's investment decisions are affected by the firm's credit rating because he/she is seeking to maintain it, the firm is reluctant to make acquisitions; they also argue that this effect is more pronounced for highly rated firms. We do not empirically analyze their hypothesis; rather, we focus on the cut-off grade (BBB-) than on high credit ratings (e.g., AA, AAA).

If managers make decisions based on the minimum rating or target rating, the management of near-BBB firms will not set BB+ as the target (or minimum) rating. Previous studies of downgrading, or the investment grade cut-off, support this assertion. Kisgen (2009) finds that the debt reduction of firms that downgrade from investment grade to speculative grade is twice as large as that of other downgraded firms. However, rating upgrades do not affect debt activity (Kisgen, 2009). Chernenko and Sunderam (2012) also show that speculative rating (BB+) firms are significantly affected by investment activities according to capital flows into high-yield funds compared with investment grade (BBB-) firms. Following their evidence, a downgrade to speculative grade results in an increase in the cost of capital.

The literature on the Korean public market reaction to changes in credit ratings has found that the impact is stronger for downgrades than for upgrades (Jeong and Chung, 2014; Kim and Shin, 2017; Ryu et al., 2013; Sul and Jung, 2017). Jeong and Chung (2014) show that the negative effect of a credit rating downgrade on the market reaction is almost four times larger when a credit rating is downgraded from investment grade to speculative grade in the Korean public market. This implies that the effect of a downgrade on managers' decision making may be more pronounced when their credit ratings are in the BBB interval (BBB+, BBB, BBB-). Therefore, even if the NPV is above zero, and the project may affect the firm's future credit quality positively, managers may be reluctant to invest when the failure of the project could lead to a credit rating downgrade. In addition, the penalty for a downgraded credit rating is more pronounced when the ratings involved are non-investment (or speculative) grade. Sul and Jung (2017) analyze the relationship between credit ratings and firms' lending rates, finding that as credit rating is downgraded, firms' lending rate increases. They also find that the effect of upgraded ratings leading to decreased lending rates is not significant. This means that the effect of upgraded or downgraded credit ratings on firms' lending rate is asymmetric.

Ryu et al. (2013) and Jeong and Chung (2014) show that the market reacts more strongly to a downgrade than to an upgrade. Yi (2016) shows that investors are interested in the BBB grade and investigates the informational value of a credit watchlist. He finds that the proportion of credit watches represented as "down" is greater in Korea than in the U.S. market. The credit watchlist tends to precede credit rating downgrades. In addition, managers may be reluctant to attract this type of monitoring. Kim and Shin (2017) find that a change in investment is negatively affected by downgrades but not by upgrades. The negative effect of a downgrade on the change in capital investment is more pronounced when the rating changes to speculative grade. Overall, downgrading leads to various penalties, which are stronger for speculative grade than for investment grade.

According to U.S. and Korean evidence, a downgrade to speculative grade has more negative changes in firms' value and cost of capital as well as less capital financing ability than other downgrades. In addition, managers are reluctant to monitor because they are intensified or their discretion with respect to financing is reduced. Again, the management of BBB-near firms are unlikely to use BB+ as their target or minimum rating. Therefore, we posit that the probability of a downgrade is considered carefully in the BBB interval compared with in other intervals.

The more debt firms use (or the more leverage increases), the higher is the probability of default and the more default risk is highly related to credit rating. Thus, management of near-BBB firms take fewer risks with debt, which limits debt use. In other words, financial constraints on debt are added because of the proximity of investment grade cut-offs. If there is a constraint on debt financing, firms reduce their investment (Aktas et al., 2018; Harford and Uysal, 2014).

A downgrade to near-BBB can result in a greater financial loss than that to other intervals. Even if near-BBB firms are financing in a different way than bonds, there is a large financial loss if an investment that can downgrade credit ratings fails. They therefore have to be careful about investment decisions (i.e., take conservative investment decisions).

If the potential loss due to a downgrade is large, the risk of the project is high. This effect increases the discount rate when evaluating a project. Therefore, the project estimates of near-BBB firms (e.g., NPV) are likely to be lower than those of other firms. This is not because they lack the ability to implement the project compared with other sectors, but because they are close to the cut-off rating. For example, for the same investment opportunity, if the abilities of the management of a BB-rated firm and a BBB-rated firm and the fundamentals of the two companies are similar, but the project fails, the BBB-near firm will experience a larger financial loss if the credit rating falls.

For these reasons, although near-BBB firms have better creditworthiness than speculative rated firms, they will not increase the scale of investment to the extent of their better debt capacity. This will appear as underinvestment for near-BBB firms. Therefore, although our first empirical prediction is that higher ratings lead to increased investment, we expect this effect to reduce or disappear for near-BBB firms. We thus propose our second, and main, hypothesis:

H2. The effect of credit rating on the capital expenditure of rated firms is positive, whereas the joint effect of credit rating and the dummy variable representing a grade at or near BBB is significantly negative.

We argue that near-BBB firms have additional constraints on debt financing due to the threat of a downgrade to speculative grade and that the discount rate is likely to be high when evaluating a project. If our view affects firms' investment decisions, it will become more apparent in a project where the risk of a downgrade is high. M&A is a relatively large investment. Aktas et al. (2018) state that an acquisition is likely to downgrade credit ratings because it can lead to increased leverage and the associated default risk (Bessembinder et al., 2009; Furfine and Rosen, 2011). Thus, M&A is an appropriate setting in which to confirm our hypothesis.

Harford and Uysal (2014) argue that constrained access to the debt market could lead to underinvestment, which tends to be more value-increasing and less costly (financial constraints hypothesis). Since firms with financial constraints are unable to realize all investment opportunities, they will invest in the highest NPV projects. As a result, they will have a higher average return than firms without financial constraints. When examining the bidder's CAR around an M&A announcement, Harford and Uysal (2014) find that rated firms have a lower CAR for M&A announcements than non-rated firms. Aktas et al. (2018) show that the effect of credit rating on a bidder's CAR is negative, following the financial constraints hypothesis. In addition, if the probability of a downgrade to speculative grade increases the discount rate in a project evaluation, then near-BBB firms are likely to execute more profitable projects than other rated firms. We propose the following:

H3. The joint effect of credit rating and a grade at or near BBB on a bidder's CAR is significantly positive.

3. Methodology and sample data

3.1 Methodology

We use panel data (longitudinal and cross-sectional time-series data) in our empirical tests. The models used are a two-way fixed effects model and a two-way random effects model. We use a Hausman test (Wu–Hausman specification test) to decide between the fixed and random effects models. The null hypothesis of the Hausman test is that the random effects model is preferable. In addition, the standard errors for the parameter are heteroscedasticity-robust and corrected for clustering of the variance–covariance matrix (Wooldridge, 2002, p. 152).

Our first empirical prediction is that credit ratings ($Rating_{i,t-1}$) affect firms' investment ($Invest_{i,t}$) positively. Thus, the first model used to test H1 is as follows:

$$Invest_{i,t} = \beta_0 + \beta_1 Rating_{i,t-1} + \gamma Controlvaiables_{i,t-1} + \mu_i + \upsilon_t + \epsilon_{i,t} \quad (1)$$

The control variables used in equation (1) are introduced in Section 3.3. Our main hypothesis (H2) predicts that as credit ratings improve, the investment of rated firms increases. whereas the positive effect of ratings decreases when the rating is at or around BBB. As the BBB grade is an investment grade, it is relatively stable. However, BBB-near firms tend to reduce their investment according to H2 and the related literature. Therefore, ratings ($Rating_{i,t-1}$) and the near-BBB dummy variable ($BBBnear_{i,t-1}$) have a positive effect on investment ($Invest_{i,t}$), whereas the joint effect of ratings and the near-BBB dummy variable ($BBBnear_{i,t-1} * Rating_{i,t-1}$) has a negative effect:

$$\begin{aligned} Invest_{i,t} = {} & \beta_0 + \beta_1 Rating_{i,t-1} + \beta_2 BBBnear_{i,t-1} + \beta_3 BBBnear_{i,t-1} Rating_{i,t-1} \\ & + \gamma Controlvaiables_{i,t-1} + \mu_i + \upsilon_t + \epsilon_{i,t} \end{aligned} \quad (2)$$

