Credit Ratings and Corporate Investment: UK Evidence

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Abstract

We investigate the effect of credit ratings on corporate investment. We extend the conventional view, which predicts a positive linear relationship between credit ratings and firm investment, by highlighting a perspective of corporate governance that emphasizes the impact of managerial career concerns. The evidence from a panel of 576 UK public nonfinancial firms during 1996-2004 shows that in addition to the conventional view, there are several other possibilities which describe the relation between credit ratings and fixed investment. Specifically, we find that: (a) the relation between credit ratings and investment may be nonlinear and can be represented by an inverted U curve; (b) changes in credit ratings are negatively associated with investment; (c) the negative effect of the changes in credit ratings on investment is exacerbated by high levels of credit ratings; and (d) the results in (b) and (c) are more pronounced for firms that are facing credit ratings upgrades.

JEL Classifications: G240, G310, M510

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1. Introduction

'For richer or poorer', credit rating agencies seem to be attracting a lot of attention. For example, recent research suggests that credit ratings directly affect capital structure decisions to the extent that the pecking order and trade-off capital structure theories are greatly enhanced by incorporating discreet costs and benefits of rating changes (Kisgen, 2006, 2007 and 2008). Credit ratings also tend to influence IPO pricing: An and Chan (2008) show that when firms issue IPOs, those with credit ratings are less vulnerable to underpricing than firms without credit ratings. But today rating agencies are highly criticised as culprits in the subprime mortgage crisis, for understating the risk involved with mortgage-backed securities. It is interesting that the actual implications of credit ratings may contradict conventional expectations, in terms of risk monitoring by financial regulators, impact on capital structure decisions by firms, or perhaps corporate investment decisions. Perhaps, the behaviour of corporate financial managers also matters.

We focus on the implications of credit ratings for corporate investment decisions. The conventional view is that when a firm is seeking external debt financing for fixed investment, its credit reputation matters. Potential external lenders tend to rely on a third party, namely a credit rating agency, to vouch for the credit reputation of the firm. Credit rating agencies provide the public with an evaluation of the firm's quality in terms of either its overall creditworthiness or the default risk of a particular debt security. A firm's overall credit rating reflects a rating agency's opinion of the firm's overall creditworthiness and its capacity to satisfy its financial obligations. Potential external lenders always prefer to lend to good quality firms, where good quality is normally indicated by a high credit ratings score assigned to the firm. Therefore, it is commonly accepted that high credit ratings indicate a good quality of the firm; the firm can borrow more at lower costs in order to expand investment, hence the firm's fixed investment is positively associated with credit ratings. This view is consistent with the financial constraint literature, stemming from work by Fazzari et al. (1988). In this literature, whether or not the firm has credit ratings is taken as an indicator for the firm to have more access to external debt financing at lower costs (e.g. Whited, 1992; Kaplan and Zingales, 1997).

However, the above-mentioned conventional view on the relationship between credit ratings and investment is perhaps true if we only consider the supply side of external financing, i.e. if we assume that the firm will borrow as much as the supply allows. This view emphasizes too much the financial constraints faced by the firm because it assumes that the firm is financially constrained and will use up whatever financing is available to it. The conventional view may not be sustainable if the demand side for external financing is also considered. Our paper examines the relation between credit ratings and fixed investment by taking into consideration both the demand and supply sides and thus departs from the conventional view of the relationship between credit ratings and fixed investment.

We argue that the firm may not use up all available supply of external financing for fixed investment due to managerial career concerns of the decision-makers. For example, managers may not find a high credit ratings score attractive due to managerial career concerns. Managerial career concerns refer to the fact that managers may manipulate the decision-making process in order to protect their reputation in the managerial labour market and to influence the *ex-post* labour market assessment of their human capital (Holmström, 1999). When credit ratings are too high to sustain, the firm will face a higher probability to have a credit ratings downgrade in the near future. Managers will do their best to avoid credit ratings downgrades because downgrading damages managers' reputation and leads to negative assessments of their ability in the managerial labour market. This type of managerial career concerns becomes more pronounced if the firm is operating under a high uncertain external environment. Facing high external uncertainty, managers are not sure about investment outcomes, therefore they prefer to make safer investment decisions by investing less than they should, in order to avoid credit rating downgrades. This is particularly the case when the firm is struggling to maintain a high level of credit ratings and is actually facing a higher probability of being downgraded. For example, managers can choose investment projects that enable them to influence the *ex-post* assessment of the credit ratings agency on the quality of the firm. Hence, some investment distortions may arise due to managerial career concerns. One possible investment distortion that may result from managerial career concerns is underinvestment or lack of innovation and conservation in investment (see Zwiebel, 1995, and Prendergast and Stole, 1996).

The above-mentioned notion may explain some stylized facts on credit ratings. For example, it may explain the observed declining trend of credit ratings, particularly in corporate America (Blume et al., 1998; also, the New York Times, November 11, 2006). This declining trend may be explained by the fact that managers may not like to target high credit ratings.

To extend the conventional view on the relation between credit ratings and firm investment, we present evidence showing that there are several other possibilities that can describe the relation between credit ratings and fixed investment. Using a panel of 576 UK public nonfinancial firms over the period 1996-2004, we find that: (a) the relationship between credit ratings and investment may be nonlinear and can be represented by an inverted U curve, which implies that when the level of credit ratings is too high and beyond a certain threshold, a higher level of credit ratings is associated with lower investment; (b) changes in credit ratings are negatively associated with changes in firm investment; (c) the negative effect of the changes in credit ratings on investment is exacerbated by high levels of credit ratings; and (d) the results in (b) and (c) are more pronounced for firms that are facing credit ratings upgrades.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 discusses some empirical issues. Section 4 presents empirical analyses on the relation between credit ratings and corporate investment. Section 5 concludes. In the appendix, we present a theoretical model to illustrate the idea that managers may use fixed investment decisions to influence the assessment of credit rating agencies on the quality of the firm; in turn, the *ex-post* perception of the quality of the firm alters investment behaviour.

2. Literature Review

The research idea of this paper is synthesized from at least two strands of the economics and finance literature. The first strand focuses on managerial career concerns and stems from the work by Fama (1980) who claims that explicit incentive contracts are not necessary for the firm since the labour market disciplines managers. Holmström (1999), however, argues that the ability of the manager is revealed over time via the history of his performance. Using a formal theoretical model, Holmström shows that as long as the manager's ability is not completely known by the managerial labour market, the manager has strong motivation to manipulate the decision-making process in order to influence assessment by the market. Gibbons and Murphy (1992) provide a different perspective to the view by Fama (1980) and Holmström (1999) by arguing that even in the presence of explicit contracts, career concerns are still important incentives. Hence, in a broad context where incentive contracts contain both explicit and implicit components and the design of optimal compensation schemes is important, the foregoing discussion suggests that managerial career concerns play an important role in corporate decisions.

Indeed, some scholars have investigated explicitly the relationship between managerial career concerns and investment. It has been analytically shown by Scharfstein and Stein (1990) that managerial career concerns motivate the managers to mimic others in making corporate investment decisions (see also Devenow and Welch, 1996). Such herd behaviour by managers is further investigated by Zwiebel (1995). By linking corporate conservatism with managerial reputational concerns, Zwiebel (1995) finds that the latter may lead managers to refrain from deviating from the herd. Rather, managers choose to take inferior standard actions which serve as an accurate benchmark for evaluating future actions. Over time, the learning process between 'impetuous youngsters' and 'jaded old-timers' further ensures that managerial career concerns drive managers to make investment decisions, as shown by Prendergast and Stole (1996).

The second strand of the literature relates to investment under financial constraints and emphasizes the fact that firms face constraints in using external financing for fixed investment (Fazzari, et al,. 1998). In this literature, the credit rating of the firm is taken as an important indicator of the firm's ability to access external debt financing at lower cost (e.g. Whited, 1992; Kaplan and Zingales, 1997). It has been shown that credit ratings reduce information asymmetry (Sufi, 2007). Also, evidence shows that credit ratings reduce the credit constraints faced by firms by enabling highly rated firms to raise more debt (Faulkender and Petersen, 2006). In addition, in the analytical models by Boot et al. (2006), investors rationally base their investment and pricing decisions on credit ratings. The clear line of argument is that a firm with higher credit ratings is able to access more external financing for investment at lower cost, such that one plausible interpretation of the impact of credit ratings on the firm's investment, according to this literature, is that the firm's higher credit rating implies more investment. Hence, the relation between credit ratings and investment is linear and positive.

Besides the prediction of the financial constraint literature, Shah (2006) documents that when the firm is facing a change in credit ratings, it is likely to cut investment in order to keep sufficient cash reserve to avoid a credit ratings downgrade. This impact is more pronounced for firms which are more actively involved in debt markets. Financial managers are reluctant to aim for credit rating upgrades, which may not be sustainable. According to Shah (2006), when it is granted a high credit ratings score, the firm will then respond by cutting investment expenditure to save some cash in order to avoid a credit ratings downgrade. However, it is important to stress that Shah (2006) examines the relation between credit ratings and the firm's cash holding policy; investment is seen as a channel through which credit ratings affect the cash holding policy of the firm. Our paper differs from Shah (2006). We focus on the relation between credit ratings and investment directly; the channel through which credit ratings affect investment is managerial career concerns; effectively, therefore we synthesize the two strands of the literature.

3. Empirical Issues

3.1 Empirical Specifications

Motivated by the theoretical model which is presented in the appendix, we specify an empirical investment equation of the firm, which includes: (a) investment fundamentals; (b) external uncertainty; and (c) a proxy for the firm's credit quality. Specifically, we use annual growth rate of sales $(SALES)$ as the investment fundamental variable. The 3-year moving standard deviation of cash flow scaled by total assets of the firm is used as an indicator of external uncertainty (UM). We proxy for the firm's credit quality by the level of and the changes in the QuiScore. We are particularly interested in how credit ratings and their changes affect the firm's investment decisions. Hence, we experiment with the following alternative empirical specifications:

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \varepsilon_{it} \quad (1)$$

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 CR_{it}^2 + \varepsilon_{it} \quad (2)$$

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 \Delta CR_{it} + \varepsilon_{it} \quad (3)$$

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 \Delta CR_{it} + \beta_5 \left(\Delta CR_{it} * CR_{it}\right) + \varepsilon_{it} \quad (4)$$

Where I_{it} stands for investment for firm i in year t, which is measured by net changes in fixed assets of the firm. K_{it} is the beginning-of-period capital stock of the firm measured by total assets of the firm. f_i and f_t are firm effects and time effects, respectively. $SALES_{it}$ is the annual growth rate of sales for firm i in year t. UM_{it} is an measure of external uncertainty, which is the 3-year moving standard deviation of cash flow scaled by total assets of the firm. CR_{it} is the QuiScore assigned to firm i in year t. ΔCR_{it} is the change in the QuiScore for firm i in year t. ε_{it} is an error term. β 's are the parameters to be estimated for the explanatory variables.

3.2 Data and Measurement

The data are taken from *FAME*, which is published by the company Bureau van Dijk. *FAME* collects and publishes company level information of UK and Irish public and private companies. Our sample includes only UK public nonfinancial firms that have at least five continuous years of observations.[1] Overall, we have a panel of 576 firms over the period of 1996-2004, such that the total number of firm-year observations for the whole sample is 3640.

For the purposes of empirical analysis, we derived the following information: total assets, fixed assets, sales (turnover), cash flow, and the QuiScore. The QuiScore is an indicator of the firm's overall financial stability and capacity. It is a measure of the likelihood of the firm's failure in the year following the date of calculation. The QuiScore is assigned on a yearly basis to the firm as a number in the range 0 to 100. A larger value of the QuiScore indicates a better financial capacity of the firm.[2] The QuiScores is developed and maintained by CRIF Decision Solutions Limited.

When determining the QuiScore for nonfinancial firms, the agency CRIF Decision Solutions Limited takes into account a range of factors, including: (a) factors relating to the financial performance of the firm as evidenced by the balance sheet and profit and loss statement; (b) the presence of any adverse documents about the firm and the timeliness of getting the accounts filed; and (c) the underlying economic conditions. Hence, the QuiScore in our data reveals the general creditworthiness of the firm rather than creditworthiness with respect to a particular debt security. The QuiScore is used by all parties involved in the firm, including debt issuers, bond

[1] We lose two observations in computing the 3-year moving standard deviations for cash flow in order to construct the external uncertainty measure. By including only firms that have at least five continuous years of observations, we ensure that the shortest time series is 3 years, which is required by the DPD98 GMM estimation programme.

[2] The Quiscore can be further classified into five bands: 81-100 is the secure band; 61-80 is the stable band; 41-60 is the normal band; 21-40 caution band; and 01-20, high risk band.

investors, portfolio managers, and other market participants. In this study, therefore, the QuiScore is used as a proxy for the firm's overall credit quality in the capital market.