To test H3, we analyze the relationship between a bidder's CAR and credit rating variables. However, our M&A sample is limited to 188 observations to satisfy the specific characteristics of M&A transactions and firms (see Section 3.2). In addition, some bidder samples were not observed more than once, which is unsuitable for panel analysis. Therefore, we use a pooled OLS regression and a year dummy to control for time, but we cannot use industry dummy variables because some industries had fewer than two observations. The pooled OLS model used for the hypothesis testing is as follows:

$$\begin{aligned} CAR_{i,t} = {} & \beta_0 + \beta_1 Rating_{i,t-1} + \beta_2 BBBnear_{i,t-1} + \beta_3 BBBnear_{i,t-1} Rating_{i,t-1} \\ & + \lambda M\&Avariable_{i,t} + \gamma Controlvariables_{i,t-1} + \varphi Year_{i,t} + \epsilon_{i,t} \end{aligned} \quad (3)$$

In equation (3), the bidder's CAR ($CAR_{i,t}$) is calculated using a market-adjusted model. This model is suitable for M&A because firms can participate in another M&A during the estimation period

(Bouwman et al., 2009). For market returns, we use the value-weighted portfolio of all public firms in Korea. In some cases, the same firm is involved in several M&As at the same time. If a firm has more than two M&A transactions at the announcement date, we omit the M&A transaction from the sample. In addition, if a firm has more than two M&A transactions in a month, we use the first transaction only. We found 4,899 transactions in which the bidder was a public firm and 324 transactions were deleted based on the abovementioned criteria. We add the characteristics of M&A transactions into equation (3) following empirical studies. Finally, if the results of equation (3) support H3, the coefficient of ratings (β_1) will be negative and the joint effect of ratings and the near-BBB dummy variable (β_3) will be positive.

3.2 Sample data

Our sample includes Korean public firms and Korean domestic M&As between 2001 and 2017. We use FnGuide for the credit rating data and financial and accounting data and use Thomson Reuter's Securities Data Corporation's database for the M&A announcement data. We exclude sample firms with no reported financial data, which are required for our empirical tests. We also exclude firms in the financial and insurance industries (KSIC 64–66). We use stock price data, and exclude firms with fewer than 150 price observations in the fiscal year. To be eligible for the analysis, the M&A deals must meet the following conditions: bidders had to be public and rated firms; deals had to be completed; the deal's announcement date had to occur between January 1, 2002 and December 30, 2017; deals had to have a reported transaction value of more than 1 million dollars; acquirers had to own less than 50% of the target before the deal occurred and more than 50% thereafter; acquirers had to have the required basic financial and accounting data (i.e., credit rating, financial and accounting data, and stock price data); and the bidder and target had to have different parent firms. The final panel dataset comprises 2,633 observations and the M&A dataset comprises 188 events.

3.3 Variables

Our basic empirical test focuses on the relationship between the credit rating and investment decisions of rated firms. Thus, our main variables are investment and credit rating. We measure capital investment following Kim and Shin (2017). The credit ratings of rated firms range from AAA to D and the grades include the + and - qualifiers. The total number of possible ratings is 20. We assign "20" to AAA and "1" to D in descending order. The variables are defined in Appendix 1.

We use several control variables following the literature. Lee et al. (2012) analyze the relationship between firms' investment activity and the financial index in the Korean market. They find that return on assets (ROA) and the growth rate of sales have significantly positive effects on investment activity and that leverage has a significant negative effect. Lee (2007) finds that the growth rate of sales and operating cash flow affect investment activity positively. Ban et al. (2012) find that R&D expenditure has a positive effect on investment activity. Among studies conducted in other countries, To et al. (2018) analyze the effect of financial analysts on firms' investment decisions, using control variables for size, leverage, the market-to-book (M/B) ratio, asset growth, cash flow, and ROA. Aivazian et al. (2005) find that firms' cash flows are important for capital expenditure. Further, a firm's dividends can have a negative effect on investment decisions (Brav et al., 2005; Fazzari et al., 1988). Therefore, we control for the firm's size, leverage, growth opportunity, cash, sales, ROA, dividends, and R&D expenditure in our empirical model using control variables.

In equation (3), we use variables related to the characteristics of M&A deals to control for their effect on the bidder's CAR. Because the M&A payment method can affect returns (Chang, 1998; Fuller et al., 2002), we use a cash dummy variable (Harford and Uysal, 2014; Kim, 2018), which takes 1 if the payment is only cash and 0 otherwise. Second, we use a tender offer dummy variable to reflect related agency costs, following Ahern (2012) and Kim (2018). The public status of firms and relation between the transaction value of the M&A and acquirer's size have been controlled for in previous empirical analyses (Aktas et al., 2018; Harford and Uysal, 2014; Kim, 2018). However, we cannot use the number of bidders, indicating the bidding competition (Ahern, 2012; Kim, 2018) or takeover defenses (Ahern, 2012) because the data are not observable for our sample. The number of bidders in M&A transactions is set to 1, and no defense methods such as poison pills or defensive recapitalizations are considered. We add to the firm's financial and accounting variables those related to fixed assets and the scarcity of the firm's product following Ahern (2014) and Kim (2018). These variables are defined in Appendix 1.

3.3 Summary statistics

Table 1 presents the summary statistics for the financial and accounting variables. The measure of firms' investment activity is capital expenditure in fiscal year *t*. Other variables represent the value of year *t*-1. Table 1 shows that the mean of *Invest* (i.e., capital expenditure / tangible assets) is -0.122 and the median is 0.1038. Some of the variables are more than double the difference between the mean and median. Therefore, we winsorize the variables from the top 5% and bottom 5%. Even when we test our hypothesis using the raw data, the results are similar (see also Table 5).

Table 2 reports the Pearson correlations among the variables. First, *Invest* has significantly positive correlations with *Rating, Size, Cash_incre, ROA, Salesgrow_ratio, R&D_ratio*, and *Dividend_ratio* but a negative correlation with *Leverage*. The positive correlation between capital investment (*Invest*) and credit rating (*Rating*) is relevant to our hypothesis. This result is similar to that in Kim and Shin

(2017). However, the positive correlation with *Dividend_ratio* does not seem to match the results of previous studies predicting that dividends affect firms' investment activity negatively (Brav et al., 2005; Fazzari et al., 1988). Table 2 shows that credit rating (*Rating*) seems to have a strong correlation with the other variables. Specifically, the Pearson correlation between credit rating and firm size is 0.723. This value is above the threshold of 0.5. This occurs because credit rating agencies conduct financial analyses using financial and accounting data to evaluate a firm's credit status. For example, in Griffin et al.'s (2018) analysis of the effects of firms' innovative efficiency on credit ratings, a Pearson correlation test using data on U.S. firms shows that credit rating's correlation with size and leverage is above 0.5. Thus, considering the potential multicollinearity problem, we calculate the variance inflation factor (mean = 1.596 and maximum = 3.079). Therefore, we consider that these correlations are suitable for the analysis.

Our main proposal is that the relationship between firms' investment activity and credit ratings may vary depending on the credit rating interval. Table 3 presents the distribution of the credit ratings of the samples used in the empirical test and summary statistics for capital investment (*Invest*) by credit rating.

In Table 3, we divide credit ratings into four intervals following the definitions of issuer ratings by the Korea Investors Service (an affiliate of Moody's investor service). The "Very High" interval ranges from AAA to AA-, which indicates a very strong capacity for timely repayment. The "Stable" interval ranges from A+ to BBB-, which indicates a strong capacity for timely repayment but warns that adverse changes in circumstances may impair capacity. The "Uncertain" interval ranges from BB+ to B-, which indicates that capacity is uncertain. The "Default" interval ranges CCC to D, which indicates a high credit risk or insolvency. The "Stable" interval is observed in 1,523 firms, the largest number in the sample. Speculative grade accounts for 18.22% of the sample. The mean and median of *Invest* seem to increase relatively steadily as credit ratings improve, whereas its standard deviation decreases steadily. However, the mean and median of *Invest* for BBB-rated firms are lower than those for BBB- and BB+ firms.

4. Results

4.1 Baseline results (H1)

This study supports the view that the credit rating of a rated firm indicates its financial constraints and debt capacity. We assume that more highly constrained firms tend to invest less than unconstrained firms because it is difficult to realize good projects (NPV > 0) even if the circumstances are otherwise favorable. Thus, our first prediction is that the effect of credit rating on firms' capital investment (*Invest*) is significantly positive. Table 4 summarizes the results of this prediction.