[Table 1 about here]

Table 1 presents summary statistics for the variables used in the empirical analysis. As shown in Table 1, the average QuiScore for the sample firms is 61.56 (median 61) during the sample period, suggesting that the majority of the sample firms have a relatively stable financial capacity. In addition, Table 1 shows that an average sample firm experienced a negative change in the QuiScore, as indicated by the fact that the mean of the difference between the current year's QuiScore and the last year's QuiScore is -0.098.

3.3 Estimation Methods

Estimation and testing of the empirical equations are performed using the Generalised Method of Moments (GMM) procedure, which controls for the endogenous problem and allows for heterosckadasticity. We follow Blundell and Bond (1998) and adopt the system GMM estimation procedure in which moment conditions for equations in first differences are combined with moment conditions for equations in levels to compute the optimal weighting matrix that provides consistent system GMM estimators.

The GMM estimation is conducted by using DPD98 for Gauss (Arellano and Bond, 1998). Time dummies are added in all estimations. We also control for the industry effect by adding industry dummies. In theory, all the past observations of the right-hand side variables can be used as instruments for the first differenced equations in the system GMM estimations. In this paper the number of the lagged observations of the right-hand side variables used as the instruments for the first difference equations varies slightly across estimations. We use the Sargan test statistics to assess the validity of the chosen instruments. In addition to the instruments for the first difference equations we use first differences lagged once of the right-hand side variables as the instruments for the level equations. We report two-step estimates with corrected standard errors based on

Windmeijer (2005) who shows that two-step estimates are more efficient than one-step estimates.

4. Estimation Results

We start with the simplest empirical model (equation 1) in which we test how the level of credit ratings alone affects investment. The first column of Table 2 shows that the estimated coefficient for the level of credit ratings is highly significant with a positive sign. This result is consistent with the conventional view. Because a higher level of credit ratings is taken as an indicator of lower borrowing costs of and more access to external financing, the firm which has a higher credit ratings score can therefore borrow more funds at lower costs, and hence increase its investment.

[Table 2 about here]

However, as we argue in this paper that the linear and positive relation between credit ratings and investment may not be sustainable if we take into consideration the demand side for external financing. For example, as shown in the theoretical model presented in the appendix, managerial career concerns may lead to lower investment when the level of credit ratings is too high to be sustained, which suggests that the relation between credit ratings and investment may be nonlinear. The estimation results (based on empirical model (2)) shown in column (2) of Table 2 confirm our conjecture. It is apparent that although the estimated coefficient for the linear term of credit ratings is positively significant, the estimated coefficient for the quadratic term of credit ratings is negatively significant. These results provide us with an inverted U shape relation between credit ratings and investment, which implies that when the level of credit ratings is too high beyond a certain threshold, a higher credit ratings score is associated with lower investment. We argue in this paper that this type of nonlinearity can be explained by managerial career concerns.

In Table 3 we focus on the relationship between the changes in credit ratings and investment after controlling for the level of credit ratings (the empirical investment model (3)). We propose and implement three alternative measures of a change in credit ratings. First, the change in credit ratings is measured simply as the annual change in credit ratings, i.e. the difference between the current year's QuiScore and the firm's QuiScore in the previous year: $\Delta CR_t^a = CR_t - CR_{t-1}$. Second, the change in credit ratings is measured as the rate of change in the firm's QuiScore, i.e. $\Delta CR_t^b = \Delta CR_t^a / CR_{t-1}$. Third, the change in credit ratings is measured as a categorical variable constructed from ΔCR^a. We define ΔCR_t^c =1 if ΔCR^a is negative; ΔCR_t^c =2 if the firm's QuiScore does not change, i.e. ΔCR^a =0; and ΔCR_t^c =3 if the firm experiences a positive change in the QuiScore, i.e. ΔCR^a >0. Therefore, ΔCR_t^c is a categorical variable with a larger value indicating an upward change in the firm's credit ratings.

[Table 3 about here]

What is of particular interest in the empirical results reported in columns 1-3 of Table 3 is that no matter how we measure the changes in credit ratings, we obtain consistent results concerning the relation between changes in credit ratings and investment. In all the three variants of empirical equation (3), the estimated coefficient for the changes in credit ratings is highly significant with a negative sign. The results in Table 3 confirm our conjecture that the firm negatively reacts to changes in credit ratings as far as investment decisions are concerned. This result can be explained by the notion that managers do not like changes in credit ratings due to managerial career concerns. Also, the result is consistent with the argument by Bertand and Mullainnathan (2003) that corporate executives enjoy a quite life. Thus changes in credit ratings, in particular credit ratings downgrades, disturb the managers' quite life and actually may damage the managers' reputation in the managerial labour market. Therefore changes in credit ratings may lead to stronger managerial career concerns, which in turn will lead to a safer investment policy, which arguably is characterised by reduced investment by the firm.

If the managers do not like the changes in credit ratings, then it is logical that the managers have intention to cut investment after the firm is credit upgraded because higher credit ratings are more likely to bring about credit ratings downgrade in the near future. Indeed, from column 3 of

Table 3, we observe that upward changes in credit ratings have negative effects on investment, i.e. the firm intends to cut investment after being upgraded. Therefore, it is interesting to further test whether the negative impact of the changes in credit ratings on investment is related to the level of credit ratings.

[Table 4 about here]

In the estimations shown in Table 4, we use the interactive term between the level of credit ratings and the changes in credit ratings (see the empirical investment model (4)). Columns 1-3 of Table 4 correspond to different measures of the changes in credit ratings ΔCR_t^a ΔCR_t^b , and ΔCR_t^c , respectively. It is to be noted that in two out of three cases, the estimated coefficient for the interactive term is negatively significant, suggesting that the negative association between the changes in credit ratings and investment is exacerbated by high levels of credit ratings. This result suggests that high credit ratings are not necessarily good for firm investment. One possible reason may be that high credit ratings indicate a higher probability of credit ratings downgrade, therefore managers would take precautionary actions to avoid credit ratings downgrades by making safer investment decisions, for example, by cutting risky investment projects.