The coefficient of credit rating has a significance of 0.003 in model (1) of Table 4. The other models using subsamples by specific credit intervals show that the coefficients of credit rating are positive but significant only in the Stable and Invest intervals. These results support our first empirical prediction but show a weaker relationship than expected. For the control variables, we predict that *Size, M/B ratio, Cash_incre, ROA, Sales*, and *R&D* have positive effects and that *Leverage* and *Dividend* have negative effects on firms' investment activity following the literature. These results are in line with our expectations, but are significant only for *Salesgrow_ratio, R&D_ratio*, and *ROA*. Previous studies of the Korean public market show that the effects of these features on investment activity are as follows: the growth rate of sales is positive (Lee, 2007), leverage is negative (Lee et al., 2012), and R&D expenditure is positive (Ban et al., 2012). However, our result for ROA differs from that in Lee et al. (2012), who show a negative effect. We argue that a firm with high profitability is more likely to invest in a new project than a lower-profitability firm.

While no studies, to the best of our knowledge, have directly examined the relationship between capital investment and credit ratings, the effects of our control variables on investment activity are similar to those seen in research from other countries. Using Canadian data, Aivazian et al. (2005) show that the effect of leverage (the M/B ratio) on capital expenditure is negative (positive). Using U.S. data, To et al. (2018) use productivity as a proxy for the quality of firms' investment decisions and show that size, ROA, asset growth, and cash flow have positive effects on productivity. In addition, Brav et al. (2005) find that a firm's dividends can have a negative effect on its investment decisions.

Collectively, the results of our control variables are similar to those in the literature. Our prediction is shown to be valid even when we control for several of firms' financial and accounting characteristics. If we do not control for a firm's financial and accounting features, the coefficient of the ratings in the panel regression is 0.011, significant at the 1% level.

4.2 Results for the panel regression (H2)

Our main hypothesis (H2) is that the effect of credit rating on the capital expenditure of rated firms is positive, whereas the joint effect of credit rating and a dummy variable representing proximity to near-BBB grade is significantly negative. Table 5 reports the results of the panel regression for this proposal. The results of model (1) in panel A support H2. The coefficient of credit rating (*Rating*) is significant (0.003). This means that as credit ratings improve, firms' capital expenditure (or investment activity) increases. However, the joint effect of ratings and the near-BBB dummy is significantly negative (-0.012). This result also supports H2. Therefore, we posit that managers tend to increase investments as credit ratings improve; however, when firms near a BBB rating, they tend to underinvest rather than increase their average investment as credit rating increases.

Previous studies of the Korean market show that the penalty for investors' reactions to rating changes depends on the market environment. Lee et al. (2015) analyze the effect of the weighted average cost of capital on investment activity, finding that the investment behavior of small and medium-sized firms changed before and after the 2008 financial crisis. According to the data examined by Sul and Jung (2017), firms' lending rate was more than 1% higher during the financial crisis period than in other periods. In addition, the rate change due to a credit rating change is found to have been greater during the financial crisis. They also find that the effect of a change in credit rating on firms' lending rate is more pronounced in small and medium-sized firms. In the Korean market, the KOSDAQ mainly lists small and medium-sized firms and venture companies in contrast to the KOSPI. Therefore, we should consider the financial crisis and distinctiveness of the KOSDAQ. To address these concerns, we tested subsamples for the non-financial crisis period and non-KOSDAQ firms. Models (2) and (4) in panel A of Table 5 report the results of these subsamples. Specifically, model (2) presents the results of the subsample for the period excluding the financial crisis and model (4) contains only the public firms in the KOSPI market. These panels show that the results of the subsample are similar to the results of the full sample.

The results of the raw data before being winsorized (model (5)) are less significant even though the direction of the coefficient is the same as in the results of the full sample. For the control variables, the coefficients have the same direction and significance as those in our baseline results in Table 4. Therefore, the results in panel A of Table 5 indicate that the joint effect of ratings and near-BBB status are consistent except for during the financial crisis period.

One interesting result shown in panel A of Table 5 is that the absolute value of the coefficient of credit rating is less than the absolute value of the coefficient of the interaction variable between credit rating and the near-BBB dummy. This finding suggests that when a firm nears the BBB grade, as its credit rating improves, the trend of increasing capital investment reverses. When we test the same panel regression for only the BBB+ to BB+ interval (i.e., dropping the 28 sample firms used for the fixed effects), reducing the total number of this interval's sample to 730, the coefficient of the rating is -0.0078. This is similar to the sum (-0.009 = 0.003 - 0.012) of the coefficients of the rating and interaction variables (*Rating*near*) in model (1) shown in panel A of Table 5. Therefore, the joint effect of ratings and near-BBB status is stronger than expected.

In addition, we tested a broader interval for near-BBB status. The near-BBB dummy variable in panel B of Table 5 indicates that the credit ratings belong to the BBB+ to BB- interval. The results are similar to those in panel A of Table 5. However, the significance of the coefficient of the interaction variable (*Rating*near)* is diminished in models (2), (3), and (5). This means that the joint effect of credit rating and the rating interval is pronounced when the ratings are closest to the BBB grade.

Collectively, the results of Table 5 show that rated firms tend to consider their credit rating in their investment decisions. The effect of credit ratings on capital investment increases with improved ratings, whereas the effect is diminished when such ratings are close to the BBB grade. Our hypotheses would be strengthened if this diminished effect cannot be found for the other intervals.

Table 6 presents the results of the panel regression to test the joint effect of credit rating and the other credit intervals on investment activity. If our hypotheses are supported, the negative coefficient of the joint effect (*rating*interval*) would not be found in the other intervals. The definitions of the interval dummy variables in models (1)–(5) are that the credit ratings belong to AAA to AA- (Very high), A+ to BBB- (Stable), BB+ to B- (Uncertain), BB to B (*BB_near*), and B to CC (*B_near*), respectively. The coefficients of the interaction variables (*Rating*Interval*) are positive in models (1), (3), (4), and (5). This means that the joint effect of the credit rating and credit interval are different from that seen in the near-BBB interval in Table 5. Therefore, the tendency of rated firms to underinvest appears only when their credit ratings are close to BBB. Model (2) of Table 6 shows that the coefficient of the interaction variable is negative, but not significant (and this interval dummy contains the BBB category). Thus, H2 is supported by these results. The coefficients of the control variables in model (1) of Tables 5 and 6 are moving in the same direction and have the same significance level. The values of these coefficients are all similar.

4.3 Results for the matching sample analysis (H2)

Our main result in Table 5 is that near-BBB firms see a statistically significant reduction in the positive relationship between credit ratings and investment. Although Table 6 shows that these results do not appear in the other rating intervals, near-BBB firms still may have different characteristics and investment opportunities from firms in the other intervals. Therefore, we use the near-BBB (BBB+, BBB, BBB-, BB+) sample (treatment group) and match it with the near-A (AA-, A+, A, A-) sample (control group). We use the upper rating interval as the control group because our argument is related to underinvestment and it is robust to match with companies with less financial constraints than near-BBB firms. For the average of investment rate, the near-A sample is 0.127, whereas the near-BBB sample is 0.096.

In the matching procedure, we use size, leverage, the M/B ratio, ROA, the R&D ratio, the dividend ratio, and PCM as the matching variables because these have high explanatory power for whether a firm belongs to the near-BBB interval. We use the Mahalanobis distances among the firms within the same industry as the matching method. In our sample, there are 758 near-BBB firms and 1137 near-A firms. When matching them, we narrow the closeness of the matched samples using the pooled estimate of common standard deviations to show the consistency of the results. We use

SAS program's *caliper = r* option, which means r times the pooled estimate of the common standard deviation. We obtain three matched samples based on caliper values of 1, 0.2, and 0.1. Following Austin (2011), about 99% of the bias associated with the measured confounders can be reduced using 0.2.

Table 7 shows that the difference in *Invest* between the treatment group (near-BBB) and control group (near-A) narrows in the matched sample. In the matched samples using caliper = 1, the absolute value of the difference between the groups among the nine variables is larger than that of the raw sample for only the *Cash_incre* variable. In the matched samples using caliper = 0.1, the differences are also close. Therefore, we can conclude that the matched samples have similar firm characteristics between the two groups.