The evidence we have obtained so far shows that there are several other possibilities in addition to the conventional view regarding the impact of credit ratings on fixed investment: (a) the relation between credit ratings and investment may be nonlinear, which can be presented by an inverted U curve; (b) firm investment is negatively associated with the changes in credit ratings; (c) high levels of credit ratings exacerbate the negative effect of the changes in credit ratings on investment. These results, in particular the result (c) suggest that managers do not always like high credit ratings, they may respond to high credit ratings by cutting investment to avoid credit ratings downgrade due to managerial career concerns. To provide further evidence on this argument, we define a dummy variable which takes the value of one when the observation on the changes in the firm's QuiScore is positive, while it takes the value of zero otherwise, i.e. $Dum(up) = 1$ and

$(1 - Dum(up)) = 0$. The idea is to check whether the firm responds to credit ratings upgrades differently from the way it responds to non-upward adjustments in credit ratings. For the purpose of this paper, we focus on the differences between upgraded and non-upgraded cases in terms of how the firm responds to changes in credit ratings and how the level of credit ratings affects the relationship between the changes in credit ratings and investment. The empirical specifications for this set of estimations are:[3]

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 CR_{it} + \beta_3 Dum(up) * \Delta CR_{it} + \beta_4 (1 - Dum(up)) * \Delta CR_{it} + \varepsilon_{it} \quad (5)$$

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 CR_{it} + \beta_3 \Delta CR_{it} + \beta_4 Dum(up) * (\Delta CR_{it} * CR_{it}) + \beta_5 (1 - Dum(up)) * (\Delta CR_{it} * CR_{it}) + \varepsilon_{it} \quad (6)$$

Table 5 reports estimation and testing results for empirical model (5). It is shown that for each of the three variants of the model, the estimated coefficients for β_3 and β_4 are different: in each case, while the estimated coefficient for β_3 is negative and statistically significant, the coefficient for β_4 is not significant. This evidence suggests that the firm is more likely to cut investment in response to a credit ratings upgrade.

[Tables 5 and 6 about here]

Table 6 reports the results of estimating the empirical model (6) and confirms that the interactive effect between the level of credit ratings and changes in credit ratings also differs between credit ratings upgrades and non-upgrades. In all the three variants of the equation, the estimated coefficient for the interactive term between the level of and the changes in credit ratings is negatively significant only for the credit ratings upgrades, while it is not significant for the non-upgrades variable. This result suggests that for firms whose credit ratings are upgraded, a higher level of credit ratings is more likely to lead to a larger negative effect of the changes in credit ratings on investment as compared with their non-upgraded counterparts. The evidence shown in

[3] We had to drop the proxy for external uncertainty in this set of estimations due to the non-positive definite matrix problem.

Tables 5 and 6 provides even stronger support for our argument that there are other possible explanations, in addition to the conventional view, of the impact of credit ratings on fixed investment. Moreover, this relation can be a nonlinear one: when they are too high and beyond a certain threshold, credit ratings are likely to lead to a downgrade; the downgrade will then lead to less investment. This result can be explained by the notion that higher credit ratings intensify managerial career concerns; mangers will take precautionary actions in making investment decisions to protect their reputation in the managerial labour market by cutting investment.

5. Conclusion

In this paper, we examine the relationship between credit ratings and firm investment from a corporate governance perspective, i.e. managerial career concerns. We argue that the conventional perception that the relation between credit ratings and investment is linear and positive is not sustainable if we add the firm's demand for external financing and consider how managerial career concerns can change this relationship.

We support our argument by providing consistent evidence based on a panel of 576 UK public nonfinancial firms during 1996-2004. We find that there are a few other possibilities in addition to the conventional view that can describe the impact of credit ratings on fixed investment, including (a) the relationship between credit ratings and investment may be nonlinear and can be represented by an inverted U curve, which implies that when the level of credit ratings is too high and beyond a certain threshold, then a higher level of credit ratings is associated with lower investment. (b) the changes in credit ratings depress firm investment; (c) the negative effect of the changes in credit ratings on investment is exacerbated by high levels of credit ratings. (d) The results (b) and (c) are more pronounced for the firms that are facing credit ratings upgrades.

Our results suggest that managers may not like high credit ratings due to managerial career concerns. Under the pressure of sustaining high credit ratings, managers would take precautionary actions to avoid credit ratings downgrades by making safer investment decisions, for example, by cutting risky investment projects.

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Table 1: Descriptive Statistics and Correlation Matrix for the Empirical Variables

(a) Descriptive Statistics

Variables	Mean	Median	Standard Deviation	Number of Observations
I/K	0.0271	0.0130	0.1474	3640
$SALES$	0.1170	0.0531	0.5720	3640
UM	0.0747	0.0303	0.2327	3640
CR	61.566	61	21.4262	3609
ΔCR^a	-0.9899	0	13.5906	3595
ΔCR^b	-0.0982	0	0.6819	3595
ΔCR^c	1.9732	2	0.9417	3595

(b) Correlation Matrix

	I/K	$SALES$	UM	CR	ΔCR^a	ΔCR^b	ΔCR^c
I/K	1.000						
$SALES$	0.2480	1.000					
UM	-0.2522	-0.0810	1.0000				
CR	0.1389	-0.01511	-0.2229	1.0000			
ΔCR^a	-0.0536	-0.0507	-0.0197	0.3590	1.0000		
ΔCR^b	0.0898	0.0006	-0.1530	0.3490	0.5896	1.0000	
ΔCR^c	-0.0545	-0.0355	0.0122	0.2524	0.7017	0.3493	1.0000

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.

(2) Definition and measurement of variables:

I/K : the ratio of investment to the beginning of period capital stock, where investment is the change in fixed assets of the firm. The capital stock is measured by total assets of the firm.

SALES: the annual growth rate of sales

UM : is an external uncertainty measure, which is measured by the 3-year rolling standard deviation of CFTA, where CFTA is cash flow scaled by total assets of the firm.

CR : credit rating score, which is the Quiscore.

ΔCR^a : the change in the QuiScore, which is measured by the difference between the current year's QuiScore and the QuiScore in the previous year, i.e. $\Delta CR_t^a = CR_t - CR_{t-1}$.

ΔCR^b : the rate of change in credit rating, i.e. $\Delta CR_t^b = \Delta CR_t^a / CR_{t-1}$.

ΔCR^c : the change in credit rating, which is measured by a categorical variable, which is constructed from ΔCR^a as follows. We define ΔCR_t^c =1 if ΔCR^a is negative; ΔCR_t^c =2 if the firm's QuiScore does not change i.e. ΔCR^a =0; ΔCR_t^c =3 if ΔCR^a is positive.

Table 2: Is the Impact of Credit Ratings on Firm Investment Linear or Nonlinear?