In model (3) of Table 8, the effect of credit ratings on investment is positive at the 5% significance level. However, the interaction variable between the near-BBB dummy and credit rating indicates a significant negative effect at 10%. This is similar for models (1) and (5). However, we had to remove about 10% of the samples (45 of 490) from model (5) in Table 8. To compensate for this problem, a pooled OLS analysis was performed. In model (6) of Table 8, the sign of credit rating and the near-BBB dummy are the same as in model (5) of Table 8, but the significance disappears. However, the interaction variable shows a significant negative effect at the 10% level. Models (2) and (4) in Table 8 show the pooled OLS results. In model (2) of Table 8, the interaction variable has a significant negative effect on investment. In model (4) of Table 8, the sign of the joint effect is negative but not significant. However, since these results are generally similar to those of model (1) in Table 5, we can say that the main result is also robust in the matched sample. Although the results of Table 8 are weakly significant, this is because we did not use the full sample unlike in Table 5. Rather, we analyzed the relationship between credit rating and investment using only the near-BBB and near-A samples (i.e., eight credit ratings).

4.4 Results for the rank biserial correlation for each credit rating dummy

In this section, we report the statistical association between investment and the credit rating dummies. So far, we have used the ordinal variable (*Rating*), which has a value from 1 to 20 for credit rating. However, the credit rating categories are not equally spaced because the size of the difference between categories is inconsistent. BBB- and BB+ are divided into investment grade and speculative grade, whereas BBB and BBB- represent merits and demerits within the BBB category (i.e., within a homogeneous range of credit ratings). For each rating dummy, we thus calculate the rank biserial correlation to confirm the relationship between credit rating and investment non-parametrically.

In column 4 of Table 9, the rank biserial correlation coefficient shows a significant positive correlation with investment for the A+ to AAA categories. For example, if firms belong to the A+ category, they are higher than other rated firms. However, the A- dummy shows a negative correlation. The A category shows strong capacity but this is more vulnerable to adverse changes in economic conditions than the higher rating categories by the Korea Investors Service. In addition, A- is the seventh highest rating. Therefore, when they belong to A-, it is doubtful that investment is less than that for rated firms that are not A-.

Columns 2 and 3 of Table 9 show the distribution of rated firms. Rated firms belonging to categories higher than A- comprise 45% of all rated samples and 43.1% of samples lower than A-. If the value of the A- dummy is 0, the higher rating sample is more than the lower rating sample, based on A-. These characteristics confuse the interpretation of the relationship between creditworthiness and investment, which is presented as credit rating. Nonetheless, except for the four dummies (AA, BBB-, BB+, and B), the relationships between each category and investment are statistically significant and linear. In addition, except for B+ and C, the coefficients start to increase gradually from –0.605 for the D dummy to 0.373 for the AAA dummy. The result in column 5 of Table 9 also supports this. For example, the coefficient of the BBB dummy is -0.183, which means that when belonging to the BBB rating, investment is significantly lower than that for the other firms that have a higher rating than BBB. These results show the statistical association between a firm's credit rating and investment.

The results in column 6 of Table 9 are not significant as expected. This column shows the rank biserial correlation between investment and whether a firm belongs to a category (dummy), using only two rating categories. For example, if firms belong to AAA, their investment is higher than that of other firms (i.e., lower than AAA). In column 8 of Table 9, the dummies representing BB, BBB, A, AA, and AAA have positive correlations with investment. This means that rated firms belonging to each interval receive more investment than those belonging to an interval one level below. Even BBB and BB are classified into investment grade and speculative grade, but the positive coefficient of BBB is the lowest.

Thus, we can confirm that a firm's creditworthiness represented by credit rating has a statistical association with investment. Using the dummies for firms with a high rating, we find that their investment is higher than those with low ratings. In particular, the result in column 8 of Table 9 indicates that investment in BBB is higher than that in BB, while this relationship is weaker than that in the other intervals.

4.5 Results for the non- and semi-parametric tests (H2)

We showed in Sections 4.2 and 4.3 that near-BBB firms weaken the positive relationship between investment and credit rating (H2), or this relation disappears altogether. This finding suggests that there may be a non-linear relationship between credit rating and investment. To illustrate this, we show smoothing component plots produced using generalized additive models and LOESS.

Figure 1 shows two plots produced by the generalized additive model using a cubic smoothing spline. The left plots in Figure 1 show that the smoothing component decreases from Rating 10 (BB+) and then increases after Rating 14 (A-). The right plots in Figure 1 show that the additive components increase linearly with credit rating, whereas they decrease from Rating 10 (BB+) to Rating 14 (A-) and then begin to show a linear trend again. These results support that the positive relation between investment and credit rating reduces or disappears in the interval (BBB+, BBB, BBB-, BB+).[3]

Figure 2 shows the smoothing component plots using a semi-parametric spline. We use smooth functions only for credit rating, and the model contains the parametric functions of all the variables used in the empirical analysis. The left plots in Figure 2 show that the smoothing component decreases from Rating 10 (BB+) and then increases after Rating 14 (A-), similar to Figure 1. However, the right side of Figure 2 has no linear trend. This result indicates that controlling for the parametric effect of the variables weakens the linear relationship between credit rating and investment. Instead, a negative relation appears for near-BBB firms, supporting H2. In Section 4.1, we mentioned that in the panel regression, which does not include the control variables, the linear relationship between investment and credit rating becomes stronger.

The left plot of Figure 3 shows that the LOESS smoother decreases after Rating 10 (BB+) and then increases after passing Rating 14 (A-). Although it decreases again from Rating 17 (AA-), the smoother maintains a positive value. The plot on the right side of Figure 3 shows a positive linear trend from Rating 1 (D) to Rating 11 (BBB-), while the linear trend disappears from Rating 12 (BBB) to Rating 14 (A-).

In summary, the non-parametric and semi-parametric models show a positive relationship between investment and credit rating, whereas the relationship decreases (Figure 1) or disappears (Figure 3). In addition, Figure 2 shows a negative relationship for near-BBB firms. These results are consistent with our view that investment decisions differ by rating interval because near-BBB firms feel a greater risk related to the probability of a downgrade to speculative grade than firms in other segments.

4.6 Bidder's CAR and credit rating

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[3] We checked the functional form of the relationship between investment and credit rating parametrically by adding *Rating* squared (quadratic function) and *Rating* cubed (cubic function). However, *Rating* squared (estimate = -0.00122) and *Rating* cubed (estimate = 0.00004) were not statistically significant.

So far, our results show that rated firms tend to reduce their capital investment when their ratings are close to BBB. For the empirical test for H3, we use a sample of 188 observations (see Sections 3.1 and 3.2). Table 10 shows that the announcement returns of rated acquirers are favorable. According to the free cash flow hypothesis, firms with less financial constraints (high ratings) are more likely to be value-decreasing (or have agency problems). In this case, the cumulative average abnormal return (CAAR) of firms with the highest grade (or investment grade) should be negative. In this regard, Harford and Uysal's (2014) argue that the positive CAAR of rated acquirers cannot be explained by the free cash flow hypothesis. Similar to them, our results show that rated firms' CAAR is 0.021, significant at the 1% level. As shown in Table 10, the CAAR is larger in the order BBB_near1 (0.033), BBB_near2 (0.030), Full (0.021), and > BBB+ (0.013). BBB_near1 and BBB_near2 are the same intervals as in Table 5 where our main hypothesis is tested. This evidence shows that high rated acquirers are not value-decreasing on average. Rather, confirming our hypothesis, BBB-near firms had the highest returns. If near-BBB firms' high returns are the result of preventing a value decrease through financial constraints (or effective monitoring), this should be stronger in speculative grade where credit monitoring is more severe and financial constraints are higher. However, no such evidence was found, confirming our view that near-BBB firms have additional financial constraints for debt financing and an increased discount rate for evaluating potential projects because of the probability of a downgrade to speculative grade.

The results of the pooled OLS (see Table 11) support H3. The results of models (1) and (4) in Table 11 show that the joint effects of credit rating and near-BBB status are significantly positive. However, the coefficients of credit rating are close to 0 in all the models in Table 11 in contrast to Harford and Uysal (2014) and Aktas et al. (2018). The results in Table 4 show that the effect of credit rating on capital investment is positive but less significant (10%). We argue that Korean firms have less of a tendency to increase investment because of improved ratings than seen in the U.S. market. Therefore, the effect of credit ratings on the bidder's CAR is negligible in the Korean market.