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \varepsilon_{it}$$

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 CR_{it}^2 + \varepsilon_{it}$$

	Equation (1)	Equation (2)
$Sales_{it}$	0.0601 (1.8692)	0.0671 (2.0352)
UM_{it}	-0.0647 (-1.0086)	-0.0409 (-0.6302)
CR_{it}	**0.3215** **(4.5671)**	**0.7223** **(2.7286)**
CR_{it}^2		**-0.0041** **(-1.7934)**
m_1	-8.760	-8.796
m_2	-0.089	0.075
Sargan (k) P-value	31.457(39) p=0.799	42.777(52) p=0.815
Wald test Chi-square	$H_0 : \beta_3 = 0$ 20.858(df=1)	$H_0 : \beta_3 = \beta_4 = 0$ 17.435(df=2)
Instruments (difference)	$Sales_{t-2}$ UM_{t-2} CR_{t-2}	$Sales_{t-2}$ UM_{t-2} CR_{t-2} CR_{t-2}^2
Instruments (levels)	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(CR^2)_{t-1}$

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.
(2) The two-step estimates with robust (corrected) test statistics are reported.
(3) Heteroskedasticity consistent asymptotic t-statistics are in parentheses below the estimated coefficients of the empirical variables.
(4) m_1 and m_2 are tests for first- and second-order serial correlation in the first-differenced residuals, asymptotically distributed as normal distribution under the null of no serial correlation.
(5) Sargan (k): test of the overidentifying restrictions, asymptotically distributed as Chi-square(df=k) under the null of instrument validity.
(6) Wald test is the test statistics for the estimated coefficient is zero, distributed as Chi-square(df) under the null of the estimated coefficient is zero. The critical values of Chi-square (df=1) are 2.706, 3.841, and 6.635 at the 10%, 5% and 1% significant levels, respectively. The critical values of Chi-square (df=2) are 4.61, 5.99, and 9.21 at the 10%, 5% and 1% significant levels, respectively.
(7) Time effects and industry effects are controlled for in the estimations.
(8) See notes to Table 1 for definition and measurement of variables; df = degrees of freedom; p = p-value.

Table 3: The Impact of Changes in Credit Ratings on Firm Investment

$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 \Delta CR_{it} + \varepsilon_{it}$

	Variant (1) of Equation (3) ($\Delta CR_{it} = \Delta CR_{it}^{a}$)	Variant (2) of Equation (3) ($\Delta CR_{it} = \Delta CR_{it}^{b}$)	Variant (3) of Equation (3) ($\Delta CR_{it} = \Delta CR_{it}^{c}$)
$Sales_{it}$	0.0814 (3.4055)	0.0717 (2.1518)	0.0858 (3.0133)
UM_{it}	-0.0536 (-0.9731)	-0.0585 (-0.8931)	-0.0618 (-0.9455)
CR_{it}	0.3330 (6.4721)	0.3745 (6.6712)	0.3085 (5.1339)
ΔCR_{it}	**-0.0026** **(-3.9106)**	**-0.0358** **(-1.9815)**	**-0.0515** **(-2.0608)**
m_1	-8.836	-8.853	-8.798
m_2	0.357	0.220	0.209
Sargan (k) P-value	52.134(64) p=0.856	51.725(58) p=0.706	41.953(58) p=0.944
Wald test Chi-square (df=1)	$H_0 : \beta_4 = 0$ 15.293	$H_0 : \beta_4 = 0$ 3.926	$H_0 : \beta_4 = 0$ 4.246
Instruments (difference)	$Sales_{t-2,t-3}$ UM_{t-2} CR_{t-2} $\Delta CR_{t-2,t-3}$	$Sales_{t-2}$ UM_{t-2} CR_{t-2} $\Delta CR_{t-2,t-3}$	$Sales_{t-2}$ UM_{t-2} CR_{t-2} $\Delta CR_{t-2,t-3}$
Instruments (levels)	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.

(2) The two-step estimates with robust (corrected) test statistics are reported.

(3) Heteroskedasticity consistent asymptotic t-statistics are in parentheses below the estimated coefficients of the empirical variables.

(4) m_1 and m_2 are tests for first- and second-order serial correlation in the first-differenced residuals, asymptotically distributed as normal distribution under the null of no serial correlation.

(5) Sargan (k): test of the overidentifying restrictions, asymptotically distributed as Chi-square(df=k) under the null of instrument validity.

(6) Wald test is the test statistics for the estimated coefficient is zero, distributed as Chi-square(df) under the null of the estimated coefficient is zero. The critical values of Chi-square (df=1) are 2.706, 3.841, and 6.635 at the 10%, 5% and 1% significant levels, respectively.

(7) Time effects and industry effects are controlled in the estimations.

(8) See notes to Table 1 for definition and measurement of variables; df = degrees of freedom; p = p-value.

Table 4: The Impact of Interactions between Credit Ratings and their Changes on Firm Investment

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 UM_{it} + \beta_3 CR_{it} + \beta_4 \Delta CR_{it} + \beta_5 (\Delta CR_{it} * CR_{it}) + \varepsilon_{it}$$

	Variant 1 of equation (4) ($\Delta CR_{it} = \Delta CR_{it}^{a}$)	Variant 2 of equation (4) ($\Delta CR_{it} = \Delta CR_{it}^{b}$)	Variant 3 of equation (4) ($\Delta CR_{it} = \Delta CR_{it}^{c}$)
$Sales_{it}$	0.0823 (2.2258)	0.0678 (2.0123)	0.0865 (2.9488)
UM_{it}	-0.0611 (-1.0823)	-0.0532 (-0.8424)	-0.0455 (-0.7109)
CR_{it}	0.2890 (5.1354)	0.2992 (4.9560)	0.2707 (1.7687)
ΔCR_{it}	0.0016 (0.6000)	0.0355 (1.4861)	-0.0360 (-0.6944)
$\Delta CR_{it} * CR$	**-0.0077** **(-1.6787)**	**-0.3238** **(-3.3966)**	-0.0025 (-0.0278)
m_1	-9.462	-9.200	-8.599
m_2	0.252	0.195	0.215
Sargan (k) P-value	56.148(71) p=0.901	59.338(65) p=0.675	53.577(65) p=0.843
Wald test Chi-square (df=1)	$H_0 : \beta_5 = 0$ 2.812	$H_0 : \beta_5 = 0$ 11.537	$H_0 : \beta_5 = 0$ 0.0007
Instruments (difference)	$Sales_{t-2,t-3}$ UM_{t-2} CR_{t-2} ΔCR_{t-2} $(\Delta CR * CR)_{t-2,t-3}$	$Sales_{t-2}$ UM_{t-2} CR_{t-2} ΔCR_{t-2} $(\Delta CR * CR)_{t-2}$	$Sales_{t-2}$ UM_{t-2} CR_{t-2} ΔCR_{t-2} $(\Delta CR * CR)_{t-2}$
Instruments (levels)	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta(\Delta CR * CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta(\Delta CR * CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(UM)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta(\Delta CR * CR)_{t-1}$