We also analyze subsamples reflecting the 2008 global financial crisis and difference in the KOSDAQ, in line with the results of related studies in the Korean market. Models (2) and (5) of Table 11 represent the subsample for the non-crisis period and models (3) and (6) of Table 11 represent the non-KOSDAQ (i.e., KOSPI) subsample. In these models, we find that the coefficients of the interaction variable between credit ratings and the near-BBB dummy variables are significantly positive, similar to the results for models (1) and (4) of the full sample. We thus use many control variables to address the effects of other characteristics on bidders' CAR in line with related empirical studies (see Section 3.2).

5. Conclusion

Our baseline analysis examines the relationship between firms' investment activity and credit rating. Our main argument is that BBB-near firms are likely to passively invest because the probability of downgrading their credit rating is a greater risk to them than to other rated firms. Following the literature, a downgrade to speculative grade is more penalized than other downgrades. Thus, near-BBB firms have additional constraints on debt financing and a higher minimum attractive rate of return for potential projects, which can downgrade their credit rating. We argue that their investment decisions are therefore passive. As a result, their capital investment shows that they do not increase the scale of investment to the extent of their better debt capacity. In addition, their investments are likely to be more profitable than those of other rated firms. The results of our empirical tests support our argument. Therefore, we conclude that the managers of rated firms consider credit ratings in their investment decisions and that this behavior varies when the firm's rating is at or near BBB. Our evidence shows that these firms tend to reduce their capital investment because of the threat of a downgrade to speculative grade.

This study adds to previous research showing that the managers of rated firms consider credit ratings in their investment decisions. Further, managers who consider credit ratings in their decision making may behave differently based on their firm's credit rating. This behavior may then affect the quantity of their investments as well as the return on investment, indicating that managers adjust their decisions to maintain their firm's target credit rating.

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Appendix 1. Variable definitions

Invest = (ending tangible assets – beginning tangible assets + depreciation of tangible assets) / lagged tangible assets

CAR = five-day CAR around the M&A announcement date (-1, +3). We use the adjusted market model and value-weighted portfolio of public firms in the Korean market

Rating = takes 20 to AAA, 19 to AA+,..., and 1 to D sequentially

Size = natural log of market capitalization

Leverage = total debt / total assets

M/B ratio = (book value of debt + market value of equity) / total assets

Cash_incre = (ending cash holding – beginning cash holding) / total assets

ROA = net profit / total assets

Salesgrow_ratio = (sales – lagged sales) / lagged sales

R&D_ratio = R&D expenditure / total assets

Dividend_ratio = (cash dividend + stock dividend) / operating profit

D_public = takes 1 if target is a public firm and 0 otherwise

D_cash = takes 1 if the method of payment in M&A is only cash and 0 otherwise

D_tender = takes 1 if the deal is a tender offer from Thomson Reuter's Securities Data Corporation and 0 otherwise

Rel_value = transaction value of M&A / bidder's total assets

collateral = (property assets + plant and equipment assets) / total assets

PCM = (sales – costs of sales – expenses of general and administrative) / sales

Table 1. Summary statistics

	Raw Data		Winsorized (5%) Data				
	Mean	Median	Mean	Median	Std	Min	Max
Invest	-0.1225	0.1038	0.1101	0.1038	0.171	-0.322	0.440
Size	26.8048	26.6957	26.8033	26.696	1.786	23.85	30.04
Leverage	0.5953	0.6064	0.5953	0.6064	0.175	0.087	2.215
M/B ratio	1.0414	0.9223	0.9175	0.8923	0.299	0.113	1.870
Cash_incre	0.0041	0.0020	0.0041	0.0020	0.0295	-0.0562	0.0682
ROA	0.0089	0.0231	0.0173	0.0231	0.060	-0.148	0.113
Salesgrow_ratio	0.1262	0.0624	0.0873	0.0624	0.200	-0.262	0.588
R&D_ratio	0.0050	0.0008	0.0039	0.0008	0.006	0.000	0.022
Dividend_ratio	0.1120	0.0701	0.0957	0.0701	0.102	0.000	0.351

Table 2. Pearson correlations among the variables

	Invest	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Rating	0.227								
	(0.00)								
(2) Size	0.176	0.723							
	(0.00)	(0.00)							
(3) Leverage	-0.211	-0.366	-0.107						
	(0.00)	(0.00)	(0.00)						
(4) M/B ratio	0.003	0.019	0.179	0.150					
	(0.87)	(0.58)	(0.00)	(0.00)					
(5) Cash_incre	0.069	0.042	0.043	-0.038	-0.028				
	(0.00)	(0.03)	(0.03)	(0.05)	(0.15)				
(6) ROA	0.310	0.528	0.330	-0.446	-0.067	0.147			
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
(7) Salesgrow_ratio	0.178	0.111	0.045	-0.056	-0.001	0.137	0.266		
	(0.00)	(0.00)	(0.02)	(0.00)	(0.96)	(0.00)	(0.00)		
(8) R&D_ratio	0.127	0.079	0.173	-0.115	0.120	0.008	0.042	0.015	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.67)	(0.03)	(0.43)	
(9) Dividend_ratio	0.135	0.406	0.177	-0.373	-0.030	0.001	0.380	0.028	0.027
	(0.00)	(0.00)	(0.00)	(0.00)	(0.12)	(0.96)	(0.00)	(0.15)	(0.16)

p-values are reported in parentheses.

Table 3. Distribution of credit ratings

		Credit rating		Capital expenditure (*Invest*)		
		Observation	Distribution (%)	Mean	Std.	Median
INVEST	Very high (obs: 630, ratio: 23.23%)					
	AAA	85	3.23	0.1997	0.1074	0.1780
	AA+	99	3.76	0.1422	0.1151	0.1161
	AA	178	6.76	0.1515	0.1191	0.1469
	AA-	268	10.18	0.1555	0.1415	0.1405
	Stable (obs: 1523, ratio: 57.84%)					
	A+	264	10.03	0.1470	0.1387	0.1299
	A	291	11.05	0.1126	0.1719	0.1060
	A-	314	11.93	0.1007	0.1456	0.0895
	BBB+	221	8.39	0.0942	0.1664	0.0884
	BBB	260	9.87	0.0929	0.1685	0.0722
	BBB-	173	6.57	0.1049	0.1917	0.1071
SPECULATIVE	Uncertain (obs: 413, ratio: 15.68%)					
	BB+	104	3.95	0.0937	0.2047	0.1031
	BB	113	4.29	0.0575	0.2198	0.0485
	BB-	81	3.08	0.0728	0.1533	0.0502
	B+	39	1.48	-0.0177	0.2338	0.0112
	B	33	1.25	0.0499	0.2895	0.0385
	B-	43	1.63	0.0308	0.2356	0.0435
	Default (obs: 67, ratio: 2.54%)					
	CCC	39	1.48	0.0169	0.2376	0.0134
	CC	4	0.15	-0.1738	0.1377	-0.1867
	C	16	0.61	0.0186	0.1644	0.0412
	D	8	0.3	-0.0773	0.2566	-0.0438

Distributions of intervals over the full sample are reported in parentheses

Table 4. Effect of credit ratings on capital expenditure

	Random Effects Model			Fixed Effects Model		
	Full sample	Very high	Uncertain	Stable	Invest	Non-invest
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.027	0.062	0.131			
	(0.34)	(0.31)	(0.42)			
Rating	0.003*	0.006	0.008	0.012*	0.01**	0.008
	(1.83)	(0.91)	(0.84)	(1.75)	(2.07)	(1.11)
Size	0.002	-0.001	-0.001	-0.001	-0.004	-0.012
	(0.68)	(-0.1)	(-0.05)	(-0.12)	(-0.5)	(-0.4)
Leverage	-0.073**	-0.07	-0.156**	-0.129	-0.139**	0.116
	(-2.22)	(-1.56)	(-2.08)	(-1.6)	(-2.37)	(0.87)
M/B ratio	0.000	0.022**	-0.02	0.00	0.012	-0.06
	(0.04)	(2.12)	(-0.4)	(-0.01)	(0.9)	(-1.03)
Cash_incre	0.101	-0.097	0.171	0.093	0.028	0.117
	(0.87)	(-0.52)	(0.48)	(0.69)	(0.26)	(0.29)
ROA	0.552***	0.661***	0.387**	0.428***	0.437***	0.549***
	(6.58)	(3.48)	(2.07)	(3.05)	(3.81)	(2.66)
Salesgrow_ratio	0.079***	0.094***	0.065	0.054*	0.069***	0.023
	(3.7)	(2.8)	(1.3)	(1.76)	(2.77)	(0.45)
R&D_ratio	2.234***	1.684*	1.592	2.582	0.892	3.298
	(4.16)	(1.67)	(0.89)	(1.46)	(0.74)	(0.85)
Dividend_ratio	-0.016	-0.067	0.199	-0.065	-0.069	0.431*
	(-0.43)	(-1.07)	(0.88)	(-1.02)	(-1.35)	(1.73)
N	2633	624	392	1509	2146	465
Hausman m	6.16	0.81	9.85	28.2	28.72	22.99
	(0.724)	(0.99)	(0.363)	(0.00)	(0.00)	(0.00)

The p-values are adjusted for heteroscedasticity and for clustering by firm. The z-statistics are reported in parentheses. Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Joint effects of credit rating and neighborhood of BBB grade on investment

Panel A. BBB_near: BBB+ to BB+

	Full sample	Not crisis	Crisis	Not KOSDAQ	Not winsorized
	(1)	(2)	(3)	(5)	(6)
Constant	0.002	-0.078		-0.006	-4.105*
	(0.02)	(-1.05)		(-0.08)	(-1.88)
Rating	0.003*	0.003*	0.021	0.004**	0.078**
	(1.92)	(1.87)	(0.64)	(2.57)	(2.12)
BBB_near	0.152**	0.155*	-1.335*	0.193**	3.105*
	(2.02)	(1.89)	*(-2.15)	(2.22)	(1.9)
Rating*near	-0.012**	-0.012*	0.102**	-0.015**	-0.229*
	(-2.01)	(-1.83)	(2.00)	(-2.18)	(-1.68)
Size	0.003	0.006*	-0.057	0.002	0.101
	(0.93)	(1.82)	(-0.89)	(0.48)	(1.53)
Leverage	-0.074**	-0.05	0.449	-0.069**	-0.214
	(-2.19)	(-1.4)	(1.01)	(-2.26)	(-0.29)
M/B ratio	0.000	-0.008	-0.121**	0.016	0.125
	(0.01)	(-0.7)	(-2.52)	(1.28)	(1.26)
Cash_incre	0.104	0.081	0.241	0.109	0.969
	(0.9)	(0.69)	(0.38)	(0.99)	(0.98)
ROA	0.543***	0.498***	0.546	0.598***	0.371
	(6.47)	(5.61)	(0.81)	(6.07)	(0.56)
Salesgrow_ratio	0.079***	0.081***	-0.321**	0.08***	0.329
	(3.7)	(3.55)	(-1.99)	(3.29)	(1.41)
R&D_ratio	2.22***	2.579***	1.879	2.38***	9.705***
	(4.13)	(4.83)	(0.13)	(4.47)	(2.6)
Dividend_ratio	-0.012	-0.023	-0.399	-0.013	0.001
	(-0.32)	(-0.67)	(-1.21)	(-0.35)	(0.73)
Observation	2633	2304	228	2281	2633
Hausman m	7.60	7.68	39.0	12.24	0.47
	(0.75)	(0.74)	(0.00)	(0.35)	(1.00)

Panel B. BBB_near: BBB+ to BB-

	Full sample	Not crisis	Crisis	Not KOSDAQ	Not winsorized
	(1)	(2)	(3)	(4)	(5)
Constant	-0.02	-0.085		-0.046	
	(-0.24)	(-1.08)		(-0.54)	
Rating	0.003**	0.003**	0.005**	0.005***	0.031
	(2.12)	(2.01)	(2.07)	(2.91)	(0.43)
BBB_near	0.08*	0.054	0.049	0.13***	1.763
	(1.79)	(1.09)	(0.59)	(2.7)	(1.55)
Rating*near	-0.006*	-0.004	-0.005	-0.01**	-0.116
	(-1.74)	(-0.97)	(-0.8)	(-2.49)	(-1.27)
Size	0.004	0.006*	-0.005	0.003	0.26
	(1.05)	(1.77)	(-0.62)	(0.74)	(1.28)
Leverage	-0.076**	-0.051	-0.031	-0.07**	-0.312
	(-2.18)	(-1.39)	(-0.43)	(-2.32)	(-0.2)

M/B ratio	0.000	-0.008	0.009	0.016	0.033
	(0.01)	(-0.65)	(0.58)	(1.25)	(0.17)
Cash_incre	0.107	0.083	-0.012	0.11	-0.268
	(0.92)	(0.7)	(-0.1)	(1)	(-0.16)
ROA	0.54***	0.496***	0.557***	0.601***	0.146
	(6.38)	(5.56)	(5.34)	(6.08)	(0.17)
Salesgrow_ratio	0.079***	0.082***	0.074***	0.08***	0.476
	(3.72)	(3.56)	(2.91)	(3.31)	(1.41)
R&D_ratio	2.194***	2.547***	0.867	2.317***	14.421*
	(4.03)	(4.69)	(0.7)	(4.31)	(1.82)
Dividend_ratio	-0.008	-0.022	-0.034	-0.006	0.001
	(-0.22)	(-0.64)	(-0.68)	(-0.17)	(0.26)
N	2633	2304	228	2281	2633
Hausman m	7.25	9.66	38.89	7.31	42.44
	(0.78)	(0.56)	(0.00)	(0.77)	(0.00)

The p-values are adjusted for heteroscedasticity and for clustering by firm. The z-statistics are reported in parentheses. Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Results of the panel regression for the other intervals

	Very high	Stable	Uncertain	BB_near	B_near
	(1)	(2)	(3)	(4)	(5)
Constant	0.062	0.012		0.032	0.027
	(0.73)	(0.13)		(0.42)	(0.34)
Rating	0.002	0.003**	0.005**	0.003	0.003**
	(1.39)	(2.11)	(2.09)	(1.58)	(2.01)
Interval_variable	-0.065	0.035	-0.069	-0.039	-0.016
	(-0.76)	(1.03)	(-0.5)	(-0.47)	(-0.12)
Rating * Interval	0.004	-0.003	0.007	0.004	0.006
	(0.91)	(-1.29)	(0.46)	(0.42)	(0.22)
Size	0.001	0.003	-0.004	0.002	0.002
	(0.33)	(0.7)	(-0.53)	(0.69)	(0.57)
Leverage	-0.071**	-0.074**	-0.038	-0.075***	-0.069**
	(-2.14)	(-2.1)	(-0.56)	(-2.99)	(-2.05)
M/B ratio	0.001	0.001	0.004	0.001	0.000
	(0.04)	(0.05)	(0.24)	(0.07)	(0.02)
Cash_incre	0.102	0.107	0.056	0.102	0.098
	(0.89)	(0.92)	(0.49)	(0.97)	(0.86)
ROA	0.56***	0.55***	0.529***	0.548***	0.562***
	(6.64)	(6.47)	(5.16)	(7.67)	(6.56)
Salesgrow_ratio	0.08***	0.079***	0.067***	0.08***	0.079***
	(3.72)	(3.7)	(2.81)	(4.84)	(3.7)
R&D_ratio	2.259***	2.228***	0.739	2.228***	2.253***
	(4.2)	(4.1)	(0.62)	(3.62)	(4.19)
Dividend_ratio	-0.015	-0.01	-0.03	-0.017	-0.016
	(-0.39)	(-0.27)	(-0.62)	(-0.44)	(-0.43)
N	2633	2633	2633	2633	2633
Hausman m	6.20	8.34	19.31	16.63	5.21
	(0.86)	(0.68)	(0.05)	(0.12)	(0.92)

The p-values are adjusted for heteroscedasticity and for clustering by firm. The z-statistics are reported in parentheses. Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Mean and median for the raw sample and matched sample