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.
(2) The two-step estimates with robust (corrected) test statistics are reported.
(3) Heteroskedasticity consistent asymptotic t-statistics are in parentheses below the estimated coefficients of the empirical variables.
(4) m_1 and m_2 are tests for first- and second-order serial correlation in the first-differenced residuals, asymptotically distributed as normal distribution under the null of no serial correlation.
(5) Sargan (k): test of the overidentifying restrictions, asymptotically distributed as Chi-square(df=k) under the null of instrument validity.
(6) Wald test is the test statistics for the estimated coefficient is zero, distributed as Chi-square(df) under the null of the estimated coefficient is zero. The critical values of Chi-square (df=1) are 2.706, 3.841, and 6.635 at the 10%, 5% and 1% significant levels, respectively.
(7) Time effects and industry effects are controlled in the estimations.
(8) See notes to Table 1 for definition and measurement of variables; df = degrees of freedom; p = p-value.

Table 5 The Impact of Changes in Credit Ratings on Firm Investment: Upgraded versus Non-upgraded Firms

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 CR_{it} + \beta_3 Dum(up) * \Delta CR_{it} + \beta_4 (1 - Dum(up)) * \Delta CR_{it} + \varepsilon_{it}$$

	Variant 1 of Equation (5) ($\Delta CR_{it} = \Delta CR_{it}^a$)	Variant 2 of Equation (5) ($\Delta CR_{it} = \Delta CR_{it}^b$)	Variant 3 of Equation (5) ($\Delta CR_{it} = \Delta CR_{it}^c$)
$Sales_{it}$	0.1536 (2.9410)	0.0859 (1.9888)	0.0743 (1.7311)
CR_{it}	0.3151 (4.6032)	0.2977 (3.3358)	0.3718 (4.6721)
$Dum(up) * \Delta CR_{it}$	**-0.0046** **(-2.1887)**	**-0.2463** **(-1.6459)**	**-0.0458** **(-1.7228)**
$(1 - Dum(up)) * \Delta CR_{it}$	-0.0006 (-0.4199)	0.0355 (1.1180)	-0.0440 (-0.8171)
m_1	-8.854	-8.801	-8.381
m_2	0.165	-0.448	0.148
Sargan (k) P-value	69.178(64) p = 0.307	52.842(57) p=0.632	54.423(56) p=0.535
Wald test Chi-square (df=2)	$H_0 : \beta_3 = \beta_4 = 0$ 7.910	$H_0 : \beta_3 = \beta_4 = 0$ 2.851	$H_0 : \beta_3 = \beta_4 = 0$ 3.318
Instruments (difference)	$Sales_{t-2}$ CR_{t-2} $(Dum(up) * \Delta CR)_{t-2,t-3}$ $(1 - Dum(up) * \Delta CR)_{t-2,t-3}$	$Sales_{t-2}$ CR_{t-2} $(Dum(up) * \Delta CR)_{t-2,t-3}$ $(1 - Dum(up) * \Delta CR)_{t-3}$	$Sales_{t-3}$ CR_{t-2} $(Dum(up) * \Delta CR)_{t-2,t-3}$ $(1 - Dum(up) * \Delta CR)_{t-3}$
Instruments (levels)	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(Dum(up) * \Delta CR)_{t-1}$ $\Delta(1 - Dum(up) * \Delta CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(Dum(up) * \Delta CR)_{t-1}$ $\Delta(1 - Dum(up) * \Delta CR)_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(Dum(up) * \Delta CR)_{t-1}$ $\Delta(1 - Dum(up) * \Delta CR)_{t-1}$

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.
(2) The two-step estimates with robust (corrected) test statistics are reported.
(3) Heteroskedasticity consistent asymptotic t-statistics are in parentheses below the estimated coefficients of the empirical variables.
(4) m_1 and m_2 are tests for first- and second-order serial correlation in the first-differenced residuals, asymptotically distributed as normal distribution under the null of no serial correlation.
(5) Sargan (k): test of the overidentifying restrictions, asymptotically distributed as Chi-square(df=k) under the null of instrument validity.

(6) Wald test is the test statistics for the estimated coefficient is zero, distributed as Chi-square(df) under the null of the estimated coefficient is zero. The critical values of Chi-square (df=2) are 4.61, 5.99, and 9.21 at the 10%, 5% and 1% significant levels, respectively.

(7) Time effects and industry effects are controlled in the estimations.
(8) See notes to Table 1 for definition and measurement of variables; df = degrees of freedom; p = p-value.

Table 6: The Impact of the Interactions between Credit Ratings and their Changes on Firm Investment: Upgraded versus Non-upgraded Firms

$$\left(\frac{I}{K}\right)_{it} = f_i + f_t + \beta_1 SALES_{it} + \beta_2 CR_{it} + \beta_3 \Delta CR_{it} + \beta_4 Dum(up) * (\Delta CR_{it} * CR_{it}) + \beta_5 (1 - Dum(up)) * (\Delta CR_{it} * CR_{it}) + \varepsilon_{it}$$

	Variant 1 of Equation (6) ($\Delta CR_{it} = \Delta CR_{it}^a$)	Variant 2 of Equation (6) ($\Delta CR_{it} = \Delta CR_{it}^b$)	Variant 3 of Equation (6) ($\Delta CR_{it} = \Delta CR_{it}^c$)
$Sales_{it}$	0.1074 (2.0811)	0.1069 (1.9502)	0.1014 (2.4811)
CR_{it}	0.3312 (4.5872)	0.2969 (4.6180)	0.7822 (4.9453)
ΔCR_{it}	0.0026 (0.9369)	0.0438 (1.1089)	0.0617 (1.3745)
$Dum(up) * (\Delta CR * CR)_{it}$	**-0.0095** **(-2.1901)**	**-0.4341** **(-2.4820)**	**-0.2192** **(-2.5638)**
$(1 - Dum(up)) * (\Delta CR * CR)_{it}$	-0.0084 (-1.1451)	-0.3036 (-1.4541)	**-0.2954** **(-2.7662)**
m_1	-9.043	-8.434	-8.631
m_2	0.204	0.202	0.400
Sargan (k) P-value	48.413(63) 0.912	59.153(64) 0.648	61.527(64) 0.564
Wald test Chi-square (df=2)	$H_0 : \beta_5 = \beta_6 = 0$ 6.541	$H_0 : \beta_5 = \beta_6 = 0$ 11.288	$H_0 : \beta_5 = \beta_6 = 0$ 7.681
Instruments (dif.)	$Sales_{t-2}$ CR_{t-2} ΔCR_{t-2} $[Dum(up) * (\Delta CR * CR)]_{t-3}$ $[(1 - Dum(up)) * (\Delta CR * CR)]_{t-3}$	$Sales_{t-2}$ CR_{t-2} ΔCR_{t-2} $[Dum(up) * (\Delta CR * CR)]_{t-2}$ $[(1 - Dum(up)) * (\Delta CR * CR)]_{t-2}$	$Sales_{t-2}$ CR_{t-2} ΔCR_{t-2} $[Dum(up) * (\Delta CR * CR)]_{t-2}$ $[(1 - Dum(up)) * (\Delta CR * CR)]_{t-2}$
Instruments (levels)	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta[Dum(up) * (\Delta CR * CR)]_{t-1}$ $\Delta[(1 - Dum(up)) * (\Delta CR * CR)]_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta[Dum(up) * (\Delta CR * CR)]_{t-1}$ $\Delta[(1 - Dum(up)) * (\Delta CR * CR)]_{t-1}$	$\Delta(Sales)_{t-1}$ $\Delta(CR)_{t-1}$ $\Delta(\Delta CR)_{t-1}$ $\Delta[Dum(up) * (\Delta CR * CR)]_{t-1}$ $\Delta[(1 - Dum(up)) * (\Delta CR * CR)]_{t-1}$

Notes:

(1) Data source: *FAME*, 576 UK public firms during the period 1996-2004, total firm-year observation is 3640.
(2) The two-step estimates with robust (corrected) test statistics are reported.
(3) Heteroskedasticity consistent asymptotic t-statistics are in parentheses below the estimated coefficients of the empirical variables.
(4) m_1 and m_2 are tests for first- and second-order serial correlation in the first-differenced residuals, asymptotically distributed as normal distribution under the null of no serial correlation.
(5) Sargan (k): test of the overidentifying restrictions, asymptotically distributed as Chi-square(df=k) under the null of instrument validity.
(6) Wald test is the test statistics for the estimated coefficient is zero, distributed as Chi-square(df) under the null of the estimated coefficient is zero. The critical values of Chi-square (df=2) are 4.61, 5.99, and 9.21 at the 10%, 5% and 1% significant levels, respectively.
(7) Time effects and industry effects are controlled in the estimations.
(8) See notes to Table 1 for definition and measurement of variables; df = degrees of freedom; p = p-value.

Appendix: An investment model with credit ratings

We model how managers may manipulate investment decisions to influence the assessment of the firm's credit quality by potential external lenders and credit ratings agencies and how the *ex-post* perception of the firm's quality in turn affects the firm's investment behaviour. We assume that managers and incumbent shareholders have the same interests in responding to credit ratings. Managers driven by their career concerns do not like too high credit ratings due to the possibility of a credit ratings downgrade. Incumbent shareholders do not like too high credit ratings either, due to two main reasons. First, the stock price reacts negatively to credit ratings downgrade (Griffin and Sanvicente, 1982; Holthausen and Leftwich, 1986; Cornell *et al.*, 1989). When credit ratings are too high to sustain, the likelihood of a credit ratings downgrade is higher. Second, the firm may borrow more with higher credit ratings, which may increase the risk of bankruptcy and induce assets substitution between debtholders and shareholders (Myers, 1977). Hence, in deriving the model, we treat managers and incumbent shareholders as being on the side of the firm, while potential external lenders and credit ratings agencies are on the other side of the game. Conflicts of interest exist between the two players on each side.

Potential external lenders are not able to distinguish between good and bad firms due to asymmetric information problems, so they rely on a recommendation from a third-party, such as a credit ratings score provided by a recognised credit ratings agency, to update their beliefs about the quality of the firm. All parties involved have the same prior beliefs about the quality of the firm based on public available information. The investment decision made by management (on behalf of incumbent shareholders) is not observable for potential external lenders and credit ratings agencies. But they can observe the outcome of the investment decision based on some indicators of operating performance, for example, the level of output. They update their beliefs about the firm's quality following a Bayesian updating process. However, investment outcomes cannot be observed with 100% precision. There are two types of uncertainty. First, the quality of the firm is not completely known by potential external lenders and credit ratings agencies, which means that there is some uncertainty with respect to the quality of the firm. Second, there are some external stochastic forces outside the firm that are relevant, e.g. the macroeconomic situation, competition, and the capital market, etc. These external uncertainties blur the observation of investment outcomes and hence provide managers with chances to influence the *ex-post* assessment on the firm's quality by potential external lenders and credit ratings agencies.

We formalize the investment decision using the following investment model:

$$MaxE_0 \sum_{t=0}^{T} \rho^t \pi_t \quad \text{(A1)}$$

$$\text{s.t.} \qquad \pi_t = p_t Y_t - w_t L_t - p_t^I I_t - p_t G(I_t, K_t) \quad \text{(A2)}$$

$$K_t = I_t + (1-\delta)K_{t-1} \quad \text{(A3)}$$

where E is the expectations operator; ρ is the discount factor; π_t is net operating profits for period t; Y_t, K_t, L_t, and I_t are output, beginning-of-period capital stock, labour input, and gross investment of the firm at time t, respectively; w_t, p_t, and p_t^I are the nominal wage rate, the output price and the price of capital goods for the period t;. $G(I_t, K_t)$ is the internal convex cost function of adjusting the capital stock; and δ is the constant depreciation rate of capital. Following Narayanan (1985) and Holmström (1999) we assume that the observable output is a linear function of investment, the firm's quality, and a random factor:

$$Y_t = I_t + \eta + \varepsilon_t \quad \text{(A4)}$$

Where Y_t is the output observed by potential external lenders and credit ratings agencies at the end of period t; I_t is the investment decision variable; η denotes the firm's quality; and ε_t's are random terms, which are independently and normally distributed with mean zero and variance σ_ε^2. Expression (A4) states that the observable investment outcome (i.e. output) is determined by the action taken by management (i.e. investment), the quality of management (the firm), and some random factors. The quality of the firm η is unknown but potential external lenders and credit ratings agencies hold a prior belief about η. The prior distribution of η is assumed to be normal with mean m_0 and variance σ_0^2. At time t potential external lenders and credit ratings agencies update their beliefs about η based on observations of the investment outcomes in the past, i.e. the history of output $(Y_1, Y_2, \cdots Y_{t-1})$. Therefore, using (A4) in (A2), we obtain the following first order conditions of investment:

$$\lambda_t + \frac{\partial \sum_{t=0}^{T} \rho^t E_0[\eta / Y_t]}{\partial I_t} = \frac{\partial G(I_t, K_t)}{\partial I_t} \tag{A5}$$