	Raw Sample			Matched (caliper=1)			Matched (caliper=0.1)		
Mean	A	BBB	A-BBB	A	BBB	A-BBB	A	BBB	A-BBB
N	1137	758		934	934		490	490	
Invest	0.1274	0.0961	-0.0313	0.1069	0.1005	-0.0064	0.1036	0.0892	-0.0144
Lnsize	27.3871	25.7736	-1.6135	26.6655	26.0268	-0.6387	26.3712	26.3779	0.0067
Leverage	0.5616	0.6434	0.0819	0.5946	0.6357	0.0410	0.6112	0.6247	0.0136
Tobinq	0.9293	0.8790	-0.0503	0.8972	0.8781	-0.0191	0.8798	0.8973	0.0175
Sash_incre	0.0062	0.0024	-0.0038	0.0074	0.0032	-0.0042	0.0074	0.0041	-0.0034
ROA	0.0359	0.0072	-0.0287	0.0255	0.0159	-0.0096	0.0229	0.0217	-0.0012
Salesgrow_ratio	0.1070	0.0904	-0.0165	0.1110	0.1039	-0.0071	0.1049	0.1057	0.0008
R&D_ratio	0.0042	0.0034	-0.0009	0.0038	0.0032	-0.0006	0.0033	0.0028	-0.0005
Dividend_ratio	0.1189	0.0788	-0.0401	0.1009	0.0896	-0.0113	0.0955	0.1036	0.0081
Median									
Invest	0.1109	0.0881	-0.0228	0.0966	0.0898	-0.0067	0.0887	0.0807	-0.0081
Lnsize	27.4205	25.7033	-1.7171	26.5512	25.9685	-0.5827	26.2237	26.2409	0.0172
Leverage	0.5839	0.6549	0.0709	0.6128	0.6515	0.0387	0.6330	0.6501	0.0171
Tobinq	0.9001	0.8516	-0.0485	0.8596	0.8519	-0.0077	0.8456	0.8617	0.0161
Cash_incre	0.0049	0.0011	-0.0039	0.0048	0.0020	-0.0028	0.0046	0.0034	-0.0012
ROA	0.0338	0.0132	-0.0207	0.0234	0.0159	-0.0075	0.0205	0.0213	0.0008
Salesgrow_ratio	0.0782	0.0599	-0.0183	0.0782	0.0762	-0.0020	0.0758	0.0889	0.0131
R&D_ratio	0.0012	0.0005	-0.0007	0.0008	0.0006	-0.0003	0.0007	0.0005	-0.0003
Dividend_ratio	0.1002	0.0420	-0.0582	0.0881	0.0586	-0.0294	0.0818	0.0687	-0.0131

Table 8. Results for the matched sample

	caliper=1		caliper=0.2		caliper=0.1	
	Panel	OLS	Panel	OLS	Panel	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.027	0.197	-0.309	0.198	-0.25	0.192
	(0.14)	(1.22)	(-1.47)	(0.81)	(-1.1)	(0.71)
Rating	0.011	0.008	0.024**	0.016	0.025**	0.014
	(1.39)	(1.00)	(2.01)	(1.44)	(2.12)	(1.11)
BBB_near	0.307*	0.326**	0.382*	0.287	0.42*	0.364
	(1.81)	(2.07)	(1.78)	(1.38)	(1.85)	(1.58)
Rating*near5	-0.023*	-0.025**	-0.027*	-0.021	-0.031*	-0.028*
	(-1.77)	(-2.12)	(-1.71)	(-1.35)	(-1.86)	(-1.67)
Lnsize	-0.005	-0.011*	0.002	-0.013	-0.003	-0.014
	(-0.65)	(-1.67)	(0.22)	(-1.43)	(-0.3)	(-1.47)
Leverage	-0.102**	-0.099**	-0.122**	-0.093	-0.153***	-0.173***
	(-2.38)	(-2.04)	(-2.34)	(-1.49)	(-2.76)	(-2.71)
Tobinq	0.088***	0.082***	0.091***	0.085**	0.147***	0.178***
	(3.00)	(3.15)	(2.78)	(2.29)	(3.3)	(4.29)
Cash_incre	-0.04	0.001	-0.011	0.082	0.285	0.486**
	(-0.23)	(0.01)	(-0.05)	(0.37)	(1.09)	(2.01)
ROA	0.758***	0.778***	0.68***	0.806***	0.656***	0.663***
	(5.46)	(5.00)	(4.02)	(4.02)	(3.39)	(3.37)
Salesgrow_ratio	0.048	0.044	0.107***	0.101***	0.144***	0.125***
	(1.48)	(1.51)	(3.04)	(2.75)	(3.44)	(3.1)
R&D_ratio	2.075**	2.872***	3.433**	2.93**	3.414*	3.665**
	(2.14)	(3.04)	(2.56)	(2.27)	(1.69)	(2.53)
Dividend_ratio	-0.032	-0.025	-0.101	-0.099	-0.068	-0.07
	(-0.49)	(-0.41)	(-1.39)	(-1.25)	(-0.87)	9(-0.95)
N	889	934	527	570	445	490
Hausman m	5.75(0.89)		17.3(0.10)		10.11(0.52)	

Panel regression uses fixed effects. Pooled OLS model contains year dummies. The z-statistics (or t-statistics) are reported in parentheses. Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9. Rank biserial correlation between investment and the rating dummies

Rating	N and % (2)	% for high (3)	RB corr (4)	RB with high (5)	RB_paired (6)	Category	RB_cate (8)
AAA	85(3.2%)		0.373***		0.337***	AAA	0.230***
AA+	99(3.8%)	3.2%	0.117**	-0.337***	-0.112	AA	0.140***
AA	178(6.8%)	7.0%	0.190***	-0.040	-0.006	A	0.100***
AA-	268(10.2%)	13.7%	0.190***	-0.018	0.034	BBB	0.089**
A+	264(10.0%)	23.9%	0.160***	-0.046	0.116**	BB	0.146**
A	291(11.1%)	34.0%	0.028	-0.147***	0.093**	B	0.073
A-	314(11.9%)	45.0%	-0.074**	-0.223***	0.000		
BBB+	221(8.4%)	56.9%	-0.069*	-0.169***	0.036		
BBB	260(9.9%)	65.3%	-0.106**	-0.183***	-0.048		
BBB-	173(6.6%)	75.2%	-0.028*	-0.076*	0.023		
BB+	104(3.9%)	81.8%	-0.048	-0.087	0.104		
BB	113(4.3%)	85.7%	-0.186***	-0.219***	-0.013		
BB-	81(3.1%)	90.0%	-0.221***	-0.253***	0.263**		
B+	39(1.5%)	93.1%	-0.401***	-0.420***	-0.140		
B	33(1.3%)	94.6%	-0.157	-0.168***	0.039		
B-	43(1.6%)	95.8%	-0.225**	-0.234***	0.052*		
CCC	39(1.5%)	97.5%	-0.354***	-0.359***	0.519**		
CC	4(0.2%)	98.9%	-0.842***	-0.845***	-0.719*		
C	16(0.6%)	99.1%	-0.386***	-0.389***	0.469*		
D	8(0.3%)	99.7%	-0.605***	-0.605***			

Column 2 represents the number of samples in each grade and the distribution of each grade in parentheses is expressed in %. Column 3 shows the distribution of the sample with a credit rating higher than each grade in %. Columns 5, 6, 7, and 9 represent the rank biserial coefficients. Each model is distinguished by how we construct the sample with a dummy value of 0 when constructing the dummy variable. "RB corr" covers the entire sample (2,633). "RB with high" uses a dummy variable that is 0 if it belongs to a higher grade than the corresponding grade and 1 if it belongs to that grade. Therefore, specimens with a rating lower than each grade are excluded. "RB_paired" uses a dummy variable of 1 if it belongs to the corresponding grade and 0 if it belongs to a grade one level higher than the corresponding grade. Therefore, samples that do not belong to the two paired credit ratings are excluded. Finally, "RB_cate" is similar to "RB_paired" but it creates a dummy by grouping the ratings separated by the same alphabet into one group. For example, AAA represents the rank biserial coefficient between investment and a dummy equal to 1 if it belongs to AAA and 0 if it belongs to the AA group. Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 10. T-test of CAAR (average of the acquirer's CAR)

	Full	>AA-	>BBB+	>BB+	BBB_near1	BBB_near2	<BBB-
CAAR	0.021***(3.27)	0.008(1.21)	0.013**(2.14)	0.0194**(3.12)	0.033*(1.93)	0.03*(2.01)	0.031(1.21)
N	188	60	128	161	38	46	27

Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The t-statistics are reported in parentheses