Where λ is the Lagrange multiplier (the shadow price of capital). It is to be noted that the investment decision policy equation (A5) shows an important difference from the standard investment model; that is, an additional term $\frac{\partial \sum_{t=0}^{T} \rho^t E_0[\eta / Y_t]}{\partial I_t}$ appears in the first order conditions of investment and this is the marginal returns of investment to the firm's quality.

We need to solve $\frac{\partial \sum_{t=0}^{T} \rho^t E_0[\eta / Y_t]}{\partial I_t}$: the marginal return of investment to the firm's quality, which depends on the *ex-post* assessment on the firm's quality $\sum_{t=0}^{T} \rho^t E_0[\eta / Y_t]$. Adapting the ideas from Narayanan (1985) and Holmström (1999), we assume that although potential external lenders and credit ratings agencies are not able to observe the investment decision made by the firm, they are able to infer the equilibrium decision, therefore in equilibrium observing output Y_t will be equivalent to observing the sequence:

$$\eta + \varepsilon_t = Y_t - I_t^*\left(Y^{t-1}\right) \tag{A6}$$

where $I_t^*\left(Y^{t-1}\right)$ stands for the equilibrium decision rule, $Y^{t-1} = (Y_1, Y_2, \ldots Y_{t-1})$ is the history of output. Since the prior distribution of η is known with mean m_0 and variance σ_0^2, the posterior distribution of η at time t is normal with mean m_t, and variance σ_t^2 (see DeGroot, 1970):

$$m_t = \frac{\sigma_\varepsilon^2 m_0 + \sigma_0^2 \left(\sum_{t=0}^{T} \left(Y_t - I_t^* \left(Y^{t-1} \right) \right) \right)}{\sigma_\varepsilon^2 + t\sigma_0^2} \quad \text{(A7)}$$

$$\sigma_t^2 = \frac{\sigma_0^2 \sigma_\varepsilon^2}{\sigma_\varepsilon^2 + t\sigma_0^2} \quad \text{(A8)}$$

Taking expectations of (A6), the term $E_0[\eta/Y_t]$ can be computed by using (A7). It can be shown that the marginal returns of investment to the firm's quality at time t is (also see Narayanan, 1985; and Holmström, 1999):

$$\frac{\partial E_0[\eta/Y_t]}{\partial I_t} = \frac{\sigma_0^2}{\sigma_\varepsilon^2 + t\sigma_0^2} \quad \text{(A9)}$$

Using the standard adjustment cost function (see Whited, 1992), $G(I_t, K_t) = \frac{a}{2}\left(\frac{I_t}{K_t} - c \right)^2 K_t$, then:

$$\frac{\partial G[I_t, K_t]}{\partial I_t} = a\frac{I_t}{K_t} - ac \quad \text{(A10)}$$

Using (A9) and (A10) in (A5), the optimal investment equation becomes:

$$\frac{I_t}{K_t} = c + \frac{1}{a}\lambda_t + \frac{1}{a}\frac{\sigma_0^2}{\left(\sigma_\varepsilon^2 + t\sigma_0^2 \right)} \quad \text{(A11)}$$

The investment equation (A11) introduces external uncertainty $\left(\sigma_\varepsilon^2 \right)$ and the perception of the firm's quality $\left(\sigma_0^2 \right)$ into the standard investment model. We see that the firm's investment rate is a function of not only the shadow price of capital (λ), a traditional determinant of fixed investment, but also external uncertainty and the perception of the firm's quality.

A huge amount of evidence shows that external uncertainty discourages investment (Lensink, Bo and Sterken, 2001). Our model confirms this stylized fact on the investment-uncertainty relationship. From the investment model (A11) it is evident that $\frac{\partial (I/K)_t}{\partial \sigma_\varepsilon^2} = -\frac{1}{a}\frac{\sigma_0^2}{\left(\sigma_\varepsilon^2 + t\sigma_0^2 \right)^2} < 0$, i.e. external uncertainty has a negative effect on investment.

Besides external uncertainty, our model shows that the perception of the firm's quality σ_0^2 is also important for investment. As we can see from equation (A11), $\frac{\partial (I/K)_t}{\partial \sigma_0^2} = \frac{1}{a}\left(\frac{\sigma_\varepsilon^2 / \sigma_0^4}{\frac{\sigma_\varepsilon^2}{\sigma_0^2} + t}\right) > 0$, which suggest that when the firm's quality is not well-known to the public (a larger σ_0^2), then the firm will invest more, while when the firm's quality is well-known to the public (a smaller σ_0^2), then the firm investment less. If we use the level of and the changes in the firm's credit ratings score to proxy for the perception of the firm's quality (σ_0^2), then our model predicts that firms that have higher credit ratings (a smaller σ_0^2) will have lower investment. This is because if the firm is well-known to potential external lenders and credit ratings agencies, then the managers who are highly exposed to the public will have much less discretion in making corporate decisions. When external uncertainty is high, the managers are more uncertain about the investment outcomes. No matter how hard the managers try, only a small proportion of the variation of the outcome is attributed to the firm's quality (to the managers), while the variation of the outcome of the investment decision will be largely attributed to uncertainty surrounding external factors. This reduces the incentives for the managers to invest. When conditions are unfavorable, by following a safer investment policy, the managers can at least avoid damaging their reputation. Hence in particular when external uncertainty is high, the firm that has high credit ratings, i.e. well-known to the public (a smaller σ_0^2), will be unwilling to undertake additional risky investment.

In sum, our theoretical model shows that a firm's credit rating, as a proxy for the firm's credit quality, may affect the firm's investment decision via corporate governance channels. In the model we emphasize that managerial career concerns may be an effective mechanism in shaping the relationship between credit ratings and investment.