Table 11. Bidder's CAR and credit ratings

	Near-BBB: BBB+ – BB+			Near-BBB: BBB+ – BB-		
	Full sample	Not crisis	Non-KOSDAQ	Full sample	Not crisis	Non-KOSDAQ
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.304**	0.267	0.182	0.328**	0.304*	0.22
	(2.04)	(1.56)	(1.26)	(2.20)	(1.77)	(1.49)
Rating	0.001	0.000	0.003	0.000	-0.002	0.002
	(0.35)	(-0.12)	(0.95)	(0.15)	(-0.51)	(0.72)
BBB_near	-0.222**	-0.246**	-0.158	-0.183*	-0.228**	-0.214***
	(-2.07)	(-2.27)	(-1.29)	(-1.93)	(-2.12)	(-2.81)
Rating*near	0.02**	0.022**	0.016	0.016**	0.019**	0.02***
	(2.15)	(2.27)	(1.57)	(2.01)	(2.16)	(2.95)
D_publicT	-0.01	-0.013	-0.011	-0.011	-0.014	-0.01
	(-0.72)	(-0.85)	(-0.75)	(-0.71)	(-0.92)	(-0.69)
D_cash100	-0.003	-0.014	-0.005	-0.003	-0.015	-0.006
	(-0.23)	(-1.03)	(-0.47)	(-0.25)	(-1.14)	(-0.51)
D_tender	-0.087***	-0.079**	-0.103***	-0.09***	-0.086**	-0.106***
	(-3.01)	(-2.19)	(-3.39)	(-3.14)	(-2.35)	(-3.47)
Rel_value	0.015***	0.015***	-0.063	0.014***	0.015***	-0.063
	(8.65)	(8.08)	(-1.19)	(8.75)	(8.19)	(-1.21)
Collateral	0.009	0.01	-0.014	0.02	0.025	-0.008
	(0.16)	(0.16)	(-0.41)	(0.37)	(0.39)	(-0.25)
PCM	-0.076	-0.171	-0.314	-0.139	-0.268	-0.350
	(-0.36)	(-0.74)	(-1.42)	(-0.62)	(-1.09)	(-1.57)
Size	-0.011*	-0.008	-0.007	-0.011*	-0.008	-0.008
	(-1.71)	(-1.11)	(-1.16)	(-1.79)	(-1.13)	(-1.31)
Leverage	-0.032	-0.062*	-0.011	-0.035	-0.076**	-0.004
	(-1.4)	(-1.97)	(-0.29)	(-1.4)	(-2.1)	(-0.12)
M/B ratio	-0.005	0.004	-0.007	-0.004	0.004	-0.005
	(-0.3)	(0.16)	(-0.39)	(-0.24)	(0.19)	(-0.29)
Cash_incre	-0.365**	-0.33*	-0.257	-0.349*	-0.328*	-0.241
	(-2.01)	(-1.66)	(-1.56)	(-1.96)	(-1.69)	(-1.5)
ROA	0.143	0.091	0.576**	0.182	0.14	0.616**
	(0.6)	(0.33)	(2.4)	(0.78)	(0.54)	(2.54)
Salesgrow_ratio	-0.005	0.009	-0.079**	-0.004	0.008	-0.074**
	(-0.13)	(0.18)	(-2.46)	(-0.11)	(0.18)	(-2.33)
R&D_ratio	1.16	1.42	0.989	1.172	1.533	1.018
	(0.99)	(1.13)	(0.75)	(1.03)	(1.28)	(0.79)
Dividend_ratio	-0.117**	-0.146**	-0.148**	-0.126**	-0.16**	-0.15**
	(-1.98)	(-2.3)	(-2.55)	(-2.13)	(-2.5)	(-2.6)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	188	157	166	188	157	166
R^2 (adj. R^2)	0.32 (0.17)	0.35 (0.19)	0.37 (0.22)	0.32 (0.18)	0.36 (0.20)	0.37 (0.22)

Symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The t-statistics from the heteroskedasticity robust standard errors are reported in parentheses.

Figure 1. Smoothing component plots using a cubic spline

This figure shows the cubic smoothing plots of the 2633 samples for the relationship between investment and credit rating. The smoothing parameter is 0.991 and the degrees of freedom are 3. The smoothing parameter has values of 0 and 1 and the smoother curve is drawn closer to 1. The left plot is the smoothing component plot and the right plot is the additive component plot, which combines the linear trend and the non-parametric prediction for each spline.

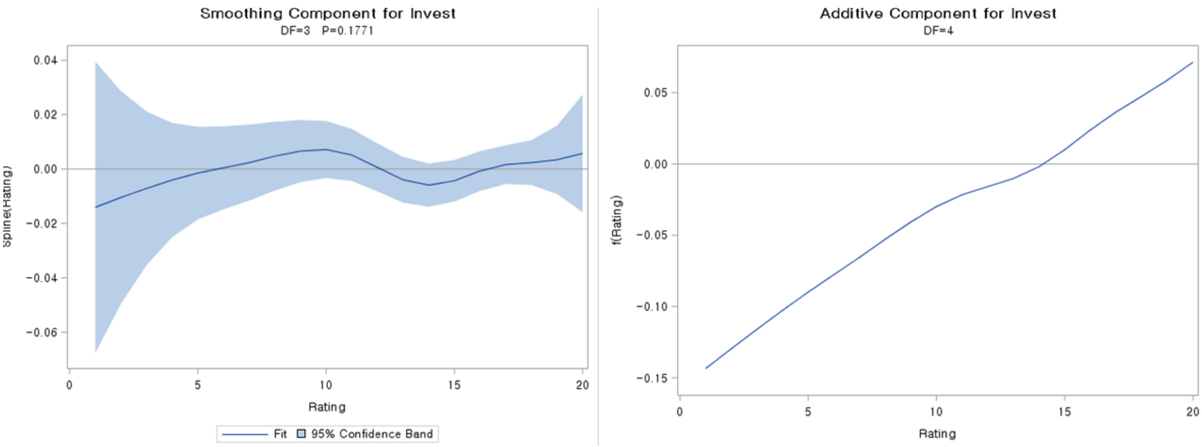

Figure 2. Smoothing component plots using a semi-parametric spline

This figure shows the semi-parametric plots of 2633 samples for the relationship between investment and rating. We use the rating and control variables (size, leverage, M/B ratio, ROA, PCM, R&D ratio, and dividend ratio) as explanatory variables (=X) for investment (=Y) and add a non-parametric smooth function to fit the graph. The smoothing parameter is 0.991 and the degrees of freedom are 3. The left plot is the smoothing component plot and the right plot is the additive component plot, which combines the linear trend and the non-parametric prediction for each spline.

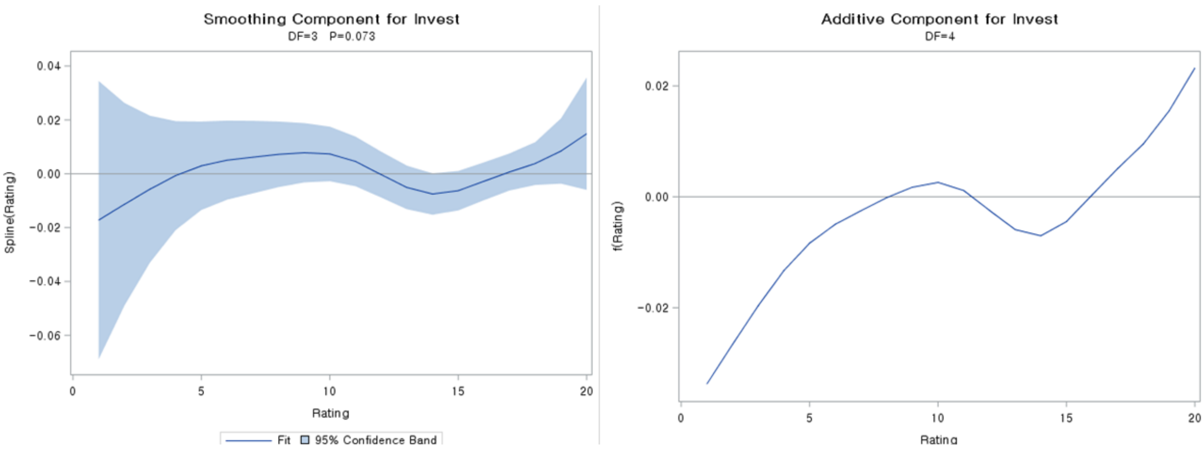

Figure 3. LOESS for credit rating on investment

This figure shows the relationship between investment and credit rating using LOESS for the 2633 samples. The smoothing parameter is 0.4175 and the degree of freedom are 2.959. The smoothing parameter represents the degree to which the data are used to fit each local polynomial. The left plot is a LOESS smoother plot and the right plot is an additive component plot, which combines the linear trend and the non-parametric prediction for each LOESS effect.